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GEOLOGICAL SURVEY

VOLUME XIX

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WITH

ACCOMPANYING PAPERS

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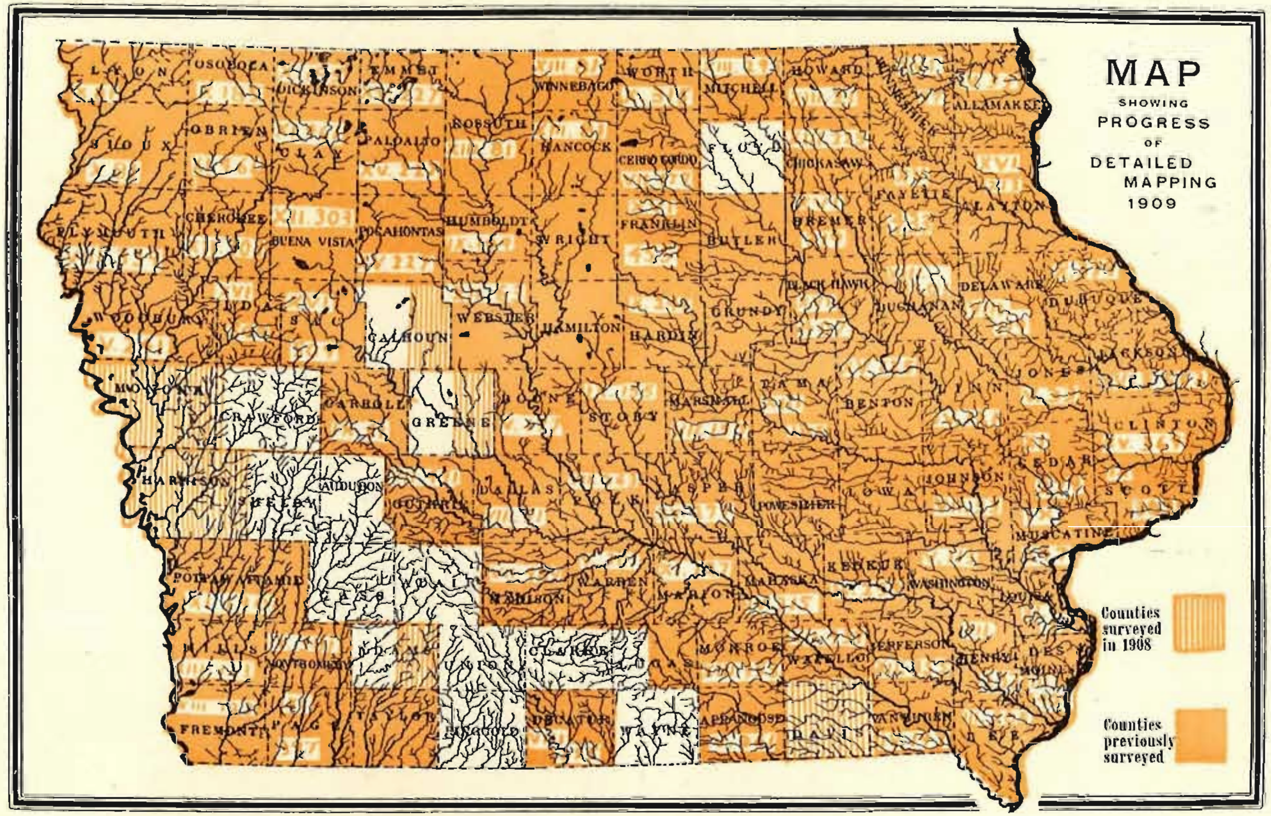
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SEVENTEENTH ANNUAL

Report of the State Geologist

IOWA GEOLOGICAL SURVEY,
DES MOINES, IOWA, DECEMBER 31, 1908.

To Governor Warren Garst and Members of the Geological Board:

GENTLEMEN:—During the year 1908 the Geological Survey has been active in a number of lines affecting the welfare of the state. Co-operation with the United States Geological Survey, in the work of preparing a topographic map of the state, has been continued on the same terms as during the year 1907, the work of 1908 being limited as before to the coal producing portion of the state, and chiefly to the Pella quadrangle. It would be a matter of very great economic importance if our coal areas were covered with standard topographic maps, and it is the purpose to extend the mapping in these areas as rapidly as possible. Such maps are needed as a basis for the study of the vertical distribution of the coal seams, a matter of much scientific, as well as of economic interest. Giving reliable detailed knowledge of the surface configuration of the region they represent, they are of the highest value in the solution of problems relating to drainage and soil conservation. The best location for wagon roads, electric lines and steam railways, so far as grades are concerned, is determined at once by reference to such maps. In a few of the states the topographic work is complete as a result of active co-operation of state and national surveys; in the other states the urgent call for co-operation is very much greater than the United States Survey has been able to meet. It is hoped that the work in Iowa may be continued until, not only the coal areas, but the entire state has been reliably mapped. In the north-central part of the state, where questions of drainage are vital and must be settled by comprehensive plans that have no regard to township or county lines, maps showing minute details of topography are among the prerequisites to success. The rate at which topographic mapping can be carried on in the several states depends on the national appropriations for topographic work. Iowa, in common with many of the other states, has a very direct interest in the progress of the topographic branch of the United States Geological Survey.

Besides the Director and the Assistant State Geologist the corps employed in the regular work of the State Survey has been about the same as during previous years. S. W. Beyer and Ira A. Williams, with such assistants as they were authorized to employ, have continued the investigations on peat and road materials. The peat work is practically finished and the report will appear as one of the papers making up Volume XIX. It will require another season to complete the field work on road materials. Henry Hinds, under the direction of F. A. Wilder, completed the field work on coal, and the report on this subject will soon be ready for the printer. Dr. Geo. A. Smith of Shenandoah has re-studied the section of the Missouri stage, generously devoting a large amount of time to field work in order that he might personally visit and re-observe the natural exposures and gather data for more detailed correlation. His paper has been re-written and is now ready for publication. W. H. Norton has collected the facts disclosed by the activities of the present year relative to deep wells, well sections and underground waters. S. W. Stookey completed the survey of Poweshiek county. M. F. Arey finished the work in Grundy and made a survey of Davis county. T. H. Macbride worked in Calhoun and Greene counties. B. Shimek made a very thorough survey of Harrison and Monona counties, adding to our knowledge many facts of exceeding interest from both the practical and the scientific points of view. The Mineral Statistics have, as usual, been compiled by Dr. S. W. Beyer.

I have the honor to remain, gentlemen,

Yours respectfully,

SAMUEL CALVIN.

MINERAL PRODUCTION IN IOWA

IN 1908

BY

S. W. BEYER

MINERAL PRODUCTION IN IOWA FOR 1908*

BY S. W. BEYER.

VALUE OF MINERAL PRODUCTION.

1906

Coal	$11,619,455
Clay	3,477,237
Stone including lime	577,782
Gypsum	573,498
Lead and zinc	26,300
Sand-lime brick	38,225
Mineral water†	27,540
Sand and gravel	74,380
Total	$16,414,447

1907

Coal	$12,258,012
Clay	3,733,476
Stone including lime	648,135
Gypsum	730,383
Lead and zinc	58,400
Sand-lime brick	55,618
Mineral waters‡	33,400
Sand and gravel	110,501
Total	$17,627,925

1908

Coal	$11,772,228
Clay	4,078,627
Stone including lime	569,775
Gypsum	564,688
Lead and zinc	26,799
Sand-lime brick	42,881
Mineral waters§	58,900
Sand and gravel**	976,549
Total	$18,090,447

*The mineral statistics for 1908 were collected through co-operation of the Iowa Geological Survey and the United States Geological Survey. The slight differences in results shown below are due to natural variations in interpretation and editing of returns.

†Mineral paint is combined with mineral water.

‡Mineral paints and iron ore are included with mineral waters.

§Mineral paints included with mineral waters.

**Portland cement included with sand and gravel.

The mineral production for 1908 shows a gain in the value of clay products, mineral waters and sand and gravel and a falling off in all of the other mineral products produced in the state. The greatest shrinkage was in the coal production. The total value of mineral products marketed shows a gain due to the opening and operation of the Portland cement plant at Mason City. Prices for all the mineral products of the state, save coal, were lower than for the preceding year. The manifold uses of cement and the greater effort directed toward the betterment of the public highways are responsible for the increase in the production of sand and gravel. The great increase in the manufacture and use of drain tile owing to the continuance of wet years swells the clay output. The outlook for 1909 is favorable for an increased production in all of the more important mineral industries.

Table I gives the total mineral production by counties and follows herewith:

TABLE NO. I.

Value of Total Mineral Production by Counties for 1908.

Counties	No. of producers	Coal	Clay	Stone and Lime	Miscellaneous	Total Value
Adair	2		$ 7,300			$ 7,300
Adams	14	$ 42,235	25,289			67,524
Allamakee	2			$ 242		242
Appanoose	71	2,151,905	28,648			2,170,894
Audubon	1					
Benton	9		28,674	491		29,165
Black Hawk	17			13,405	$ 41,915	69,920
Boone	15	461,544	53,475			515,019
Bremer						
Buena Vista	4		40,000			40,250
Butler	1					
Calhoun	3		36,900			36,900
Carroll	1					
Cass	2		19,200			19,200
Cedar	3					38,199
Cerro Gordo	11		723,988	30,775		1,447,868
Clarke	5			1,345		2,745
Clay	1					
Clayton	11		5,272	9,804	905	15,981
Clinton	10		15,450	1,870		44,699
Crawford	2		6,520			6,520
Dallas	7	299,407	178,488			477,910

TABLE NO. I—CONTINUED

Counties	No. of producers	Coal	Clay	Stone and Lime	Miscellaneous	Total Value
Davis	4	7,400				7,600
Decatur	2					4,157
Delaware	6		6,904	120		7,024
Des Moines	17		11,484	18,798	10,100	40,382
Dubuque	22		29,536	39,017	32,224	110,777
Emmet	1					
Fayette	9			5,665	1,890	17,555
Floyd	7			1,650	2,680	5,313
Franklin	1					
Fremont	5		25,082			25,082
Greene	5	30,581	29,549			60,130
Grundy	1					
Guthrie	14	36,975	20,218			57,193
Hamilton	2		60,342			60,342
Hancock	2		8,500			8,500
Hardin	14		59,520	37,852	209	97,581
Harrison	4		6,300			6,300
Henry	7		21,557			23,732
Howard	5			578		6,678
Humboldt	3			1,454		21,454
Ida	3				2,600	2,600
Iowa	6		37,230			37,230
Jackson	5		4,750	49,756		54,506
Jasper	13	695,078	29,470			766,548
Jefferson	5		71,168			71,268
Johnson	11		23,580		8,095	32,487
Jones	14		13,211	53,707		66,918
Keokuk	19	34,044	72,804	623		107,471
Kossuth	1					
Lee	13		8,220	33,472		41,692
Linn	20		18,517	75,065	16,229	120,454
Louisa	7		7,850	5,623		13,473
Lucas	2					16,343
Lyon	2				5,831	5,831
Madison	5			29,428		45,165
Mahaska	28	1,182,648	68,814			1,251,462
Marion	18	432,390	45,360			478,112
Marshall	9		39,087			71,965
Mills	3		7,840			7,840
Monroe	13	2,801,465				2,801,465
Montgomery	5		5,780			5,810
Muscatine	2		23,635		12,880	36,515
Osceola	2				2,534	2,534
Page	12	31,993	35,995		12,175	80,163
Palo Alto	5				3,209	3,209
Plymouth	1					
Pocahontas	2					14,656
Polk	56	2,816,082	560,026		66,416	3,442,524
Pottawattamie	5		49,791			49,791
Poweshiek	6		44,020			44,020
Sac	3				5,470	5,470
Scott	15		26,871	88,450		120,005
Shelby	1					

TABLE NO. I—CONTINUED

Counties	No. of producers	Coal	Clay	Stone and Lime	Miscellaneous	Total Value
Sioux	2	----------	----------	----------	----------	----------
Story	4	----------	37,860	----------	----------	37,860
Tama	6	----------	75,391	----------	----------	75,391
Taylor	3	33,881	9,207	----------	----------	43,088
Union	2	----------	33,925	----------	----------	33,925
Van Buren	13	26,964	6,939	492	----------	34,395
Wapello	21	291,079	76,434	18,150	9,365	398,028
Warren	8	16,633	19,847	----------	----------	36,480
Washington	10	----------	42,511	1,701	----------	44,212
Wayne	9	234,843	----------	----------	----------	236,593
Webster	30	127,604	578,310	----------	567,238	1,273,152
Winnebago	1	----------	----------	----------	----------	----------
Winneshiek	1	----------	----------	----------	----------	----------
Woodbury	10	----------	224,623	----------	46,370	270,993
Worth	1	----------	----------	----------	----------	----------
Wright	8	----------	98,800	----------	14,870	113,670
Single Producers	----	17,477	232,565	50,242	806,612	143,987
Totals	----	$11,772,228	$ 4,078,627	$ 569,775	$1,669,817	$18,090,447

Coal

The coal production for 1908 shows a shrinkage of nearly six per cent while the average price was about three cents per ton higher, the highest price on record since 1880. Monroe county shows the largest shrinkage and all but two of the leading coal producing counties show a falling off in production. Polk and Mahaska are the exceptions. The average number of men employed is the largest in the history of the industry in Iowa while the average number of days worked is the lowest since 1897. The output, disposition of product, value, average price per ton, average number of days worked and average number of men employed are given by counties below:

TABLE NO. II.

COAL PRODUCTION OF IOWA IN 1908, BY COUNTIES.

Counties	Loaded at mines for shipment—Short Tons	Sold to local trade and used by employes—Short Tons	Used at mines for steam and heat—Short Tons	Total quantity—Short Tons	Total value	Average price per ton	Average number of days worked	Average number of employes
Adams	300	17,152	40	17,492	$ 42,235	$ 2.47	141	83
Appanoose	1,101,788	45,901	11,492	1,159,181	2,151,905	1.86	175	4,170
Boone	196,537	32,421	8,540	237,498	461,544	1.95	184	735
Dallas	160,315	7,130	7,140	174,585	299,407	1.71	234	407
Davis	----------	3,700	----------	3,700	7,400	2.00	146	24
Greene	----------	12,531	400	12,931	30,581	2.37	223	37
Guthrie	----------	13,179	5	13,184	36,975	2.80	170	72
Jasper	364,500	10,682	18,334	393,516	695,078	1.77	233	804
Keokuk	----------	17,206	1,095	18,301	34,044	1.86	219	31
Lucas	----------	----------	----------	----------	----------	----------	----------	----------
Mahaska	755,653	34,032	19,548	809,233	1,182,648	1.46	203	1,852
Marion	265,401	26,896	2,290	294,587	432,390	1.47	201	646
Monroe	1,864,440	49,074	52,105	1,965,619	2,801,465	1.44	244	3,171
Page	----------	11,364	----------	11,364	31,993	2.82	124	59
Polk	1,351,356	226,995	40,544	1,618,895	2,816,082	1.74	228	3,129
Scott	----------	----------	----------	----------	----------	----------	----------	----------
Taylor	7,806	7,887	140	15,833	33,881	2.12	211	67
Van Buren	7,476	5,341	45	12,862	26,964	2.10	190	34
Wapello	126,671	55,249	2,732	184,652	291,079	1.58	190	440
Warren	----------	6,670	50	6,720	16,633	2.44	145	36
Wayne	114,074	12,053	32	126,159	234,843	1.86	234	421
Webster	46,937	15,180	1,101	63,218	127,604	2.02	183	187
Single Producers	----------	9,987	----------	9,987	17,477	1.75	124	34
Total	6,363,254	620,630	165,633	7,149,517	$ 11,772,228	$ 1.65	205	16,439
The returns of the United States Geological Survey are as follows.	6,345,590	650,481	165,239	7,161,310	11,706,402	1.63	214	16,021

The table given herewith presents a fair picture of the Iowa coal industry during the past ten years:

Year	Total Tons	Value	Average Price	Average Number of Days Worked	Average Number of Men Employed
1899	5,177,479	$ 6,397,338	$ 1.24	229	10,971
1900	5,202,939	7,155,341	1.38	228	11,608
1901	5,617,499	7,822,805	1.39	218	12,653
1902	5,904,766	8,660,287	1.47	227	12,434
1903	6,365,233	10,439,139	1.64	232	13,583
1904	6,507,655	10,439,496	1.60	213	15,373
1905	6,798,609	10,586,381	1.56	209	15,113
1906	7,266,224	11,619,455	1.60	224	15,260
1907	7,574,322	12,258,012	1.62	230	15,585
1908	7,149,517	11,772,228	1.65	205	16,439

The ten leading producers during 1907 according to the authority of the United States Geological Survey were as follows:

State	Short Tons	Value	Average Price	Average No. of Days Worked	Average No. of Men Empl'd
1. Pennsylvania	150,143,177	$155,664,026	$ 1.04	255	163,295
2. Illinois	51,317,146	54,687,382	1.07	218	65,581
3. West Virginia	48,091,583	47,846,630	0.99	230	59,029
4. Ohio	32,142,419	35,324,746	1.10	199	46,833
5. Alabama	14,250,454	18,405,468	1.29	242	21,388
6. Indiana	13,985,713	15,114,300	1.08	197	21,022
7. Colorado	10,790,236	15,079,449	1.40	258	14,223
8. Kentucky	10,753,124	11,405,038	1.06	210	16,971
9. Iowa	7,574,322	12,258,012	1.62	230	15,585
10. Kansas	7,322,449	11,159,698	1.52	225	12,439
Whole United States	480,363,424	$614,798,898	$ 1.14	234	513,258

The following table based upon figures given by the United States Geological Survey gives the production for the ten states which were the leaders in output of coal in 1908. It will be seen that Iowa maintains her rank of the preceding year although there are some changes among other states. As compared with the preceding year there is a sharp decline, both in quantity produced and in spot value:

TEN LEADING PRODUCING STATES IN 1908.

	State	Short Tons		State	Value
1.	Pennsylvania	117,179,527	1.	Pennsylvania	$118,816,303
2.	Illinois	47,659,690	2.	Illinois	49,978,247
3.	West Virginia	41,897,843	3.	West Virginia	40,009,054
4.	Ohio	26,270,639	4.	Ohio	27,897,704
5.	Indiana	12,314,890	5.	Alabama	14,647,891
6.	Alabama	11,604,593	6.	Colorado	13,586,988
7.	Kentucky	10,246,553	7.	Indiana	13,084,297
8.	Colorado	9,634,973	8.	Iowa	11,706,402
9.	Iowa	7,161,310	9.	Kentucky	10,317,162
10.	Kansas	6,245,508	10.	Kansas	9,292,222
	Whole United States	415,842,698			$532,314,117

The outlook for 1909 is for an increase in production and a slight falling off in average price per ton.

Clay Products

The value of clay products marketed in 1908 shows a splendid growth of approximately ten per cent. This growth is recorded in spite of the fact that there was a falling off in production of the majority of the common clay products. Iowa holds her position in first place as a producer and user of drain tile and doubled her output of sewer pipe during the year. Mason City in Cerro Gordo county is the greatest center for the manufacture of drain tile in the United States, and for that matter in the world. Eight plants, fully equipped and up-to-date, are in operation at the present time. Webster county is rapidly coming to the front in the manufacture of hollow ware, including drain tile, sewer pipe and hollow building block.

The clay products for 1908 were distributed as follows:

Article	Quantity in Thousands	Value	Compared With 1907	
			Incr'ase per cent	Decr'ase per cent
Common Brick	135,678	$ 896,890	-------	17 +
Paving Brick and Block	16,672	185,112	-------	17
Face Brick	7,900	86,232	-------	10 +
Drain Tile	-----------	2,522,363	25 +	-------
Sewer Pipe	-----------	211,044	104 +	-------
Building Block	-----------	129,003	-------	27 +
Pottery	-----------	18,710	-------	1 −
Miscellaneous*	-----------	29,273	140+	-------
Total†	-----------	$ 4,078,627	10 −	-------

*Includes raw clay mined and sold, $3,690.

†The returns of the United States Geological Survey give the total as $4,073,187. The figures for pottery and raw clay are as above.

TABLE NO. III.

VALUE OF IOWA CLAY PRODUCTS FOR 1908, TABULATED BY COUNTIES.

Counties	Number of producers	Com'on Brick	Paving Brick or Block	Face Brick	Drain Tile	Miscel-laneous	Total Value
Adair	2	$ 3,600	-------	-------	$ 3,700	-------	$ 7,300
Adams	4	7,780	-------	-------	17,509	-------	25,289
Appanoose	3	19,314	-------	-------	9,334	-------	28,648
Audubon	1	-------	-------	-------	-------	-------	-------
Benton	6	5,960	-------	-------	22,714	-------	28,674
Black Hawk	1	-------	-------	-------	-------	-------	-------
Boone	3	15,308	$ 19,161	$ 5,194	10,812	$ 3,000	53,475
Buena Vista	3	1,000	-------	-------	39,000	-------	40,000
Butler	1	-------	-------	-------	-------	-------	-------
Calhoun	3	1,000	-------	-------	35,400	500	36,900
Carroll	1	-------	-------	-------	-------	-------	-------
Cass	2	5,500	-------	7,000	2,700	4,000	19,200
Cedar	1	-------	-------	-------	-------	-------	-------
Cerro Gordo	6	20,097	-------	-------	692,291	11,600	723,988
Clarke	1	-------	-------	-------	-------	-------	-------
Clay	1	-------	-------	-------	-------	-------	-------
Clayton	4	4,312	-------	-------	960	-------	5,272
Clinton	3	9,590	-------	-------	5,000	860	15,450
Crawford	2	6,110	-------	110	-------	300	6,520
Dallas	7	8,774	-------	-------	169,714	-------	178,488
Decatur	1	-------	-------	-------	-------	-------	-------

TABLE NO. III—CONTINUED

Counties	Number of producers	Com'on Brick	Paving Brick or Block	Face Brick	Drain Tile	Miscellaneous	Total Value
Delaware	3	1,600	--------	-------	2,304	3,000	6,904
Des Moines	3	5,901	--------	83	5,500	--------	11,484
Dubuque	3	29,536	--------	-------	--------	--------	29,536
Emmet	1	-------	--------	-------	--------	--------	--------
Fayette	1	-------	--------	-------	--------	--------	--------
Floyd	1	-------	--------	-------	--------	--------	--------
Fremont	5	4,999	--------	-------	--------	20,083	25,082
Greene	2	500	--------	-------	29,049	--------	29,549
Grundy	1	-------	--------	-------	--------	--------	--------
Guthrie	3	2,554	--------	-------	13,418	4,246	20,218
Hamilton	2	11,142	--------	-------	49,200	--------	60,342
Hancock	2	-------	--------	-------	8,500	--------	8,500
Hardin	5	500	--------	-------	58,520	500	59,520
Harrison	4	6,300	--------	-------	--------	--------	6,300
Henry	6	1,707	--------	-------	19,850	--------	21,557
Howard	1	-------	--------	-------	--------	--------	--------
Humboldt	1	-------	--------	-------	--------	--------	--------
Ida	1	-------	--------	-------	--------	--------	--------
Iowa	6	10,750	900	-------	25,580	--------	37,230
Jackson	2	550	--------	-------	4,200	--------	4,750
Jasper	6	13,200	--------	-------	16,020	250	29,470
Jefferson	4	12,005	--------	-------	59,163	--------	71,168
Johnson	4	15,080	--------	-------	8,500	--------	23,580
Jones	3	2,393	--------	-------	10,818	--------	13,211
Keokuk	10	5,712	--------	-------	67,092	--------	72,804
Kossuth	1	-------	--------	-------	--------	--------	--------
Lee	3	6,850	--------	250	1,120	--------	8,220
Linn	6	8,553	--------	-------	9,964	--------	18,517
Louisa	2	1,250	--------	-------	6,600	--------	7,850
Lucas	1	-------	--------	-------	--------	--------	--------
Madison	1	-------	--------	-------	--------	--------	--------
Mahaska	4	14,213	25,000	1,600	28,001	--------	68,814
Marion	3	18,260	--------	-------	22,800	4,300	45,360
Marshall	8	7,550	--------	5,967	20,570	5,000	39,087
Mills	3	7,840	--------	-------	--------	--------	7,840
Montgomery	4	3,830	--------	-------	1,700	250	5,780
Muscatine	9	14,024	--------	-------	1,500	8,111	23,635
Page	5	27,775	--------	-------	8,220	--------	35,995
Palo Alto	1	-------	--------	-------	--------	--------	--------
Plymouth	1	-------	--------	-------	--------	--------	--------
Pocahontas	1	-------	--------	-------	--------	--------	--------
Polk	15	115,579	128,415	22,135	164,449	129,448	560,026
Pottawattamie	5	49,541	--------	-------	250	--------	49,791
Poweshiek	6	6,364	--------	-------	37,656	--------	44,020
Scott	3	12,890	650	-------	4,221	9,110	26,871
Shelby	1	-------	--------	-------	--------	--------	--------
Sioux	1	-------	--------	-------	--------	--------	--------
Story	4	6,100	200	360	31,200	--------	37,860
Tama	6	27,205	--------	16,670	31,516	--------	75,391
Taylor	2	4,236	111	-------	4,860	--------	9,207
Union	2	7,875	--------	-------	20,500	5,550	33,925
Van Buren	3	2,861	--------	-------	4,078	--------	6,939

TABLE NO. III—CONTINUED

Counties	Number of producers	Com'on Brick	Paving Brick or Block	Face Brick	Drain Tile	Miscel-laneous	Total Value
Wapello	4	39,522	9,036	916	24,611	2,349	76,434
Warren	3	570	________	_______	19,277	_________	19,847
Washington	5	6,039	________	_______	36,472	_________	42,511
Wayne	1	________	________	_______	__________	_________	___________
Webster	12	37,999	1,541	7,500	356,584	174,686	578,310
Winnebago	1	________	________	_______	__________	_________	___________
Winneshiek	1	________	________	_______	__________	_________	___________
Woodbury	6	184,275	________	18,447	21,871	30	224,623
Worth	1	________	________	_______	__________	_________	___________
Wright	3	600	________	_______	98,200	_________	98,800
Single Producers..	27	52,315	98	_______	179,295	857	232,565
	301	$896,890	$185,112	$86,232	$2,522,363	$388,030*	$4,078,627*

*Includes pottery and raw clay mined and sold.

Iowa ranked ninth in the total production for 1907, maintaining her rank and showing an increase in production over the preceding year of 7.49 per cent against a decrease of 1.30 per cent for the whole United States. The ten leading producers, with number of firms in operation, value and percentage of total products, are given below, as tabulated by the United States Geological Survey:

State	No. of Operating firms reporting	Value	Percentage of total Product
Ohio	736	$ 30,340,830	19.09
Pennsylvania	487	20,291,621	12.77
New Jersey	165	16,005,460	10.07
New York	417	13,220,489	8,32
Illinois	247	11,772,874	7.41
Indiana	172	6,898,871	4.34
Missouri	392	6,858,124	4.32
California	118	5,740,537	3.61
Iowa	276	3,728,785	2.35
West Virginia	63	3,640,387	2.29
Total for United States...............	5,536	$ 158,942,369	100.00

Pottery

The production of pottery for the year 1908 shows but little change when compared with that for 1907. The output for 1908 was as follows:

Red earthen ware	$ 8,161
Stoneware	7,549
Miscellaneous	3,000
Total	$18,710

An increased output is expected for the present year owing to the enlargement of the plant at Ottumwa.

Clay

The production and sale of raw clay during 1908 was less than for the preceding year. This is shown not so much in the diminished tonnage as in the lower prices received, especially for fire clay. These facts are shown in the following table:

Kind	Quantity in Short Tons	Value
Fire Clay	6,234	$ 1,990
Brick Clay	2,400	1,200
Miscellaneous	500	500
Total	9,134	$ 3,690

Stone

The quarry production for 1908 shows a falling off of about twelve and one-half per cent. The greatest shrinkage is in stone used for building purposes. The amount of crushed stone used for concrete shows a marked increase. The production for the year was distributed as follows:

Limestone—	
Building stone	$ 87,846
Paving, curbing and flagging	12,239
Rubble and riprap	119,709
Crushed stone used for—	
Roadmaking	65,175
Railway ballast	51,688
Concrete	149,439
Lime burned	79,400
Other purposes	1,942
*Total	$567,438
Sandstone	2,337
Total stone	$569,775

*The returns of the United States Geological Survey give the total output of limestone as $610,345. The lime produced is valued at $79,400, as above.

TABLE NO. IV.

PRODUCTION OF LIMESTONE IN 1908.

Counties	Number of producers	Building	Paving, Curbing and Flagging	Rubble and Riprap	Crushed Stone			Lime	Other Purposes	Total Value
					Road-making	Railroad Ballast	Concrete			
Allamakee	2	$ 242	-------	-------	-------	-------	-------	-------	-------	$ 242
Appanoose	1	-------	-------	-------	-------	-------	-------	-------	-------	-------
Benton	3	491	-------	-------	-------	-------	-------	-------	-------	491
Black Hawk	5	6,534	$ 248	$ 932	$ 645	-------	$ 5,046	-------	-------	13,405
Cedar	1	-------	-------	-------	-------	-------	-------	-------	-------	-------
Cerro Gordo	3	5,850	700	250	2,125	-------	1,100	$ 20,000	$ 750	30,775
Clarke	4	745	600	-------	-------	-------	-------	-------	-------	1,345
Clayton	5	4,404	200	1,900	140	-------	2,400	400	-------	9,444
Clinton	3	1,050	-------	500	300	-------	-------	-------	2	1,852
Dallas	1	-------	-------	-------	-------	-------	-------	-------	-------	-------
Davis	1	-------	-------	-------	-------	-------	-------	-------	-------	-------
Decatur	1	-------	-------	-------	-------	-------	-------	-------	-------	-------
Delaware	3	60	-------	60	-------	-------	-------	-------	-------	120
Des Moines	7	1,120	158	3,122	6,522	$ 375	7,036	-------	-------	18,333
Dubuque	8	12,760	4,230	5,398	1,205	60	5,914	9,450	-------	39,017
Fayette	5	4,615	-------	500	200	-------	50	-------	300	5,665
Floyd	2	1,050	300	300	-------	-------	-------	-------	-------	1,650
Hardin	4	1,528	-------	-------	-------	-------	35,774	-------	-------	37,302
Henry	1	-------	-------	-------	-------	-------	-------	-------	-------	-------
Howard	3	578	-------	-------	-------	-------	-------	-------	-------	578
Humboldt	2	1,454	-------	-------	-------	-------	-------	-------	-------	1,454
Jackson	3	256	-------	100	-------	-------	-------	49,350	50	49,756
Johnson	1	-------	-------	-------	-------	-------	-------	-------	-------	-------
Jones	10	13,175	3,030	26,322	1,098	5,522	3,695	-------	-------	52,842
Keokuk	4	488	-------	15	70	-------	50	-------	-------	623
Lee	9	6,382	-------	2,840	12,575	11,625	-------	-------	-------	33,422
Linn	7	3,121	-------	35,841	10,300	24,442	1,361	-------	-------	75,065

Louisa	5	2,600	---------	3,023	---------	---------	---------	---------	---------	5,623
Madison	4	1,700	---------	---------	5,900	7,700	13,628	---------	500	29,428
Marshall	1	---------	---------	---------	---------	---------	---------	---------	---------	---------
Pocahontas	1	---------	---------	---------	---------	---------	---------	---------	---------	---------
Scott	10	6,419	2,696	5,399	23,373	1,950	48,584	---------	---------	88,421
Van Buren	6	192	---------	300	---------	---------	---------	---------	---------	492
Wapello	3	6,800	---------	5,120	---------	---------	6,230	---------	---------	18,150
Washington	5	496	---------	125	---------	---------	1,050	---------	30	1,701
Single Producers	9	3,736	77	27,662	722	14	17,521	200	310	50,242
	131	$ 87,846	$ 12,239	$ 119,709	$ 65,175	$ 51,688	$149,439	$ 79,400	$ 1,942	$ 567,438

The outlook for the stone industry is not encouraging save in the line of crushed stone for road work and concrete. The growth in the use of cement and cement products is reducing the demand for stone and brick for structural purposes.

Sand and Gravel

According to the reports received the production of sand and gravel for 1908 more than doubled the output for 1907. The records for both years are more or less incomplete. During the latter year the majority of commercial producers responded. The production reported by ninety-four producers representing twenty-nine counties may be classified as follows:

Kind	Quantity in cubic yards	Value
Moulding Sand	3,635	$ 5,054
Building Sand	388,644	205,121
Engine Sand	20,826	5,811
Furnace Sand	2,000	875
Other Sands	36,146	14,039
Gravel	167,559	55,544
Total	618,810	$ 286,444

The value of the output reported for 1907 was $110,501.

Table V shows the value of sand and gravel produced in Iowa in 1908 by counties:

TABLE V.

SAND AND GRAVEL PRODUCTION IN IOWA IN 1908 BY COUNTIES.

Counties	No. of produ'rs	Molding Sand	Building Sand	Engine Sand	Furnace Sand	Other Sand	Gravel	Total Value
Appanoose	1							
Black Hawk	10	$2,475	$ 34,000	$1,000		$ 4,240	$ 200	$ 41,915
Cerro Gordo	1							
Clayton	2	30			$ 875			905
Clinton	1							
Des Moines	5		4,875				5,225	10,100
Dubuque	5	6	4,913	98		410		5,427
Fayette	3		1,090				800	1,890
Floyd	4					1,700	980	2,680
Hardin	2		59				150	209
Howard	1							
Ida	2		2,600					2,600
Johnson	6	120	6,425			120	1,430	8,095
Linn	6		15,959				270	16,229
Lyon	2		3,918	38		1,875		5,831
Marion	1							
Marshall	1							
Montgomery	1							
Muscatine	3		11,900			480	500	12,880
Osceola	2		2,000				534	2,534
Page	3		12,150			25		12,175
Palo Alto	4		1,895				1,314	3,209
Polk	11	1,359	55,568	821			8,668	66,416
Scott	1							
Sac	3		900				4,570	5,470
Sioux	1							
Wapello	3	50	3,180			3,975	2,160	9,365
Woodbury	4		29,325	795			16,250	46,370
Wright	5		6,448	2,693			5,729	14,870
Single Producers		1,014	7,916	366		1,214	6,764	17,274
Total	94	$5,054	$205,121	$5,811	$ 875	$14,039	$55,544	$ 286,444

Gypsum

The production of gypsum and gypsum products for 1908 was less than for the preceding year. The statistics of the industry for the year 1908 were as follows:

	Short Tons	Value
Crude gypsum mined	240,270	----------------
Distributed as follows:		
Sold crude—		
To Portland cement mills	18,960	$ 25,429
As land plaster	1,128	2,087
To plaster mills	856	1,632
Sold burned—		
Plaster of Paris, wall plaster, etc.	158,043	535,540
Total	179,987	$ 564,688

The production of crude gypsum for 1907 was 251,874 short tons and was distributed as crude gypsum 18,834 tons valued at $29,115 and burned gypsum 162,965 tons valued at $701,268. The price per ton was considerably lower for 1908 than for the preceding year.

Mineral Water

The amount of mineral water produced and sold was the largest in the history of the industry in Iowa. Five counties reported sales during the year. The springs at Colfax in Jasper county are by far the largest producers. The amount and value of the water sold were as follows:

	Quantity in gallons	Value
Medicinal	381,500	$ 41,650
Table	102,000	13,700
Total sold	483,500	$ 55,350

Used for soft drinks 317,500 gallons, not included in above figures.

The sales for 1907 amounted to 127,200 gallons valued at $30,500.

Lead and Zinc

On account of the slump in the price of pig lead the amount of lead ore produced and sold in the Dubuque region was much less than for the preceding year. The sale of zinc ores accumulated during several years brought up the zinc figures. The amount of ore sold during the year was as follows:

	Quantity in pounds	Value
Lead ore	124,900	$ 3,614
Zinc ore	950,000	23,183

The outlook for the present year is not promising unless the prices of pig lead and spelter increase. Some lead is being mined and held in stock. Prospecting and development work continue in a small way.

Sand-lime Brick

The sand-lime brick industry shows a falling off both in quantity and value of output. There was no change in the number of plants. The product was distributed as follows:

	Number in thousands	Value
Common brick	4,701	$ 33,784
Front brick	535	5,223
Miscellaneous		3,874
Total	5,236	$ 42,881

Portland Cement

Iowa for the first time appears as a producer of Portland cement. The Northwestern States Portland Cement Company of Mason City was the only plant in operation during the year. The plant of the Iowa Portland Cement Company of Des Moines is approaching completion and will probably be a producer during the present year. The Hawkeye Portland Cement Company has made but little progress during the year. The price of cement to Iowa consumers is the lowest it has ever been. The Lehigh Portland Cement Company has purchased property in the vicinity of Mason City and contemplates putting up a plant in the near future.

Iron

The Missouri Iron Company continued development work during 1908 and perfected its plant for handling and treating ore. Ore on a commercial basis was not produced during the year.

Peat

But little progress was made during the year toward the production and utilization of peat on a commercial scale. The plant installed near Fertile in Worth county was operated during a portion of the year but rather in an experimental way.

THE COAL DEPOSITS OF IOWA

BY

HENRY HINDS

THE COAL DEPOSITS OF IOWA

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CONTENTS

CHAPTER I

THE COAL DEPOSITS OF IOWA

INTRODUCTION.

Owing to the irregular lenticular arrangement of the greater part of the coal beds of Iowa and to the heavy deposits of glacial drift which obscure outcrops of beds except along the courses of the major streams, a geological examination of the area under consideration is attended with considerable difficulty, and generalizations as to the location and extent of unprospected fuels are frequently rendered either impossible or extremely uncertain. During the early days of the development of the Iowa coal field, when the nature of the deposits was very imperfectly understood, it was generally considered that two or three persistent coal beds underlay essentially the entire region and that it would be possible to trace certain continuous seams from Fort Dodge to Des Moines and thence to What Cheer, Oskaloosa and other parts of the field. Systematic prospecting, especially in the southern counties, has, however, proved that few coal basins contained over a few thousand acres and that the greater number carry thick coal under no more than 500 or 600 acres. In many cases drill records have shown workable coal at one point and a mere carbonaceous film in the same horizon a few hundred feet distant. It is this lenticular character of the deposits that makes imperative a fairly large outlay of capital for the thorough prospecting of any given field before the installation of expensive mine equipments is undertaken.

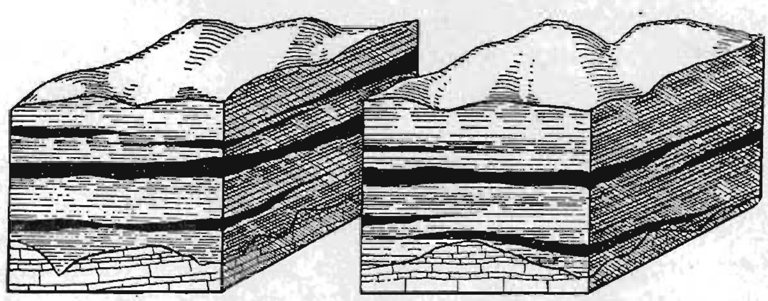


Figure 1. Stratigraphical arrangement of Iowa coal beds.

An exception to the generally inconstant character of Iowa coal seams is furnished by the bed mined in the Appanoose-Wayne field in the south-central part of the state, and by the thin coal mined in the southwestern corner of the state. The latter is a member of the Missouri stage and is described in a special chapter on the stratigraphy of the southwestern counties. The Mystic seam of the Appanoose-Wayne field lies in a section of the Des Moines stage that was deposited under singularly uniform conditions of plant growth and sedimentation. Throughout an area containing at least 275,000 acres in Iowa alone, this bed is present everywhere except where locally removed by old erosion channels, and formerly it extended an unknown distance north and east of its present line of outcrop. The field occupies also a considerable territory in adjacent portions of Missouri. A remarkable feature is the persistency and uniformity of the characteristics of the coal bed: it nowhere varies more than a few inches either way from a thickness of thirty inches, and in Iowa it always bears in its middle portion a clay parting from one-half to two inches in thickness. Microscopic examination of clay from this parting shows that if it were once a soil it has since lost all the characteristics of modern soils. It is difficult to imagine the conditions under which so thin and uniform a parting could have been laid down. Accompanying the Mystic coal are thin limestones which also preserve their character and stratigraphic position over a wide stretch of territory. The Appanoose-Wayne field produces about sixteen per cent of all the coal mined in Iowa.

In by far the greater part of the Iowa field, calcareous strata are conspicuously absent. The beds associated with the coal are chiefly argillaceous and arenaceous shales, with rather thin intercalated sandstones. These deposits, when traced either vertically or horizontally, change places one with the other with startling rapidity, so that drill records from even neighboring localities can be only approximately correlated. In many cases, however, the lenticular coal basins appear to lie in fairly persistent horizons, and where coal is absent in these, strongly bituminous shales are often found occupying stratigraphic positions corresponding with those of neighboring coals.

In almost all cases coal beds are underlain with structureless clays, usually, but often erroneously, termed "fire clays." The roof over the coals is commonly black fissile shale, termed "slate" by the miners, that grades upward into light-colored argillaceous material. A fair amount of timbering is required in mining under such roofs, but "draw slate" is seldom very troublesome. In any drilling, coal horizons are usually numerous, but most of these bear only thin coal or mere indications of coal. Traced laterally, a horizon that is valueless in one locality may become of economic importance in another not far distant.

Aside from irregularities in the coal beds already mentioned, other factors destroy to a limited extent the continuity of some basins. The floor upon which the coal plants grew was often

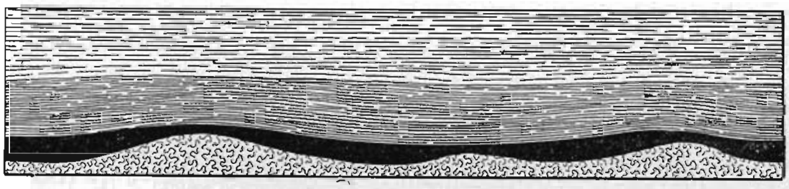


Figure 2. Uneven character of surface upon which coal was deposited.

very uneven, producing undulations in the beds of an amplitude of forty feet or less, and other features, as "horsebacks," etc.

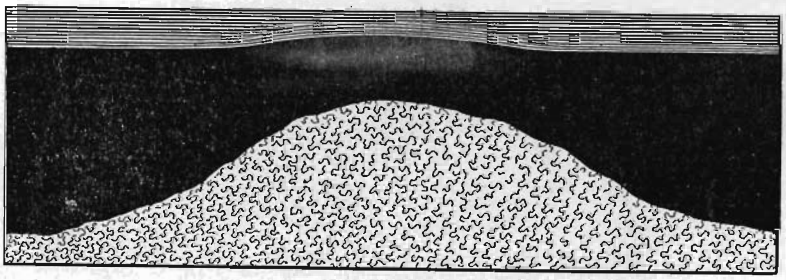


Figure 3. "Horseback" in coal bed.

In mining parlance, the coal usually "thins to the rise" and "thickens in the swamps" (low places). Several types of stream channels have locally effected the removal of all or parts of some beds. Sometimes shifting streams flowing through the

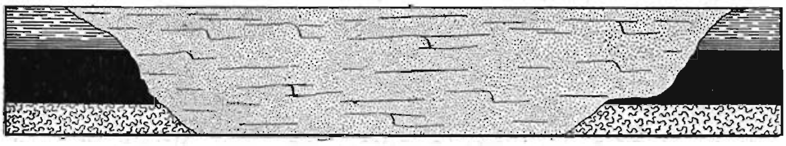


Figure 4. Carboniferous erosion: Sandstone occupying "cutout" in coal seam.

Carboniferous peat bogs, excavated and carried off some of the vegetal material. These channels were subsequently filled with clay and sands that today are found consolidated into shales and sandstones. The so-called "rolls" in the roofs of many mines are usually to be attributed to the partial removal of the coal producing peat by Carboniferous erosion. A second type of channel is the result of stream action during the long period of erosion which existed between the last emergence of the Coal Measures from the sea and the coming of glacial ice from the

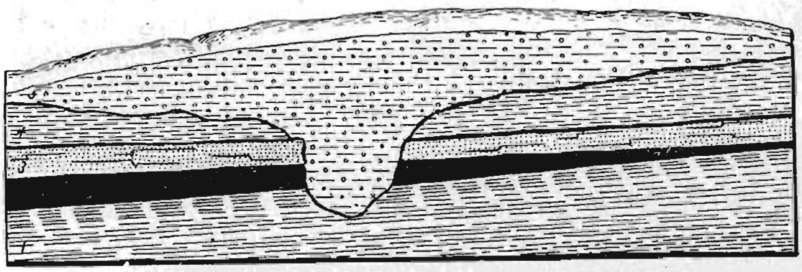


Figure 5. Preglacial erosion: Drift occupying small gorge.

north. These pre-glacial channels were filled with loose, unconsoldated material during the ice age, and sometimes their unexpected appearance gives much trouble in mines. The third type of channel is the work of modern streams acting since glacial time. As only the larger rivers have cut through the drift deposits in much of the Iowa field, and as the result of such action is plainly evident at the surface, post-glacial channels cause little anxiety to the miner. They have, in fact, been of great service in laying open to view the coal beds which now outcrop along their sides.

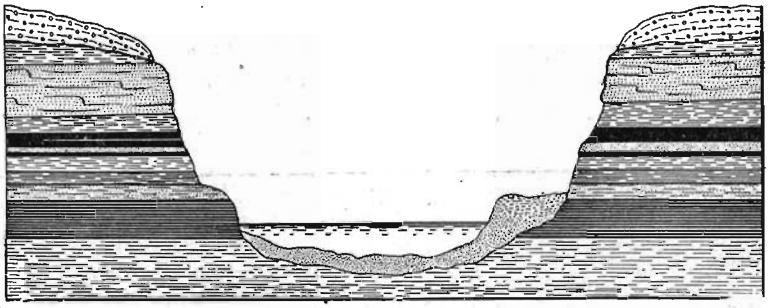


Figure 6. Postglacial erosion: gorge of Des Moines river at city of Des Moines.

Geological faults that affect mining operations at all seriously are extremely rare in Iowa. Where faults or "slips" are known to occur in and above coal beds they are almost always simply the result of the unequal shrinking of the carbonaceous material during the process of its conversion into bituminous coal. The throw of these faults is usually only a few inches or a few feet. Care should be taken to distinguish here geological faults, properly so-called, and the "faults" of mining phraseology. The term "fault" is often used by mining men to designate those portions of a local field in which coal is lacking because of removal by erosion channels or through lack of deposition between closely associated basins.

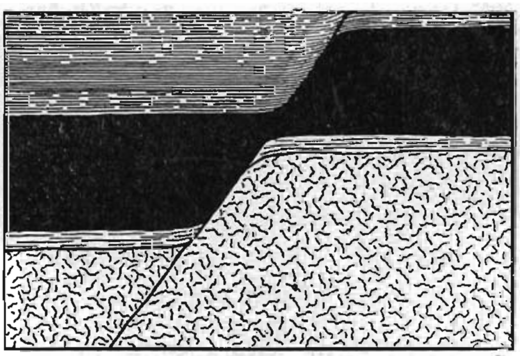


Figure 7. Fault in coal bed.

Other features characteristic of the coal beds are of minor importance and are such as are found in most fields. These characteristics will be more specifically mentioned in the detailed descriptions of various mining counties. A full treatment of the stratigraphical relationships and lithology of the Pennsylvanian rocks and of the chemical and physical properties of typical coals may be found in other chapters of this volume.

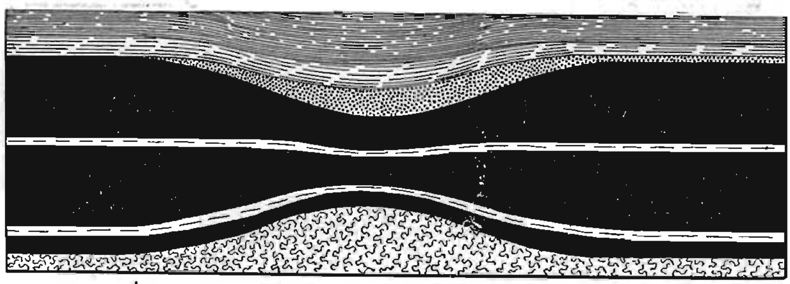


Figure 8. "Pinch" in coal bed.

The Iowa coal field contains about 19,000 square miles, possibly two-thirds of which may in time become productive. These figures do not take into consideration that portion of the most productive formation, the lower Pennsylvanian (Des Moines) which is covered by the Cretaceous and upper Pennsylvanian (Missouri) and which will certainly become in part productive, or of that portion of the Missourian outcrop that is with little doubt barren. Mr. Campbell, of the United States Geological Survey, estimates the original coal supply of Iowa at 29,160,000,000 tons. Subtracting the 141,608,792 tons mined from 1840 to January 1, 1908, from the original supply, we still have left 3,820 times the production of 1907. If the present ratio of a half ton lost for every ton marketed continues, the supply will last 2,550 years at the present rate of production of about 7,500,000 tons a year.*

In the early days of mining, and indeed even now, operators confined their attention largely to the valleys of the major streams where coals are naturally exposed. The Iowa Geological Survey has insisted for many years that there could be no reason why the valleys should be more productive than the uplands, yet it remains true today that comparatively few mines are situated on the prairie levels. This state of affairs is in large part due to the greater ease of prospecting in the lowlands and to the

*The production of coal in 1907, Advance Chapter from Mineral Resources of the United States for the Calendar year 1907, p. 125, U. S. G. S., Washington.

heretofore abundant reserves of coal found in such situations. As competition becomes more keen, more of the higher divides will be prospected. Recent attempts to locate profitable basins well back from the larger streams have proved suggestively successful. The thickness of individual coal beds is not great. The thickest coal is perhaps to be found in Marion county, where the Mammoth Vein Coal Company has encountered as much as sixteen feet in local "swamps." Where such thick coal occurs, however, it is often of poor quality and filled with concretions of clay-ironstone and sandstone. The greater part of the mining in the state is in beds from four to six feet in thickness, though the most extensively worked single seam, the Mystic of the Appanoose-Wayne field, shows only thirty inches, and considerable coal is taken from a fourteen to twenty-inch seam in Taylor, Page and Adams counties. Data recently compiled by Mr. Fisher, of the United States Geological Survey, appear to show that fourteen inches is about the minimum thickness for profitable working. Many operators in Missouri mine coal no thicker than this and the Al Russell mine, in Nodaway county, works in twelve inches.*

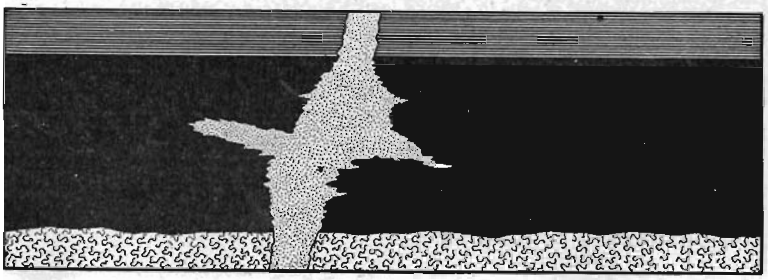


Figure 9. Fissure filled with clay.

The depth at which coal may be profitably mined is a factor that has not yet entered into consideration in Iowa. The deepest mine in the state, No. 3 of the Hocking Coal Company, is only 315 feet in depth. Coal does not occur in any part of the state, even in the Des Moines of the extreme southwestern corner, which lies at too great depth to be profitably mined if other conditions are favorable. The limit of practicable depth in working

*19th Annual Rept. Bureau of Mines, p. 260, 1905.

was adopted as 4,000 feet by the Royal Commission of Great Britain in 1871 and again in 1905.* Professor W. Calloway says, "it is probable a depth of 8,000 feet will be attained."† The deepest shaft in England is at the Pendleton colliery, where a bed from two to six feet thick is reached at 3,483 feet. A seam only two feet thick is mined at the Kingswood colliery, in Sumerset, at 2,460 feet. In Belgium, there are fourteen mines over 3,000 feet in depth, the deepest being 3,937 feet. In France and Germany are also deep shafts. "The German miner has no doubt that not only is there a possibility, but the greatest likelihood of pushing down to a depth of 1,500 M. (4,921 feet) or more, and of mining coal there at a profitable cost."‡

In the following pages the details of the present status of the Iowa coal industry are discussed by counties. As each small mining district is a field by itself and the deposits are almost always lenticular, generalizations and correlations of distant beds are dangerous and usually unwarranted. A presentation of facts alone, with but few theorizations, is all that can be safely attempted with strata constituted as are those of the Des Moines stage. This is especially true when, as in Iowa, the coal bearing formations are concealed almost universally by a heavy mantle of drift averaging 100 feet or more in thickness.

*Digest of Evidence, Royal Commission on Coal Supplies, 1901-05, p. XXXII.
†Trans. Inst. Min. Eng., Vol. 21, 1900-1, p. 67.
‡Dig. of Evi., Roy. Com. on Coal Supplies, 1901-05, pp. 76, 77.

PART I

COAL DEPOSITS OF CENTRAL IOWA

HUMBOLDT COUNTY

The greater part of the indurated rocks that lie beneath the heavy drift area of Humboldt county belong to Mississippian limestone formations. During the interval between the deposition of the limestones and the appearance of Coal Measure conditions, the region was a land surface trenched by valleys as at present, and it was in these depressions that most of the Des Moines strata now remaining were laid down. One such erosion valley extends from immediately south of the town of Humboldt nearly to the south county line. Lower Coal Measure strata also outcrop at intervals for a distance of four miles along the east fork of the Des Moines river above its junction with the west fork. The strata represented are chiefly sandstones and shales, the latter being in places so bituminous as to have encouraged prospecting for coal in them. Experimental drifts were started in section 18 (Se. qr.) of Beaver township and section 12 (Sw. qr.) of Corinth, but, aside from a few tons of coal obtained from the latter prospect, little success attended these attempts to obtain fuel. Back from the river valleys a heavy cover of drift effectually conceals the indurated rocks, yet well records and theoretical considerations indicate that the northern extension of the main Iowa coal field reaches interruptedly three to five miles north of the Webster county line. The chances for finding on the southern edge of Humboldt county coal basins of workable extent and with sufficient roof are not particularly bright, yet lie entirely within the range of possibilities.

WRIGHT COUNTY

Little is known as to the actual occurrence of Coal Measures in Wright county, for the heavy cover of glacial drift on the uplands conceals the underlying indurated rocks. It seems certain, however, that only a small area is underlain by the fragmentary remnants of the northern extension of the Iowa coal field. Des Moines rocks may be found in the two southern tiers of sections in Wall Lake and Vernon townships and in most of the western half of Troy township. It is not probable that workable beds of coal will be discovered in this county.

WEBSTER COUNTY

The surface of the greater part of Webster county is a gently undulating plain or prairie, poorly drained. A large section of country in the southwestern portion of the county is destitute of streams of any consequence, so that no natural outcrops of the indurated rocks beneath the heavy cover of drift may be seen, and prospect records and wells furnish the only clue to the geo-

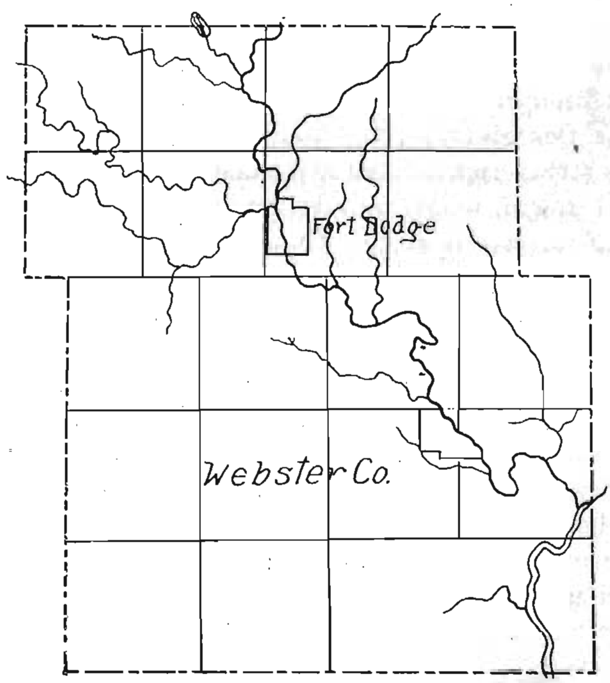


Figure 10. Sketch of Webster county which shows the immature state of drainage.

logical structure of the region. In other parts of the county, however, the Des Moines river and its few important tributaries have cut deep, narrow, sharply V-shaped valleys more than one hundred feet through the surface formations, exposing here and there splendid geological sections which include in places thick coal beds.

It is owing largely to the restriction of natural exposures of the coals to the immediate vicinity of the Des Moines river that the inception and growth of coal mining has been almost entirely confined to points along and near that stream. The finding of coal near Tara, Otho, and Dayton indicates that other coal basins exist at points remote from the main valleys and that only the expense and uncertainty of prospecting operations have prevented their discovery.

Coal Measures of the Des Moines stage underlie the greater part of the county. The underlying Mississippian limestone is exposed in the bottom of the lower portion of Lizard river valley, in the Des Moines valley from Fort Dodge northward to beyond the Humboldt county line, and in small sections of the river bottom above and below Kalo. It lies immediately beneath the drift in several small isolated areas of small importance. Resting unconformably on Mississippian limestones near Fort Dodge and on the Des Moines strata in many other districts are the gypsum-bearing rocks of Permian age. The area underlain by Permian is irregularly oval in shape and extends entirely across the county from northeast to southwest. At its maximum, between Fort Dodge and Kalo and northeast of these points, the area is six miles broad; southwest of Moorland it is not more than one mile in breadth. Coal has been found, although not usually in thick seams, beneath the gypsum in many parts of the area just outlined. The well on the Webster County Poor Farm (Elkhorn Tp., Sec. 3, Sw. qr.) penetrated the drift with its heavy clays, the Permian with its gypsum, the Des Moines with its coals, and stopped in the massive limestone of the Saint Louis. The detailed record of this boring is as follows:

WELL ON WEBSTER COUNTY POOR FARM.

		FEET.	INCHES.
23.	Soil	2	
22.	Yellow clay	13	
21.	Blue clay	47	
20.	Sand	1	6
19.	Red shale	19	4
18.	Gypsum	17	
17.	Blue shale	6	2
16.	Limestone	2	
15.	Coal		9
14.	Fire clay	1	6
13.	Shale, light colored	1	4
12.	Coal	1	3
11.	Sandstone	4	
10.	Black shale	4	2
9.	Coal		3
8.	Fire clay	1	
7.	Sandstone, white	4	6
6.	Shale, with limestone bands	34	6
5.	Shale, light colored	5	
4.	Shale, blue	4	
3.	Calcareous shale	6	5
2.	Shale, blue	21	2
1.	Limestone (penetrated)	40	
	Total	237	10

Because of the great irregularity of the surface of the Saint Louis limestone, it is impossible to give an exact idea of the depth of the base of the Coal Measures in various parts of the county. Roughly speaking, the limestone in the northern third of the county may be said to be at and slightly above the level of the Des Moines river (about 1,000 feet above tide). When allowance is made for the thickness of the mantle of drift under the uplands, it will be seen that the Coal Measures are quite thin in this region and that the chances for finding coal are proportionately small. In the southern half of the county the base of the Des Moines is found at depths of 150 to 250 feet below the prairie level. The drift is from 50 to 150 feet in thickness, leaving in many places 100 feet or more of strata which may include workable coals. Developments in Boone county on the south suggest that prospecting on the uplands of southern Webster county, while somewhat expensive and hazardous, might yield good results.

Owing to its strategical position as the most northerly productive area in Iowa, mining was energetically pursued at an early date and the output soon reached a large figure. In 1862 a production of only 250 bushels was recorded by the State Census. In 1870 the United States Census showed that an output of 34,400 tons had placed Webster fourth in rank among the coal producing counties of the state. In 1880 a production of 126,712 tons made her fifth in rank, while in 1890 she had dropped to twelfth place with a showing of 137,739 tons. The partial exhaustion of the known coal basins has led in recent years to a notable falling off in production. The statistics for the years 1898 to 1906 given below are taken from reports of the Iowa Geological Survey; for 1907 from those of the United States Geological Survey:

YEAR	TONS	YEAR	TONS
1898	137,787	1903	131,698
1899	118,770	1904	134,538
1900	135,661	1905	113,393
1901	127,894	1906	109,522
1902	140,007	1907	80,275

As shown by the report of the State Mine Inspectors, the decline in production was still further accentuated in the early part of 1908, the output for the year ending June 30, 1908, being only 59,031 tons. Eight mines, aside from small country banks, were in operation and 229 men were employed. The average price per ton at the mines was about $2.10.

Details in regard to the various mining districts may be found in the following pages.

DES MOINES VALLEY.

Fort Dodge. The Colburn, the lowest seam found in the Holaday creek area, lies in the upper portion of the Coal Measures present at Fort Dodge and has been mined in a small way in times past by drifts and shallow shafts at and above that point. A little coal is still taken out during the colder months of the year about two miles north of the city, where both the Colburn and a higher coal are found. Just above "the slide" on the west bank of the river (Douglas Tp., Sec. 7, Sw. qr.), the upper bed is shown in the following section:

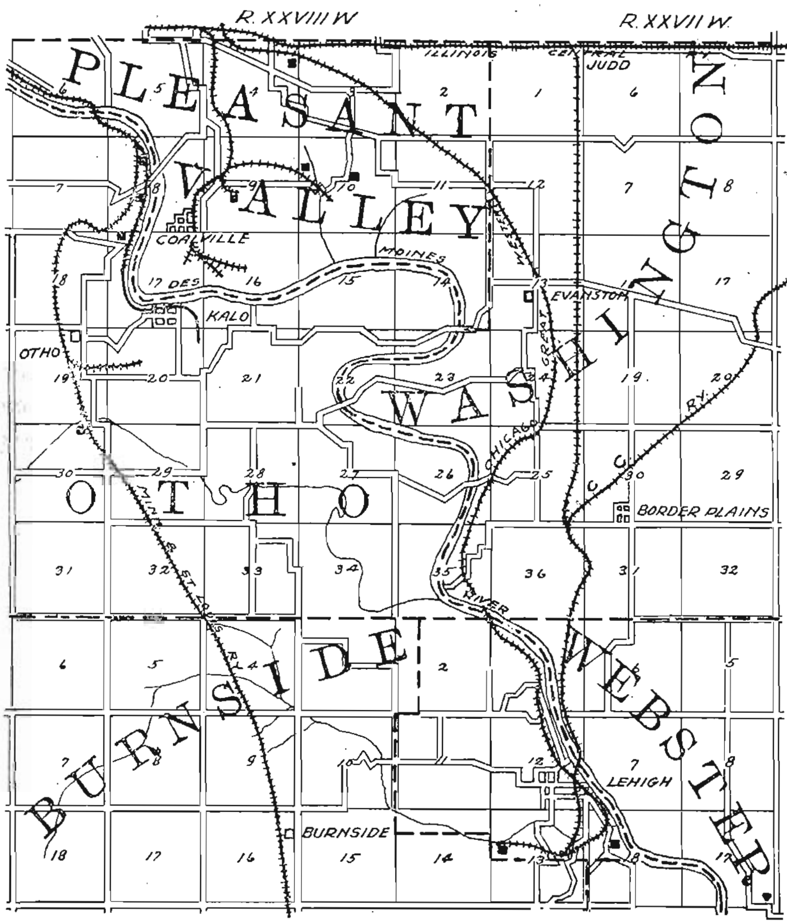


Figure 11. Map showing location of the principal mines in Webster county.

		FEET.
5.	Drift	8
4.	Argillaceous limestone, a single heavy layer	2
3.	Coal	2
2.	Shale, fissile, very bituminous	44
1.	Sandstone, red and white, with fossils of coal plants; to water	6

One-fourth mile below this, the same bed is shown at some old mines and what is probably the Colburn seam appears a few feet below in two benches, thus:

		FEET.	INCHES.
3.	Coal	2	
2.	Shale	2	
1.	Coal		6

Coal corresponding to that already mentioned is exposed one mile below the Minneapolis and Saint Louis station, along the railway tracks (Cooper Tp., Sec. 29, Sw. qr.). Numbers 3, 4 and 5 in the section given below probably occupy the Colburn horizon.

		FEET.	INCHES.
8.	Limestone, argillaceous, a single, solid layer	1	6
7.	Coal		10
6.	Shale and clay	3	
5.	Coal, impure	1	
4.	Shale, carbonaceous	1	6
3.	Coal, fair quality	1	6
2.	Shale, sandy, yellow; to level of railway track	4	
1.	Shale, nearly covered with talus to water level	25	

Kalo, Coalville, and Holaday Creek. For some distance below Fort Dodge outcrops of the Permian gypsum-bearing strata replace those of the Des Moines stage in the valley of the river. Where the river leaves this younger formation and again flows in a valley in which coal-bearing strata are found, many mines have at one time and another been located. Shafts and slopes have dotted the hillsides from Kalo two miles northward, as well as the right side of the valley below that village. The Coalville basin as now known comprises about six square miles, all in Otho and Pleasant Valley townships. Possibly the Otho field once formed part of the Coalville basin and has since been cut off from it by pre-glacial erosion. At any rate, the basin is now limited to sections 16, 17, 8 and 9, the west half of 15, 10 and 3 and the southeast half of 4. Three horizons have been recognized, the lowest the Colburn or "Cannel" seam, the second the "Big" coal, and the highest a thicker seam sometimes termed the "Soft" coal. Considerable difference of opinion exists as to the exact relationship of these beds, owing largely to the irregular character of the "Big" coal.

The Colburn seam, as we have already seen, is not confined to the Colburn basin and has been mined as far north as two miles above Fort Dodge. It is exceedingly variable in level; thus, on Holaday creek it lies about twenty-five feet above the level of the creek bottom or fifty feet above the river level, while in the vicinity of Kalo it is ten feet below the river on the east bank and ten to eighteen feet above the water level on the west side of the valley. Above Kalo the seam rises rapidly toward the north until it is cut off for a space by the Permian rocks. The bed also undergoes marked lithological variations, there being an increase on the western edge of the basin of the quantity of impurities present and in the percentage of volatile gases. On Holaday creek the bed consists of from four to nine inches of cannel above from one to three feet of bituminous coal; along the river above Kalo the seam bears nearly three feet of cannel in places. While inferior in fuel value to the bituminous coals, the cannel is growing more and more in importance as the other seams become exhausted. The following, published in the Mining World by G. H. Ashley, sums up the situation:

"No typical cannel coal has yet been reported from Iowa, though the region near Fort Dodge in Webster county supplies a so-called 'cannel.' An examination of its analysis shows it to have 39.04 per cent of volatile matter, 39.22 per cent fixed carbon, and 15.87 per cent ash, giving it a fuel ratio just below one, or on the borderland between cannel and bituminous coals. The coal is low in the coal series, occurring only about fifty feet above the Lower Carboniferous limestone. The seam * * * appears to be somewhat more regular than some of the bituminous seams near it in the series. * * * In its best section the cannel shows thirty inches immediately overlying twelve inches of bituminous coal. Where principally mined it shows sixteen inches of cannel separated by three inches of shale, and twenty-two inches of bituminous coal, the cannel in all cases being above."

It has often been stated that the so-called "Upper Bituminous" bed and the "Big" coal are distinct seams. This is only in part true. The confusion evidently arises from the presence in several parts of the basin of a higher coal lying not far above the "Big" coal and mined at a few points. This higher seam is the true "Upper Bituminous." It is of a pockety nature and usually contains coal of a quality much inferior to that of the thicker bed beneath. Much of the coal commonly termed "Upper Bituminous," however, actually occupies the horizon of the "Big" coal. In his description of the Coalville basin Dr. Wilder says:*

"A limited portion of this area contains coal varying in thickness from six to eight feet. This is known as the 'Big coal.'

*_Geology of Webster County_, Iowa Geol. Surv., Vol. XII, p. 90: Des Moines, 1902.

The Big coal is confined to a curiously narrow and contorted strip. It is rarely over 300 feet wide and often only 200 feet. Its center lies twenty-five feet below the rest of the upper bituminous horizon. Its edges rise rapidly, however, and all of the upper bituminous coal forms with it a continuous seam. Because it lies below the rest of the seam and is of better quality, it is often regarded as a distinct seam. The coal in this horizon outside of the Big coal varies in thickness from three feet to five feet. It is generally uniform in quality and some of it is of value only as steam coal. It lies fifty feet below the prairie level, is horizontal in position and free from fault. The Big coal ranks with the best coal produced in the county.

"The Coalville basin seems to be part of the trough of an ancient river. The Big coal was formed in the stream channel, while the rest of the seam represents the bottom lands. The Big coal is too pure to admit the belief that water was flowing through the channel when the coal was deposited, and that the vegetable matter was drift material. The fact that as yet it has not been possible to connect the tortuous sections of the Big coal, also leads to the belief that the hollow in which the Big coal lies represents portions of a deserted channel, which in places was filled in and consequently is at times barren. The Big coal has an excellent shale roof and is worked very economically."

Three mines are now working on Holaday creek, cleaning up the odds and ends left from former operations. Little coal is now left in workable shape in any part of the Coalville basin. The most northerly of these mines is the Rogers and Collins shaft (Pleasant Valley Tp., Sec. 4, Ne. qr., Se. 1/4). The shaft, situated on the right bank of the creek, is forty-seven feet deep and takes coal from the "middle vein" where it is from four to eight feet thick. It is probable that this coal forms part of the "Big" seam, though it does not appear to lie in a basin which is continuous with other parts of that bed. The seam is extremely irregular; "horsebacks" and "rolls" are rather common. Northeast of the shaft is a remarkably large "bowlder," ten feet thick in the center and gradually tapering towards the ends. As nearly as can be determined at present, it occupies an area of nearly ten acres. The coal divides as this body is approached, half passing above and half below it. Above the central or thicker part of the rock the coal thins notably. Evidently at this point a quantity of sediment borne by a shifting stream gained admittance to a temporarily deserted channel, burying beneath itself the mass of vegetation which had already gained a footing there. After the disturbing influence had been withdrawn, swamp conditions again prevailed. At this mine the roof is firm, black "slate." The bottom is a sandstone and less frequently a fire clay. Entries have been driven 800 feet from the shaft. A single-cylinder hoisting engine is used. The product is shipped over the Chicago Great Western Railroad and is also sold to the local wagon trade.

Half a mile southwest of the Rogers and Collins (Sec. 4, Se. qr.), the test-hole record given below shows a section similar to that near the mine. Both the hole and the shaft are located on the southern edge of the Permian gypsum area. Drift, Permian and Des Moines strata may be distinguished in the record.

	FEET.	INCHES.
9. Soil	3	
8. Yellow clay	16	
7. Blue clay	30	
6. Red shale	4	
5. Shales	30	
4. Rock	1	10
3. Shale	9	
2. Coal	2	7
1. Black jack		8

Farther down Holaday creek, just above its junction with Miracle creek, is the Minn and Scott bank (Sec. 10, Nw. qr., Sw. ¼). This is a slope to the "Big" seam, supplying a local trade, from the bluff on the west side of Holaday creek. Forty acres have been leased and the company is working 400 feet back from the slope mouth in six feet six inches of coal. The roof is a black "slate" which requires only ordinary timbering; the bottom is sandstone. Here an upper seam is present about twenty feet above the "Big" coal, a series of shales filling the interval between them. The Colburn, only a short distance below the "Big" coal, consists of from two to two and a half feet of bituminous coal capped by five inches of cannel.

A little below, on the opposite side of Holaday creek, is another local mine, that of J. E. Martin (Sec. 10, Sw. qr., Ne. ¼). Three seams are worked here by separate drifts. The upper is reached by a steep but short incline over which cars are hauled by a cable wound on a small drum and operated on the double pull-rope system. The middle seam is the one from which the greatest amount of coal is now taken. It is the "Big" seam, with coal from two to nine feet in thickness, thinning to the east. In this vicinity the "Big" coal lies in a basin 300 feet wide, running northwest and southeast. At this mine this bed lies fifteen feet or less beneath the upper seam and has a sandstone bottom. The lower, or Colburn seam has only recently been opened by Mr. Martin by a drift a short distance down the creek. It shows from one to three feet of bituminous coal overlain by from four to eight inches of cannel.

The following section is typical for the district. The drilling was headed on high ground. The "Big" seam, always very variable in level, was penetrated at one of its highest points, while the upper seam, if it ever existed at this point, has been removed by pre-glacial erosion and its place taken by drift.

DRILLING IN PLEASANT VALLEY TOWNSHIP, SEC. 9, SE. QR.

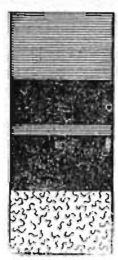
		FEET.	INCHES.
16.	Mixed clay	18	
15.	Blue clay	32	
14.	Sand and gravel	4	3
13.	Sandstone		5
12.	Sand, black	1	8
11.	"Slate," black		4
10.	Coal, soft ("Big" coal)	4	5
9.	Sandstone, white, compact	1	6
8.	Fire clay	9	1
7.	Sandstone, white	35	6
6.	"Slate," black		4
5.	Coal, cannel } Colburn seam)	1	3
4.	Coal, hard }		11
3.	Black jack }		4
2.	Sandstone		5
1.	Fire clay	1	9
	Total	112	2

The Gleason Coal Company is just beginning to drive entries in a new mine on the prairie level (Pleasant Valley Tp., Sec. 9, Sw. qr., Nw. 1/4). A steam hoist has been installed and a shipping business is to be done. In sinking the shaft, the following section was revealed:

		FEET.	INCHES.
3.	Yellow and blue clay	65	
2.	Black "slate"	15	
1.	Coal ("Big" seam)	4	2
	Total	84	2

Mr. Gleason reports that while prospecting they drilled 150 feet without finding more than the one coal. The Colburn horizon is, therefore, barren at this point. The coal found varies in thickness from one inch to four feet and a half. Other mines have recently worked this seam on the south, but 500 feet east of this shaft it is said to "go to the rise" and disappear.

In the valley bottom of the Des Moines river above Kalo, three mines are taking coal from the Cannel seam. On the southern border of the gypsum area is the Johnson mine (Otho Tp., Sec. 8, Nw. qr., Ne. 1/4). Although the mouth of the slope is at the side of the tracks of the Kalo switch, no coal is shipped, all being used at the adjacent plant of the Johnson Brothers Clay Works. As in other parts of the Cannel seam the sulphur content is often disagreeably large. Both cannel and bituminous coal are taken out. The section here is as follows:



FEET.	INCHES.	
3		5. Shale, dark colored, fissile, (exposed).
	16	4. Coal, cannel.
	3	3. Shale, dark colored.
	22	2. Coal, bituminous.
2		1. Fire clay, (exposed).

Figure 12. Cannel and bituminous veins at the Johnson mine. Kalo.

A quarter mile south, beside the tracks of the same switch, is the Irvine slope (Sec. 8, Nw. qr., Se. 1/4). The Cannel seam is reached at an elevation ten feet lower than that of the tracks of the switch. The seam is about twenty-eight inches thick at this point. The bottom is fire clay and sandstone. During the summer of 1908 attention was devoted chiefly to making roads through old workings. In the early autumn of the same year, some coal was being supplied to the Central Brick and Tile Company, whose yards are close at hand.

A half mile farther south on the same switch is the shipping mine of the Craig and Dawson Coal Company (Sec. 17, Nw. qr., Nw. 1/4). The shaft is fifty feet deep to the Cannel seam, showing that a southerly dip of about 100 feet to the mile prevails between this mine and those farther north. An upright double engine hoists the coal. The seam is from thirty-three to forty inches thick. The relationships of the strata near the seam are well shown in the following typical section found in a drilling near the mine:

DRILLING IN SECTION 17, NW. QR.

		FEET.	INCHES.
9.	Surface	8	
8.	"Slate"	3	4
7.	Rock	3	8
6.	"Slate"	9	4
5.	Coal (Cannel seam)	3	6
4.	Black jack		6
3.	Fire clay	14	
2.	Limestone (St. Louis)	21	1
1.	Sandstone	19	1

The Foster bank is a small affair in the side of a ravine at Kalo. The "Big" or "Upper Bituminous" horizon normally contains a coal bed from three to four feet thick at this place, but the present drift is taking coal from under a large "roll" which has reduced the thickness of the seam to two feet. The bottom is a very argillaceous sandrock; the roof a black bituminous shale.

For a distance of over a mile below Kalo, mining was at one time in active progress. At present only one small local mine is in operation. The Hewitt bank, a fourth mile southeast of Kalo, is a drift high on the side of a ravine in which several shipping mines were formerly located. The seam lies in the "Upper Bituminous" coal horizon and shows an average thickness of four feet at the Hewitt. "Horsebacks" and "rolls" are fairly common, though seldom of large size. Vertical "clay slips," usually about one inch thick, occur about one foot from the top. When the coal is of normal thickness a one-inch band of "bone" lies in the seam. The entry runs 1,000 feet into the bluffs, exposing a fire clay beneath the seam and a soft blue-black shale above. The coal mined is rather soft, yielding a large proportion of slack and nut. Near the bottom of the ravine, forty feet below the drift mouth, the Colburn horizon is occupied by a bed of coal eighteen inches thick. Five to seven feet above the coal mined an upper seam, two feet and less in thickness, is found in isolated patches. The following drilling made on the L. W. Hart land, near the Hewitt bank, shows the "Upper Bituminous," or "Big" coal horizon above and the Colburn below.

		FEET.	INCHES.
11.	Surface	24	6
10.	Fire clay	4	9
9.	Coal	4	2
8.	Fire clay	5	
7.	Sandstone	1	6
6.	Fire clay	6	6
5.	Rock, hard	2	
4.	Sandstone	22	6
3.	"Slate"	4	
2.	Coal	2	4
1.	Fire clay	3	
	Total	80	3

Otho. A new field has been opened south of Otho by the Craig and Dawson Coal Company (Otho Tp., Sec. 30, Ne. qr., Ne. ¼). By means of a ninety-foot shaft a seam three to four feet thick has been reached. Entries have been driven only 200 feet from the pit bottom and hoisting is done by a small single-cylinder engine and boiler which are to be replaced soon by larger ones. Shipping facilities can be easily procured when the development of the mine reaches a more advanced stage. The seam worked has a fire clay bottom and a black "slate" roof. An upper seam lies from ten to twenty feet above the other, but is not being developed at present. It is from two to three feet in thickness, has a fire clay bottom and, near the shaft, a roof of sandy shale which grades laterally into a black "slate." The upper seam is perhaps the cleaner of the two.

If this field were ever connected with the Coalville basin it has since been cut off by pre-glacial erosion. In some places the coal is cut out entirely and in others it becomes very thin. The upper seam may be tentatively assigned to the so-called "Upper Bituminous" horizon of the Kalo-Coalville area. The lower seam does not fall naturally into a position corresponding with any coal previously discovered, though it may possibly represent the Colburn horizon at a point where it approaches closely the upper coal.

In as heterogeneous a collection of strata as the Des Moines stage comprises, two horizons cannot be expected to preserve the same relations to one another, even in adjacent areas, nor can a horizon be expected to bear good coal in more than a small portion of its extent. The following is a record of a drilling made on the Doushack land (Sec. 30, Ne. qr., Ne. 1/4), near the Craig and Dawson shaft.

		FEET.	INCHES.
11.	Soil and gravel	5	
10.	Yellow and blue clay	49	
9.	Sandy shale	15	
8.	"Slate"	3	
7.	Coal (at 72 feet)	1	11
6.	Fire clay	2	
5.	Sandstone	1	
4.	Fire clay	4	7
3.	"Slate"	1	8
2.	Coal, good quality (at 83 1-6 feet)	3	
1.	Fire clay	1	
	Total	87	2

In section 18, north of Otho, attempts have been made from time to time to mine a thick seam of coal. Much of the bed has, however, been cut out by erosion and that which remains usually lacks sufficient cover. Below is given a section from the Bensing land, near the Minneapolis and Saint Louis railroad.

		FEET.	INCHES.
17.	Surface	43	1
16.	"Slate"	1	6
15.	Fire clay	1	4
14.	"Slate"	2	
13.	Coal	4	8
12.	"Slate"		2
11.	Fire clay	1	3
10.	Sandstone	5	6
9.	Sandy "slate"	12	6

8. Fire clay	1	4
7. Sandstone	6	6
6. Fire clay	2	
5. "Slate"	15	
4. Hard blue rock	1	
3. Fire clay	1	4
2. Black "slate"	13	
1. Fire clay	1	4
Total	113	6

Within a mile south and southeast of the Craig and Dawson shaft pre-glacial erosion appears to have either cut out the coal itself or to have removed so much of the cover as to render mining hazardous. The two drill records shown below (Sec. 32, Ne. qr., Ne. ¼) furnish typical sections for the district. It is possible that if drilling No. 2 had been carried farther down, a second seam would have been found and that No. 1 passed through an old channel which had removed the upper coal. The drillings do not, therefore, prove that two seams were not deposited in this district.

DRILLING NO. 1.

	FEET.	INCHES.
8. Soil	2	6
7. Yellow clay	13	
6. Blue clay	55	6
5. "Slate	8	6
4. Bowlder ("Hard band")		6
3. "Slate," coal, and calcite with hard band	5	
2. Fire clay	12	
1. Sandstone	49	
Total	146	

DRILLING NO. 2.

	FEET.	INCHES.
5. Soil	2	6
4. Yellow and blue clay	67	6
3. Black "slate"	1	5
2. Coal	1	7
1. Fire clay		7
Total	73	7

Lehigh. Of former vigorous mining in the lower valley of Crooked creek and along the river near Lehigh little remains. Clay plants, using the Carboniferous shales exposed in the valleys, have largely superseded the coal mines. In October, 1908, only two mines were in operation and a revival of the activity of the past seemed unlikely. No new light has been thrown on the geology of the basin since the following description of it was written by Wilder:*

"The Lehigh coal belt is not more than two-thirds of a mile wide and extends from northeast to southwest across section 7, Webster township, and section 13, Burnside township. It is crossed nearly in the center by the Des Moines river. On the west side of the river Crooked creek cuts through it, and coal is mined on this creek two miles from its mouth. On the east side of the creek the prospect holes of the Crooked Creek Railroad and Mining Company have found coal a mile back from the river. All of the mining has been done along the river and Crooked creek. The coal lies in four seams, one above the other, so that prospect holes often pass through more than one seam. The seams vary considerably at different points. All of the seams have produced coal, but the coal from the Tyson seam is regarded as the best and this seam up to date has been most extensively worked. The Harper seam is thirty feet above the water of the river; the Tyson is twenty feet above water level; the Pretty seam is ten to twenty feet below water level, while the Big is forty feet below the Pretty seam. The two seams above water level have been worked by drifting into the banks of the river, the banks of Crooked creek, and the sides of the numerous ravines in the vicinity. The Pretty seam and the Big seam are reached by shafts. The Big seam is said to lie at a uniform level, but the other seams are not so regular. The Tyson seam is never more than fifteen hundred feet wide, and it dips uniformly towards the center.

"The following is a composite section through the Lehigh coal seams:

		FEET.
9.	Drift	120
8.	Shale	20
7.	Coal, slate, six inches, Harper vein	0-2½
6.	Sandstone and shale	15
5.	Coal, Tyson seam	4
4.	Sandstone and shale	40
3.	Coal, Pretty seam	2-3
2.	Sandstone and shale	30
1.	Coal, Big seam, four inches bone in center	3½-4½

**Geology of Webster County*, Iowa Geol. Surv., Vol. XII, p. 88; Des Moines, 1902.

Both mines at present operating in the district are using the Pretty seam. In the valley of Crooked creek, a mile and a half above its mouth (Sumner Tp., Sec. 13, Nw. qr., Sw. ¼), is the mine of the McClure Coal Company. The shaft is seventy-five feet in depth. The mine employs steam power and does a shipping business. The Pretty seam, which is from two and a half to three feet thick at this point, is the only one now being developed, though attention will be turned to the Tyson in the near future. Under the coal is a six-inch band of a very carbonaceous and compact clay underlain by at least two feet of soft sandstone. The roof is a light gray shale containing numerous bands of iron pyrites near the coal. The long wall method of development is used, mining being done in the clay band. Work has been carried 1,300 feet north and 1,800 feet south of the shaft. The north side is now abandoned. Electric mining machines were used until the working face became so short that the time consumed in moving the machines rendered them unprofitable.

The Crooked Creek shaft Number 9 is located near the mouth of Crooked creek (Sec. 18, Nw. qr., Se. ¼). The product is hoisted by steam power and loaded on cars for shipment. The main entry runs 525 feet S. 10° E. with a cross road 675 feet to the west. "Rolls" and "horsebacks" are found, though small, and a fault with a throw of about three feet has given some trouble. The disturbance attending this dislocation of strata was not sufficiently strong to impair the value of the coal near the fault plane. The Pretty seam, where mined from this shaft, is from two feet to twenty-eight inches thick and lies about thirty-five feet beneath the surface. Often, though not always, present beneath the coal is a thin seam of fire clay. Where the clay is lacking a soft argillaceous sandstone forms the floor of the coal. The roof is a compact bluish gray shale which stands well with only a moderate amount of timbering.

Near the river, three miles below Lehigh, coal has been mined for a local trade in the valley of a small creek. A little farther down (Yell Tp., Sec. 21, Sw. qr., Sw. ¼) coal is exposed on the river bank.

	FEET.	INCHES.
5. Limestone	1	
4. Coal	1	2
3. Shale		10
2. Coal	2	
1. Fire clay (exposed to water level)	6	

Linnburg. At the mouth of Skiller creek, four miles east of Dayton, at least two seams are present. An upper seam which lies about five feet above the level of the creek bed has been reached by drifts and shafts. The bed is strongly undulatory. Only a bit over two feet of coal is shown. An attempt was made to work a lower coal here for shipping purposes, but it did not prove profitable and was soon abandoned. On the east side of the Des Moines river, opposite the mouth of Skiller creek, the Sunnyside Coal Company is now taking coal of good quality from an eighty-foot shaft (Sec. 16, Se. qr., Se. ¼). A small double engine is used for hoisting and a local trade is supplied. The bed lies forty feet below the level of low water in the river and varies between twenty-four and thirty inches in thickness. Although the mine has been opened only a short distance, there are indications that the seam is rather undulatory and has a slight general dip to the southeast. Under the coal is three feet of fire clay; above is a band of iron pyrites from one to ten inches thick. Over the "sulphur band" is a one-foot layer of "bone," a very carbonaceous shale, which is taken down only over the roads; it is capped by a black "slate" bearing Lingula and other brachiopod shells in abundance. Forty-five feet above the lower seam is an upper bed perhaps corresponding to the upper coal mined on Skiller creek. At the shaft the upper bed is quite thin, owing probably to the removal of much of the coal by the erosive action of the Des Moines at earlier periods. Locally these two coals are known as the Pretty and the Tyson, yet any attempt to correlate on but little evidence the beds of two such widely separated areas as the Lehigh and Linnburg basins seems unwarranted.

Another local mine—that of the Stratford Coal Company—is situated one mile below the Sunnyside. The seam, which is fifty feet below low water level, has an average thickness of two feet seven inches and occupies the horizon of the lower seam found opposite Skiller creek. Here the dip is to the southwest and the under-cutting is done in a layer of "bone" which lies beneath the coal, instead of above it as at the Sunnyside mine. About three acres have been mined out. In the greater part of the mine the roof is a compact, variegated sandstone, often quite argillaceous. Where this sandstone is lacking a tough fossiliferous shale takes its place and the upper portion of the coal bed becomes "bony," reproducing the conditions prevailing at the Sunnyside.

Workable coal was located near Dayton several years ago. The two sections given below, cited on the authority of the Craig Coal Company of Fort Dodge, appear to indicate a field the possibilities of which have been overlooked. The first drilling was made two miles east of Dayton (Dayton Tp., Sec. 18, Nw. ¼).

		FEET.	INCHES.
19.	Drift	92	8
18.	Sandstone	11	4
17.	Gray shale	5	
16.	Sandstone	4	3
15.	Shale	1	
14.	Rock (undet.)		4
13.	Gray shale	1	4
12.	Black shale	1	3
11.	Rock (undet.)	4	3
10.	Gray shale	18	5
9.	Hard rock (undet.)	8	
8.	White clay		4
7.	Hard shale		2
6.	Gray shale	1	5
5.	Gray shale	26	10
4.	Black shale		11
3.	Coal	3	6
2.	Fire clay		7
1.	Rock (undet.)	5	3
	Total	186	10

One mile northeast of Dayton the Craig Coal Company obtained the following section:

		FEET.	INCHES.
9.	Drift	129	1
8.	Shale	1	10
7.	Coal	3	6

6.	Fire clay	1	
5.	Shale	4	9
4.	Rock	8	11
3.	Shale	1	7
2.	Shale and black jack	41	9
1.	Coal	4	
	Total	196	5

SOUTH LIZARD VALLEY.

Tara. The Tara coal basin lies on the northwestern border of the Permian area, on South Lizard river about four miles southwest of Fort Dodge. A fairly level and apparently quite persistent seam bearing five feet and less of coal lies at a depth of 130 feet below the prairie level. For many years small mines supplying a country trade have operated here during at least the colder months, but when the region was visited by the author no coal was being taken out. The coal is of good quality. The floor is a fire clay and the roof a blue-black shale which does not always prove satisfactory. The limits of the basin have not been exactly determined, but it is known to include at least sections 33, 34 and 35 of Douglas township and section 6 of Elkhorn township. Where coal has been mined (Elkhorn Tp., Sec. 6, Ne. qr.; Douglas Tp., Sec. 33, Sw. qr. and Se. qr.; Sec. 34, Sw. qr.) the seam was from four to five feet in thickness. In adjacent territory drillings passed through coal which was not always of workable thickness. In Douglas township (Sec. 34, Se. ¼), five prospect holes were sunk and coal found in each case at about the same depth and under the same general conditions. A record of one of these holes is given below.

		FEET.	INCHES.
11.	Soil and drift	75	
10.	Shale	3	
9.	Blue clay	8	4
8.	Coal	1	6
7.	Clay ironstone ?	2	10
6.	Fire clay	4	6
5.	Sandstone	8	9
4.	Red clay	3	2
3.	Sandstone	7	4
2.	Red clay	2	4
1.	Rock (undet.)	4	

In section 35, Douglas township, Sw. 1/4, the following record reveals three coal horizons; two of them bearing seams of workable thickness.

		FEET.	INCHES.
13.	Soil	2	
12.	Drift	76	6
11.	Sandstone	4	
10.	Shale	8	6
9.	Coal	2	3
8.	Sandstone	2	
7.	Shale	2	2
6.	Coal		6
5.	Fire clay	3	3
4.	Shale	2	1
3.	Coal	2	2
2.	Fire clay	8	9
1.	Red clay	21	6

HAMILTON COUNTY

By far the greater part of Hamilton county is underlain by coal-bearing strata of Des Moines age, although the northern limit of this stage lies but a few miles beyond the northern boundary of the county. The Boone river and White Fox creek have cut down to the Mississippian limestone from the north to below Webster City and the Coal Measures are lacking also under a small area in the northeastern corner of the county. By far the greater part of the region is a gently undulating prairie, poorly drained, without outcrops, and unexplored by coal men. In the only district in which there is opportunity offered for coal beds, if such there be, to appear at the surface—namely, along Boone river below Webster City—seams are known to occur. Under the heavy cover of drift on the uplands back from the river, and especially in the southern townships, there are doubtless other basins where future wealth lies undisturbed. Prospecting to be successful must be thorough; since large sums may be expended in vain before the coveted fields are finally located. Seams have been more or less extensively worked not far from Hamilton county, in Webster on the west and in Boone and Story on the south.

Before the coming of the railroads brought cheap coal from other districts, considerable mining for local trade was in progress in the Boone river valley. Some coal is still taken out during the winter months. Old strippings, dumps, and drift openings may be seen near the river from five miles below Webster City nearly to the Webster county line. At least three horizons are known, some coal having been taken from each. Only one is considered of great importance; it lies at an average elevation of forty feet above the river level, though its altitude varies considerably at different points. Whether the coal is continuous under the entire district cannot be definitely stated from present knowledge, but the probabilities are more in favor of a number of nearly contiguous basins.

So far as known the most northerly point at which mining has been undertaken was at the Brockshink mine (Freedom Tp., Sec. 25, Sw. qr., Sw. 1/4), a short distance west of the river, where three feet of coal was capped by sandstone and underlain by fire clay. One mile south (Sec. 36, Sw. qr., Ne. 1/4), a small quantity of coal is occasionally worked by drifts on Mr. Silvers' farm. A short ravine on this place shows vestiges of extensive stripping, about two acres of surface having been removed in this way from the "upper vein." A second two-foot seam, separated from the first by three feet of shale and five of heavily-bedded sandstone, outcrops farther down the ravine. Still lower is a third bed, eighteen inches thick at the outcrop, bearing a tenacious, easily combustible coal known locally as cannel. East of Silvers', along the river, much stripping was done in former years—notably on the land of John Claffin on the west side of the river and on the Houck place opposite. The average thickness of the seam is reported to have been two feet and its elevation above low-water level about forty feet.

On the west side of the river, farther down (Webster Tp., Sec. 1), on land now belonging to Robert Lewis, coal has been removed for a distance of a fourth of a mile by stripping and at one place from a shaft. The seam worked here is from two to three feet in thickness. Two miles below, the river winds about a sharp horseshoe bend, impinging at the extremity of the curve against a steep bluff. On the brow of this declivity a shaft seventy feet deep was sunk years ago. It is said that the men worked in four feet of coal just before the caving of the shaft stopped operations. Two miles west of the bend were the most important mines of the district, the Stockdale drifts (Webster Tp., Sec. 10, S. ½). Openings have been made in both sides of the ravine through which the wagon road leads to the north. The thickness of the bed worked ranged from two to four feet, with an average of forty inches. Entries penetrated the hill for nearly half a mile, revealing a gentle dip to the west. The roof was seven feet of slate overlain by white sandstone. A sump seven feet deep failed to pass through the fire clay underlying the coal. At one time farmers came from long distances to procure this coal, but the entrance of considerable water into the mine caused operations to be discontinued about six years ago. Still farther down the river, near Bell's mill (Sec. 16, Sw. qr.), small openings have been made at various times. Nothing has been done here for several years.

Some prospecting was undertaken a short distance back from the river at several places north of the Stockdale mines and west of Silvers'. Since the results have never been made public, we have now only negative evidence derived from the fact that no shafts were sunk where the investigations were made.

The annual production of Hamilton has always been small. In 1862 it was 850 bushels; in 1880, 3,000 tons. In 1885 the total fell to 918 tons and has since shown a gradual decline.

HARDIN COUNTY

Although Hardin lies on the eastern margin of the Iowa coal field, the superficial indurated rocks beneath two-thirds of its surface may be classed as Coal Measures. The areas where Des Moines strata have not been identified form part of the northern townships and of the extreme southeastern corner of the county. Almost the only natural exposures of the Upper Carboniferous are along the Iowa river from Xenia to Steamboat Rock. At Eldora, ninety feet of Coal Measure rocks, chiefly sandstones, are exposed. The Des Moines does not possess great thickness in any part of the county. The elevation of its base is 950 feet above tide at Eldora and 970 at Steamboat Rock; farther west this altitude probably decreases somewhat. Toward the west the elevation of the surface increases by 100 to 200 feet, but a corresponding increase in the depth to which the superficial deposits extend allows no increment in the thickness of the coal-bearing rocks. The average thickness of the drift is about 100 feet for the entire county and 150 feet or more for the western tier of townships. In several localities a maximum of 300 feet and more has been recorded.

Twenty-five years ago Hardin was a producer of coal; now no mining of importance is being undertaken. In 1860 the tonnage was reported to be 262. In 1866 the production had increased to 30,000 bushels. The Census of Iowa for 1875 places the production at 7,193 tons and the U. S. Census of 1880 at 3,135 tons. A further decrease soon brought the total output to less than four figures and no recovery has since been evidenced.

Until the completion of the railroad south to Oskaloosa brought Hardin county coal into direct competition with the fields of southern Iowa, Eldora was the center of a flourishing mining industry. As many as four coal horizons have been recognized yet only one has been considered worthy of much development work. A drill record from section five of Eldora township shows this sequence of strata:

		FEET.	INCHES.
12.	Surface deposits	5	
11.	Sandstone, ferruginous	2	
10.	Coal	1	2
9.	Fire clay		6
8.	Shale		18
7.	Coal		11
6.	Fire clay	1	
5.	Shale	12	
4.	Coal	4	
3.	Fire clay	4	
2.	Coal		8
1.	Shale	5	

Number 11 of this section is the base of a thick series of sandstones through which the Iowa river has hewn its way. The coal occurs in small pockets, five feet six inches thick at the maximum. The majority of the mines were situated in sections 5 and 6 of Eldora township and section 32 of Clay township. Where mined, the seam lies above the level of low water in the river, but a dip to the southeast carries it below the river in that direction.

An abundance of water forced attempts to follow the seam down the dip to be relinquished at the river level, so that considerable thick coal was left as unworkable at the lower elevations. The coal was somewhat "soft," and contained much sulphur in the form of bands of iron pyrites. The bed thins rapidly to the west and disappears beneath the river on the east. No coal has been encountered in wells at Eldora on the south, although some is reported from the vicinity of the State Industrial School, one mile west of Eldora.

Well drillers report coal from various parts of the county, yet little reliance can be placed on their somewhat conflicting statements. No systematic search for coal has yet been undertaken. The fact that a good field was discovered on the line of the only notable Des Moines outcrop within the limits of the county leads one to infer that prospecting in the unexplored strata beneath the prairies might reveal other basins and pockets of importance.

BOONE COUNTY

The coal bearing strata of the Des Moines stage everywhere underlie Boone county to a depth of between 400 and 500 feet below the highland level. In almost all cases, however, the upper hundred or two hundred feet penetrated in drilling from points on the plain consist of drift clays, sands, and gravels. Drillings at several points furnish data for an approximate determination of the depth of the Saint Louis limestone, or in other words, of the base of the Coal Measures, beneath the Des Moines valley region. The deep well at Boone penetrated 200 feet of drift and 260 of Des Moines strata; a drilling at Moingona reached the limestone about 200 feet below the level of the station at that village; a drilling at the Driscoll Brothers slope below Moingona encountered a cherty limestone at 125 feet beneath the river level. These determinations indicate that the base of the Coal Measures may be expected to be reached at an altitude approaching 700 feet above sea level. The usual variations in the level of the top of the limestone due to its very irregular surface must, however, be taken into consideration. Toward the east the limestone rapidly rises on the side of an anticlinal arch and comes to the surface a short distance beyond the Story county line. The strata found within 200 feet above the Saint Louis comprise the lower part of the Des Moines stage, and therefore belong to the richest portion of the Iowa coal bearing rocks. Stratigraphically they correspond to the beds which include the coal seams of Polk county and the country to the southeast.

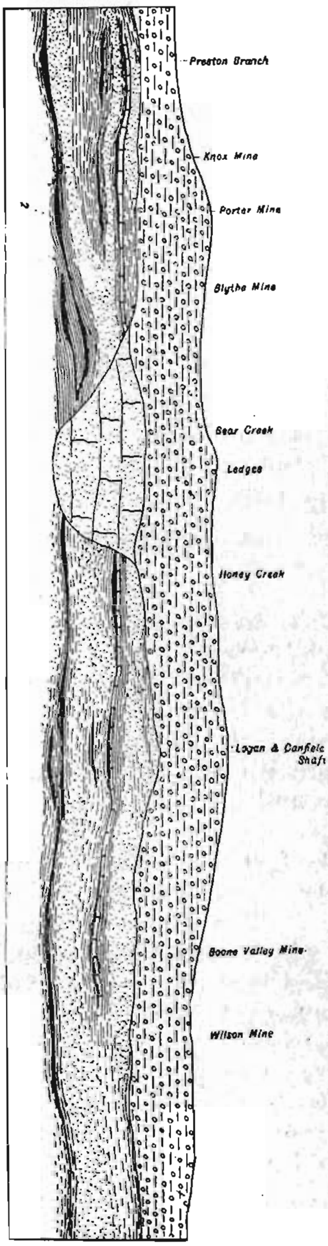


Figure 13. General geological section across Boone county along the Des Moines river.

The Des Moines river has cut for itself a deep, narrow valley, bisecting the county from north to south and exposing along its course a magnificent geological section. The coal outcropping along the bluffs soon attracted the attention of the first pioneers, so that mining began in this region during the early stages of settlement. Even in 1849 Owen noted that blacksmiths obtained their coal along Honey creek, and the building of a railroad into the district in 1866 gave a great impetus to the coal industry. The production recorded in 1860 by the Eighth Census was 630 tons, value \$1,200. In 1870 the output had increased to 42,143 tons. The State Census of 1875 shows only 955 tons, but the Tenth United States Census (1880) gives 140,000 as the figure and the Eleventh (1890) 174,392. Boone now ranks eighth among the counties of the state as a producer. According to the reports of this Survey, the tonnage for the past ten years has been as follows:

YEAR.	TONS.	YEAR.	TONS.
1898	331,543	1903	291,321
1899	262,632	1904	285,157
1900	288,742	1905	292,659
1901	257,033	1906	233,110
1902	264,524	1907	208,150

During recent years the output suffered a slight decrease, but with the opening of new fields back from the river the outlook for the future is bright. The State Mine Inspectors' report for the year ending June 30, 1908, is:

Number of tons of all kinds produced	218,491
Total number of employes	864
Number of mines	12

At $2.00 per ton, the value of this product at the mines becomes $436,982.

Several coal horizons were distinguished by Beyer in the Des Moines river valley as a result of his study of the outcrops of strata and of the mining being done in 1895. Only three coal horizons were known at that time and these are described as follows in the Geology of Boone county:*

"The first has an elevation of from fifty to seventy feet above the water in the Des Moines river and is the bed operated at the Knox and Porter slopes in the southern portion of the county, and the drifts along Honey creek in the central area. This horizon is usually overlain by a 'caprock' of hard, brittle, calcareous shale which contains in abundance the remains of a marine fauna—Rhynchonella, Discina and Productus are the more common genera represented.

"The second horizon occurs some fifty feet below the first and is the most persistent seam in the county. It is currently known as the "upper vein," or "black jack." The former name is in contradistinction to a lower vein which sometimes accompanies it; the latter name is often applied to it on account of its semi-lustrous jet-black color and somewhat bony character. This seam is operated at the Blythe [Driscoll] mine and in the Moingona, Boonesboro, Milford and Fraser areas. It is usually provided with a good roof and carries its thickness well—two essentials to profitable mining. The roof shale often contains well preserved specimens of the genus Lingula.

*Beyer, Iowa Geol. Surv., Vol. V, p. 218; Des Moines, 1896.

"The third horizon occurs from four to twelve feet below the second and is usually denominated the "lower vein." The distribution of coal in this seam is somewhat anomalous; the coal usually occurs in lens-shaped masses (pockets) of limited extent. The roof is fairly good, but often contains numerous septarian nodules and clay ironstone concretions, which render mining somewhat hazardous unless due precautions are observed. The product of this vein is much sought for furnace and domestic use and commands the highest market price. At the present time the production of this coal is almost wholly limited to the Boonesboro-Milford area."

Since the above was written mining operations have tended to show that the "black jack vein," although the most persistent of any, is far from being continuous between the points at which the horizon has been recognized. In most other parts of the state, also, the most strongly marked coal horizons of the Des Moines stage contain workable coal only in basins of limited extent separated by areas in which the coal is thin or completely lacking. To the three horizons recognized by Beyer must now be added a fourth which lies between fifty and eighty feet below the level of the Milford-Boonesboro coal. It has been found at several points during prospecting operations, but as the parties interested are not yet ready to make public their discoveries, nothing very definite can be stated at this time. The Ogden mine, north of Ogden, has opened up this coal and it has been reported from the Milford and Moingona districts as well as from fields south of Fraser, south of Ogden, and near the Driscoll slope. Like the hird horizon, it possesses coal of good quality and is "pockety." It is not probable that any of the districts just mentioned are connected uninterruptedly by workable coal. Possibly the Scandia-High Bridge coal lies in this horizon.

The outlook for further discoveries of coal in Boone county is decidedly good. Drilling from the highlands, back from the river bluffs, has only recently been attempted in a determined manner and results have justified the effort. Coal is most likely to be found between depths of 200 and 300 feet below the upland; above and below these levels it may occur, though not in the same abundance. Prospectors must expect to find no coal in many of their test holes, but a continued display of energy should bring its reward. Detailed mention of the present state of our knowledge in regard to various localities in the county, so far as it can now be made public, will be given in the following pages.

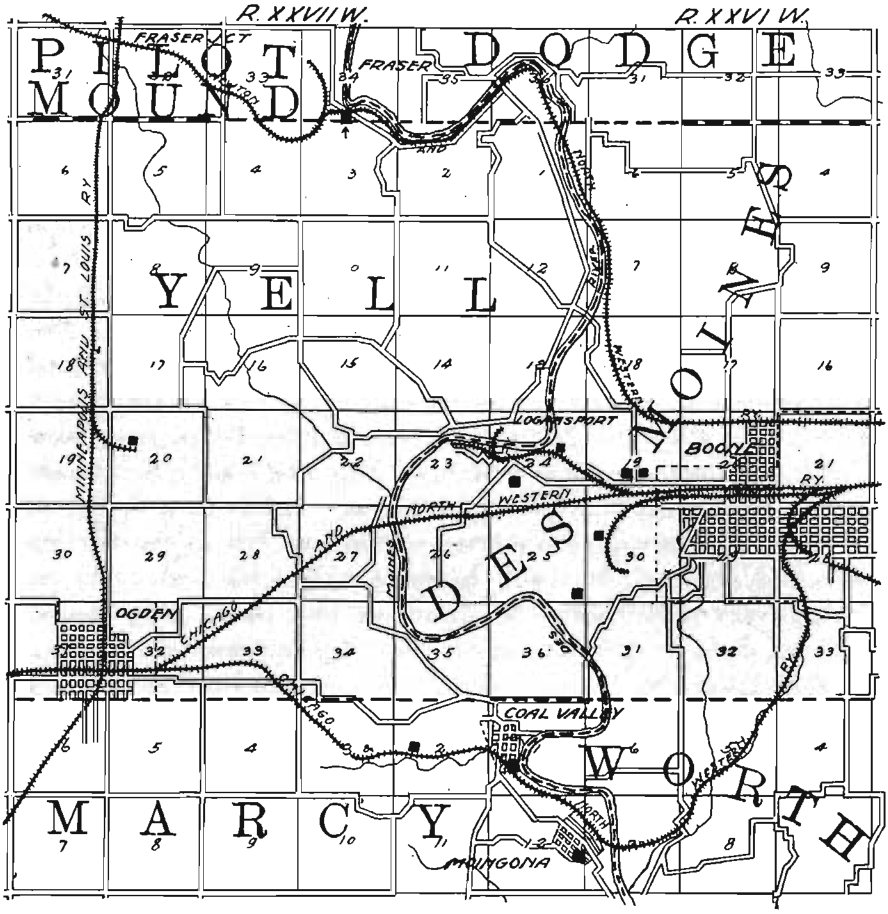


Figure 14. Map giving location of principal mines in Boone county.

DES MOINES VALLEY.

Fraser. For more than thirteen years the town of Fraser has been the center of an important mining industry which has only recently begun to show a decline. At present only one mine is in operation, but another will soon be ready for business and the output of the district may again reach an important figure.

Mine No. 5 of the Boone Coal and Mining Company loads on the tracks of the Newton and Northwestern Railway, directly behind the Fraser depot, on the west side of the river (T. 85, R. 27, Sec. 34, Se. qr., Sw. ¼). The equipment on top is modern and includes Canty self-dumping cages, tubular boilers and a geared, double hoisting engine. Two workable coal seams are found here. At the shaft the upper bed is thirty-eight feet below the surface, or about at the river level, but this elevation suffers changes of twelve feet or less because of the undulatory character of the seam. This upper coal varies in thickness between two feet six inches and four feet, thickening usually in the "swamps" and "thinning to the rise." "Sulphur balls" and "dirt bands" are irregularly distributed through the coal and calcite occurs sparingly in thin films along cleavage faces. The floor of the seam is a sandstone from six to eight feet thick. The roof is a thin cap rock of variable thickness, overlain by black fissile shale. A thin "wild cat" seam, from one inch to one foot thick, is sometimes encountered fifteen feet above the heavier bed, but is as often lacking. At a distance of 400 yards from the bottom of the shaft a slope has been driven from the upper to the lower seam and cars are soon to be hauled up the incline by an electric motor. During the six years the mine has been under development, work has been carried back 3,800 feet from the river. The two seams are now yielding nearly equal amounts of coal, although the upper was opened and developed first. The distance separating the two may be as much as eighteen feet or as little as two inches, a difference due to the fact that the upper is undulatory and the lower is practically level. Where they are most widely separated, a two-foot "bowlder," or clay-ironstone, roof overlies the lower seam. The thickness of the lower bed is quite uniformly three feet six inches. It contains some of the best coal found in the mine. The underlying stratum is a fire clay. At the recently abandoned No. 3 mine of the same company, a half mile distant, the lower bed was not found.

The Boone Coal and Mining Company have recently done considerable prospecting in the Fraser district and as a result are now sinking a shaft southeast of No. 5, near the center of section 2 of Yell township. A spur track is to be run up from Fraser. They have already worked out the coal beneath much of section 34 and the eastern part of section 33, Pilot Mound township. Prospecting has shown at least one workable bed under sections 1, 2 and 3 of Yell township, the eastern half of 4, and parts of 10. The seam probably underlies much of sections 11 and 12 and extends into sections 13, 14 and 15, the territory worked by the old Milford mine. Near Fraser, in Dodge township, seventy-five feet below the bottom lands, a bed has been found which is six feet thick in places and unworkable in others. The company reports that they have been unsuccessful in finding coal in any drill hole they have placed farther from the river than one and a half miles.

The following section illustrates the character of the strata in part of the Fraser field. Since the elevations of the heads of the bores differ greatly, the depths given for the thick coal are not uniform in the different records. Hole A was drilled from the upland, three-fourths mile west of mine No. 5. If the thick seam sought for had been persent it would have been found at a depth of about 250 feet. Hole B, one-fourth mile east and the same distance south of mine No. 5, penetrated both beds that have been mined at Fraser. Hole C, put down not far from mine No. 3, penetrated only one thick coal. It may be observed from a study of the sections that several thin seams appear in some parts of the field and are absent in others.

FRASER SECTIONS.

HOLE "A."

		FEET.	INCHES.
17.	Soil and clay	15	
16.	Drift, gray, hard bands, sand and gravel	211	
15.	Shale, pink	1	
14.	Shale, light-colored	1	
13.	Rock, dark	1	
12.	Coal		6
11.	Fire clay	1	6
10.	Shale, gray	1	
9.	"Slate"	10	
8.	Shale, gray	1	
7.	Shale, light-colored	4	
6.	Shale, gray	4	
5.	Shale, light-colored	12	

4.	Shale, gray	21	
3.	Shale, light-colored	15	
2.	"Slate," dark	10	
1.	Shale, light-colored	10	9
	Total	319	9

HOLE "B."

		FEET.	INCHES.
14.	Soil and sandy clay	10	
13.	Drift, mixed gray and yellow clay	132	
12.	Red shale	7	
11.	Shale, sandy, light-colored	1	
10.	Sandstone	2	
9.	Shale, light-colored	8	
8.	Shale, dark	3	
7.	Shale, sandy, light-colored	11	
6.	Shale, gray	15	
5.	Coal	3	6
4.	Sandstone	3	
3.	Shale, light-colored	3	
2.	"Slate," black	10	
1.	Coal	3	6
	Total	212	

HOLE "C."

		FEET.	INCHES.
21.	Soil and sandy clay	19	
20.	Drift, gray	30	
19.	Shale, mixed	32	
18.	"Slate," dark	2	
17.	Coal		6
16.	Shale, light-colored	1	6
15.	"Slate," dark	10	
14.	Coal	1	
13.	Shale, sandy, blue	1	
12.	Coal	1	4
11.	Sandstone	4	8
10.	Shale, gray	3	
9.	Rock and coal	1	
8.	Coal, pure	1	
7.	Shale, light-colored	5	
6.	Shale, gray	26	
5.	Sandstone	2	
4.	Rock, white	2	
3.	"Slate," dark	4	
2.	Coal	4	
1.	"Slate," sandy	1	6
	Total	152	6

Milford. An important mining locality for a number of years was Milford, on the west side of the river, south of Fraser and west of Boone. A long coal spur was run from Boone across the Des Moines to provide transportation for this field. Operations were continued until the district was considered worked out and was finally abandoned. Mining was done in an extravagant and wasteful manner in many cases, so that much coal is still left untouched and in such condition that it is worthless. Two coal beds were recognized in mining practice: a lower seam averaging three and one-half feet in thickness, and an upper ten feet and more above it. The latter seam was slightly thinner than the former, but was more uniform and persistent. The lower seam thickened and thinned with apparent irregularity. There was a third seam about forty feet below the "lower" coal. The "lower" seam is shown in the following section at the old Milford mine, the shaft of which, located at the base of the bluff, was 100 feet deep.

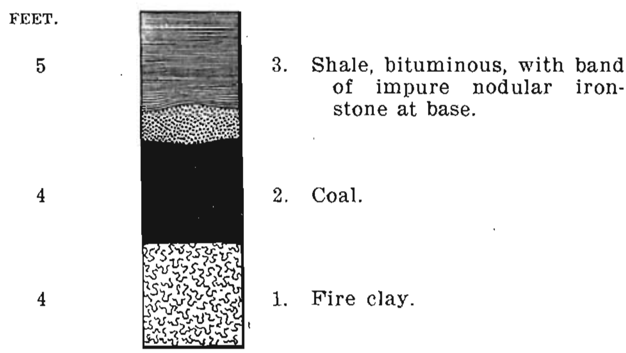


Figure 15. Bottom of shaft, Milford mine, Boonesboro.

Boonesboro. After the cessation of mining at Milford, the center of the coal industry of the Boone area was transferred to Boonesboro, on the opposite side of the river. A number of important mines have shipped coal from this district, yet recently there has been a falling off in the production of the field. At present there are five shafts on the highland, all shipping mines with steam hoists and worked long wall. The two seams developed in the Milford district are present also on the east side of the Des Moines, although the "lower" is workable for only a short distance back from the river. Details of the strata at the various mines will be found below.

The shaft farthest east is that of the Rogers Coal Company (T. 84, R. 27, Sec. 24, Sw. qr., S. ½). It is 200 feet deep, reaching a bed uniformly three feet thick. Aside from a gradual dip to the south, the level of the seam varies only a few inches in different parts of the mine. Strips and "bowlders" of rock, predominantly sandstone, are found only occasionally in the seam. Entries have been run in all four of the cardinal directions and forty acres have already been mined out. The coal is underlain by fire clay and overlain by "cap rock."

A half mile northeast (Sec. 24, Ne. qr., Sw. ¼) is the oldest shaft in the county, No. 2 of the W. D. Johnson Coal Company. It has been operated almost continuously for more than forty-three years and by the present management for over thirty-eight. Much difficulty has been experienced with an underground fire which has been burning for ten years and has finally been brought under control by the construction of a solid brick wall around it. In the early days entries were driven rapidly away from the shaft and only the best coal was taken; now work is being carried back towards the shaft to obtain the coal formerly left. Rope haulage, which was necessary when the haul was longer, is not now in use. At present the coal mined is from three to three and a half feet in thickness, with a two-inch band of black jack at the base. This is the "upper vein"; the "lower" was followed back from the river until it became too thin for profitable mining. The strata found in excavating the shaft are listed below, the lithological identifications having been made from small samples obtained by the foreman at the time of sinking.

W. D. JOHNSON SHAFT.

		FEET.
29.	Soil	5
28.	Clay, yellowish	20
27.	Clay, bluish, with considerable grit	40
26.	Clay, yellowish brown	40
25.	Shale, bluish, massive, dark below	9
24.	Sandstone, light-colored, shaly	9
23.	Shale, gray-blue	3
22.	Shale, with iron-stone concretions	3

21.	Sandstone, fine-grained, friable	12
20.	Shale, bluish and drab	6
19.	Sandstone, ash colored	12
18.	Shale, compact, massive	7
17.	Shale, light-colored ("soapstone")	5
16.	Sandstone, whitish, argillaceous	13
15.	Sandstone, compact, somewhat coarse in texture	8
14.	Shale, black, bituminous, fissile below	3
13.	Fire clay and light-colored shale	9
12.	Shale, hard, blue-black	5
11.	Fire clay	1
10.	Shale, dark, highly bituminous, brittle, compact	3
9.	Coal	½
8.	Shale, variegated	1
7.	Coal, "upper vein"	4
6.	Fire clay	3
5.	Shale, with irregular iron-stone concretions	4
4.	Coal, "lower vein"	4
3.	Fire clay	3
2.	Shale, light-colored	3
1.	Shale, dark, bituminous	2
	Total	237½

Shaft No. 3 of the W. D. Johnson Coal Company (T. 84, R. 26, Sec. 19, Sw. qr., Ne. ¼) was sunk seven years ago to avoid the long hauls then being made to No. 2 shaft. The two mines are connected underground, but both possess quarter-shafts and may be ventilated independently. The "upper vein" and its overlying strata are the same at both openings, except that there are more "bowlders" in the coal at No. 3 and a heavier cover of drift. The "bowlders" are bituminous sandstones, very hard and compact and with a lime cement. They may be as much as twenty feet in length by four in diameter, and occur usually in the top coal, next the roof. Mine No. 1 of the same company was on lower land, near the river.

The Smiley and Heaps shaft is on the east side of the wagon road, opposite the Johnson No. 3. It is 240 feet deep. The company are working east, north, and south, one main entry running east and the other northeast. The strata near the coal, which is the "upper vein," show a few minor variations in character and thickness on opposite sides of the shaft. The small seam which is shown a foot above the "upper vein" in the Johnson shaft section, has increased to a thickness of ten inches on the north side of the shaft, although it is only six inches on the south side. The bed worked is three feet thick.

A bit over three-fourths mile southeast (Tp. 84, R. 26, Sec. 30, Nw. qr., Sw. 1/4), the Eagle Coal Company is operating a shaft 230 feet deep. As shown in the accompanying figure, the strata near the coal differ but little from those found with the "upper vein" farther north.

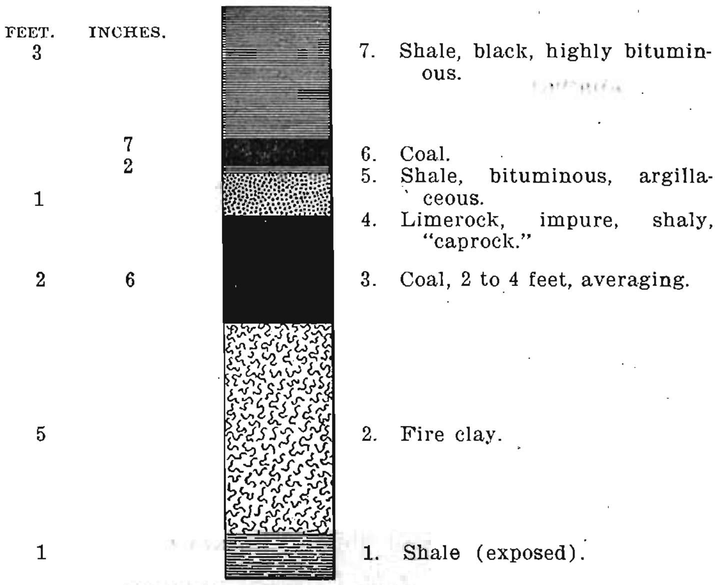


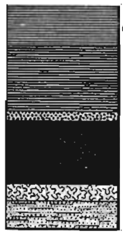
Figure 16. Section in Eagle shaft, Boonesboro.

Where the seam is thin the coal is quite free from impurities, but wherever it thickens a two-inch band of black jack appears at its base and another occasionally finds a place in the top coal. The latter band is sometimes six inches thick, yet gives little trouble as it seldom persists continuously for more than fifteen feet horizontally. No "bowlders" are reported. The "lower vein" of the Johnson shaft section is present at this point as a fourteen-inch bed about eleven feet below the "upper vein." At from seven to seventeen feet above the latter is a thin coal between four and fourteen inches thick. It is not very persistent in this field.

There are two local mines south of the Boone field proper and on lower land. The Black Diamond mine is a small shaft located in a deep gulch on the east side of the river (T. 84, R. 27, Sec. 25, Se. qr., Se. ¼). The shaft is forty-eight feet deep, the coal being a little above the river level at low water. The seam is two feet six inches thick, fairly uniform and level. The thin roof of "cap rock," with a little black shale and a four-inch coal bed above it, preserves the characteristics of the "upper vein" of the main Boonesboro area. Another seam, one foot thick, twenty feet above the bed worked, also has its representative at the Eagle mine. In the bottom coal there is a streak of black jack about one and a half inches thick and at varying distances from the base of the coal seam. In mining long wall, the coal splits as it comes down, the bottom coal being ten inches thick and the top coal constituting the remainder of the seam.

On the west side of the river (T. 84, R. 27, Sec. 35), is the Pestotnik slope. It supplies a large country trade, as there is a good demand for this coal among the surrounding farmers. Mr. Pestotnik has just completed sinking a new shaft two miles northwest of Moingona (Marcy Tp., Sec. 2, Sw. qr., Nw. ¼), on what was formerly the main line of the Chicago and North Western Railroad. The shaft is ninety-five feet deep. Tracks are now being laid for a coal switch and hoisting machinery is being shipped.

Moingona. Many years ago Moingona was the seat of a flourishing mining industry and mines were turning out coal both at the town and also north and south of it, near the river. To-day there are but two small mines open, aside from the new Pestotnik shaft already mentioned. At the junction of Wall and High streets in Moingona, is the shaft, 104 feet deep, of the Big Five Coal Company. Coal is shipped, although hoisting is done by horse and gin and the output does not reach a large figure. The seam worked shows an average of thirty inches of coal. A little black jack is known, but the bed as a whole is a clean one. There is just sufficient fire clay beneath the seam to mine in. The clay is underlain by about four feet of sandstone, that in turn by black "slate," and the latter by the so-called "lower vein." When present, the "lower" coal is variable in thickness and lies about twelve feet below the "upper." It is not, however, at all persistent in this field. The "lower vein" is undulatory, while the "upper" is practically level.



FEET.	INCHES.	
4		5. Shale, bituminous.
	4	4. Shale, light, arenaceous.
2	6	3. Coal.
	7	2. Fire clay.
1		1. Sandstone (exposed).

Figure 17. Vein at Big Five mine. Moingona.

One mile northwest of Moingona, beside the Chicago and North Western tracks, is the John Birmingham mine, now operated by the Coal Valley Coal Company. (T. 83, R. 27, Sec. 1, Sw. qr., Nw. ¼). The shaft, which is ninety-three feet deep, was sunk several years ago, but development has taken place slowly. Coal is hoisted by steam power and shipped to points in Boone and neighboring counties. The strata present but slight differences from those at the Big Five mine, except, perhaps, that the seam contains a greater amount of black jack. Between this shaft and Moingona, the following section is exposed along the railway:

		FEET.
11.	Drift, extends about fifteen feet below the road bed	50
10.	Sandstone, shaly, alternating with sandy shales	12
9.	Shale, blue	4
8.	Sandstone, both shaly and compact	4
7.	Shale, black	2
6.	Coal	¼
5.	Fire clay and shale	7
4.	Shale, containing ferruginous concretions and stems of Lepidodendra	4
3.	Shale, blue-black, containing *Lingula umbonata* Cox	2
2.	Coal	2
1.	Fire clay, exposed	2

Some deep prospecting has been done at Moingona, but detailed records could not be obtained. According to the best information procurable, the Mississippian limestone lies at a depth of about 200 feet below the level of the Moingona station. This places the base of the Coal Measures here at about 700 feet

A. T., as compared with 680 at Boone, and perhaps 720 seven miles down river at the Driscoll bank. A coal three feet six inches in thickness, about seventy-five feet below the seam now worked, is reported as struck in at least one hole.

Moingona to Madrid. Many years ago some important mines were opened along the river below Moingona in the same seams as were mined at that town. Nothing is being done in the district now. Still farther down the river, in the neighborhood of Bear and Peese creek, the Ledge sandstone, a massive arenaceous formation sometimes more than 100 feet thick, displaces the series of shales, thin sandstones, and coal beds which outcrops elsewhere along the Des Moines. This ancient channel is well shown in the geological section across Boone county already figured. Some distance below it, mines are often opened during the fall and winter for the local trade. One of the more important of these is the York bank on the east side of the stream; it was not in operation when the region was visited by the author. Two local coal banks had, however, been opened for the winter on the west side of the river and a brief description of the conditions at each of these may be taken as typical for the region.

The Driscoll Brothers mine is at the base of a steep bluff about half way between Moingona and the Dallas county line (T. 82, R. 26, Sec. 5, Se. qr., Sw. 1/4). Since the mouth of the slope is near the water level, it is necessary to raise the loaded cars along an inclined tramway from it to the top of the bluff, two hundred feet or more above the river. A small engine and boiler perform this duty. The coal is well exposed twenty feet above the river, then dips very rapidly down stream until the seam disappears beneath the water. At the present workings a slope 100 feet long reaches the coal below the water level where its average thickness is three feet. The bottom is solid arenaceous rock, the roof a firm blue "slate." Old entries have taken coal from as far back as 700 feet from the face of the bluff. Below the slope mouth the strong dip down stream ceases, so that the bed may be traced in shallow test holes as a fairly level seam for three-fourths of a mile; it then appears to thin out and disappear. Above the slope the seam persists for 300 yards and perhaps more.

Driscoll Brothers, boring from the level of low water near the entrance to their mine, encountered at a depth of 125 feet a cherty limestone which in all likelihood lies just below the base of the Coal Measures. A two-foot coal was found forty-six feet below the seam in their mine and also an eight-inch bed at greater depth; otherwise the test is remarkably barren. The detailed record follows:

		FEET.	INCHES.
22.	Mud	1	
21.	Coal	3	
20.	Shale and clay	44	6
19.	Rock, very hard	1	6
18.	Coal	2	
17.	Fire clay	2	6
16.	Shale and clay	13	6
15.	Rock, hard	2	6
14.	"Slate"	3	4
13.	Coal		8
12.	Fire clay	4	6
11.	Sandstone	9	
10.	Rock, very hard		4
9.	Sandy shale and sandstone	6	
8.	"Slate," black	6	
7.	Fire clay	1	9
6.	Sandstone, dark, compact	12	
5.	"Slate," black	7	
4.	Fire clay	1	7
3.	"Slate," black	1	8
2.	Fire clay		10
1.	Limestone, cherty		3+
	Total	125	5

The Wisecup bank is a mile below the Driscoll (Sec. 9, Sw. qr., Ne. ¼). It is a drift which has been driven into the bluff for 300 feet through an average of two feet of coal. Here, too, the loaded cars are hauled up an inclined tramway to the top of the bluffs by means of a pull rope, but in this case the motive power is furnished by two horses attached to a gin. The mouth of the drift is forty-five feet above the river. What appears to be a fairly persistent horizon is indicated at the Driscoll air shaft by a thin coal twenty-five feet above the bed mined at that point. Possibly the Wisecup coal may lie in this same horizon. In this drift, sandstone and sandy shale underlie the seam, while the roof is a black "slate" bearing below a thin layer of bluish shale containing sandy streaks and bands. The layer last mentioned is taken down with the coal in mining. The dip is to the west. A lower coal, which has not been opened near this point, appears at low-water level. At the old Knox bank, less than a mile below, a seam twenty-six inches thick has been drifted into at a height of about seventy feet above the river. Where it outcrops in the side of a ravine it has a good roof and bears coal of fair quality.

Some recent prospecting has been undertaken on the uplands on both sides of the river near Madrid. Workable coal is reported, but more tests must be made before the existence of a large field can be verified. A thick seam is reported from the vicinity of Luther, but this information is also somewhat vague.

OGDEN.

A new field which will become one of the most important in the county has recently been opened by the Ogden Coal Company.* Their shaft is located two miles north of Ogden (T. 84, R. 27, Sec. 20, Nw. qr., Sw. 1/4), and loads on a spur from the Minneapolis and Saint Louis railroad. The mine is not fully developed yet, but already turns out a large daily output which is shipped to the north and west. A large double hoisting engine is now in place and Goodman electric motors, mining machines, and automatic cages are planned for the near future. The seam has a height of from four to five feet, and dips slightly to the west. The coal is of excellent quality, being noticeably free from pyrites. Lenses of a compact, highly bituminous sandstone are occasionally found in the coal about four inches from the top of the bed, and a few clay-ironstone "bowlders" of small size may be seen in the roof. The bottom is a fire clay one to three feet thick. Above the bed worked is an upper coal bed which is sometimes three feet thick and sometimes quite thin. The bed worked lies at a depth of 270 feet and is known to be of workable thickness under all of the 1,000 acres controlled by the company.

In sinking the city well at Ogden, the Ogden mine horizon was

*Since the above was written a controlling interest in the Ogden Coal Co. has been purchased by the Fort Dodge, Des Moines & Southern Ry. Co.

penetrated at a point where there was apparently too little coal to warrant putting in a shaft. The section, as published many years ago in the reports of this survey, is:

OGDEN WELL.

		Thickness Feet.	Depth of Sample Feet.
8.	Soil and drift clays	108	108
7.	Sand and gravel, water bearing	2	110
6.	Shale, light-colored, sandy	7	117
5.	Shale, black, with some coal at base	8	125
4.	Fire clay	2	127
3.	Shale, bituminous		228
2.	Shale and sandstone mixed		256
1.	Coal, penetrated at		270

In Marcy township, not far south of Ogden, recent prospecting has proved a field two miles long from east to west by one and one-half miles north and south. A representative section from this territory follows:

		Feet.
23.	Soil and drift	120
22.	Shale, light-colored	6
21.	Shale, gray	5
20.	Sandstone, gray	3
19.	Shale, gray, sandy	2
18.	Shale, light-colored	16
17.	Shale, variegated	18
16.	Shale, light-colored, sandy, with rock bands	13
15.	Shale, gray	7
14.	"Slate," dark	5½
13.	Coal	1
12.	Shale, light-colored	6½
11.	"Slate," dark	1
10.	Shale, light-colored	4
9.	Rock, dark	3
8.	Shale, gray	2
7.	"Slate," dark	5
6.	Iron pyrites, in bands	1
5.	"Slate," dark	4
4.	Coal	3½
3.	"False bottom"	½
2.	Shale, gray	1
1.	Fire clay	2
	Total	230

SQUAW CREEK VALLEY.

At Zenorsville, near the eastern edge of the county, mining was once carried on, but no coal has been taken out for a number of years. At the Hutchinson No. 1 shaft (T. 84, R. 25, Sec. 12, Se. qr., Nw. 1/4), the section was as follows:

		FEET.
11.	Soil, gray and sandy	1
10.	Joint clay	40
9.	Shale, bluish	53
8.	Shale, light-colored	1
7.	Shale, bituminous, fissile below	2
6.	Coal	2
5.	Fire clay	3
4.	Sandstone, rather soft and friable	2
3.	Shale, light-colored	4
2.	Shale, dark, bituminous	3
1.	Coal	1½
	Total	112

Hutchinson shaft No. 2, located 300 yards northward, was on lower ground and only 105 feet in depth. At the base of the shaft were two coals, only one of which was worked. They are shown in the figure.

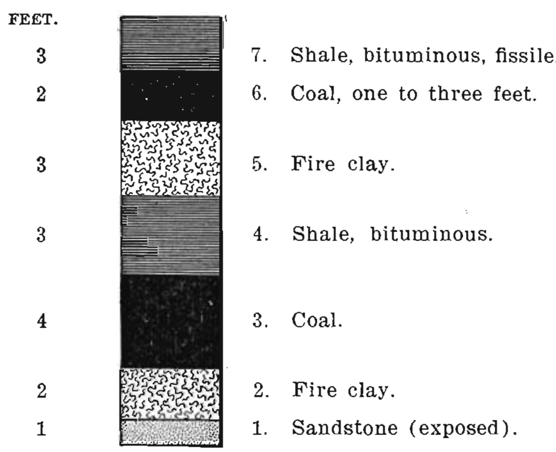


Figure 18. Coal bed in Hutchinson mine No. 2, near Squaw creek, Zenorsville.

ANGUS.

Some large mines were once in operation in Boone county near Angus. Since the only mining being done in this district at present is just over the line in Greene, the various coals of the area will be discussed in the chapter on that county.

STORY COUNTY

The Skunk river anticline brings the Mississippian limestone to the surface in the west-central portion of Story county, along Skunk river and Squaw creek and the country between. From this area the strata dip rapidly in all directions. Coal Measures of the Des Moines stage underlie the drift of the entire eastern half of the county, of practically all of La Fayette, Palestine, Grant, and Union townships, of most of Howard, Milford and Washington, and of the north-central third of Franklin. Nowhere, nevertheless, do the coal bearing strata attain any great thickness. The upper surface of the Saint Louis limestone has been found at an elevation of 900 feet above the sea level at Story City, 738 at Nevada, and 700 at Maxwell and Collins. The difference between the altitude of the surface and that of the limestone can by no means be taken, however, as a measure of the thickness of the Des Moines; for the drift commonly extends to a depth of 100 to 200 feet below the prairie level and proportionately less below the lowlands. For example, the drift is 101 feet in thickness at Nevada and the Des Moines 166 feet; at Maxwell the latter is reduced to fifty feet at some points but attains at least 150 at others not far distant.

It will be seen that the Coal Measures, while attenuated in some localities, are often present in sufficient abundance to encourage search for coal. The greater part of the surface of the county is a prairie which yields no natural outcrops; yet, in spite of this, coal has been already located in many widely separated districts by means of borings and wells. Indeed, the chief reason that Story is now producing no coal seems to rest more in the difficulties attending development work than in any lack of thick coals. Wherever mining has been attempted, the roof has proved unsatisfactory, an eventuality very probable in a region of this type. The surface is so poorly drained that large quantities of water sink beneath it and flow slowly through the heterogeneous drift deposits until from some deep-lying pockets of the latter they obtain entrance to all parts of the Coal Measures themselves. It is this water which is largely responsible for unsatisfactory characteristics of bottoms and roofs. There are, nevertheless, undoubtedly places in Story county where good coal will some day be found and where mining conditions will be excellent. Little prospecting has been done in the eastern and northeastern townships, both promising districts. The best results may be expected where the drift is thin, since in some parts of the county pre-glacial channels have cut so deeply into the indurated rocks as to largely destroy the value of what were once splendid coal basins.

The production of Story has never been noteworthy. The largest output was 12,000 tons in 1897, a tonnage which dropped to 7,885 in 1898, to 3,200 in 1900, and to 300 in 1901. Since 1902 almost no coal has been mined. Prospect records and other data may be found in the following pages. The report of Dr. S. W. Beyer on the *Geology of Story County** has been of considerable assistance to the writer.

Summit. Early in 1893 a shaft was sunk at Summit (LaFayette Tp., Sec. 21, Sw. qr.) and mining operations were conducted for a number of years. Part of the product was shipped over a short spur from the Chicago & North Western railroad. Nothing has been done at this point for some time. The coal was only of fair quality, while the roof was very poor in places and water entered in inconvenient quantities. Trouble was always experienced from the tendency of the underlying fire clay to "creep." The seam lies quite level and is uniform in thickness. In sinking the shaft no less than five coals were revealed.

SHAFT AT SUMMIT.

Surface altitude about 1,050 feet A. T.

	THICKNESS IN FEET.	DEPTH IN FEET.
20. Soil	3	3
19. Clay, yellow, gravelly	20	23
18. Clay, blue	5	28
17. Sand, bluish	1	29

*Iowa Geol. Surv., Vol. IX, pp. 155-245; Des Moines, 1899.

16.	Sea-mud (loess ?)	40	69
15.	Sand and gravel (till?)	26	95
14.	Rock, hard	1	96
13.	Clay, sandy	3	99
12.	Coal "blossom"	1-3	99 1-3
11.	Fire clay	1	100 1-3
10.	Coal	1-3	100 2-3
9.	Fire clay, bluish	11	111 2-3
8.	Coal	1-3	112
7.	Fire clay	7½	119½
6.	Coal, good	2	121½
5.	Fire clay, bluish	4	125½
4.	Shale, hard	3	128½
3.	Shale, blue	6	134½
2.	Coal	4½	139
1.	Fire clay, exposed	3	142

A well record from this vicinity shows the following sequence, including still another coal, below number 2 of the above record.

	FEET.
Fire clay	3
Rock (sandstone?)	1½
Fire clay	18
Coal	1
Fire clay	38
Shale, black	5

The Summit coal is, according to Beyer, an eastward extension of the Sugar creek basin near Zenorsville, Boone county. The altitudes and stratigraphic relationships of the two basins closely correspond. The seam worked has been reported to extend at least one mile east of the shaft, but its range toward the northeast is known to be limited. Prospecting east and south of Story City failed to locate promising coal horizons.

McCallsburg. Two miles south of McCallsburg two local mines were at one time established to supply winter trade. The seam worked was only eighteen inches in thickness, yet mining conditions were sufficiently favorable to maintain a profit. A three-foot coal is said to lie seventy-five feet below the upper seam and this report, if verified, may lead to future development.

Cambridge. In section 10 of Union township, northeast of Cambridge, a six-foot coal bed was claimed and a shaft was sunk. The latter filled with water, and positive data in regard to the coal are now difficult to obtain. Considerable prospecting has been done in and near the valley of Skunk river between Cambridge and Ames, with variable success. One or two coals were penetrated in each hole, yet usually these were under two feet in thickness. Where more promising seams were discovered they commonly thinned rapidly in all directions; yet the presence of numerous coal horizons seems so firmly established that the outlook for the future is far from discouraging. The following records of holes drilled by J. A. McElhaney, of Lovilia, give a fair idea of the stratigraphy of the district.

HOLE "A."

Grant Tp., Sec. 30, Nw. qr.

		FEET.
11.	Drift	93
10.	Shale, black	1
9.	Sandstone, blue	3
8.	Shale, gray	5
7.	Limestone, gray	½
6.	Shale, bituminous	½
5.	Coal	4
4.	Fire clay	2
3.	Shale, sandy	8
2.	Coal, impure	1½
1.	Shale, gray	16
	Total	134½

HOLE "B."

Grant Tp., Sec. 18, Ne. qr., Nw. ¼.

		FEET.
14.	Drift	95
13.	Shale	1
12.	Coal	½
11.	Sandstone	2½
10.	Coal	¾
9.	Shale, sandy	1½
8.	Shale, argillaceous	2
7.	"Sand," blue	11
6.	Coal	1
5.	Sandstone	16
4.	Shale, blue	6
3.	Shale, black	4
2.	Sandstone	2
1.	Shale, blue	8½
	Total	151¾

HOLE "C."

Grant Tp., Sec. 17, Sw. qr., Ne. ¼.

		Feet.	Inches.
14.	Drift	99	8
13.	Shale, black	3	
12.	Coal		9
11.	Fire clay	3	
10.	Shale, black	11	9
9.	Coal	1	11
8.	Fire clay	1	4
7.	Sandstone	4	8
6.	Shale, sandy	13	11
5.	Rock	2	
4.	Shale, black	4	2
3.	Coal	1	11
2.	Fire clay		4
1.	Rock		2
	Total	148	7

HOLE "D."

Union Tp., Sec. 6, Ne. qr.

		Feet.
13.	Drift	78
12.	Shale, black	2
11.	Coal	1½
10.	Rock (bowlder?)	1
9.	Coal	2
8.	Sandstone	7½
7.	Shale, sandy	2½
6.	Shale, blue	3
5.	Coal	2½
4.	Shale, gray	5½
3.	Shale, blue	11½
2.	Shale, gray	4½
1.	Sandstone	14½
	Total	136

Maxwell. The town of Maxwell recently drilled five holes on either side of Indian creek. Some coal was found in each drilling, but the cover over the thicker coal was not considered sufficiently good to warrant sinking a shaft. The drill logs of two of the holes are shown below.

HOLE "A."

Tp. 82, R. 22, Sec. 28, Ne. qr., Sw. ¼.

		FEET.
12.	Drift	9½
11.	Shale, black	50
10.	"Slate," black	5
9.	Coal	1
8.	Fire clay	5
7.	"Slate"	11
6.	Coal	1½
5.	"Slate"	30½
4.	Coal	2
3.	Clay	10
2.	Soapstone	27
1.	Limestone	..
	Total	152½

HOLE "B."

Tp. 82, R. 22, Sec. 27, Sw. qr.

		FEET.
11.	Drift	75
10.	Sandstone, and "keel"	10
9.	"Slate"	10½
8.	Coal	4½
7.	Fire clay	2
6.	Sandstone	2
5.	Coal	¼
4.	"Slate"	15
3.	Sand	10
2.	Soapstone	10
1.	Limestone	..
	Total	139¼

Eighty rods east of hole "B," the heavy seam is represented by three feet of coal which, however, is separated from the overlying drift by only two feet of "slate" and is therefore unworkable at that point. Eighty rods south of hole "B," the drill apparently penetrated an old channel from which the coal had been removed. South of hole "A" (Sec. 33, Nw. qr., S. ½), only six inches of coal was shown. In all five prospects the driller reported limestone at a depth of approximately 150 feet. If his identifications are correct, the surface of the Saint Louis lies at about 700 feet A. T. and the thickness of Coal Measures beneath the drift is in places as little as fifty feet.

A well near the clay pit of the Maxwell Brick and Tile Works, one mile east of Maxwell, passed through six feet of soil and drift and 142 feet of Des Moines strata, including three coal "blossoms" less than one foot in thickness. Although the coal found at Maxwell lies at nearly the same level as that mined at Enterprise, in Polk county, it undoubtedly represents a lower horizon.

Collins. Three miles south of Collins (Collins Tp., Sec. 34, Sw. qr., Ne. ¼), a shaft was sunk in the bottom land along Wolf creek. The coal taken out had a ready sale. The seam is known to extend some distance east and south of the shaft, but the roof is not dependable. The sequence of strata at the shaft is about as follows:

		FEET.
5.	Drift	70
4.	Coal Measure shales and clays	60
3.	Coal	2
2.	Fire clay and shale	7
1.	Coal	3½
	Total	142½

MARSHALL COUNTY

Marshall lies on the eastern border of the Coal Measure area of Iowa. Des Moines strata underlie the whole of the western half of the county with the exception of small areas at and southwest of Liscomb and above Marietta. The Des Moines also occupies all of Iowa and Jefferson townships and the divides of the western half of Timber Creek township. The youngest indurated rocks of the remainder of the county have been classified with the Kinderhook stage of the Mississippian series. On its eastern margin the Des Moines is extremely attenuated, while farther back towards the west outcrops are few and the drift on the uplands possesses an average thickness of about 200 feet. It is, perhaps, due to this concealment of the coal-bearing strata that so little coal has been found along the western border of the county. The great thickness of the drift which must be pierced in order to reach a comparatively thin series of Coal Measures renders prospecting precarious. For a full discussion of the general geology of the county the reader is referred to Beyer*.

Practically the only place where mining has been carried on is near Mormon Ridge, three miles northwest of Albion (Tp. 85, R. 19, Sec. 34, Sw. qr., Se. ¼). A shaft fifty feet deep was sunk through the following sequence of strata:

FEET.	INCHES.	
20		6. Sand.
3		5. Clay, light-colored.
2		4. Shale, dark-colored, fissile.
3		3. Coal.
	4	2. Fire clay.
1		1. Sandstone (exposed).

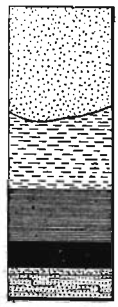


Figure 19. Bed at Mormon Ridge mine, near Albion.

Only a few feet of shale intervened between the coal and a stratum of water-bearing sand, so that work was abandoned after not more than 100 tons of coal had been excavated. Later another company endeavored to reopen the mine, but water again interfered with progress. Nothing has been done here for a long period. A quarter of a mile north of this shaft, on the north side of Mormon Ridge, some coal was taken out many years ago. A drilling one mile northwest of the Mormon Ridge shaft (Sec. 28, Sw. qr., Sw. ¼) penetrated at a depth of 118 feet a bed of black shale with some coal. The seam was reported to be several feet in thickness and to be underlain with a thin stratum of fire clay.

At one time a shaft was sunk on Minerva creek, five miles west of Bangor (Liberty Tp., Sec. 9, Se. qr., Se. ¼). Just how much coal has been found here is not now definitely known. Traces of coal have been encountered in wells at various points in the western part of the county. Coal basins of local importance will undoubtedly be located in the future, but Marshall will never rank among the chief coal counties as a producer.

*_Geology of Marshall County_, Iowa Geol. Surv., Vol. VII, pp. 199-262; Des Moines, 1897.

DALLAS COUNTY

With the exception of a small area in the southwestern corner of the county, the indurated rocks which outcrop immediately below the loose surface cover of soil and drift belong to the Des Moines stage, the lower and more productive member of the Coal Measures of Iowa. In the southern half of Union township and the southwestern quarter of Adams, the Des Moines strata are covered by those of the Missouri, the upper member of the Coal Measures, which, however, is so thin that Bear creek and most of its tributaries have cut through it so as to expose the underlying Des Moines in the bottoms of their valleys. Few coal beds have been found in the Missouri rocks and those that do occur are thin; but workable seams are plentiful in the Des Moines. Unfortunately for Dallas, a large part of the county is a high, level plain upon which there are no exposures of the solid strata; while those rocks which are to be seen in the valleys of the Des Moines river and the Raccoon and its main branches, belong to an upper section of the Des Moines which apparently contains few thick coals. Strata lower down should, however, contain coal basins at many points. Very little deep prospecting has been undertaken, yet that which has been done has in most cases yielded good results. At Van Meter and southwest of De Soto, deep coals are known to be present; while others are now being exploited in the valley of the Des Moines. The fact that a few tests holes reveal no coal should not discourage the prospector; for undoubtedly the lower seams in this county lie in basins of rather limited extent, as they do in other parts of the state, and not in beds which are continuous over whole townships or even over many sections. The future of the coal industry in Dallas lies in the hands of those who are willing to risk considerable capital in systematic prospecting.

The depth to which it would be necessary to go in order to reach the bottom of the Coal Measures varies considerably at different points. The depth is definitely known at only a few places, but may be closely estimated at others. In the valley of the Raccoon, two miles west of Commerce, the St. Louis has been found at a depth of 250 feet or at about 600 above tide. At Van Meter, the lower coal mined lies at an altitude of 590 A. T., making the base of the Coal Measures at least 430 feet below the adjacent highlands. Near De Soto, a well 321 feet deep failed to penetrate the Saint Louis. At Redfield the Saint Louis limestone was reached at about 300 feet, or at an altitude of a little more than 600 feet A. T. North of Dexter, on the South Racoon, 175 feet of Coal Measures and twenty-five of drift overlie the Mississippian. In the northeastern corner of the county coal is mined at a depth of 220 feet from a shaft situated well down in the deep valley of the Des Moines river. The thickness of the Coal Measures under the highland farther west must be at least 350 feet and is probably much more.

Dallas has never ranked as one of the leading producers of the state, but the recent developments in the Des Moines valley have caused a decided increase in its production. A still greater output may be expected in the immediate future, even though no new mines are started. In earlier years the tonnage showed considerable fluctuations. The state census of 1862 reported only 170 bushels mined in the county, but this had increased to 1,700 in 1865 and to 13,200 tons in 1880. The output increased more or less steadily until 1889, one of the banner years, for which the Eleventh United States Census reports 67,055 tons at a value of $111,472. The tonnage did not remain long at this figure, however, for in 1893 it had declined to 33,800 tons and later years witnessed a still greater fall. The statistics for the last ten years are given below; those from 1898 to 1902 are from reports of the Iowa Geological Survey, from 1902 to 1907 from those of the U. S. Geological Survey.

YEAR.	TONS.	YEAR.	TONS.
1898	8,859	1903	15,467
1899	10,813	1904	13,086
1900	16,521	1905	5,000
1901	16,988	1906	5,522
1902	18,845	1907	70,042

Though the figures given for 1905 and 1906 are probably too low, a great contrast between 1906 and 1907 is nevertheless an actuality. That the activity of the industry has continued is evident from the following extracts from the report of the State Mine Inspectors for the year ending June 30, 1908:

Number of mines	3
Tons of coal of all grades produced	108,700
Total number of employes	277

A number of small local mines which spring up in the winter months are not included in the above enumeration, but it is not probable that their total output now exceeds three thousand tons. Two of the three mines listed are near the Des Moines river; the third is a smaller mine west of Dawson. A small local mine was in operation on Panther creek during the early fall of 1907 and a few others were worked for short periods during the winter and late autumn. In the detailed discussion which follows the author has drawn freely upon previous reports of this Survey*.

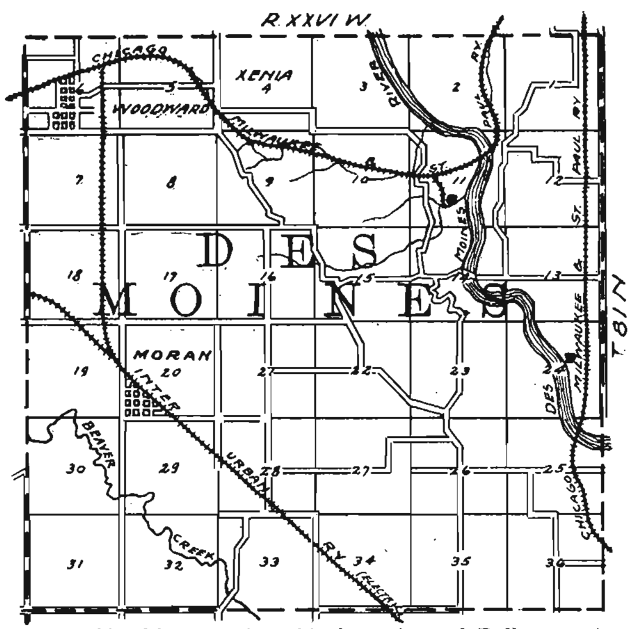


Figure 20. Map showing shipping mines of Dallas county.

DES MOINES VALLEY.

It has been known for a number of years that there are at least four thin beds of coal, two and a half feet or less in thickness, in the northeastern corner of the county, where the Des Moines river has cut for itself a deep valley through the drift and indurated rocks. Two of the seams outcrop above the water level and one is especially well shown in an exposure on the west side of the valley, just above High Bridge (Figure 21).

*Keyes: *Coal Deposits of Iowa*, Iowa Geol. Surv., Vol. II, pp. 253-267; 1894. Leonard: *Geology of Dallas County*, Iowa Geol. Surv., Vol. VIII, pp. 51-118; 1898.

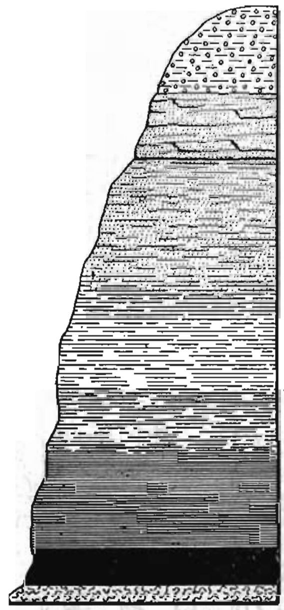


Figure 21. Bluff near old Pritchard drift, High Bridge.

The third seam, and to a less extent the fourth, were opened by shallow shafts and worked on the longwall method to supply a purely local demand. In spite of the fact that attention had been called by this Survey to the discovery of a four foot coal bed at greater depth than that to which prospecting was usually carried, no attempt was made to develop it until quite recently. The coal horizons in the strata near the present Scandia mine were published in 1897* and again in 1898† as follows:

DEPTH OF COAL.	THICKNESS.
1. 16 feet	12 to 14 inches
2. 40 feet	20 inches
3. 87 feet	28 inches
4. 109 feet	2 feet
5. 171 feet	4 feet

Coals 3 and 4 of this list were worked at the old Chestnut Valley mine (T. 81, R. 26, Sec. 14, Nw. qr., Nw. ¼) until the Scandia Coal Company was organized to sink to the lower seam in the same neighborhood. Afterward the High Bridge Coal Company sank farther down the river and the outlook for new mines in the near future is very bright.

*Iowa Geol. Surv., Vol. VII, p. 324; Des Moines.
†*Idem*, Vol. VIII, p. 100.

The shaft of the Scandia Coal Company, 166 feet deep, is situated near the middle point of the south line of section eleven, Des Moines township, on the west side of the river. A spur track has been laid to the mine from the Chicago, Milwaukee and Saint Paul railroad, a half mile to the north. Although development was not begun until the summer of 1906, a large daily output is now (1907) being shipped and sold to the local trade. The hoisting engine is of the double, direct-connected type with 14x30 cylinders and with a four-foot drum. There are two tubular boilers, one 16 ft. x 60 in., of 80 horsepower, and the other 16 ft. by 66 in., of 100 horsepower. It was the original intention to use electric mining machines and a dynamo was purchased for that purpose, but so far the plan has not been put into operation. The coal remains fairly constant at a thickness of three feet eight inches and lies fairly level at an altitude of about 700 A. T. Sometimes rolls in the roof cut out all the coal, but more often these interfere with only the upper foot or two of the seam. The company owns the coal rights of 1,400 acres of land in a basin which is elongated from the northeast to the southwest but the extent of which is not known. It is possible that another shaft may be sunk by the company on the opposite side of the river near the tracks of the Boone branch of the Chicago, Milwaukee and Saint Paul Railroad. A drilling done in that locality (Se. qr. of Sec. 12) penetrated at least three coal horizons at a considerable depth. The upper coal, as reported by the company, is sixteen inches thick, with a three foot seam forty-six feet below it and a five inch "blossom" lower down. Between the two lower horizons is a compact sandstone twenty feet thick.

Farther down the river than the Scandia mine, at High Bridge on the east bank, the High Bridge Coal Company sank a shaft 220 feet during the summer of 1907. In September of that year they had driven entries only 300 feet, but were rapidly pushing the development of the mine and preparing to install an equipment capable of handling the large output which they expect to ship over the Boone branch of the Chicago, Milwaukee and Saint Paul Railroad. The company has leased a large territory and believes most of it to be underlain with workable coal. As far as opened up the vein has proved to be about four feet thick and without noticeable dip. Sandstones and sandy shales are very common in the drill records and as many as three thin coals are sometimes found above the thick seam. Whether the latter belongs to the same coal horizon as the seam worked at the Scandia is not determinable from the data now available, yet the probabilities point strongly to such a connection.

NORTH RACCOON VALLEY.

Dawson. Dawson was for a short time the center of a fairly active mining industry. Shafts were sunk on all sides of the town, to continue in operation, however, no great length of time. Six coal horizons have been reported; yet only three are generally recognized as workable. Two of the latter were shown in the old shaft of the Chicago Coal Company, one-half mile east of Dawson.

DAWSON SECTION.

	FEET.	INCHES.
11. Soil	3	
10. Yellow clay	13	
9. Blue clay	64	6
8. "Slate," gray	2	6
7. Coal (at 83 feet)	1	10
6. Fire clay	4	
5. Sandstone	8	
4. "Slate," gray	10	
3. "Slate," black, oily	13	
2. Coal (at 120 feet)	3	
1. Fire clay	4	

Number 2 was the bed worked at this point and also at the old Tudor shaft at the foot of the bluff north of Dawson. This coal

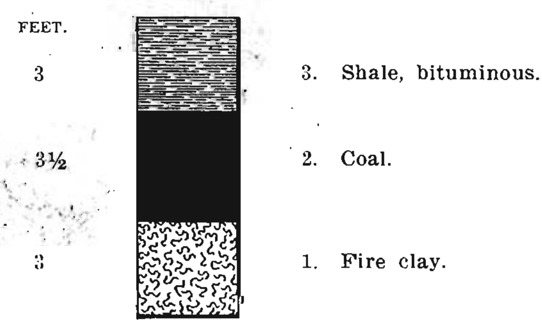


Figure 22. Coal seam at old Tudor shaft, Dawson.

did not prove suitable for a locomotive fuel because of a tendency to clinker, due probably to the iron pyrites included in the seam. Forty-five feet below number 2 is a coal bed which varies in thickness from three and a half to four feet. On the Dixon farm, two miles south of Dawson, the strata found in a shaft from which a little coal was taken are reported to be as follows:

		FEET.	INCHES.
4.	Drift	72	
3.	Shale and "slate"	38	
2.	Coal	1	7
1.	Fire clay	10+	

The shaft was unfortunately situated, reaching the coal near the top of a "rise" on the edge of the basin. Toward the southeast, the direction of a strong dip, the bed thickened gradually up to the point at which work was abandoned.

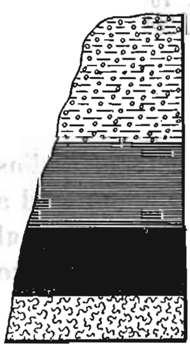
A short distance west of Dawson the two upper seams become slightly thinner than at the Dawson shaft and the other strata undergo a few changes, as shown in the following drill record (Dallas Tp., Sec. 9, Ne. qr., Se. 1/4).

		FEET.	INCHES.
12.	Soil	3	9
11.	Clay, yellow	14	6
10.	Clay, blue	26	
9.	Clay, light	14	
8.	Sandstone	12	
7.	"Slate"	12	
6.	Coal	1	2
5.	Fire clay	3	
4.	Sand rock	26	
3.	"Slate"	10	
2.	Coal	2	2
1.	Fire clay	1	5
	Total	126	

The only mining done at present in northwestern Dallas county is by the Hutchinson Brothers Coal Company, one and a fourth miles west of Dawson (Dallas Tp., Sec. 8, Ne. qr.). Coal is elevated 110 feet by steam power from a seam three feet to three feet six inches thick. The company controls 204 acres on the north side of the railroad. In the summer months only sufficient work is done to keep the mine in good condition, but in the winter a fairly large local trade is supplied and some coal is hauled to Dawson to be loaded for shipment. The seam is extremely undulatory, differences in level of twenty feet or more occurring at points not greatly distant from one another. Where coal is now being excavated, only a few irregularities are found in the roof and coal; though on the "rises" at what are supposed to be the edges of the basin, "rolls" in the roof and other "troubles" become more numerous. It is probable that this seam is the representative of the "second vein" at Dawson.

Minburn. Three miles southwest of Minburn, in section 24 of Washington township, a seam outcrops about fifty feet above the Raccoon, in the valley of a small tributary. The coal has a dip to the east and lies in two benches separated by a foot of fire clay, the upper bench varying from eighteen to twenty-four inches and the lower from twelve to thirteen inches in thickness. A roof of firm shale covers a coal of good quality, but attempts to mine it have been of a desultory character only.

Adel. Three miles north and a little west of Adel, a thin bed of coal, eighteen inches thick, outcrops in a small creek which crosses the Chaney farm (Colfax Tp., Sec. 12, Se. qr.). For many years this seam has been drifted into and mined intermittently. At the present time a little coal is obtained by stripping for the winter use of one or two families. East of the Chaney farm this bed again outcrops as a coal seventeen inches thick. Near this point well drillers report having penetrated a thicker seam sixty-six feet below this horizon. They were unable to determine its exact thickness, however.



	FEET.
4. Drift	3
3. Shale, bituminous	2
2. Coal	1½
1. Fire clay (exposed)	1

Figure 23. Section at Chaney drift. Three miles north of Adel.

A company has been formed to search for coal near Adel and several test holes have been drilled. Up to date, results have not been of an encouraging nature.

MIDDLE RACCOON VALLEY.

Redfield. In following the valley of the Middle Raccoon from the Guthrie county line to Redfield, the vestiges of numerous abandoned drifts may be seen in the slopes bordering the river and its tributary creeks. Several coals outcrop above the water level in this territory, but nothing has been found which exceeds two feet in thickness and many of the seams in which development has been attempted can scarcely be said to have returned a fair reward for the labor expended upon them. Little has been done during recent years and no coal was being taken out when the region was visited during the early autumn of 1907.

The Keeler and Topping banks have at one time and another taken coal from a tripartite seam about two miles south of Linden (Linn Tp., Sec. 31, Ne. qr.). The three benches, which together yield only eighteen inches of coal, are shown with the roof and bottom in the section given below.

		FEET.	INCHES.
3.	Sandstone (exposed)	1	
2.	Coal, 8, 4 and 6 inches, separated by thin clay partings	1	11
1.	Fire clay		6

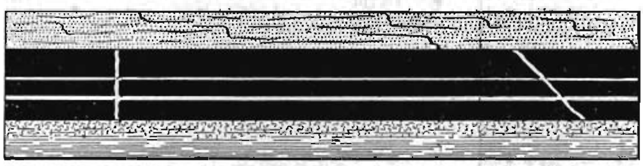


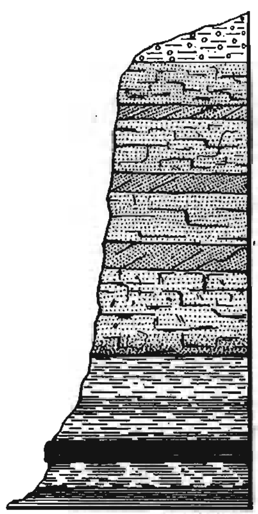
Figure 24. Clay seams in Topping mine, south of Linden.

Less than a mile down stream, two seams are known, one about ten feet above the level of the river and the other sixty-five feet higher. The upper bed is the thicker, being twenty inches at its best, so that most of the mining done here has been in this seam. Still farther down the river, a small creek empties into it from the north in the eastern portion of section 32, Linn township. An eighteen-inch bed which is perhaps the equivalent of one of the coals just mentioned has been drifted into from the valley of this tributary and the following section has been measured at one of the old mines:

	Feet.	Inches.
4. Drift	3	
3. Clay shale, compact	3	6
2. Coal	1	6
1. Fire clay	1	10

Along the valley of the Middle Raccoon between this point and Redfield and in that of Mosquito creek just above its junction with the Raccoon, thin veins similar to those mentioned above have been drifted into in the past and a few may be opened up in the future to supply a very local demand during the winter months. They are hardly worthy of detailed mention. Some drilling of rather a crude character has been attempted north and west of Redfield. North of the town a four-foot bed was reported and west of it one twenty-seven inches thick, overlain by eighteen inches of black jack. These reports need verification and amplification; though the discovery of good coal basins in this county would undoubtedly follow deep prospecting pursued on a large scale.

South of Redfield, in a bluff opposite the picnic grounds, a massive sandstone forms a steep escarpment known as "Hang-



	Feet.	Inches.
7. Drift	10	
6. Sandstone, massive, rather fine-grained, buff to dark brown in color	50	
5. Shales, ash color to drab, somewhat sandy in places	10	
4. Coal	2	
3. Clay, drab color, fossiliferous		1
2. Coal	1	
1. Shale, somewhat sandy, drab, in places carbonaceous, exposed	5	

Figure 25. "Hanging Rock" section. Redfield.

ing Rock." Twelve feet lower is a three-foot bed from which coal has been taken in the past by slopes, drifts and shafts. The section at this point is shown in figure 25. The seam is separated into two and sometimes three benches by thin argillaceous partings. One of these partings is one inch thick and always present, while the other is one-fourth inch thick and appears only occasionally. The seam has an unreliable clay roof in places. Traces of a coal seam of unknown thickness are said to have been found here at greater depths. The old Leeper mine near Redfield had a shaft sixty-five feet deep which was operated more than twenty years. The characteristics of the seam at that point are shown in the following figure.

FEET.	INCHES.	
2		7. Shale, rather massive and compact (exposed).
	8	6. Coal.
	¼	5. Clay parting.
1	7	4. Coal.
	3	3. Clay parting.
1		2. Coal.
2		1. Fire clay (exposed).

Figure 26. Bed of old Leeper mine, Redfield.

SOUTH RACCOON VALLEY.

Union Township. As along the Middle Raccoon, small mines have intermittently taken coal from thin veins at various points along the South Raccoon. Considerable coal has been removed on both sides of the river in section 12, Union township. On the land belonging to E. Woods, drifting into a twenty-inch seam had been begun as long as twenty-five years ago, and the old Dawson drift employed at times as many as sixteen men. Nothing has been done here during the last three years. On the opposite side of the river (Sec. 12, Ne. qr., Nw. ¼) Oliver Cave's mine has supplied a considerable country trade for ten years or more. The seam is the same as on the south side of the river, and the thickness is from fourteen to twenty inches. A shaft which was sunk here at one time furnished the following section:

		Feet.	Inches.
10.	Drift	25	
9.	Shale, gray	4	
8.	Limestone, blue, compact	1	
7.	Clay		6
6.	Limestone, blue, fossiliferous		10
5.	Shale, black, bituminous; "black jack"	8	
4.	Limestone, blue		10
3.	Slate, black	2	6
2.	Coal		20
1.	Fire clay	..	..

This shaft is no longer used but coal was removed by means of drifts during the winter of 1906-1907 and some of these may be reopened for winter trade. The coal thins to the south and west until it disappears altogether within a distance of a mile. To the southeast it thickens and dips so rapidly as to be carried below the river a short distance from Cave's mine. Attempts to work it beyond this have been frustrated by the amount of water which entered the seam.

Panther Creek. The only mine being worked in the southwestern part of the county in September, 1907, was the Thomas Bott bank on Panther creek, about two miles and a half above its mouth. The mine is a drift which has been driven into the hill about 300 feet through two feet to two feet ten inches of coal. Since the opening is in the bottom of a deep, steep-sided ravine, much difficulty is experienced in hauling the coal to the level of the surrounding country. One digger and two wheelers are employed in the fall and about seven men in the winter. During the remainder of the year the mine is closed. The seam dips to the south and thins to the north. Above is a good roof of a very fossiliferous shaly limestone which when fresh is hard and firm. An eighteen-inch coal is reported above the one worked, though the surface indications are a mere "blossom."

Bulger Creek. A little drifting for coal has been done on the lower part of Bulger creek. The seams are very thin and nothing has been taken from them for a long time. An interesting record is that given below of a deep well drilled one mile southwest of De Soto in section 25, Adams township. At a depth of 321 feet the base of the Coal Measures had not been reached. Four seams of coal were penetrated, one foot at a depth of 98 feet, two feet at 239 feet, eighteen inches at 255 and three feet at 350.

DE SOTO SECTION.

		FEET.
82.	Soil and subsoil	8
81.	Yellow clay	37
80.	Blue clay	12
79.	Clays and shales, red and yellow	7
78.	Soft rock	1
77.	Clay, red and blue	28
76.	Limestone	3
75.	Slate	2
74.	Coal	1
73.	Fire clay	4
72.	Shale, with marly partings	3
71.	Limestone, gray	3
70.	Shale	1
69.	Limestone, coarse grained	1
68.	Shale, with marly partings	4
67.	Sandstone	2
66.	Shale and clay	5
65.	"Coal roofing" (slate?)	1
64.	Sandstone	2
63.	Calcareous rock, hard, gray	4
62.	Rock, hard	6
61.	Shales and clays, red and blue	10
60.	Sandstone, gray	6
59.	Limestone	5
58.	Sandstone	4
57.	Shale, with thin layers of rock	5
56.	Sandstone, gray, flinty	5
55.	Clay and shale	6
54.	Limestone	10
53.	Clay	5
52.	Limestone	3
51.	Shale	3
50.	Sandstone	4
49.	Shale	2
48.	Limestone, gray	3
47.	Shales, very hard	2
46.	"Rock," hard	4
45.	Shale	4
44.	Sandstone	2
43.	"Rock," hard, white	19

42.	Slate, black	2
41.	Coal	2
40.	Fire clay	1
39.	"Rock"	7
38.	Clay	1
37.	"Rock," hard, light-colored	4
36.	Slate	1½
35.	Coal	1½
34.	Fire clay	2
33.	Shale, gray	7
32.	"Rock"	1
31.	Shale	1
30.	"Rock"	1
29.	Shale, gray	3
28.	Rock	1
27.	Shale	5
26.	"Rock," gray	8
25.	Shale	1
24.	"Rock"	2
23.	Shale	3
22.	"Rock"	10
21.	Shale	4
20.	Sandstone	3
19.	Shale	1
18.	Sandstone	8
17.	Clay, red	1
16.	Sandstone	18
15.	Shale, blue	3
14.	"Rock," gray	5
13.	Shale	2
12.	"Rock"	6
11.	Shale	2
10.	Sandstone	3
9.	Shale	3
8.	Coal	3
7.	Fire clay	1
6.	Shale, dark	1
5.	Sandstone	9
4.	Shale	7
3.	Sandstone	4
2.	Shale	1
1.	Sandstone	2

RACCOON VALLEY.

Van Meter. Below the junction of the north and south branches of the Raccoon river, abandoned drifts with their accompanying dumps may be seen at several points, but none of these have been used for a long time and the seams are in all cases very thin. The bluffs near Van Meter were the field of operations for most of the attempts to obtain fuel. Van Meter is best known for its deeper coals, however, for it was at this town that the only shipping mine in the southern half of Dallas county produced coal for many years. A shaft was sunk in the western portion of the town from a surface altitude of 878 feet A. T. to a depth of 305 feet. At the bottom of the shaft is the three-foot bed shown in figure 27. This coal was worked out at this point before being abandoned. Twenty feet higher is the middle seam, to which work was chiefly confined, the bed ranging from eighteen inches to four feet in thickness, with an average of three feet. Overlying the middle seam is from three to eight feet of fire clay which was taken out and used in the manufacture of brick. Above the clay is a thin coal, eighteen inches thick at its maximum, and thinning out entirely in places. No coal has been mined here in recent years.

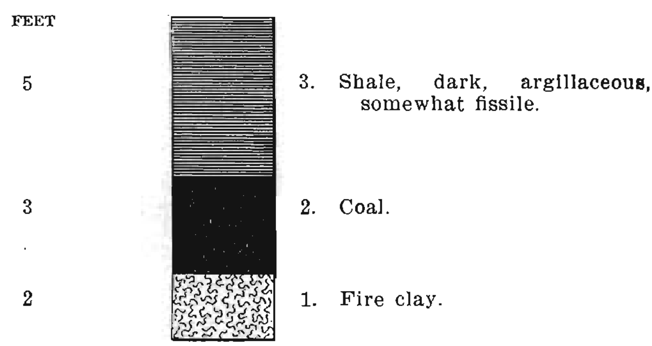


Figure 27. Bed of Van Meter and Chicago mine, Van Meter.

POLK COUNTY

The fact that the Des Moines river, which crosses Polk county, had cut down through the overlying mantle of drift and exposed Coal Measures beneath, led to the discovery at an early date of coal by explorers ascending that stream, while the establishment of an army post and the growth of a large city at the mouth of the Raccoon encouraged attempts to mine the seams exposed.

Summaries of the early history of the coal industry, which was largely confined to the neighborhood of Des Moines, will be found in previous reports of the present Survey.* Today the larger mines have withdrawn to new fields farther from the city, yet all are contained within an ellipse bounded by a line passing through Ankeny, Commerce, Fort Des Moines, Avon, Altoona, and Enterprise. With the exception of the Commerce and Avon shafts, and those near Des Moines which supply the city trade, all the mines have railroad connections and ship much coal to the west and north. The equipments both above and below ground are in general very good and all but the Avon Coal Company employ steam power for hoisting. Underground haulage is in most cases by mules, though some of the larger mines have tail-rope or motor systems in the main entries. Blasting from the solid is the common practice; the room and pillar method of working is in use at all except the Commerce mine. Mining machines do not seem to be very popular, though there is seldom anything in the nature of the coal to prevent their use. The quality of the coal differs but little from the average for the Iowa field. Block coals are uncommon, but comparatively little slack is produced and what there is finds a ready market in the city as a boiler fuel.

The growth of the industry has been steady and consistent, increasing from 600 tons in 1856 to 1,358,397 tons in the fiscal year 1907-1908. The number of mines has not increased so rapidly, however, for the tendency has been toward a concentration of capital and effort at a few points and the suppression of small banks through the competition of large mines. An illustration of this tendency is furnished by the fact that in 1908 thirty-three mines were producing four times as much as did twenty-three in 1895.

In the following table the statistics for the years 1856-74 are taken from state and federal census reports, for 1881-95 from the reports of the State Mine Inspectors and from 1896-1907 from the reports of the Iowa Geological Survey and the United States Geological Survey.

*Keyes: Iowa Geol. Surv., Vol. II, p. 267; Des Moines, 1894. Bain: *idem*, Vol. VII, p. 352, 1897.

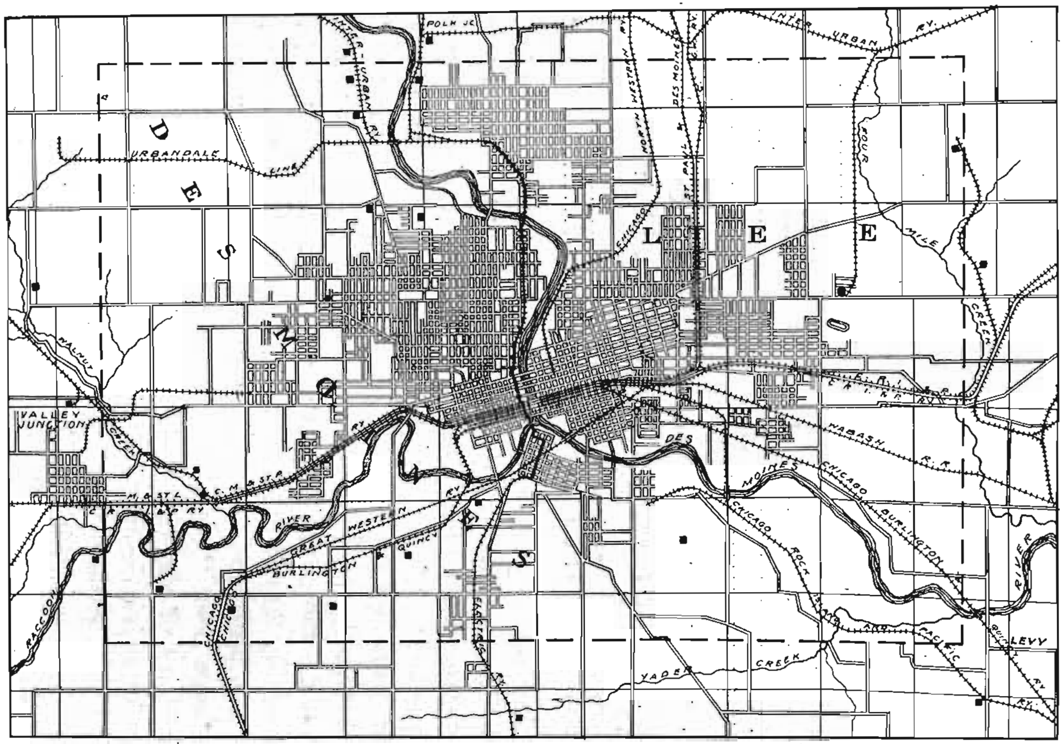
YEAR.	TONNAGE.	YEAR.	TONNAGE.
1856	600	1891	397,833
1860	1,858	1892	371,389
1862	1,418	1893	466,408
1865	1,116	1894	355,000
1866	13,310	1895	334,881
1869	27,796	1896	546,051
1874	69,327	1897	489,136
1881	473,893	1898	635,606
1882	327,819	1899	691,989
1883	558,821	1900	851,667
1884	619,921	1901	954,112
1885	462,895	1902	1,007,860
1886	337,964	1903	1,032,165
1887	305,094	1904	1,130,668
1888	386,321	1905	1,205,317
1889	356,039	1906	1,369,506
1890	408,149	1907	1,460,203

The following figures from the report of the State Mine Inspectors are for the year ending June 30, 1908:

Tons of coal of all kinds produced	1,358,097
Total number of employes	3,249

Taking the average price per ton as $1.73 at the mines, the value of the product for the fiscal year 1908 becomes $2,332,508. This represents a slight decline from the previous year due to the abandoning of a number of mines, but shafts have been sunk in new fields and the output will certainly increase in the future as it has in the past. For over ten years Polk has ranked second among the counties of the state, producing during recent years nearly 20 per cent of the total. In round numbers, about 22,000,000 tons have been mined in this county and nearly 7,000 acres have been "mined out." In spite of this, however, the possibilities of the region are as yet scarcely realized.

The following description of the present status of the industry is from data gathered during the summer of 1908. The mining districts are somewhat arbitrarily grouped along the drainage lines and on the high divides and the situation of most of the mines is shown on the accompanying maps.



Map showing location of mines in the Des Moines district.

DES MOINES RIVER VALLEY ABOVE THE RACCOON FORK.

Polk City. Between High Bridge and the immediate vicinity of Des Moines little mining of importance has been done near the Des Moines river. At one time coal was taken from a depth of 238 feet at Polk City by a shipping mine with a good equipment. There were three and one-half feet of coal in two benches separated by an eight-inch band of calcareous shale, but as the basin proved to be of limited extent nothing has been done there in recent years. In an effort to locate more coal in a place so favorably situated as regards market and shipping facilities, several companies prospected in the district. Always an exceptionally large number of thin seams were found, but none of workable thickness have been reported. About a mile north and northeast of the town, several drillings penetrated as many as seven coal beds. Unfortunately the thickest of these was a twenty-two inch seam. Another company drilled a hole 325 feet deep near Polk City and encountered ten seams, the thickest only nineteen inches. A third company tried a deep prospect southeast of Polk City Junction (Lincoln Tp., Sec. 30, Sw. qr., Sw. ¼). They record the following strata beneath the upland level:

		FEET.	INCHES.
37.	Clay and sand	10	
36.	Drift	113	
35.	Mixed shale	46	
34.	Sandy shale	7	
33.	Dark shale	2	6
32.	Coal (No. 1)		7
31.	Dark shale	2	
30.	Sandstone	6	5
29.	Gray shale	3	
28.	Coal (No. 2)		6
27.	Gray shale	3	3
26.	Dirty coal (No. 3)		5
25.	Light shale	8	
24.	Gray shale	10	3
23.	Coal (No. 4)		7
22.	Gray shale	1	7
21.	Coal (No. 5)		3
20.	Light shale	4	6
19.	Gray shale	11	2
18.	Coal (No. 6)		9
17.	Light shale	4	

16.	Sandstone	4	9
15.	Gray shale	13	
14.	Coal (No. 7)		7
13.	Light shale	2	9
12.	Coal (No. 8)		7
11.	Light shale	3	
10.	Shale, dark, "slate"	4	
9.	Coal (No. 9)		6
8.	Light shale	3	6
7.	Gray shale	6	6
6.	Sandstone	2	9
5.	Coal (No. 10)	1	4
4.	Light shale	2	6
3.	Sandstone	6	8
2.	Gray shale	7	
1.	Light shale	5	
	Total	300	2

Another prospect northwest of Polk City, in the valley of Big creek (Sw. qr., Sec. 26, Madison Tp.) brings to light several other thin coals:

		FEET.	INCHES.
32.	Clay and sand	22	
31.	Drift	31	
30.	Mixed shale	7	5
29.	Sandrock	6	
28.	Gray shale	7	8
27.	Coal (No. 1)		7
26.	Gray shale	4	10
25.	Coal (No. 2)		3
24.	Light shale	11	8
23.	Dark shale	7	10
22.	Coal (No. 3)		6
21.	Light shale	3	7
20.	Gray shale	4	
19.	Light shale	5	
18.	Gray shale	3	2
17.	Coal (No. 4)		5
16.	Light shale	2	
15.	Gray shale	13	7
14.	Light shale	1	6
13.	Dark shale		8
12.	Dirty coal (No. 5)		7
11.	Light shale	2	
10.	Dark shale	2	2
9.	Coal (No. 6)		4
8.	Light shale	7	
7.	Sandstone	14	4
6.	Dirty coal (No. 7)	1	5

5.	Light shale	4	
4.	Sandstone	5	
3.	Gray shale	10	5
2.	Coal (No. 8)		2
1.	Light shale	9	2
	Total	190	3

These two records show that frequent, though slight, oscillations of the level of the land relative to that of the sea prevailed in this district during Des Moines time. Conditions were often favorable for the formation of coal-producing swamps, yet did not remain so sufficiently long to yield deposits which would become of economic value.

Near Andrews, on the west side of the Des Moines river, the appended drill log of a hole in the southeast corner of the Jas. Stoner land again shows several coals. They are somewhat thicker than those found near Polk City. Four other drillings in this vicinity showed the variations of strata usual in the Des Moines stage; but no thicker coals were found. Prospecting farther back from the river might give better results.

		FEET.	INCHES.
31.	Soil and clay	6	
30.	Sand and gravel	3	
29.	Yellow clay	21	
28.	Mixed shale	23	
27.	Black shale ("slate")	1	
26.	Coal (at 54 feet)	1	
25.	Light shale	14	
24.	Dark shale	7	
23.	Coal (at 76 feet)	1	8
22.	Light shale	10	4
21.	Sandy shale	17	
20.	Dark "slate"	16	
19.	Coal (at 121 feet)		8
18.	Dark shale ("slate")	3	4
17.	Coal (at 125 feet)	1	
16.	Fire clay	2	
15.	Dark shale ("slate")	15	10
14.	Coal (at 143 feet)	2	7
13.	Fire clay	4	7
12.	Dark slate	2	
11.	Coal (at 151 feet)	1	
10.	Dark shale	4	
9.	Light shale	4	
8.	Dark shale	7	
7.	Light shale	4	

6.	Gray shale	32
5.	Light shale	16
4.	Dark shale	4
3.	Light shale	10
2.	Gray sandstone	6
1.	Light sandy shale	8
	Total	249

North Des Moines District. Between Polk City and the corporation limits of the city of Des Moines mining has been confined to thin veins opened at a few places by drifts and slopes in the lowlands. Old Saylor may appear to form an exception to this statement, but it lies well back from the river on the edge of the upland and will be discussed later.

A mile and a half below the mouth of Beaver creek is the shaft of the West Riverside Coal Company. It lies at the foot of the bluffs near the corporation line and ships over the Perry and Des Moines Electric railway, beside whose tracks it is situated. About fifty feet down in the shaft is a fifteen-inch seam, still lower is one twelve inches thick, while at a depth of 160 feet lies the bed worked. This latter seam is known as the "third vein," and varies in thickness from three feet six inches to five feet. The coal shoots well off the solid, contains comparatively little pyrites, and only infrequent "bowlders." While irregularities and impurities are uncommon in the coal itself, small "slips," running down to the coal, appear in the thick black shale ("slate") which forms the roof. The development of this mine has extended over a period of only three years and at present only a small engine is utilized for hoisting. The elevation of the seam worked is about 660 feet A. T., but varies considerably because of undulations.

One-half mile south, beside the tracks of the same electric railroad, is a mine of the Blount-Evans Coal Company. The shaft is 135 feet deep. The seam worked lies slightly higher here than at the West Riverside and presents somewhat different characters, yet there is little doubt that the coal of one mine is identical with that of the other. It varies in thickness from three feet to four feet six inches, and cannot be successfully shot from the solid by hand labor, as it breaks down into dust and fine fragments when such a method is employed. With the use of mining machines, however, the yield of lump is as high as ninety per cent. During the winter of 1906-07 three Ingersoll punching machines, driven by compressed air, were in operation. The freedom of the coal from impurities allowed them to do good work, so that it is the intention of the operators to install two more. After the holes are drilled two and a half feet deep, a very small charge of explosive is sufficient to bring down the coal. Ventilation is effected by means of a twelve-foot fan and hoisting by a double engine driven by steam from one boiler of eighty horsepower. A second boiler will shortly be put in position. Above the coal is a considerable thickness of the good roofing "slate" common to the district. Little difficulty is experienced in supporting it, even where it becomes quite sandy next the coal, as it does in places. A so-called "second vein" was found about 110 feet down in the shaft, where it is not sufficiently thick to be of importance. The "first vein" is present, but is also thin.

The Madison Coal Company has a mine at Twenty-third street and Hickman avenue, one mile south of the Blount-Evans, in the valley of a short tributary of the Des Moines river. About forty acres have already been worked out. At 165 feet the coal, which is at an elevation of 655 feet A. T., is reached, and although this bed is nearly twenty-five feet lower here than at the Blount-Evans, it is considered with reason that the horizon remains the same. The thickness worked remains quite constant at a little over four feet, except on the south where the coal thins to a few inches along an east and west line. The decrease takes place at some points with surprising suddenness, the normal thickness being reduced to practically nothing within a distance of eight or ten feet. Whether the "fault" is due to an erosion channel or to the natural thinning of the bed at the limit of the basin cannot be stated with certainty from the evidence now obtainable. Rolls in the roof sometimes extend down to the underlying clay. Small slips, or faults, are common in some portions of the mine, but their distribution is quite irregular. The coal is markedly, but not sharply, undulatory, there being a difference of four or five feet between the crests of the rises and the bottoms of the "swamps." Especially in the "swamps," bands of cannel coal appear and reach a thickness of eight inches or less. Above this bed there are known to be several thin coals, besides one which is thicker than the seam now being worked. Attempts to mine it would probably prove unsatisfactory because of the inconstancy of its thick coal.

One-half mile southeast, near the western boundary of the Chautauqua grounds, is the new shaft of the Eagle Coal Company. The coal bed is continuous from the Madison to the Eagle and thickens locally, being from four to seven feet thick at the Eagle. West of the shaft, which is 170 feet deep, is a low ''swamp'' into which entries are now being driven and where the best coal lies. Its axis lies northwest and southeast. Elsewhere, also, the seam is strongly undulatory. The roof is a good bituminous shale (''slate'') of varying thickness, with only occasional areas where draw slate appears. In places a layer of black jack makes its appearance at the top of the coal. All the coal produced at this mine is hauled in wagons to be sold to the city trade. A steam hoisting equipment is in use and a large output is expected during the coming winter.

Following is the drill log of a prospect hole at the shaft. Its accuracy was afterward ascertained during the excavation of the shaft.

		FEET.	INCHES.
33.	Soil and clay	3	
32.	Shale, mixed	19	
31.	Sandstone	1	
30.	Shale, dark	6	
29.	Shale, sandy, light-colored	14	
28.	Shale, mixed	3	
27.	Shale, sandy, light-colored	18	
26.	Shale, gray	2	
25.	Shale, light-colored	1	
24.	Shale, gray	2	
23.	Coal (at 69 feet)		6
22.	Shale, gray		6
21.	Coal (at 70 feet)	1	
20.	Shale, light-colored	1	
19.	Shale, dark	17	
18.	Shale, light-colored	19	
17.	Sandstone	1	
16.	Shale, sandy, light-colored	7	
15.	Shale, gray	2	
14.	Shale, light-colored	8	
13.	Sandstone, compact	5	

12.	Shale, gray	2	
11.	Shale, dark	9	
10.	Sandstone	1	
9.	Shale, sandy, gray	1	
8.	Shale, dark	5	6
7.	Coal (at 149 feet)	1	
6.	Shale, light-colored	4	
5.	Shale, dark	13	
4.	Coal, bony (at 167 feet)	1	
3.	Coal, good	4	5
2.	Shale, gray	7	
1.	Fire clay		
	Total	179	11

In the bluffs on the east side of the river, opposite the West Riverside, two mines are now in operation, both controlled by the Flint Brick and Coal Company. Shaft No. 2 is situated on the side of the bluff behind the clay plant of the same company. Steam for the hoisting engine is obtained from the clay plant and much of the coal mined is used by it, the remainder being either shipped or retailed in the city. All work underground is now to the west, on the opposite side of the river. The shaft

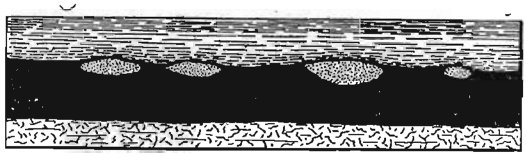


Figure 28. Ironstone nodules in roof of coal bed.

is 180 feet deep and the elevation of the seam at the shaft 675 feet. A. T. The thickness of the coal varies between three and five and one-half feet, although as much as seven feet has been found in local thickenings in "swamps." The seam thins to the west as the workings of the mines on the west side of the river are approached, while it was abandoned within a short distance east of the shaft, where its height decreases to eighteen inches. Part of the seam furnishes a good shooting coal; the remainder tends to cleave horizontally, so that great difficulty is experienced in attempting to shoot it down. Pyrite is fairly common, especially near the roof and the bottom of the vein. "Bowlders" also occur; some in the top coal are as much as fourteen feet long by three feet in diameter. Those in the coal are so compact that dynamite is employed to break them up, while those in the roof usually split easily. Ironstone concretions, locally termed "snakes" because of their great length in proportion to their other dimensions, are embedded in the clay which usually forms the floor of the coal. The seam is strongly rolling, parts of it differing as much as twenty-five feet in level in this one mine.

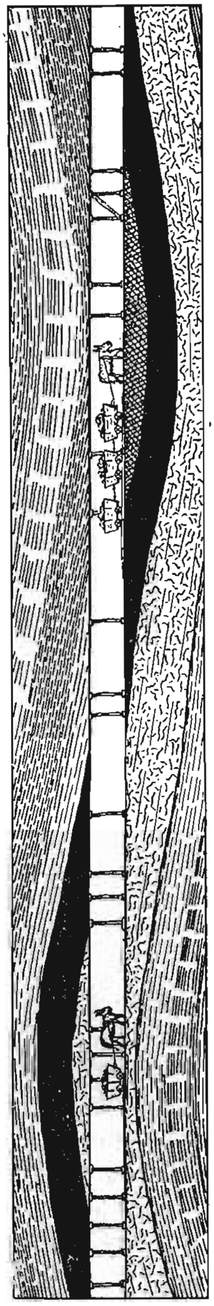


Figure 29. Section showing undulatory character of the coal seam in the Flint mine No. 2.

One-half mile north of No. 2, at Polk Junction, is shaft No. 3, more familiarly known as the Oak Park. It ships over the Des Moines & Colfax Electric railway. Eighteen feet down in the shaft is the so-called "first vein," over three feet thick but filled with clay seams. It has been reached at about the level of low water in the Des Moines river by several slopes in the neighborhood, but has not been touched in recent years. At a lower level is an eighteen-inch seam. At 130 feet below the surface lies the bed worked, four feet thick at the shaft but as high as six feet in local thickenings where work is now being prosecuted. The coal presents the same characteristics as that of the Flint No. 2. It is perfectly clean in some parts but irregularities and impurities become more conspicuous towards the thin edges of the basin on the southeast. In all of the rooms now open, the coal shows a good vertical cleavage and is shot down without difficulty. The roof is good, being both sandstone and black shale. The bottom is a fire clay, except where a shale with minute intercalated layers of coal makes its appearance. Mining is now being done northwest of the shaft. The workings are connected with those of Mine No. 2 and considerable territory has already been worked out in a strip running north and south on both sides of the river.

The North Des Moines district, as now known, embraces an area of four square miles. Two seams appear in most parts of it with reasonable persistency, while a third, lying between the others, is found less frequently and is of very variable thickness. The lower, or "third vein," in which all of the mining on a large scale has been conducted, has nearly reached the limit of its productiveness. There are undoubtedly parts of the upper coals which will repay development in the near future. Prospecting both east and west of the present mines has revealed little of encouragement; although, so far as known, investigations have not been carried west farther than a mile and a half from the river. Little coal has been found under the higher land of Highland Park; but under the lower land of the pre-glacial valley bounding it on the north and east, mining has often proved profitable from Saylor southeast to the Fair Grounds.

It must not be understood that the "third vein" is a continuous bed underlying every part of the North Des Moines district. On the contrary several "faults" are well known to the miners. On the west side of the Blount-Evans shaft is a large "fault," 400 or 500 feet wide. This feature continues to the southeast and the same or a very similar "fault" was found east of the new Eagle mine, where it is more than 300 feet in width. Near the latter mine signs of disturbance can be traced in the pit of the Shackleford Brick Company, but the exposures were very unsatisfactory at the time this was visited. The "fault" was penetrated from the southwest by an entry of the new Eagle and from the northeast by one from the former Bloomfield. In both cases rolls in the roof of the coal became more frequent as the feature was approached. A similar "fault" disturbed mining operations east of the West Riverside shaft. It proved to be 303 feet wide and the entry which was driven through it encountered sandstone, slate, and a little fire clay in succession. The coal seam, when again found on the eastern side, soon attained a thickness of five feet, although when first reached it was only six inches in height. This "fault" runs southwest and northeast, perhaps joining the one first mentioned at right angles. Somewhat similar phenomena separate the Oak Park and Saylor fields, as also those of the Oak Park and the recently abandoned O. K. mine which lay a half mile east of it.

It is altogther probable that these disturbing features are not true faults in the geological sense. That they are not preglacial erosion channels seems likely from the absence in them of a drift filling. It is not at all clear, however, whether they are valleys eroded and refilled during the Pennsylvanian period or whether they simply mark the limits of small productive areas in a coal horizon. The latter explanation is applicable to the "faults" in which the coal thins gradually until it disappears altogether, often rising as it thins. Where the coal is abruptly cut off, it is more likely that stream erosion has removed it. Both types of "faults" may, therefore, be considered to be represented in this district.

WALNUT CREEK VALLEY.

Clive. A new field has been discovered a mile east of Clive and was opened during the summer of 1908 by the sinking of the Gibson shaft No. 5 (Walnut Tp., Sec. 35, Se. qr., Se. ¼). A spur track is to be laid from the Chicago, Milwaukee and St. Paul railroad. Neat top works, protected from fire by galvanized iron sheathing have been built and an Ottumwa first-motion engine, cylinders 16x32, installed for hoisting purposes. Danville self-dumping cages are employed. Entries have not been driven far, but the coal promises to be of good quality and to preserve a thickness of at least four feet. The shaft is 160 feet deep, and the altitude of the coal at the shaft is about 675 feet above tide. Systematic prospecting by the company has revealed considerable variation in the depth of the coal from point to point: west of the shaft the bed drops ten feet in a distance of 125 feet. East of the shaft at least three coals are present above the one worked, while south of it there are probably four.

HOLE 150 FEET EAST OF GIBSON NO. 5.

		FEET.	INCHES.
21.	Fill	42	
20.	Sand	9	
19.	Soapstone	2	
18.	Rock	2	9
17.	Soapstone and fire clay	29	3
16.	Shale	2	
15.	Coal (at 87 feet)	3	8
14.	Fire clay	9	4
13.	Shale, gray	4	
12.	Shale, black	23	7
11.	Coal (at 127 feet)	3	5
10.	Fire clay	3	
9.	Soapstone	6	
8.	Shale, gray	2	
7.	Sandstone	1	
6.	Shale, black	1	6
5.	Coal (at 144 feet)	2	
4.	Fire clay	1	6
3.	Shale, gray	3	
2.	Shale, black	9	6
1.	Coal (at 160 feet)	4	6

HOLE SOUTH OF GIBSON NO. 5.

		FEET.	INCHES.
25.	Soil	2	
24.	Sand and gravel	10	
23.	Blue clay	20	
22.	Sand	10	
21.	Fire clay and soapstone	9	
20.	Sandstone	5	
19.	Fire clay	8	
18.	Shale, gray	2	
17.	Coal (at 66 feet)	3	6
16.	Fire clay	4	
15.	Sandstone	8	6
14.	Shale, gray	8	
13.	Shale, black	5	
12.	Rock, compact	1	
11.	Shale, black	3	
10.	Coal (at 99 feet)	1	7
9.	Sandstone	1	
8.	Fire clay	7	5
7.	Sandstone	7	
6.	Shale, gray	6	
5.	Shale, black	5	
4.	Coal (at 127 feet)	2	2
3.	Fire clay	2	
2.	Shale, black	11	8
1.	Coal (at 143 feet)	2	8

It seems probable that the last drilling did not reach the horizon of the coal mined at the shaft and that numbers 1, 4 and 10 of the second section correspond respectively with 5, 11, and 15 of the first. Number 17 of the second may have been cut out of the first section by erosion. These suggestions are only tentative, however, since all the strata, including the coals, are so changeable both in their vertical dimensions and lithographic characters that exact correlations are made extremely difficult.

Valley Junction. Another new mine is that of the Keystone Coal Company, north of Valley Junction (Walnut Tp., Sec. 11, Nw. qr., Ne. 1/4). When visited during the summer of 1908 entries were just being started and a double, geared hoisting engine had but recently been set up. The section at the shaft is:

		FEET.	INCHES
26.	Soil and clay	12	6
25.	Sand	12	
24.	Shale, light-colored	6	9
23.	Sandstone (water bearing)	1	
22.	Shale, light-colored	9	
21.	Shale, dark	3	
20.	Coal (at 44 1/4 feet)		7
19.	Fire clay	1	2
18.	Shale, light-colored	24	
17.	Shale, dark	2	
16.	Shale, black	5	
15.	Coal (at 77 feet)	3	
14.	Fire clay	3	
13.	Shale, light-colored	7	
12.	Shale, dark	10	
11.	Hard rock band		6
10.	Shale, dark	8	6
9.	"Bowlder"	1	8
8.	Shale, black	4	
7.	"Bowlder"	1	
6.	"Slate," black	7	6
5.	Coal (at 121 1-6 feet)	4	4
4.	Fire clay	1	8
3.	Coal (at 127 1-6 feet)	1	
2.	"Slate," black	19	6
1.	Coal (at 147 2-3 feet)	5	

The coal horizons shown here agree very well with those found at the Gibson mine near Clive. The altitude of No. 1, the seam worked, is about 676 feet A. T. It may be seen that a field rich in possibilities is being newly developed along Walnut creek. Considerable prospecting has recently been conducted between Valley Junction and Commerce, and new mines may be expected in that district some time in the near future. It is not to be understood, however, that the coal lies in continuous beds, even between points where the seams are evidently closely related, as are those at the Gibson and the Keystone. Under the lands prospected by the Keystone Coal Company, for instance, number 5 of their shaft section is not very persistent, and number 1 appears to be confined to a basin which is elongated from southwest to northeast. The lower seam was only eighteen inches thick in test holes drilled one mile west and two miles northwest of the shaft.

Mouth of Walnut Creek. Two mines are in operation about one-fourth mile above the mouth of Walnut creek beside the tracks of the Chicago, Milwaukee and St. Paul railroad. On the east side of the tracks is the shaft of the Walnut Creek Coal Company, which is working the "third vein." The maximum thickness of the seam is four feet, but it thins so as to become unworkable north and northeast of the mine workings. Another coal, eighty feet and more above the lower, is workable over part of the company's land, though it is only six inches thick at the shaft. Most of the coal has been taken from the east side of the shaft, but the work is now to the west.

DRILLING NEAR SHAFT OF WALNUT CREEK MINE.

Surface Altitude 818 feet A. T.

		FEET.
20.	Fill	22
19.	Soapstone shale	19
18.	Rock	2
17.	Fire clay	10
16.	Soapstone shale	11
15.	Shale	4
14.	Fire clay	5
13.	Coal	½
12.	Soapstone shale	7
11.	Fire clay	14
10.	Shale	9
9.	Coal	1
8.	Soapstone shale	14½
7.	Rock	1½

6.	Fire clay	8
5.	Shale, black	10
4.	Coal	2
3.	Fire clay	4½
2.	Shale, black	9
1.	Coal	3½
	Total	157½

DRILLING 2,000 FEET NORTHEAST OF WALNUT CREEK SHAFT.

Surface Altitude 890 feet A. T.

		FEET.	INCHES.
26.	Soil	3	
25.	Yellow clay	30	
24.	Sandstone	2	
23.	Soapstone shale	6	
22.	Sandstone	3	
21.	Soapstone shale	6	
20.	Sandstone	1	
19.	Soapstone shale, blue	8	
18.	Coal	2	3
17.	Soapstone shale, sandy	4	
16.	Sandstone	4	
15.	Soapstone shale	8	
14.	Sandstone	4	
13.	Soapstone shale	16	
12.	Coal	1	3
11.	Soapstone shale	42	5
10.	Coal	2	9
9.	Soapstone shale	12	
8.	Sandstone	4	
7.	Soapstone shale	50	
6.	Shale, black	9	4
5.	Coal	1	4
4.	Shale, black	18	10
3.	Coal	2	2
2.	Fire clay	7	
1.	Shale, black	34	2
	Total	282	6

The mine of the Coaldale Fuel Company is on the opposite side of the tracks, a short distance south. Both of the two lower seams found at the Walnut Creek shaft are here much thicker, the lower varying between three and one-half and five and one-half feet, the upper being five feet three inches and lying fourteen feet above the lower. Both these seams are now worked from the same shaft. Both contain quite clean coal with very little dirt, no "clay slips," and with the "sulphur" confined chiefly to the roof. The roof is in part black "slate" and in part a clay ironstone ("bowlder") which requires little timbering. Entries have been extended three-fourths mile to the south, in which direction there is a gentle dip, and the main haulage is by Goodman electric motors.

RACCOON RIVER VALLEY.

Commerce. Coal has long been known at Commerce and has been worked by small shafts at both the western and eastern edges of the town. Only one mine is in operation now, a gin shaft supplying local trade only. It is on the land of Dr. Hulme, just east of Commerce (Tp. 78, R. 25, Sec. 28, Nw. qr., Nw. ¼). A number of coal seams are known at this point. Twenty feet below the surface is the first seam, ten inches thick and with a good "slate" roof and fire clay bottom. The second seam is the one which has been chiefly worked. It lies seventy-five feet below the uppermost coal, at an altitude of about 755 A. T. and with a dip to the northwest. Its thickness is variable, but the average may be taken as three feet. The roof is so firm that the coal can be worked longwall. The third seam, three feet three inches thick, is thirty feet farther down and has a sandy soapstone shale roof. Two and one-half feet below the third is a twenty-inch coal, while other thinner seams are known at still greater depths. Where mining has been carried on just west of Commerce, the succession of coals is much the same. The second seam, however, is only twenty inches thick and a third two and a half feet.

Valley Junction. The Valley Union Coal Company is operating a new mine at the foot of the bluffs on the south side of the Raccoon near the Valley Junction bridge. At a depth of 150 feet, at an altitude of about 680 A. T., a four-foot coal bed is reached; while seventeen feet above it a two-foot coal is reported and forty-three feet still higher is a two and a half foot seam. The mine supplies a local trade in Valley Junction and the country districts on the south. Entries running east, west and south, have been driven a total distance of 1,700 feet. The roof of the lower coal is a tough bituminous shale. Hoisting is done by a small single engine.

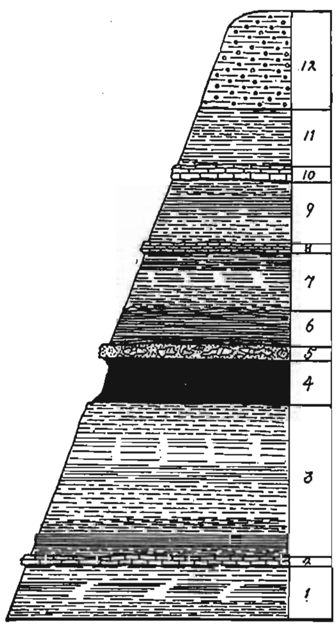
Park Avenue and Vicinity. In the southwest corner of Section 13, three-fourths mile southeast of the Valley Union mine, is the shaft of the Hollingsworth Coal Company. Hoisting is effected by a double, geared engine with 10x18-inch cylinders. The product is shipped over a spur from the Minneapolis and St. Louis railroad. The seam mined lies 150 feet below the surface, at an altitude of about 670 feet A. T. The coal bed is slightly undulatory, without noticeable dip in any particular direction and the average thickness of the coal is four feet. Entries extend from the shaft in all four of the cardinal directions, the main entries being north and south. At present the work is about half way between the shaft and the Raccoon river. In general, the coal may be said to be clean; a few dirty streaks and irregularly placed bands of iron pyrites give little trouble. The roof is alternately "slate" and sandstone, one giving place to the other without apparent regularity. The presence of a thick bed of coal below the one now being developed, as well as of one above it, is shown by the following section:

SECTION 992 FT. S. AND 25 FT. E. OF HOLLINGSWORTH SHAFT.

Surface altitude about 840 A. T.

THICKNESS.			DEPTH OF BASE.	
FEET.	INCHES.		FEET.	INCHES.
20	..	Clay	20	..
5	..	Shale, light-colored	25	..
2	9	Shale, dark	27	9
..	10	Coal	28	7
29	4	Shale, light-colored	57	11
1	..	Shale, dark	58	11
..	9	Coal	59	8
62	1	Shale, light-colored	121	9
2	11	Coal	124	8
6	7	Shale	131	3
..	11	Coal	132	2
8	8	Shale, light-colored	140	10
8	6	Sandstone	149	4
34	8	Shale, dark	184	..
3	2	Coal	187	2
1	6	Shale, light-colored	188	8
2	..	Shale, dark	190	8
3	4	Shale, light-colored	194	..
8	8	Shale, dark	202	8
5	..	Coal	207	8
8	..	Shale, light-colored	215	8
42	4	Sandstone	258	..
2	..	Shale, sandy	260	..

Three-fourths mile east and a little south of the Hollingsworth, beside the Chicago, Burlington & Quincy tracks, is the Iowa mine (T. 78, R. 25, Sec. 24, Ne. qr., Nw. ¼). The shaft is 150 feet deep to a coal bed which varies in thickness between four and four and a half feet and lies at an altitude of about 690 feet A. T. This seam is reported to be present under all of the 300 acres controlled by the company. At first entries were driven under the railroad tracks toward the west, then attention was turned toward the north. For 400 feet from the shaft the coal dips to the west, then lies level for a short distance until it begins to rise toward its initial level. A thin band of black jack and pyrites is quite generally present about eighteen inches below the roof of the coal. Immediately above the seam is a "dirt band" between one-half and two feet in thickness, and lying on it a foot or less of coal. The latter is seldom removed during mining operations, being left to render notable service as a roof. A lower seam, perhaps identical with the one shown in the Hollingsworth section, is reported; but information on this subject is somewhat vague.



No.		FEET.
12	Drift	10
11	Clay shales, red and drab, variegated	6
10	Limestone, earthy, nodular	½
9	Shales, variegated	5
8	Limestone, impure, nodular	½
7	Clay, yellow and drab, variegated	4
6	Clay shale, dark drab, somewhat bituminous	2
5	Ironstone, black, nodular	1
4	Coal, impure	3
3	Clay shale, hard, drab, somewhat sandy in places	15
2	Limestone, nodular	1
1	Clay shale, blue (exposed to track level)	6

Figure 30. Railroad cutting near Rose Hill mine, four miles west of Des Moines.

The Midway Coal Company is now operating the Shaw mine, one mile east of the Iowa (T. 78, R. 24, Sec. 19, Ne. qr., Ne. 1/4). The shaft cuts two seams at this point, but it is not the intention of the operators to mine in the lower coal for some time to come. The lower seam is 180 feet below the surface at the shaft and is four feet eight inches thick at that point. The coal now being excavated lies forty feet higher, at an altitude of about 700 feet A. T. Its thickness varies between four and six feet. There is a small general dip to the west, though it is somewhat obscured by the local grades due to the undulatory character of the seam. A single-cylinder, geared engine is utilized for hoisting. There are no shipping facilities here, yet a considerable trade is supplied locally and in Des Moines.

One mile northeast is the Bennett (T. 78, R. 24, Sec. 17, Se. qr., Nw. 1/4), another mine which, although without railroad connections, is able to market a large daily output in Des Moines. Steam power is used. The shaft is 125 feet deep to a level, clean coal bed which varies irregularly in thickness between three and a half and five feet. The seam is known to the miners as the "third vein," though its altitude of about 715 feet A. T. and its relation to the limestone bands to be mentioned later seems to indicate a probable correspondence with the "second vein" of the territory farther east. The "second vein" is absent; but the "first vein," 100 feet above the third at this point, is workable in places. It has a poor roof, however, and is largely cut into by pre-glacial channels. No coal was found in the first fifty feet of shales and thin sandstones which lie below the so-called "third vein."

The Johns Coal Co. opened a new mine in the autumn of 1907 about one mile northeast of the Bennett, at the base of the bluffs near the brick plant (T. 78, R. 24, Sec. 16, Nw. qr., Ne. 1/4). Two tubular boilers, one 60-in. x 18-ft. and the other 40-in. x 16-ft., furnish steam to a single-cylinder hoisting engine. Although the mine lies close to the Chicago Great Western railroad tracks, no coal is shipped. Various manufacturing industries in Des Moines consume the entire product. The seam mined belongs in the same horizon as the lower coal at the Bennett and is four feet thick.

DES MOINES VALLEY BELOW THE RACCOON FORK

South Des Moines. Owing to the strategical position of a field so close to the business center of a large city, mining was energetically prosecuted in the South Des Moines district at an early date and was continued until the complete exhaustion of the known supply was in sight. Three horizons at which coal has been found are generally recognized, the first a little above the river level, the second about seventy feet lower, and the third, from 120 to 150 feet below the bottom lands. Coal does not always exist at all three of these horizons at any given point, nor are the horizons always separated by exactly the same intervals. Changes in level of a coal bed from place to place may be due to "rolling" of the coal seam, to a dip common to all the strata, or to a thickening or thinning of certain strata below the coal. Nor are the three horizons of which mention has been made the only ones known, though they are perhaps the most persistent. A general idea of the relations of the strata in the district may be gained from the following shaft record of the old Clifton mine, which was situated a short distance south of the West Ninth street bridge.

CLIFTON SHAFT RECORD.

Elevation of Surface About 890 Feet A. T.

		FEET.	INCHES.
42.	Drift	11	
41.	Sandstone, soft	2	
40.	Shale, argillaceous	9	
39.	Limestone		8
38.	Shale, argillaceous	8	
37.	Limestone		9
36.	Shale, argillaceous	5	
35.	Shale, black	2	
34.	Coal		10
33.	Fire clay	2	
32.	Sandstone, compact	3	
31.	Sandstone, soft	3	
30.	Fire clay	3	
29.	Shale, argillaceous	12	
28.	Shale, black	6	
27.	Coal	2	
26.	Fire clay	6	
25.	Sandstone	9	
24.	Fire clay	6	

23.	Shale, brown	2	
22.	Coal	1	11
21.	Fire clay	16	
20.	Sandstone, compact	6	
19.	Fire clay	8	
18.	Shale, argillaceous	4	
17.	Coal	6	
16.	Fire clay	13	
15.	Shale, black	10	
14.	Limestone		10
13.	Shale, black	3	
12.	Coal, impure	3	
11.	Rock		3
10.	Coal	2	3
9.	Fire clay	8	
8.	Sandstone	2	
7.	Shale, black	5	
6.	Sandstone	3	
5.	Shale, black	5	
4.	Coal	1	8
3.	Fire clay	4	
2.	Shale, black	10	
1.	Coal	5	6

Very little mining is done today in the South Des Moines district. The only mine now in operation between the West Ninth street bridge and Levey is that of the Beck Coal Company at Sevastopol. The present shaft of that company opens to a new mine situated near the center of section 14, range 24, township 78. Hoisting is done by steam. There are no railroad connections. Work is being done in the "third vein," which is here quite level and roofed by a firm bituminous shale. Scattered ironstone segregations may be seen here and there in the coal, but clay seams and small faults, often numerous in the "first" and "second" veins, are lacking. Not more than two or three acres have been worked out.

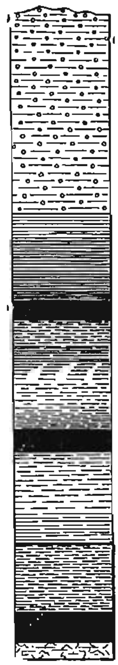
Fort Des Moines. Several attempts have been made to locate fields near the army post, but so far the only successful one appears to have been that of the Blount-Evans Co. They have recently sunk 218 feet near the crossing of the Fort Des Moines electric line over Yader creek, about a mile north of the Fort. This coal appears to be in an isolated pocket of 200 acres, with the long axis lying northeast-southwest. Although the company drilled seventeen holes on the 360 acres owned by them, the remainder of the tract proved barren. A test hole near the present shaft shows:

		FEET.
16.	Soil and clay	12
15.	Sand and gravel	3
14.	Yellow clay	3
13.	Gray rock	3
12.	Hard, dry sand	96
11.	Shale, sandy, gray	9
10.	Shale, sandy, light-colored	7
9.	Sandstone, gray	15
8.	Shale, sandy, light-colored	13
7.	Sandstone, gray	3
6.	Shale, light-colored	4
5.	Shale, mixed	3
4.	Shale, dark	7
3.	Coal (altitude about 647 A. T.)	4½
2.	"False bottom"	½
1.	Shale, light-colored	24½
	Total	207½

Other prospects in the vicinity show that there is a barren succession of shales and sandstones for a considerable distance below the bottom of the shaft. There is a marked predominance of sandstones, some bearing highly mineralized waters, among the superficial strata for a radius of a mile from Fort Des Moines.

East Des Moines. Like South Des Moines, the district east and northeast of the Capitol became the scene of extensive mining early in the history of the industry. Three coal seams of encouraging size—the "first," "second" and "third"—became in succession the foci of operations in various mines; then as the fields near the centers of congestion were exhausted, new shafts were opened farther and farther to the north and to the east until the present locations were reached. The stratigraphical relations of the coal horizons are illustrated by the accompanying section from the shaft of the old Giant No. 1, which was a short distance east of the Capitol.

At the present day the only mining being done in East Des Moines is by the Glenwood Coal Company, whose shaft No. 3 was sunk on the north side of the State Fair Grounds. At a depth of 110 feet they found four feet six inches of coal, increas-



FEET.	INCHES.	
40		11. Drift.
16		10. Shale, black and bituminous below, light-colored above.
4		9. Coal.
2		8. Fire clay.
12		7. Shale, light-colored.
5	6	6. Shale, bituminous.
4	6	5. Coal.
4		4. Fire clay.
30		3. Shale, light-colored above, bituminous below.
6		2. Coal.
1		1. Fire clay.

Figure 31. Shaft of Giant number 1, East Des Moines.

ing to six feet in a few spots and overlain by a tolerably firm calcareous shale. Near the shaft there is a slight grade, but as a rule the entries are quite level. Of the 200 acres leased by the company, fifteen have been worked out, and during the summer of 1908 entries were being driven east and north in a little less than five feet of coal. Steam for hoisting is furnished by two tubular boilers capable of producing a total of 160 horsepower. The product is hauled by wagon into the city.

It is difficult to connect the Glenwood coal with any of the seams found near the Capitol. Perhaps it may best be correlated with the "third vein" of the Giant section and with the coal now worked at the Economy mine in Four Mile valley, and the conception advanced that it lies near the crest of a very low anticline.

Carbondale. For more than twenty years mining was prosecuted at Carbondale, until the last mine to continue was closed during the summer of 1908 because of the numerous pre-glacial and Pennsylvanian erosion channels encountered on the edges of the workings. The following section of the strata at old Carbondale No. 2 (Tp. 78, R. 23, Sec. 9) is taken from Bain's "Geology of Polk County,"* which has been freely drawn upon for material relating to mining districts which are no longer active.

CARBONDALE NO. 2.

		FEET.	INCHES.
21.	Soil	2	
20.	Marly clay	17	
19.	Sand and clay	3	
18.	Shale, gray	39	5
17.	Sandrock and shale	3	9
16.	Limestone, white, brittle	1	10
15.	Shale, light blue	1	6
14.	Shale, sandy	8	4
13.	Shale, light blue	1	4
12.	Sandstone	1	6
11.	Shale, gray	2	
10.	Sandstone	3	4
9.	Shale, sandy	12	9
8.	Shale, gray	5	5
7.	Coal and black jack	1	2
6.	Fire clay	1	8
5.	Shale, gray	1	1
4.	Rock, hard, gray		7
3.	Rock, hard, blue	3	8
2.	Shale, black	3	
1.	Coal	4	4

A record from section 10, farther east, is as follows:

		FEET.	INCHES.
30.	Soil	4	
29.	Clay and sand	42	
28.	Gray soapstone shale	5	
27.	Blue clay	39	
26.	Shale, black	3	
25.	Sandstone	2	
24.	Shale, gray	6	
23.	"Slate," black	1	6
22.	Coal		8
21.	Fire clay	3	
20.	Soapstone shale, gray	4	
19.	Shale, black	22	
18.	Coal	4	
17.	Pyrites		6
16.	Fire clay	3	
15.	Sandstone, soft	1	
14.	Shale, clayey, white	6	

*Iowa Geol. Surv., Vol. VII; Des Moines, 1897.

13.	Sandstone	1	6
12.	Shale, clayey, brown	2	6
11.	Shale, black	10	6
10.	Sandstone	1	6
9.	Shale, white	1	
8.	Sandstone, hard, gray	3	7
7.	Pyrites		1
6.	Shale, gray	19	
5.	Sandstone, hard	6	
4.	Shale, gray	13	
3.	Rock, hard	1	6
2.	Shale, black	4	9
1.	Coal	4	9½

The correspondence of the last two sections is only approximate. Numbers 18 and 22 of the last are not represented in the first, and number 7 of the first is not found in the last. The thick coal at the base of both sections represents the same horizon and lies at an altitude of a little over 700 feet A. T. The horizon of number 22 of the last section yields thicker coal in other places, notably in the northwest quarter of the northeast quarter of section 9, where a boring started on the upland found a five-foot bed at sixty feet. The Saint Louis limestone has been found only eighty-four feet below the horizon worked at Carbondale, and so far no coal has been reported from the strata between the limestone and this horizon.

A mile northwest of Carbondale several mines were formerly located near the tracks of the Chicago, Rock Island and Pacific railroad. The record of a drilling near old Gibson No. 2 (Sec. 5, Ne. qr.) is as follows:

		FEET.
13.	Soil	2
12.	Red sand	12
11.	Blue clay	32
10.	Soft clay and sand	10
9.	Shale, black	32
8.	Coal	3½
7.	Fire clay	4
6.	Sandstone, soft	5
5.	Shale, black	15
4.	Cap rock	1
3.	Coal	4½
2.	Fire clay	2½
1.	Sandstone	7
	Total	130½

Number 8 of the above section probably lies in the horizon of the coal mined at Carbondale (No. 1 of both Carbondale sections). The coal is not particularly persistent in the neighborhood, but in many cases its absence in drill records is due to removal by pre-glacial erosion, which reached to a great depth in the valley of Fourmile creek. Number 3 of the section was located over a considerable area.

Ross Junction. Coal which corresponds in position with that mined at Carbondale was formerly developed at Hastie (Ross Junction) by several companies. The shaft of the Wabash mine was 100 feet deep. One mile southeast of this point the Iowa Coal and Mining Company once operated a shipping mine (Fourmile Tp., Sec. 15, Se. qr., Ne. 1/4). Four coal horizons have been recognized here. The upper coal, mined by drifting, is shown in the accompanying section and sketch of a near-by railroad cut.

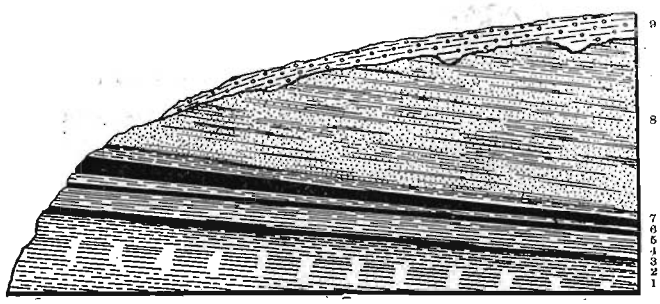
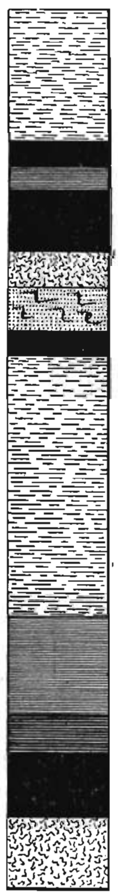


Figure 32. Railroad cut one mile east of Hastie.

		FEET.
9.	Drift	4
8.	Shale, sandy, yellow	30
7.	Shale, bituminous	3
6.	Coal	3
5.	Clay, white and ash-colored	2
4.	Coal, impure	1/2
3.	Shale, yellow and white	4
2.	Coal, impure	2-3
1.	Shale, dark, drab (exposed)	6

As shown in the old Iowa shaft there are about thirty-five feet below this horizon a three-foot seam, twenty-five feet lower one three feet eight inches thick, and fifty-four feet still farther down a three-inch representative of the coal at Hastie.

Levey. On the south side of the Des Moines river, one-half mile south of Levey station, the small gin shaft of the Avon Coal Company is supplying a local trade. Although it is only 300 feet from the Winterset branch of the Chicago, Rock Island and Pacific Railroad, no railroad facilities are utilized. The shaft is thirty-four feet deep to the top of the coal, which is three feet eight inches thick and lies at an altitude of about 770 feet A. T. The strata in the shaft are said to be practically the same as those occurring three-fourths mile northwest at the old Manbeck mine and shown in the accompanying figure.



FEET.	INCHES.	
6		12. Shale, light-colored above, bituminous below.
1	3	11. Coal.
1		10. Clay, drab, carbonaceous, "clod."
3		9. Coal.
1	5	8. Fire clay, light-colored.
2		7. Sandstone, massive, yellow.
1	2	6. Coal.
12		5. Fire clay and gray shale, "soapstone."
3		4. Shale, bituminous, hard and compact.
1	8	3. Ironstone, irregular, nodular.
3	4	2. Coal.
		1. Fire clay.

Figure 33. Part of shaft of Manbeck mine, north of Avon.

The coals numbered 11, 9, and 6 in the figure correspond to the tripartite seam mentioned as exposed in the railroad cut near the old Iowa mine on the opposite side of the river, so that number 2 falls into a position corresponding with that of the upper seam in the Iowa shaft. The two upper benches of this tripartite coal found in the Manbeck shaft have been mined by drifts at numerous points to the southeast, along the Winterset branch of the Chicago, Rock Island and Pacific Railroad. In an attempt to discover workable horizons below those already known, a drill rig was set up in the bottom of the Avon Coal Company shaft, and the following sequence of strata recorded:

DRILLING IN AVON MINE.

		FEET.	INCHES.
	Depth of shaft	34	
41.	Coal at bottom of shaft	3	8
40.	Clay	3	
39.	Shale, bituminous	30	
38.	Coal	1	
37.	Clay	2	
36.	Rock	2	
35.	Fire clay	3	
34.	Rock	2	
33.	Clay, sandy	2	
32.	Shale, sandy	5	
31.	Rock	3	
30.	Clay	3	
29.	Sandstone	10	7
28.	Rock, hard	3	6
27.	Shale, black	5	
26.	Clay	1	
25.	Shale, sandy	30	
24.	Sandstone	2	
23.	Limestone	1	
22.	Clay	1	
21.	Rock		10
20.	Shale, sandy	3	
19.	Shale, black	1	6
18.	Sandstone	2	
17.	Shale, carbonaceous	1	6
16.	Clay, compact, brown	1	
15.	Coal, black jack	3	
14.	Shale, black	1	
13.	Clay, cream-colored		6
12.	Shale, black		4
11.	Coal		3

10.	Shale, bituminous	1	
9.	Coal		3
8.	Clay, blue, sandy	1	
7.	Shale, black	17	
6.	Cap rock	2	3
5.	Shale, black	6	
4.	Rock		9
3.	Shale, carbonaceous	4	6
2.	Fire clay	2	6
1.	Sandstone (?)		10
	Total	193	9

It will be seen that no workable coal was found in this prospect. Number 38 may be correlated with the second coal seam found in the old Iowa shaft, on the opposite side of the river; but the Carbondale-Hastie horizon cannot be recognized. There was some dispute among the drillers as to the proper identification of number 1; it may, perhaps, be the Saint Louis limestone.

Runnells. The upper coal horizon (numbers 6 to 11 of the Manbeck mine section) outcrops at many points in the bluffs on both sides of the river. At Ford it is well exposed and drift mines working it will be discussed in the chapter on Warren county. At Runnells and for some distance east and west of the town, the same seam has been worked by drifts and slopes, as well as by shafts located a short distance back from the bottom lands. Figure 34 illustrates a section measured in a cut on the Wabash railroad, about a mile east of Runnells.

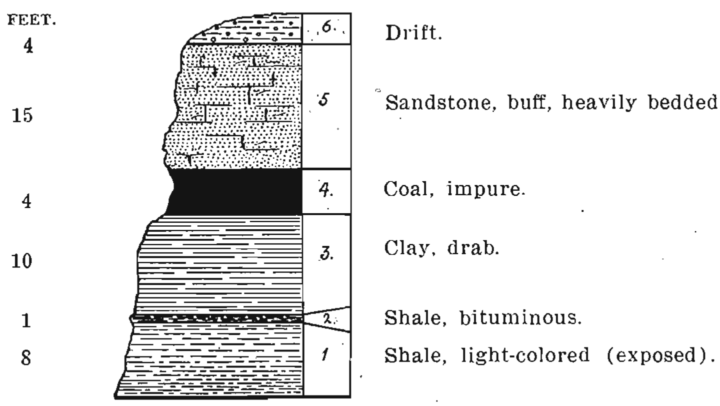


Figure 34. Railroad cutting near east county line, below Runnells.

The Ford-Runnells coal horizon may usually be recognized by the heavy sandstone, known as the Ford sandstone, which often overlies it. This is best shown at Ford, but is also represented by sandstones and sandy shales on the north side of the river. A stratum of clay shale, often bituminous, sometimes intervenes between the sandy layers and the coal, but it is erratic in appearance and variable in thickness. Prospecting four miles north of Runnells failed to reveal the Ford horizon in a convincing manner.

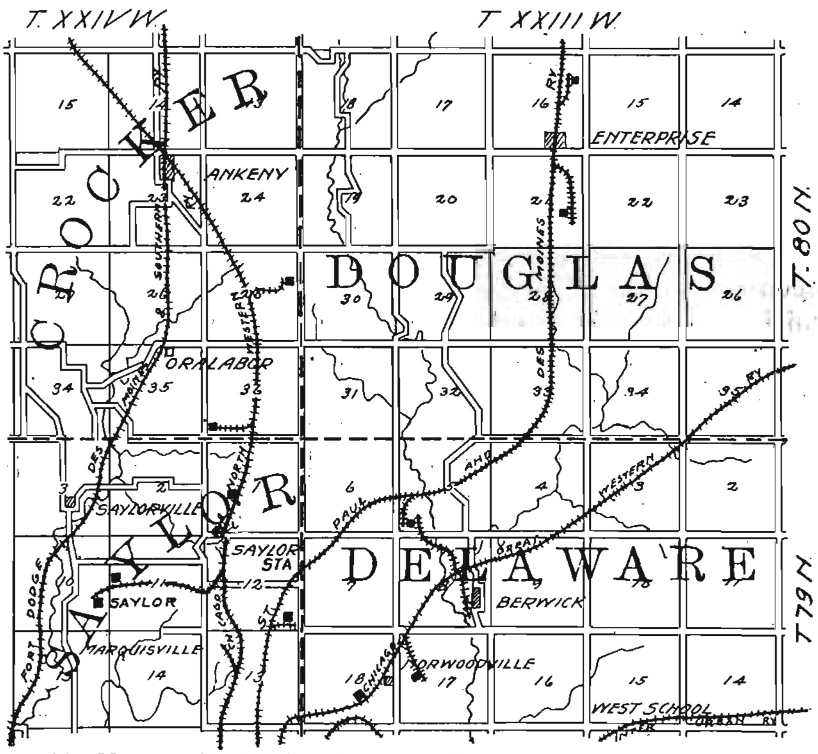


Figure 35. Map showing location of principal Polk county mines outside of the Des Moines district.

THE DES MOINES—FOURMILE DIVIDE.

For many years mining operations have been conducted in the neighborhood of Marquisville, but it was not until recently that attention was turned to the upland district on the north. Today a very respectable portion of the coal produced in Polk county is taken from the prairie region lying between Ankeny and Marquisville; while indications point to the continuance and probable extension of the present industry for many years to come.

Ankeny. Two miles southeast of Ankeny (Crocker Tp., Sec. 25, Ne. qr.), the Anderson Coal Company sank a shaft early in 1908 to a thick bed of coal. The main entry has been driven 500 feet due south and development work has advanced far enough to promise a large production during the coming winter. The product is loaded on a spur of the Chicago and North Western railway, over which most of it is shipped north. Three tubular boilers of eighty horsepower each furnish steam for the Eagle first-motion hoisting engine. Hopper scales and Olson automatic cages form part of a modern equipment. The tipple is arranged so that three cars may be loaded simultaneously. The coal seam, which lies at an elevation of 675 feet A. T., has so far proved to be a clean one. The field, so far as prospected by this company, consists of 700 acres. The 285-foot shaft lies in about the center of the field. The drift is as much as 100 feet thick at this point, yet four small seams, ranging from six to eighteen inches in thickness, occur between it and the bed worked.

Carney. The new mining camp, Carney, is three miles south of Ankeny. Shaft No. 2 of the Saylor Coal Company is located here (Crocker Tp., Sec. 36, Sw. qr., Sw. 1/4) and, although but two years old, the mine already ranks as the largest producer in the county. Houses for the new camp have been moved over from old Saylor. The hoisting is done by a first-motion Eagle Iron Works engine, cylinders 18x36, drum six feet. Five boilers, one two-flue and four tubular, of about 100 horsepower each, supply the power. The tower and other top works are modern and well equipped. The tipple is so arranged that loading may be done on all or any of three tracks which join to form a short spur to the Chicago and North Western railway. Automatic cages and hopper scales facilitate loading. A large part of the interior of the mine is lighted by electricity, while the same power is also employed for the main haulage, which is done by two Goodman haulage motors. Three cutting machines, driven by two air compressors, are in use in the mine. The coal seam is quite uniformly four feet thick and is practically free of "bowlders." It sometimes is slightly rolling, yet it runs for long distances with little change of altitude. In spite of small clay seams in the roof and coal, as well as the usual amount of "sulphur," the bed may be ranked as a clean one. The following is the record of a drilling made near the shaft.

DRILLING AT CARNEY.

		FEET.	INCHES.
17.	Clay	10	
16.	Drift	84	
15.	Shale, light-colored	64	7
14.	Shale, black	10	7
13.	Coal		8
12.	Shale, light-colored	7	7
11.	Sandstone	8	6
10.	Shale, light-colored	9	
9.	Sandstone	4	
8.	Shale, dark	7	1
7.	Coal		6
6.	Shale, dark	4	7
5.	Coal		5
4.	Shale, light-colored	3	6
3.	Shale, drab	17	4
2.	Coal	4	2
1.	Shale, light-colored	1	1
	Total	237	7

One-half mile south of Saylor No. 2, beside the tracks of the Chicago and North Western railway, over which it ships (Saylor Tp., Sec. 1, Nw. qr., Sw. ¼), is the present mine of the Bloomfield Coal Company. The output is quite large and is shipped north chiefly, only a comparatively small amount going to Des Moines. The equipment is of the type commonly seen in Polk county mines of the better class. Three boilers of seventy-five horse power each furnish steam to the hoisting engine, which has two 18x32 cylinders and is directly connected to the six-foot drum. Hopper scales and Olson self-dumping cages are employed. There are two workable coals at this mine. The shaft extends to the upper seam, which lies 271 feet below the surface of the ground. This bed was mined successfully until the roof became troublesome. The coal was found to be four to four and a half feet thick. A slope was run from the upper to the lower seam, fifteen feet below, and an engine was placed under ground to haul loaded cars up the incline by means of a pull-rope. The roof of the lower bed is good, while the thickness of the coal is satisfactory (three feet eight inches to five feet). The work at present is to the west and south. The company controls about 600 acres. What the miners describe as a "fault" coming in from the north and going off toward the southeast checked operations on the east side of the workings. The so-called "fault" appears, however, to mark simply the limit of the coal basin, for the coal thins gradually toward it until the overlying shale and the underlying fire clay meet. Toward the west the upper seam appears to split into two thin veins, if the record of a prospect hole one-fourth mile west of the shaft be taken as accurate. The strata at this point may be easily correlated with those at Saylor No. 2, the lower coal at the Bloomfield being the same as the bed worked at Carney.

HOLE WEST OF BLOOMFIELD SHAFT.

Surface Altitude About 935 Feet A. T.

		DEPTH.
28.	Soil and drift	
27.	Soapstone shale at	135
26.	Red shale at	139
25.	Soapstone shale at	144
24.	Hard rock (undet.) at	151
23.	Sandstone at	153
22.	Soapstone shale at	160
21.	Red shale at	165
20.	Soapstone shale at	166
19.	Black shale ("slate") at	170
18.	Black jack at	176
17.	Coal at	176-6
16.	Black shale ("slate") at	177-6
15.	Coal at	178
14.	Fire clay at	178-4
13.	Sandstone at	179
12.	Soapstone shale at	183
11.	Sandstone at	191
10.	Bituminous shale ("slate")	194
9.	Coal at	219-6
8.	Fire clay at	222-7
7.	Black shale ("slate") at	226
6.	Coal at	230
5.	Black shale ("slate") at	230-3
4.	Coal at	237

3.	Black shale ("slate") at	237-4
2.	Coal at	258
1.	Fire clay at	261-2

Saylor. At the old mining camp of Saylor, at the end of a spur track which runs one mile due west from Saylor Station, is the mine of the Western Coal Company, formerly known as Saylor No. 1. During its ten years of service this mine has produced a large amount of coal and has enjoyed at times a larger output than any of its contemporaries. At the present time, pillars are being pulled and preparations made to abandon the mine in the course of one or two years. Since little water enters the workings and mining has always been conducted in a scientific manner by the old company, the coal found in the pillars is still in good condition in many places. Two tubular boilers and a first motion Ottumwa engine are used for hoisting purposes. Two cars are loaded simultaneously and the screens are usually arranged to sort the coal into three grades. The elevation of the bed, 216 feet below the surface at the shaft, is about 680 feet A. T. The coal averages four feet in thickness and is fairly clean. The roof of bituminous shale ("slate") stands well.

Marquisville. For a long time Marquisville was the center of an important mining industry. The Des Moines Coal Company operated a shaft in section 13 (Nw. qr.) until a fire caused the mine to be abandoned in October, 1907. The coal is said to have been removed from nearly 600 acres and an upper seam to have been worked out under the Poor Farm, farther north. An old record of the Des Moines shaft shows that this coal occupied a higher horizon than does that of the mines previously described. The altitude of number 3 of the following section is about 720 feet A. T., the surface at the shaft being about 900 feet A. T. Numbers 3, 9 and 11 occupy the same horizons as numbers 9, 15 and 17, respectively, of the Bloomfield section.

DES MOINES SHAFT, MARQUISVILLE.

		FEET.
24.	Drift	49
23.	Sandstone, soft	6
22.	Shale, black	12
21.	Fire clay	12

20.	Rock	1
19.	Fire clay	3
18.	Shale, black	5
17.	Fire clay	4
16.	Sandstone	3
15.	Fire clay and sandstone	22
14.	Rock, hard	1
13.	Fire clay	6
12.	Shale, gray	4
11.	Coal	2½
10.	Fire clay	2
9.	Shale ("slate"), black	2
8.	Rock, hard	1
7.	Shale, black, with some coal	4
6.	Fire clay	2
5.	Rock, hard	3
4.	Shale, gray	31
3.	Coal	4½
2.	Fire clay	1½
1.	Sandstone	3
	Total	184½

Coal has been known for some time to exist east of this territory, and during the summer of 1908 a shaft was sunk by the Swanwood Coal Company near the tracks of the St. Paul and Des Moines Railway (Saylor Tp., Sec. 12, Se. qr., Se. ¼). About 200 feet of entries have been driven and the intention is to push the development of the mine rapidly until a large production is assured. The elevation of the seam worked is a little below 700 feet A. T., and a record of the strata shows several thin coals.

SWANWOOD SHAFT SECTION.

		FEET.	INCHES.
20.	Soil and drift	94	2
19.	Shale	4	
18.	Rock	4	6
17.	Shale, mixed	4	
16.	Shale, sandy	4	6
15.	Shale, mixed	33	5
14.	Shale, gray	6	2
13.	Coal, dirty	1	6
12.	Shale, light-colored	1	
11.	Sandstone	3	
10.	Shale, light-colored	9	6
9.	Shale, dark	12	

8.	Coal, dirty	1	5
7.	Shale, light-colored	1	
6.	Sandstone	28	3
5.	Shale, gray	5	
4.	Coal, soft		8
3.	Shale, light-colored	3	8
2.	"Slate"	15	
1.	Coal	4	2
	Total	236	11

The company has determined by prospecting that at least 300 acres are underlain with workable coal. The greatest thickness found was four feet ten inches; while the seam thins toward the edges of the property. The record cited below of a drilling made 1,500 feet east of the Swanwood shaft shows how rapid are the lithological variations in the Des Moines stage when strata are traced either laterally or vertically. Number 18 of the following record may be correlated with number 13 of the Swanwood shaft section, 10 with 8, 7 with 4, and 3 with 1.

DRILLING EAST OF SWANWOOD SHAFT.

		FEET.	INCHES.
28.	Drift	130	
27.	Shale, light-colored	6	
26.	Rock, light-colored	1	
25.	Shale, gray	5	
24.	Shale, black	4	
23.	Shale, gray	5	
22.	Shale, pink	10	
21.	Rock, gray	1	
20.	Shale, mixed	23	
19.	Shale ("slate"), black	8	
18.	Coal	1	
17.	Shale, sandy, light-colored	2	
16.	Rock, light-colored	1	
15.	Shale, light-colored	8	
14.	Coal	1	6
13.	"False bottom"		6
12.	Shale, light-colored	2	
11.	Shale, black	2	
10.	Coal		6
9.	Shale, sandy, light-colored	22	6
8.	Shale, black	6	
7.	Coal	1	
6.	Shale, black	5	
5.	Shale, light-colored	4	

4.	Shale, black	15	
3.	Coal	3	11
2.	"False bottom"		6
1.	Shale, light-colored	1	
	Total	270	5

South of the Swanwood (E ½ of Sec. 24, Saylor Tp.; the Sw. ¼ of Sec. 19, and the N. ½ of Sec. 30, Lee Tp.) a group of mines worked out a higher seam where the coal was three to four feet thick. This horizon may perhaps be represented in the Swanwood sections by one of the thin coals found above the seam that is workable at that point.

FOURMILE CREEK VALLEY.

Berwick District. The Delaware Coal Company sank a 170 foot shaft northwest of Berwick a few years ago (Delaware Tp., Sec. 5, Sw. qr., Sw. ¼). Ordinarily the seam is three and one-half to four feet thick, sometimes running locally to higher figures, and all the coal is of good quality, with few "bowlders" or clay seams. The roof is "slate" and an ironstone "cap rock." Most of the section of land in which the mine is located has been proved to be underlain with workable coal. The seam is practically level so far as now known, though as only ten or fifteen acres have been mined out this statement is not of wide application. The seam, lying at an elevation of 708 feet A. T., can best be correlated with the horizon of number 4 of the Swanwood shaft record and with one of the coals mined at Marquisville. Eighteen feet higher is another four-foot seam, containing good coal, but possessing a poor roof which renders mining in it difficult. A spur runs to the mine from the St. Paul and Des Moines tracks on the north. Most of the product is shipped either north or east, some going even as far as Milwaukee.

One mile north and east of the Delaware, just east of the intersection of the Douglas-Delaware township line and Fourmile creek, a prospect record shows the succession of strata given below. The elevation of the surface is uncertain, yet the coal may reasonably be supposed to lie in the horizon of that at the Delaware mine.

		DEPTH IN FEET.
7.	Soapstone shale	112
6.	Black shale	150
5.	White soapstone	152
4.	Hard rock	165
3.	Black "slate"	169½
2.	Coal	183½
1.	Fire clay	186

Norwoodville. Norwoodville, a coal camp, is situated two miles due south of the Delaware mine. Mining has been carried on in a desultory fashion at this point for a number of years, but it was not until recently that the present large production was attained. The company now in charge of operations has met all difficulties in a determined and scientific manner.

The Norwood-White shaft No. 1, commonly known as Klondike No. 1, lies on the north side of the Chicago Great Western tracks, near the camp (Delaware Tp., Sec. 18, Se. qr., Ne. ¼). The shaft, which is 215 feet deep, reaches, at an altitude of 715 feet A. T., a coal seam which averages four feet in thickness, varying between three and five feet in the various parts of the mine. The mine is fully developed and entries have been carried a considerable distance. Trains of cars going north are hauled 2,700 feet by tail-rope; those going west are drawn 3,300 feet by the same method. What appears at first sight to be too small an engine for the depth of the shaft and the amount of mine run produced is reported capable of hoisting five cars in two minutes during the regular course of a day's work. The coal bed follows a succession of "swamps" and "rises." Small clay seams and veins of calcite may be seen running through the coal, while others appear only in the roof. A mile north of the shaft the coal bed is beginning to pinch out as the workings are carried forward. This is true toward the east also, where the presence of an erosion channel is thought to be the cause of the decrease in the size of the seam. There is not much "draw-slate" in the roof, yet the latter is rather uncertain. "Slate" lies immediately above the coal in part; while those portions of the mine in which the "slate" is replaced by sandstone have usually been abandoned because of an influx of water.

A short distance east of No. 1, in section 17, is shaft No. 2 of the same company. Loading is done on a short spur running south from the Chicago Great Western railway. Steam is supplied to a first-motion double hoisting engine by a 150 horse power marine boiler and a 100 horse power horizontal boiler. Hopper scales and self-dumping cages add to the efficiency of the equipment. Not over forty acres have been mined out. The nature of the coal bed is much the same as in Mine No. 1, except that the thickness of the seam is more variable (two to five feet) and the bed is more level. Lying in the top of the coal are occasional "bowlders," sometimes as much as twelve feet in their largest dimensions. Water gives so much trouble that entries have to be abandoned now and then.

DRILL LOG TAKEN NEAR NORWOOD-WHITE NO. 2.

		FEET.	INCHES.
14.	Soil and clay	112	
13.	Shale, gray, sandy	4	
12.	Sandstone, gray	9	
11.	Shale, light-colored	14	
10.	Coal		4
9.	Shale, gray, sandy	5	8
8.	Shale, dark	1	
7.	Shale, sandy, with rock	7	
6.	Shale, gray, sandy	6	
5.	Shale, light-colored	2	
4.	Shale, dark, sandy	3	8
3.	Coal (at about 715 A. T.)	3	8
2.	"Brown bottom"		4
1.	Rock, light-colored		4
	Total	169	

Lower Fourmile Valley. On the eastern slope of Fourmile valley, at the end of a long spur extending to the north from the Chicago, Rock Island and Pacific railway, is the Maple Block shaft (Tp. 79 N., R. XXIII W., Sec. 28, Se. qr., Nw. ¼). The depth of the shaft is 168 feet and the elevation of the bed worked 702 feet A. T. This mine, with its well equipped top works and conveniently arranged underground workings, ranks as one of the largest producers of the county. Hoisting is effected with a first-motion engine with two cylinders, each 18x36. Loading is done on three tracks. The coal bed is fairly level, undulating gently. In some of the "swamps" seven-foot coal is found; but this maximum thickness is quite local and on the "rises" the bed thins sometimes to as little as three feet six inches. The average thickness of the seam where it has been mined may be taken at a little under five feet. "Bowlders" and other impurities are not conspicuous, although a few clay-ironstone masses are found in the main dips. The bottom is a hard fire clay which shows little tendency to heave. Only a little "draw-slate" is found above the coal, the roof being in general a fairly firm bituminous shale. The seam worked here is known to underlie at least 1,200 acres. The Maple Block Coal Company controls 900 acres, all well prospected. The long axis of the coal basin lies southwest-northeast, with one end about one-half mile south of the shaft and the other two miles or more northeast of it. An attempt has been made to mine another vein which lies not far above the one already described. In places it is found to be of workable thickness, but it is not constant in its appearance. In the following record of a hole drilled one-fourth mile west of the Maple Block shaft, this upper seam is shown to have split into thin beds divided by shale.

HOLE WEST OF MAPLE BLOCK SHAFT.

		FEET.	INCHES.
21.	Yellow sand	23	
20.	Drift	24	
19.	Shale	32	4
18.	Coal		7
17.	Shale, light-colored	21	1
16.	Sandstone	3	
15.	Shale, light-colored	8	
14.	Sandstone	9	7
13.	Shale, light-colored	4	
12.	Sandstone	10	4
11.	Shale, dark	3	10
10.	Coal	1	8
9.	Shale, dark	5	8
8.	Coal		8
7.	Shale, light-colored	3	6
6.	Shale, dark	8	
5.	Rock	1	6
4.	Shale, dark	2	9
3.	Rock		11
2.	Coal	4	
1.	Fire clay		10
	Total	169	3

The mine of the Economy Coal Company loads on the same spur, a little more than a mile farther south (Tp. 79, R. XXIII W., Sec. 33, Se. qr., Ne. ¼). At the pit bottom, 110 feet below the surface, the coal lies at practically the same elevation above sea level as at the Maple Block shaft and it undoubtedly lies in the same coal horizon. Between the territories of the mines, however, a "fault," encountered 1,500 feet south of the Maple Block shaft, intervenes. This seems to extend from northeast to southwest; but whether it is an old erosion channel which has cut out the coal, or simply the barren measures between adjacent coal basins is not determinable from the present condition of the mine workings. At the Economy the seam varies in thickness from three and a half to five and a half feet, with five-foot coal where the miners are at present employed. When the mine was new, difficulty was experienced from the wet shaft and numerous "bowlders" in the coal, but these conditions have steadily improved. A thick bituminous shale forms the roof. Eight to ten inches of "draw-slate" which, however, does not fall if properly and promptly supported, usually tops the coal.

The company has leased 1,000 acres, much of it known to be underlain by this seam. Here, as at the Maple Block, an upper coal is found twenty feet above the one worked. A half mile southwest of the shaft it is four feet thick; a fourth mile east it shows only twenty inches.

Altoona. The Gibson Coal Company operate their No. 4 mine one mile southwest of Altoona, near the upper portion of one of the chief tributaries of Fourmile creek (Clay Tp., Sec. 23, Ne. qr., Sw. ¼). At a depth of 186 feet lies a four-foot bed of good coal that probably forms part of the basin already mentioned in connection with the Maple Block seam. Except where rolls in the roof cut out part of the coal, sometimes rendering it unworkable, the thickness of the bed is uniform. The roof is, in general, either a black "slate" or a compact siliceous "bowlder" formation. No regular "draw slate" has been encountered, but the operators are forced to leave the coal in a narrow strip in the midst of the main workings where the roof is a soft, sandy shale. Southeast of the shaft pre-glacial erosion has cut out the strata above the coal along a line parallel to the long axis of the coal basin (northeast-southwest), rendering further operations in that direction impossible because of the filling of drift, sand and clay immediately over the seam. About 100 acres have been worked out, chiefly to the west and south, and the limit of coal available from the present shaft has been almost reached.* Another shaft may be sunk on the opposite side of the pre-glacial channel cited.

What is probably a continuation of the same seam was worked from a shaft 215 feet deep near the Altoona station, until an influx of water forced a cessation of operations. The seam thinned east and west of the shaft and thickened to the south, the direction of the main dip. Fig. 36 gives the characteristics of the strata at this point.

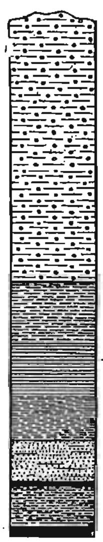


Figure 36. Shaft of mine near Altoona.

THE HIGHLANDS EAST OF FOURMILE CREEK.

Enterprise. Shaft No. 1 of the Enterprise Coal Company is located a half mile north of Enterprise, near the tracks of the St. Paul and Des Moines Railway and reaches the coal at a depth of 212 feet. The mine has been in operation about five years and may be ranked as one of the best equipped in the central

*This shaft was abandoned May 1, 1909.

part of the state. The buildings constituting the top works are protected from fire by galvanized iron sheathing. Hoisting is done by a double, first-motion, Eagle Iron Works engine with 13x38 cylinders and a six-foot drum. There is one boiler of 125 horse power and two of 100 horse power. The tower is sixty feet high from the surface to the sheave wheels. Olson automatic cages are employed. Loading is done on two tracks and is facilitated by the use of a Christy box-car loader. A small amount of coal may be stored in an elevator into which it is carried by an endless chain conveyor. The main haulage underground is by Goodman electric motor, trolley system, on 3,500 feet of track, each train consisting of from fifteen to twenty cars. One Goodman cutting machine is being tried as an experiment.

Shaft No. 2 of the same company was sunk during the summer of 1907 in the southeast quarter of section 21, Douglas township. A short spur track leads from it to the main line near Enterprise. The depth of the shaft and the character of the equipment are essentially the same as at mine No. 1, although No. 2 is as yet too young to employ electric haulage to advantage. Entries are being driven from the shaft in all of the cardinal directions. The east entry, at present the longest, has been driven 300 feet.

The Enterprise seam exhibits many of the characteristics of the so-called "second vein" of the Des Moines district. Especially in mine No. 1 are "clay slips" numerous. In most cases the fissures are filled with a soft white clay; yet a few contain an argillaceous sandstone which is significant because totally unlike the material underlying the coal. The thickness of the seams averages two inches and their lateral extension is often considerable. Individual streaks have been followed for long distances during the progress of mining operations. They intersect the shale of the roof at a high angle and extend downward into the coal bed; but they almost always thin out and disappear at some point above the floor of the coal. Thus it is evident that they have no genetic relationship with the fire clay underlying the coal. They may be simple or branching, and either curved, zigzag, or strictly vertical. The Enterprise coal shoots well off the solid, except where these "slips" are so numerous that their yielding qualities have a deadening effect on the force of the explosives.

In both of the Enterprise mines a band of black jack, usually slightly exceeding one inch in thickness, is found near the middle of the seam. This black jack is a feebly combustible mixture of "slate" and coal, often with abundant inclusions of iron pyrites. The stratum above the coal bed is in most places a shale which requires close timbering. Occasionally a layer of more tenaceous shale, known as "slate," makes its appearance next the coal and forms a firm roof over small areas.

The Enterprise Coal Company has proved by prospecting the presence of good coal under more than 1,100 acres; while it is probable that about 300 acres more should be included in the same field. From north to south the workable basin is at least two and one-half miles long, with a width from east to west of one-half to three-fourths of a mile. The thick coal lies at an elevation of about 765 feet A. T. and is four feet thick at Enterprise No. 1. At No. 2 the thickness varies from two to six feet, but nothing under four feet is utilized for room work. One mile northwest of No. 1 the company sank a shaft to three feet eight inches of coal, but soon abandoned the mine because of trouble with a roof of white clay and shale. Thirty feet above this seam is a thinner coal which is fairly persistent. The relationships of the strata in this district are shown by the sections given below.

DRILLING ONE MILE DUE WEST OF ENTERPRISE NO. 1.

		DEPTH IN FEET.
19.	Soil and drift	
18.	Shale, red, at	60
17.	Soapstone shale at	80
16.	Shale, black, at	85
15.	Soapstone shale at	86
14.	Shale, black, at	104
13.	Coal at	110½
12.	Fire clay at	111½
11.	Soapstone shale at	118
10.	Sandrock at	127
9.	Soapstone shale at	128
8.	Sandrock, soft, at	129
7.	Soapstone shale at	132

6.	Sandrock at	142
5.	"Slate, black, at	153
4.	Coal at	156
3.	"Slate" at	157
2.	Coal at	160
1.	Fire clay at	161

This test did not extend to the Enterprise coal horizon, but no workable coal has been reported from deeper holes in the vicinity.

PROSPECT NEAR ENTERPRISE NO. 2 SHAFT.

(Douglas Tp., Sec. 21, Center of Se. ¼.).

		FEET.	INCHES.
23.	Soil and drift	100	
22.	Shale, mixed	15	
21.	Limestone		6
20.	Shale, mixed	4	6
19.	Limestone	1	
18.	Shale, gray	11	
17.	Shale, blue	15	
16.	Limestone		3
15.	Shale, light-colored	3	9
14.	Limestone		9
13.	Shale, blue	10	3
12.	Shale, mixed	6	
11.	Shale, dark	6	
10.	Coal (at 174 feet)		8
9.	Shale, light-colored	3	4
8.	Limestone	-2	
7.	Shale, light-colored	5	
6.	Shale, dark	1	
5.	Shale, light-colored	6	
4.	Shale, dark	8	6
3.	Coal (at 200½ feet)	4	6
2.	Shale, brown, sandy	2	
1.	Shale, blue	1	
	Total	208	

The limestones cited in the above section are stratigraphically important if correctly identified. Samples for inspection could not be obtained by the author. The record given below is of a hole made by another driller in the same section of land, but on the west side of the St. Paul and Des Moines tracks. No limestones are reported.

		DEPTH IN FEET.
	Clay, sand and gravel	
17.	Soapstone shale at	101
16.	Soapstone shale, red, at	108
15.	Soapstone shale, white, at	112
14.	Rock, hard, at	116
13.	Soapstone shale at	117
12.	Shale, blue, at	151
11.	Soapstone shale at	157
10.	"Slate," black, at	166
9.	Coal at	172½
8.	Fire clay at	173½
7.	Sandstone at	175
6.	Soapstone shale at	179
5.	Shale, black, at	192
4.	Soapstone shale at	196
3.	Rock at	201
2.	Coal at	202
1.	Shale at	206½

Two miles south of Enterprise the Enterprise coal is still in evidence, as shown below. Thicker coal is present in the same horizon in neighboring drillings.

		DEPTH IN FEET.
8.	Clay at	50
7.	Gravel and sand at	60
6.	Blue clay and bowlder at	80
5.	Gravel and sand at	108
4.	Soapstone shale at	138
3.	Slate, black, at	154
2.	Coal at	179
1.	Fire clay at	180¾

Bondurant. It is claimed that good coal has been found in workable thickness near Bondurant. Nothing definite could be ascertained in regard to this report.

CAMP CREEK VALLEY.

Lower Camp Creek Valley. A systematic attempt to locate a profitable field was made in sections 11, 12, 13 and 14 of Camp township. In most of the test holes only two feet or less of good coal was found. The record of one of the deeper holes (Camp Tp., Sec. 14, Nw. qr., Sw. ¼) is as follows:

		Feet.	Inches.
26.	Clay and sand	33	
25.	Shale, mixed	24	
24.	Shale, dark	6	1
23.	Coal	1	2
22.	Shale, light-colored	3	
21.	Sandstone	6	
20.	Shale, light-colored	16	9
19.	Shale, dark	10	
18.	Sandstone	2	10
17.	Shale, light-colored	8	
16.	Shale, dark	8	2
15.	Shale, gray	6	5
14.	Coal	1	5
13.	Sandstone, light-colored	12	
12.	Shale, dark	7	6
11.	Shale, light-colored	10	4
10.	Sandstone	2	
9.	Shale, dark	16	8
8.	Shale, light-colored	5	
7.	Shale, dark	29	1
6.	Rock	2	10
5.	Shale, dark	15	10
4.	Rock	2	
3.	Shale, dark	10	
2.	Rock	1	4
1.	Shale, dark	9	11
	Total	251	4

One of the holes (Camp Tp., Sec. 14, Ne. qr., Se. ¼), which penetrated somewhat thicker coal than is common in this district, is as follows:

		Feet.	Inches.
6.	Clay	28	
5.	Shale, gray	32	2
4.	Coal		1
3.	Pyrite		2
2.	Coal	3	1
1.	Shale, light-colored	9	9
	Total	73	3

SKUNK RIVER VALLEY.

Santiago. Some prospecting has been done in Franklin and Washington townships. Several holes drilled near Santiago failed to bring to light coal in paying quantities. One of these prospects, although carried 100 feet, did not reach the solid strata below the drift. Another which was continued to twice this depth did, however, penetrate the surface formations. Extensive mining has been carried on near the Skunk in Jasper county, a few miles beyond the county line.

Resume

The coal bearing strata of Polk county belong exclusively to the Des Moines stage of the Pennsylvanian or Upper Carboniferous series. No other rocks outcrop below the heavy mantle of drift within the limits of the county; for the Saint Louis limestone, the stage immediately underlying the Pennsylvanian, lies 200 feet and more below the bottom lands of the Des Moines and Raccoon rivers. The contact of the Saint Louis and the Des Moines is by no means, however, a plane surface, a fact elaborated in another portion of this volume. At Mitchellville the limestone lies 224 feet below the surface, or at an altitude of about 764 feet A. T.*; at Greenwood Park it is 498 feet down at an altitude of 374; while at Carbondale it lies 200 feet below the bottom lands at an altitude of 600. One interpretation of the Avon mine boring would place the Saint Louis at the same level near Levey as on the north side of the river at Carbondale. Some interesting results have been obtained in the southwestern part of the county, indicating the presence of a deep and remarkably steep sided post-Mississippian valley at Commerce. A mile and a half south of Commerce, south of Millman, and at Valley Junction, the altitude of the top of the Mississippian is 565 feet or more above sea level. A boring made by Dr. Hulme at Commerce passed through a series of shales, sandstones, and thin coals, characteristic of the Des Moines strata, to a depth of 500 feet or an altitude of 320 feet A. T. Two miles west of Commerce the surface of the Saint Louis is found to have regained a level of about 250 feet higher.

From the above it will be seen that the Saint Louis furnishes no datum plane upon which the geologist may base his conclusions. Even though it were conformable beneath the coal bearing strata, it would still be of little assistance, since coal

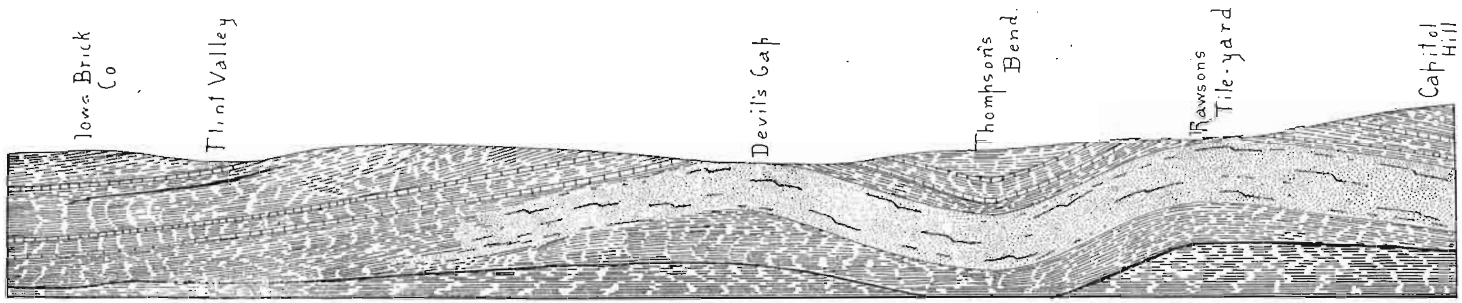
*This altitude is based upon data received from the Chicago, Rock Island & Pacific Railway, which places Mitchellville station 988 feet above sea level, Cairo datum.

companies seldom carry their test holes below horizons which lie at least 100 feet above the base of the Des Moines beds. Nor is much aid given to stratigraphical research by the lithological characters of the Des Moines strata themselves; as already explained in a previous chapter, few strata have any considerable lateral extent or vertical thickness. A study of the records of shaft borings and prospect holes cited in this report reveals the difficulties attending an attempt to correlate the coals found in even adjacent situations and these difficulties are by no means alleviated by the carelessness exhibited by drillers in identifying strata.

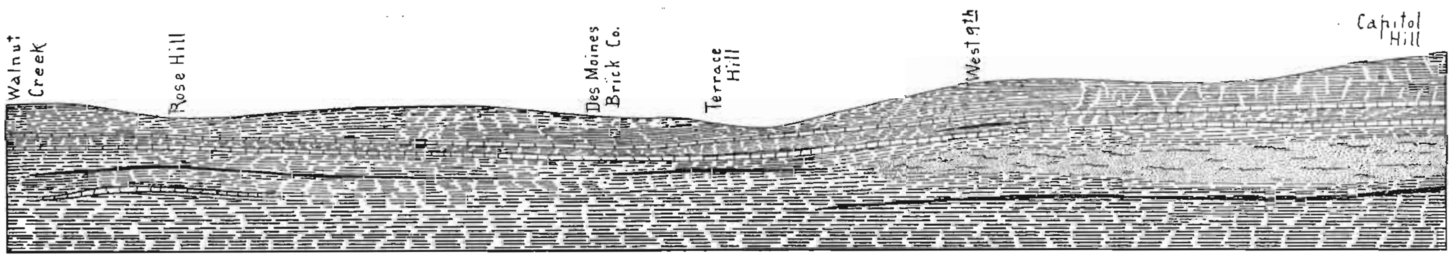
Argillaceous shales of many hues are predominant among the Des Moines strata of Polk county and with them may be included the black bituminous "shales" so eagerly sought by prospectors as possible indications of coal. The white structureless clays, commonly, though often improperly, termed "fire clays," are found in thin beds under most of the important coals. Sandy shales are not uncommon, but true sandstones are rare and lie in thin beds of limited lateral extent, except in the southern part of the county where the Ford sandstone appears. Limestones are exceedingly rare and are always thin, but when present are a great help to the stratigrapher. Three thin bands found in the vicinity of Des Moines enabled Bain to construct the two cross-sections shown in Plate III. Those interested in the data upon which these sections are based are referred to his "Geology of Polk County."*

An interesting and significant fact in connection with the coal seams at present being developed within the county is that, with the exception of the beds at Commerce, Fort Des Moines, Levey and Enterprise, all lie at an altitude between 675 and 720 feet above sea level. Two possible explanations present themselves: (1) many of the coal basins lie in the same coal horizon and the general dip to the southwest prevalent throughout much of the Iowa field flattens out in the central portion of the county, or (2) the basins lie in several horizons separated by no great vertical interval. Of these explanations the first appeals most strongly to the writer, the term "horizon" being applied in its

*Iowa Geol. Surv., Vol. VII., pp. 302-310; Des Moines, 1897.



A. Geological section from Capitol Hill to the mouth of Beaver creek.



B. Geological section from Capitol Hill to Walnut creek.

broadest sense. The "rolling" common in some basins accounts satisfactorily for differences of elevation of twenty feet or less between related coals.

There seems little doubt that the basins utilized by the Anderson, Saylor No. 2, Bloomfield and Western mines occupy the same horizon and are separated from one another by rather limited barren areas of irregular shape. There is a considerable gap between the fields of the Western and the Oak Park, yet there is a strong suggestion that the "third vein" in which the North Des Moines mines are working may be correlated with the coal under the highlands farther north. Stratigraphic studies of exposures along the Des Moines river seem to establish the equivalence of the "third veins" of the North and East Des Moines districts. The "first vein" on the East side is probably the "second" of South Des Moines. The "third veins" of East and South Des Moines may possibly be equivalent; but the nature of the coal and the material immediately overlying it does not bear out this supposition. The seams now worked at the Johns, Bennett, Midway, and Iowa mines, south of the Raccoon river, apparently lie slightly above the "third vein" horizon of East Des Moines, though those at the Hollingsworth, Walnut Creek and Coaldale may be tentatively correlated with the lower coal of the east side. Possibly the Valley Union, Keystone and Gibson No. 5 shafts of the Valley Junction district, reach coal which may be assigned to the horizon of the Iowa-Johns basins. The Commerce mine is developing a basin which is stratigraphically higher than any other now worked in the county. The thick coals of the Marquisville, Berwick, and Norwoodville fields belong to slightly higher levels than those worked between Marquisville and Ankeny. The Enterprise seam cannot well be connected with any other, though the characteristics of the bed are reported by experienced mining men to be surprisingly like those of the "second vein" of East Des Moines. The relationships of the beds in the southeastern corner of the county have already been sketched. With the coal once worked near Youngstown by the Christy and Gibson No. 2 mines may perhaps be correlated the "third vein" of East Des Moines and the coal of the Economy, Maple Block, Gibson No. 4, and old Altoona mines.

The visible supply of coal in this county appears to be more than adequate for many years to come, and there are undoubtedly undiscovered basins more than equal in aggregate magnitude to those already known. Less than eight per cent of the county has been prospected; while even in the prospected lands a lower series of Coal Measures from 100 to 200 feet thick has been left uninvestigated. The results of the few holes carried all the way to the Saint Louis limestone have not been encouraging, yet it should be remembered that a certain number of fruitless prospects are often drilled in the midst of valuable coal territory and that the strata lying immediately above the Saint Louis are known to be exceedingly prolific in other parts of the state.

JASPER COUNTY

With the exception of the extreme northeastern corner of the county, constituting about half of Hickory Grove township, Jasper is underlain by strata classified with the Des Moines stage. The formations underlying the Des Moines, and the latter itself at many points, have a moderate general dip to the southwest. The geological structure along a line running from southwest to northeast across the county is illustrated diagrammatically in the accompanying sketch. The drawing is on a vertical scale of 350 feet to one inch.

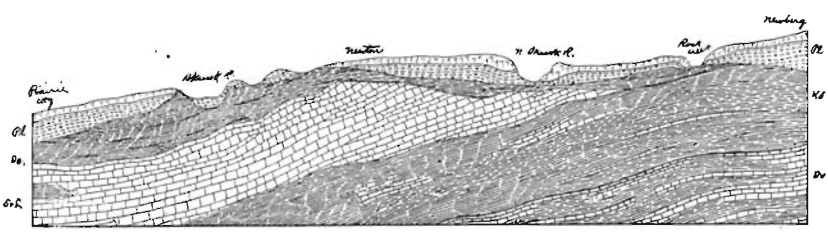


Figure 37. Geological section from Prairie City to Newberg (Williams).
Pl. Pleistocene. St. L. Saint Louis. Ds. Des Moines.
Kd. Kinderhook. Dv. Devonian.

Owing to their irregular basement and to the varying degrees of erosion which they underwent before the invasion of the ice sheet, the Coal Measures vary in thickness within wide limits. The underlying limestones and calcareous shales of Mississippian age have been doubtfully identified in drillings at a number of localities, but the accuracy of none of these determinations can be vouched for by the author. It seems certain, however, that there is a notable thinning of the Des Moines in the eastern and northeastern sections of the county, while the figures given below for the central and west central portions have about them the elements of probability. At Mitchellville, just over the Polk county line, the base of the Coal Measures was reached at a depth of 224 feet, making its altitude about 764 feet above tide.* In drillings in the Oswalt coal-field, a limestone, possibly the St. Louis, was reached at a depth about eighty feet below the level of Skunk river. The altitude of the Mississippian at this point is, if the above assumption be correct, about 730 feet A. T.; but unfortunately the data obtained for the district are not such as can be fully relied upon. Considerable difference of opinion exists as to the thickness of the Coal Measures at Colfax. Norton refers the aquifer, which is reached in the majority of the wells at about 300 feet, to the St. Louis.† Basing his deductions on a somewhat generalized record furnished from memory by one who had to do with the sinking of several of the wells, Williams gives the thickness of the drift as eighty feet and of the Des Moines as 217 feet, placing the base of the latter at about 544 feet A. T.‡ This furnishes rather a surprisingly low altitude for the top of the St. Louis, although it is not at all an impossible one. Dr. T. D. Hulme of Commerce, who has had a wide range of experience in drilling deep wells in various parts of the state, considers the Coal Measures to extend downward only 100 feet in a hole headed on lower ground at the old Hotel Sanitarium. He describes the following generalized section from memory:

	FEET.
Drift, shale, sandstones, limestones, thin coal beds	100
Heavy beds of cherty, fossiliferous limestone, containing large cavities; also one or two beds of sandstone and thin beds of calcareous soapstone	100
Soft sandstone bearing artesian waters	6
Heavy beds black shales with beds of limestone; no coal	300

It is, perhaps, dangerous to base any conclusion upon records given from memory of holes sunk so many years ago. Just east

* cf. p. 149 of the chapter on Polk county.
†*Report on Artesian Wells*, Iowa Geol. Surv., Vol. VI, p. 293; Des Moines, 1897.
‡*Geology of Jasper County*, Iowa Geol. Surv., Vol. XV, p. 307; Des Moines, 1905.

of the Chicago, Rock Island and Pacific railroad bridge over Cherry creek, a limestone has been reached which, if referred to the St. Louis, would place the base of the Coal Measures a very moderate depth below the creek bottom, at about 725 feet A. T. The log of a hole put down in the southeast corner of Newton, if the record has been correctly given, places the top of the St. Louis at about the same altitude there. The basement limestone was struck at depths between 117 and 161 feet in a series of drillings in sections 28, 31 and 32 of Independence township. Just above it, from one to five feet of coal was encountered.

As in so many other sections of the Iowa field, mining in Jasper county has been largely confined to the valleys of the main streams where coal has been seen to outcrop or where it may be easily traced in test holes of shallow depth. The future will reveal lucrative basins in other parts of the county, where only systematic prospecting can hope to locate them. The workable seams lie in basins of limited extent, distributed along a number of horizons, and there appear to be two groups of such horizons separated by a short stratigraphic interval. Present knowledge of the conditions is not, however, sufficiently definite to permit of correlating the coals of the different fields. The southwestern portion of the county contains much undeveloped coal; it is the logical field for thorough exploration. The northeastern portion is not so promising, both because the Coal Measures are thinner there and because the strata present were deposited contemporaneously with those which have not so far yielded abundant coal in neighboring counties on the west and north. There are strong possibilities, nevertheless, in even the northeastern townships.

Coal mining began at an early date in Jasper and increased steadily. In 1860 the production was 2,336 tons; in 1870, 20,720; in 1880, 74,462; in 1890, 192,152, and in 1892, 293,255. The annual output for the past ten years has been:

YEAR.	TONNAGE.	YEAR.	TONNAGE.
1898	151,816	1903	270,804
1899	214,677	1904	258,098
1900	100,256	1905	306,164
1901	183,500	1906	388,582
1902	235,390	1907	397,297

Jasper now ranks fifth among the coal counties of the state. According to the report of the State Mine Inspectors, the production for the year ending June 30, 1908, was 467,552 tons. Ten mines employed 836 men.

The occurrence of coal in various parts of the county and the mines in operation in September, 1907, are described below. Mr. Ira Williams ably described the status of the Jasper coal industry as recently as 1905.* In order to avoid duplication of work, his report has been freely drawn upon for material.

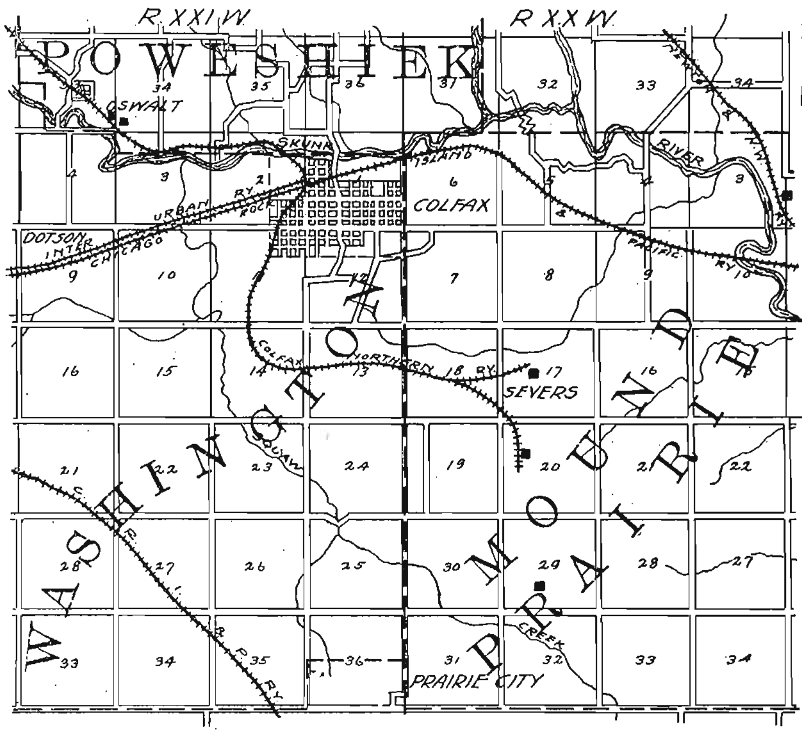


Figure 37a. Map showing the principal mines of Jasper county.

Oswalt. Along the northern side of Skunk river valley from Valeria to Colfax, extensive mining was undertaken many years ago. The Jasper County Coal and Mining Company removed the coal from much of a thick bed, ranging in thickness from three to six and a half feet, which lies twenty-five feet below the level of the river. This one company mined out as much as 500

*Geology of Jasper County, Iowa Geol. Surv., Vol. XV, pp. 335-348.

acres in sections 34 and 35 of Poweshiek township, while others sank shafts to the same seam in adjacent territory, notably the Valeria and the Diagonal companies, whose shafts were a short distance from Oswalt. Throughout the field, the roof of black "slate" occasionally becomes so attenuated that the drift comes dangerously near the coal, allowing quantities of water to enter the mines. The dip is, in general, to the west. A lower coal, somewhat thinner than the first seam, lies from thirty to forty feet below the one chiefly exploited. A generalized section for the region is:

OSWALT FIELD.

		FEET.
13.	Soil and drift	70
12.	Coal	1
11.	"Slate," black	0-35
10.	Coal	3-6½
9.	Fire clay	½-10
8.	Sandstone	15-20
7.	"Slate"	1-10
6.	Coal	2½-3½
5.	Fire clay	0-3
4.	Sandstone	15-30
3.	Shale, bituminous	8
2.	Fire clay	¼
1.	"Rock"	

Number 1 of this section was found in a few other drillings and may possibly be the St. Louis limestone. Its altitude is slightly lower than that of the limestone encountered at Mitchellville, in Polk county.

Two small mines are now working the "upper vein" in this district. Both supply an important country trade and haul some coal to a neighboring switch for shipment. The Warrick mine (Poweshiek Tp., Sec. 34, Sw. qr.) is entered by a slope 210 feet long with a grade of one foot in three. Cars are hauled to the surface by steam power. Four hours' pumping daily is required to remove the water entering the mine. The seam is undulatory and shows an average thickness of four feet. Thirty feet and more of shale intervene between this bed and a higher one, thirteen inches thick. The Adams mine, operating a gin shaft, is situated a short distance west. In sinking the shaft, thirty feet of surface material and thirty-five of "slate" were encountered. The coal is said to average five feet in these workings.

Southwest of Oswalt, number 10 of the Oswalt section given above apparently becomes attenuated, although it does not disappear; the lower coal, number 6, thickens slightly and remains of economic importance; while the thin bed, number 12, persists essentially unchanged. On the south side of Skunk valley, southwest of Oswalt, the Burris and Davis shaft reached a four-foot seam at a level about fifty-five feet above that of the water in the river. Two thin beds were penetrated at elevations of about fifty and eighty feet, respectively, above the thick coal. Near the old Cook shaft, east of Mitchellville (Washington Tp., Sec. 6, Se. qr., Se. 1/4), the three Oswalt horizons may be recognized, as shown in the following section.

OLD COOK MINE, EAST OF MITCHELLVILLE.

		FEET.
8.	Surface	27
7.	"Slate"	3
6.	Coal	1
5.	"Slate" and soapstone	45
4.	Coal	2-3
3.	"Slate," with a band of soapstone	16
2.	Coal	4
1.	Fire clay	

The lower coal "pinches out" to the north. In a well on the farm of A. W. MacDonald, southeast of the Cook shaft (Washington Tp., Sec. 8, Sw. qr.) two seams, possibly corresponding to numbers 2 and 4 of the Cook section, were associated with the following sequence of strata.

		FEET.	INCHES.
10.	Yellow bowlder clay	100	
9.	Rock, hard	1	
8.	"Slate" and coal	40	
7.	Coal	2	
6.	Fire clay	2	6
5.	"Slate"	18	
4.	Coal	2	6
3.	Fire clay	4	
2.	Sandstone, gray, magnetic	8	
1.	Rock, brown	62	6

Colfax. Colfax is now the main center of the Jasper county coal industry. The first mining in the county was done at the

Slaughter bank, one and a half miles east of Colfax (Sherman Tp., Sec. 32, Sw. qr.). A six-foot seam has been removed from about thirty acres of land by means of drifts slightly above low water in the Skunk river. The roof is a "slate" of fair stability and the seam dips to the south one foot in 216. Drilling on the south, between the Slaughter bank and the railroad, failed to find the coal in some cases; while in others little or no roof was present. No coal was found in an interval of sixty-five feet below this bed. About the same conditions were met in drillings just south and west of Colfax. The Slaughter coal appears to occupy the horizon of the principal bed of the Oswalt district.

The largest mines in the county are located southeast of Colfax near Severs, a mining camp. Two shafts, shipping over the coal spur of the Colfax Northern Railroad, are being operated by the Colfax Consolidated Coal Company. The company control about 1,000 acres of coal rights in Mound Prairie and eastern Washington townships. The whole has been thoroughly prospected and workable coal found to underlie considerable areas. Their mine No. 7 (Mound Prairie Tp., Sec. 17, Sw. qr., Ne. 1/4) is developing coal three feet six inches to six feet in thickness at a depth of fifty-five feet. The seam is undulatory. The roof is a bituminous shale, bearing in places thin streaks of limestone which weaken it to some extent. Hoisting is done by a geared, two-cylinder Ottumwa engine, supplied with steam by five boilers, one of 100 horsepower and four of forty horsepower each. The haulage engine, situated above ground, is a four-drum, double Ottumwa tail-rope engine, ninety horsepower at eighty pounds pressure. Coal is supplied to the engine room by an endless chain purveyor. Jackson "half dump," automatic cages are in use and chutes are arranged so that three freight cars may be loaded simultaneously. Workings are planned on the room and pillar, double entry method. Tail-rope haulage is extensively employed.

Mine No. 8 of the same company is one mile south of No. 7 (Sec. 20, Nw. qr.). The shaft is 164 feet deep. The tipple is excellently well arranged to handle a large output. From the automatic cages the coal descends over a somewhat complicated system of screens. Five cars may be loaded at once, three with various grades of large coal and two with pea and slack. The two-cylinder hoisting engine is direct-connected and is supplied by three boilers of 100 horsepower each and one of 150 horsepower, fed by two Penworthy injectors. A McEwen high-speed engine and a Goodman multipolar generator furnish the electric power used in the mine for illumination and for the recently installed Goodman haulage motor. The coal at No. 8 exhibits the same variations in thickness as does that at No. 7 and is connected with it at one point at least. As in many other portions of the Iowa field, however, the thick coal here lies in adjacent basins separated by areas where the bed becomes attenuated or fails completely. The seam at No. 8 is strongly undulatory and possesses a "slate" roof which requires much timbering. In parts of the workings, iron pyrite is found freely distributed in irregularly placed bands and nodules. Running north and south near the shaft is an ancient channel of erosion, which has cut out some of the coal. Rolls in the roof are occasionally found, but give little trouble.

Following is a section in a drill hole put down on high ground near shaft No. 8. The churn drill is used by this company in all of its prospecting. Essentially the same sequence was found also one-half mile east.

		FEET.	INCHES.
17.	Soil	4	
16.	Clay	26	
15.	Sea mud	13	
14.	Sand	4	
13.	Sandy shale	3	
12.	Blue clay	16	
11.	Soapstone	3	
10.	Sand rock	4	
9.	Soapstone	7	
8.	Slate	10	
7.	Coal blossom		6
6.	Slate	11	6
5.	Coal	1	
4.	Soapstone	7	
3.	Slate	58	
2.	Light slate	3	
1.	Coal	5	
	Total	176	

A mile and a half south of No. 8 is the Shorten bank (Mound Prairie Tp., Sec. 29, Sw. qr., Se. 1/4), reopened during the summer after an idleness caused by the burning of the shaft. A four-foot coal bed is reached at a depth of 100 feet. Impurities, especially "sulphur," are common in the seam. This is a local mine, hoisting with a twenty-horsepower double engine. Less than one acre has been worked out.

Metz. Local mines have operated intermittently in the vicinity of Metz. Northwest of Metz (Mound Prairie Tp., Secs. 1 and 2) two seams, both outcropping in the vicinity, have been worked. The lower seam is eighteen inches to four feet thick and lies at about the water level in Skunk river. The upper bed lies just below the drift, thirty-nine feet above the river, and varies in thickness between fourteen inches and three feet. The lower coal is the one usually developed. It has a good roof of sandstone, beneath which "bowlders" and masses of calcareous ironstone sometimes appear, replacing all or part of the coal. In the edge of the Skunk river flood plain, a twenty-two inch coal was found at a depth of twenty-five feet below water level. Some mining has also been undertaken in a small way southwest of Metz (Mound Prairie Tp., Sec. 15, Se. 1/4). On the land of Dexter Fowles, coal of good quality was taken from a shaft fifty-seven feet deep. The seam is four feet six inches thick and has a roof of firm "slate."

Newton. For many years coal has been mined south and southwest of Newton, chiefly for local use. Four coal banks are now in operation during part of the year in the district lying about three miles southwest of Newton, in Palo Alto township. The field, which includes all or parts of sections 5, 8, 9, 10, 3, 15 and 16 and small portions of adjoining sections, bears two seams separated by a short interval. The following section may be taken as typical for the district:

		FEET.
7.	Soil and drift	20
6.	Sandstone or "slate"	6-20
5.	Coal	½-4
4.	Fire clay	0-6
3.	"Slate"	3-20
2.	Coal	½-5
1.	Fire clay	

The strata exhibit even more pronounced variations in thickness than is indicated in the above section and their lithological characters are not at all constant. Where one coal is well developed the other is apt to be thin or lacking, while throughout the field there are barren areas in which neither seam is found. True faults of small throw, known locally as slips, are common, especially in the lower seam. Drillings on both sides of the railroad in the northern part of section 8, Palo Alto township, are said to have stopped in a stratum of limestone about fifty feet below the level of the track. It is possible, though by no means certain that this is the St. Louis limestone at the base of the Coal Measures.

Mr. Lister, who has operated several mines in this field, is now working a small slope on section 10 (Nw. qr., Ne. ¼). The opening penetrates the hill for about seventy yards through coal that is from eighteen inches to two feet thick. Old workings not far distant show four feet of coal in the same seam and the present slope is being excavated in the hope of finding a similar thickness at this point. In ascending order, the strata above the coal are: "slate," 3 feet; fire clay, 4 feet; coal, 8 inches; soft sandstone, 8 feet.

The McAllaster bank is a new mine (Sec. 9, Ne. qr., Sw. ¼) with a shaft thirty-four feet in depth. The "upper seam" is the one worked; the "lower" has been found also. On the west side of this forty-acre tract, drillings are said to reveal a thickness of four feet or more for the "upper" bed. Entries have been driven a short distance. A twenty-horsepower engine is used for hoisting.

Carson Brothers Coal Company have a forty-foot gin shaft not far from the McAllaster (Sec. 9, Sw. qr.). The seam is four and one-half to five feet thick with a slight general dip to the west. Over the coal is a fairly firm roof made by thirteen to eighteen feet of fissile shale or "slate." The bottom is a fire clay, occasionally replaced by white argillaceous shale.

French Brothers sank seventy feet to a five-foot coal southeast of the Carson (Sec. 16, Se. qr., Nw. ¼). Hoisting is done with a twenty-two horsepower engine. As the "slate" and soapstone roof proved dangerous, six inches of coal is now left up and gives ample warning before a fall occurs. Under the three feet of fire clay that underlies the bed worked another coal, which, however, is only three inches thick, occurs. Fifteen feet and less above the principal seam is a nine-inch coal.

Some of the earliest mining in the state was inaugurated on Cherry creek (Newton Tp., Sec. 32, W. ½), where there are two seams bearing a close relationship to the field just described. The lower coal is about at the creek level and is one foot in thickness. The upper lies close to the drift, twenty feet higher and is eighteen inches to two feet thick. The interval between the two is bridged by shale. Deeper drilling revealed no other seams. Four miles southeast of Newton, near the Iowa Central tracks (Buena Vista Tp., Sec. 7), several drifts have been operated on the land of A. C. Davis. The seam is eighteen inches to two feet in thickness. Water caused considerable trouble.

Vandalia. At the village of Vandalia, two seams have been utilized. The Cavitt shaft, sixty-five feet deep, reached the lower bed, which is four feet in thickness. The Pulver slope mined from a three-foot coal twenty-five feet higher. A drilling in the town brought to light a third horizon, thirty feet below the second and bearing coal eighteen inches thick. In the northeast corner of section 30, a seam twenty-two inches thick has been drifted into to some extent. Wells near Vandalia seldom fail to penetrate coal beds at moderate depths. On Walnut creek (Des Moines Tp., Sec. 34, Ne. ¼) coal was taken from a thirty-inch seam until trouble with water and a poor roof caused it to be abandoned. Two miles to the north, coal is still taken out by two local mines during the fall and winter months. The White mine is west of Walnut creek (Sec. 22, Nw. qr.) and drifts into a seam four feet thick, twenty-eight feet above the creek level. Two feet of "slate" above the coal is overlain by an eighteen-inch limestone "caprock." There is a gradual dip to the southeast. The Norris drift (Sec. 22, Ne. qr., Se. ¼) has been in operation on the opposite side of the creek for more than twenty-five years, and about thirty-three acres have been mined out. It is now worked by Charles Calvert. A "sulphur band" of black jack and iron pyrites, two inches in thickness, occurs persistently in this coal. The bed is very similar to that mined on the west side of the creek.

Prairie City. Coal northeast of Prairie City has already been described in connection with the Colfax district. One-half mile east of Prairie City, at the north edge of section 1, a drill hole 185 feet deep penetrated three and one-half feet of coal at the bottom. Mining was not undertaken on account of water.

Monroe. On Calhoun creek, four miles west of Monroe, drifts were at one time run into a four-foot coal which outcrops in the hillsides (Des Moines Tp., Sec. 32). Water and a poor roof have prevented mining here during the last twenty-three years.

Four miles east of Monroe are a group of local mines working in a district which was once one of the most active in the county. An important mining camp named Draper was established and operations were undertaken on a large scale by the Jasper County Coal and Mining Company and others. At present only a few small mines are in existence. There are two coals in this district, a lower four feet thick and an upper sometimes slightly thinner. The two beds are separated by from ten to forty feet of shale and sandstone. The larger mines worked both beds; but at present only the upper is being developed. Considerable coal is still to be won from the area, but many of the property owners are reserving their coal rights for future sale.

Wm. Marshall is hoisting coal from a shaft fifty-six feet deep by means of horse and gin (Fairview Tp., Sec. 33, Ne. qr.). The upper seam is from three to four feet in thickness. The second seam, about twenty feet below, is a "shooting" coal and is not worked. Long wall mining in the upper bed is rendered peculiarly easy by the presence of a clay band, from eight inches to one foot in thickness, separating the coal into two benches. Upon the removal of the clay band, the top coal wedges down by its own weight, while the bottom coal may be pried up with bars. This mine is quite new.

A fourth mile northeast of the Marshall is the Shaw mine, entered by a slope ninety feet in length with a grade of one in twelve. The upper seam is three feet eight inches thick at this point and is split into two divisions by a clay band, fourteen inches in thickness on an average. In one part of the workings this band is only six inches thick; while at the other end of the breast, only 300 feet distant, it has increased to three feet. The lower seam is found as at the Marshall and was formerly worked. The present slope is a new opening into old workings. The old Shaw slope, a short distance south (Sec. 33, Ne. qr., Ne. 1/4), had removed the upper seam from under more than eighteen acres.

The Gray slope and Sheeler Brothers shaft are adjacent mines working on the northern border of the old Gilchrist workings (Sec. 34, Sw. qr., Nw. 1/4). A layer of impure coal about one foot in thickness lies in the middle of the seam here. The coal is three feet six inches thick. It lies so close to the surface that water gives much trouble after heavy rains.

The McConoghey mine is situated northeast of the ones previously mentioned, near the Skunk river (Sec. 26, Ne. qr., Sw. 1/4). A slope enters a four-foot seam, which is capped by arenaceous limestone, a rather common occurrence in this field. The dip is to the southwest. An unusual feature for the district is a well defined fault which occurs here. A displacement of two feet has been measured; the fault plane is nearly vertical and strikes northwest-southeast. A lower bed, penetrated in a well at a depth of forty-five feet, is reported to be eight feet in thickness. Southwest of the McConoghey, in the same section, the lower seam is known to be thirteen feet below the upper. The latter shows the thin clay band characteristic of it farther west. In the southwest part of section 36, the coal occurs in the hills bordering the Skunk river flood-plain, and a small amount of mining has been done here.

Lynnville. Considerable coal has been found north and west of Lynnville along North Skunk river and its tributaries. In section 3 of Lynn Grove township, two seams outcrop above river level. Farther north, in sections 33 and 34 of Richland township, three seams are known. Only the upper bed, which varies between one and four feet in thickness and lies about twenty-five feet above the river flood-plain, has been mined. Under quite a large area here, at least one workable seam may commonly be found at any given point not too near the river bottoms. A general idea of the sequence of strata in the district may be gained from the shaft record of the old Black Oak mine (Sec. 34, Se. qr., Nw. ¼):

FEET.	INCHES.	
5		11. Drift.
6		10. Clay shale, light-colored above.
4		9. Coal.
5		8. Fire clay.
5		7. Sandstone, soft, massive, upper six inches indurated.
20		6. Shale, somewhat fissile, irregular concretionary bands of impure limestone, "niggerhead," at base.
1	10	5. Coal.
	3	4. Fire clay.
8		3. Shale, bituminous.
1	4	2. Coal.
2		1. Fire clay (exposed).

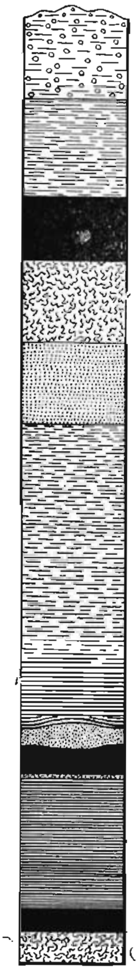


Figure 38. Shaft of old Black Oak mine, Lynnville.

PART II

COAL DEPOSITS OF SOUTH CENTRAL IOWA

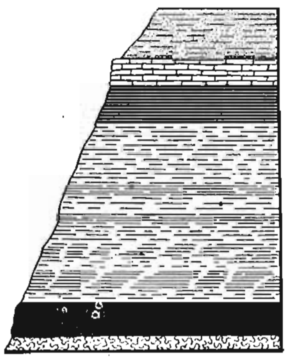
MADISON COUNTY

The southwesterly dip of the Des Moines strata carries them under the Missouri in Madison county. Des Moines rocks are the highest of the indurated series in the northeastern section of the county and in long re-entrants running far up all the main valleys; but in other parts of the region the barren lower section of the Missouri stage lies over and conceals the more freely coal-bearing members of the Pennsylvanian. Outcrops of the Des Moines are of that upper portion which preserves its characteristics more persistently than do the more heterogeneous strata below it, as has been more fully described in the section on Guthrie county. It is probable that the three coal horizons found along the Raccoon river in Guthrie are represented also in Madison. For example, what is probably the Panora coal appears on Bulger creek in Jefferson township and the Lonsdale and Marshall in Madison township (section 25). Coal is also found on Cedar creek (Crawford Tp., Secs. 17 and 18), southwest of Bevington (Sec. 36), near St. Charles, and along Clanton creek and Middle river. All these seams are, however, quite feebly developed and hardly of even local importance.*

The heaviest of these coals, where they approximate a thickness of two feet, have been mined for local consumption during the fall and winter months. Less of this is done now than a decade or more back. A two-foot bed has been drifted along Middle river near Patterson and near North river in Madison township (Sec. 25, Nw. qr.). There are probably basins of good coal underlying Madison county; but it will be necessary to drill

*This, *et seq.*, is taken largely from Tilton and Bain: *Geology of Madison County*, Iowa Geol. Surv., Vol. VII, pp. 537-539; Des Moines, 1897. Recent developments are practically negligible.

200 or 300 feet in order to reach the horizons which have yielded the best coal in other parts of the state. Thick coal was found at Van Meter in Dallas county at a depth of 285 feet in a shaft the mouth of which had an elevation above sea level of 878 feet.



		FEET.
6.	Shale, sandy	32
5.	Limestone, impure, bluish	2
4.	Shale, black, bituminous	3
3.	Shale, argillaceous, bluish	14
2.	Coal	2
1.	Fire clay	1

Figure 39. Coal on North river (Madison Tp., Sec. 25).

At Lucas, in Lucas county, four to five feet of coal is found at a depth of about 290 feet, with another thick seam slightly lower. Conditions at Lucas should be very similar to those in the lowlands of northeastern Madison county. Rumors have been circulated of discoveries made in deep drillings near Peru, but nothing at all definite could be learned. Thinner, but still profitable, seams may be expected nearer the surface. Such beds are found in Dallas, Warren, and Lucas counties. Southwest of Norwalk, about four miles east of the Madison county line, a thirty-two inch seam lies at an altitude of about 890 feet A. T., and is reached by a shaft sixty-five feet deep.

WARREN COUNTY

In no other county in the state, apparently, are the possibilities of finding hitherto undiscovered coal so bright as in Warren. In Polk on the north, Marion on the east, and Lucas on the southeast, strata corresponding stratigraphically with those underlying Warren are known to include coals in abundance. Owing to the fact that numerous thin coals outcrop in the many deep valleys into which the surface of the county is carved, the temptation has always been to neglect search for deeper seams and to confine attention to those already in sight. Even the latter, however, are worthy of development on a much larger scale than they have received. A serious check on attempts to establish shipping mines within the confines of the county has been the poor transportation facilities at hand and the difficulty of constructing new lines in so rough a country. This is a drawback which will be obviated in the course of time.

As in other sections of the Iowa field, the coals of Warren lie in more or less isolated basins that are surrounded by areas in which the seams are either attenuated or absent. These basins exhibit a certain amount of regularity in their arrangement along stratigraphic horizons or groups of horizons, as has been carefully worked out by Tilton and described by him several years ago in the following paragraphs:*

Coal Seams of the Lower Group. In this line of strike the borings at Milo and southeast of Palmyra are the only ones, having accessible records, that have pierced the Saint Louis formation below the Coal Measures. The "Carbonaceous shale" at Milo, at a depth of about 328 feet from the surface or 609 feet above sea level, marks the lowest horizon at which there is now any evidence of coal in the county. It might be regarded as the lowest possible horizon were it not that the floor on which the Coal Measures rest is so irregular. Southeast of Palmyra (Tp. 76 N., R. 22 W., Sec. 5) the Saint Louis is 329 feet below the uplands or 546 feet above sea level.

The strata are nearly horizontal, the dip rarely reaching as much as two degrees southwest, but because of the slight dip to the southwest and the slope of the surface to the northeast, the several strata gradually approach the surface toward the northeast and recede farther and farther from it toward the southwest. Southeast and northwest the old Saint Louis surface lies as nearly horizontal as any surface carved into ridges and valleys by erosion may be expected to lie.

About sixty-eight feet above the lowest horizon are unsatisfactory indications of a second horizon; while a marked third horizon lies 712 feet above sea level, or 225 feet below the upland surface at Milo. This latter horizon is the upper one in the two groups found at and below the altitude of 725 feet above sea level, and marks the upper part of the group of strata in

*Geology of Warren County, Iowa Geol. Surv., Vol. V, pp. 344-347; Des Moines, 1896. Immediately after the panic of 1893, there were a large number of farmers' mines taking coal from thin seams. The number of these has steadily decreased: while all of the mines now in operation, with one unimportant exception are working coals known for many years. Professor Tilton's account takes cognizance, therefore, of all information obtainable at the present time.

which coal has been formed of greatest thickness near Des Moines on the north and Lucas on the south. At this same level lies the lowest coal penetrated by Earle Brothers, in section 9, southeast of Spring Hill. At this same level also lies Caldwell and Cassidy's mine in section 31, just west of Summerset; and in section 28, east of Summerset, Jones and Benham have mines where there is a local thickening of the coal, if not an independent basin. To a continuance of this same horizon belongs the seam of coal in the bluff at Ford. This particular horizon, then, is marked by evidence of coal so widespread and of such thickness (two and a half to three feet) that the horizon may be considered as one especially rich in coal.

Coal Seams of the Upper Group. All seams, evidences of which have been found above the horizon last described, outcrop along ravines at different points in the county. The first of these, the lowest of the group, is to be found in the central part of the county, at and above a level of 800 feet. It lies at the level of Middle river east of Spring Hill, in section 2, and at the level of North river in sections 19 and 20, Greenfield township. On South river it is about on a level with the river bed south of Indianola, but it dies out before reaching Milo. Another seam, a few feet below the position of the one last mentioned, is at Summerset, about the level of the railway tracks. East of Summerset it is frequently drifted as a surface seam. Another seam on this same horizon appears at the level of Whitebreast creek, in section 35 of Whitebreast township.

These upper seams mark quite an important coal horizon. The coal, under favorable conditions, is quite uniformly eighteen to thirty inches thick.

Above this horizon, in the west-central part of the county, two others exist over quite an area, the first about thirty-five feet above it, the second forty-five still higher up. The lower of these two seams furnishes an easily accessible supply of coal in Jefferson township, the upper seam appearing only at the higher points along the divides. The horizons of these two seams are also marked in White Oak, Otter and Liberty townships by indications of coal. The upper seam is drifted in a few places while the lower of the two horizons is drifted in the vicinity of Milo and in the south-central part of Belmont township. Both horizons appear in the ravine of section 26, southeast of Lacona, and the lower of the two is mined a mile north of Lacona.

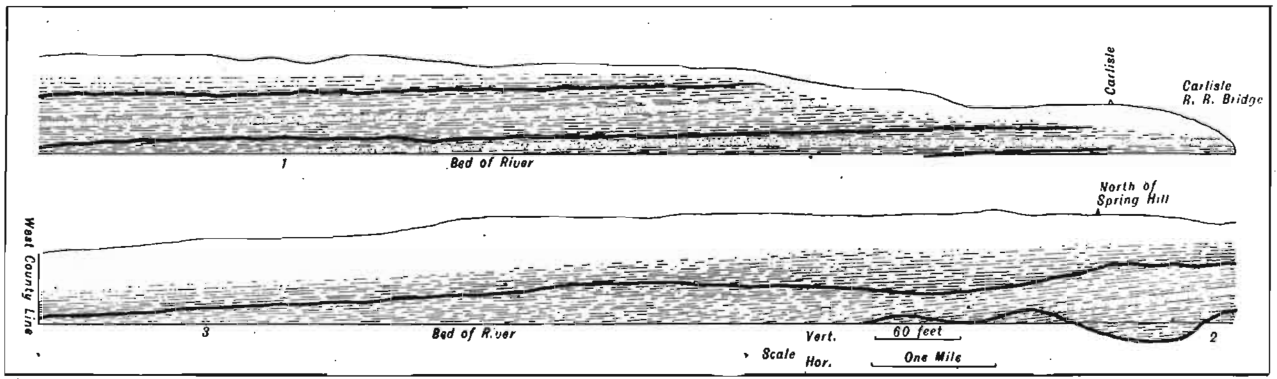
Intermediate Coal Seams. Between these two groups of seams, one at and below a level of 725 feet in the central part of the county, and the other at and above 800 feet—belong the seams outcropping along the ravines in southern Richland, Palmyra and Union townships, where they are often drifted for local use. These latter seams frequently present a thickness of eighteen inches of good coal, and are more nearly related to the upper of the two groups of seams in the central part of the county than to the lower group.

The carbonaceous material found in the well at Milo at a depth of 150 feet from the surface, or at an elevation of 775 feet, suggests, together with the position of coal in Palmyra and Union townships, a coal horizon that may be looked for at a corresponding level in the southern part of the county.

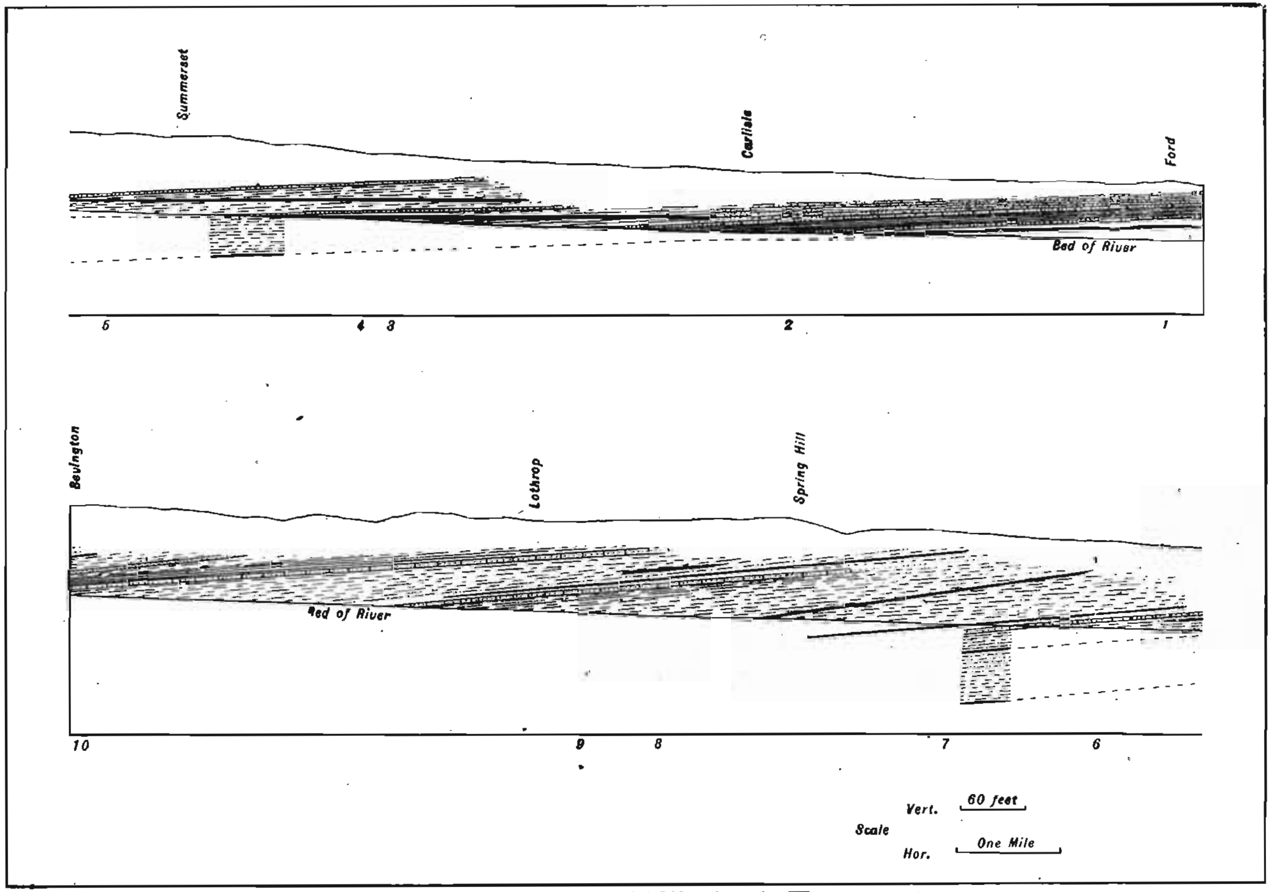
In the southwestern part of the county the single coal seam that exists will not afford very profitable mining, nor are there local indications that there are seams to be reached by shafts of moderate depths. The nearest coal seam to the northeast would, if extended beneath Virginia township, lie about thirty feet beneath the river bed at the mouth of Limestone creek. To the east of Limestone creek, nothing but sandstone appears till the vicinity of Squaw creek is reached.

All of the mines in operation in this county are small local affairs, using man and car haulage, and if shafts, primitive methods of hoisting. The more important banks are near Lacona, Milo, Summerset, Carlyle and Norwalk. They will be mentioned more minutely below. Practically all of the county's production has been consumed within its own borders. The annual output has never been considerable; but, on the other hand, it has seldom dropped as low as 1,000 tons. Commonly, Warren has mined between 5,000 and 25,000 tons per year. In 1900, one of the banner years, the tonnage published by the Iowa Geological Survey was 27,824. Since that year the output has gradually declined; for the year ending June 30, 1908, the State Mine Inspectors report a production of 5,950 tons. These figures do not, however, include coal taken out by small country banks, working only two or three men for part of the year. The six principal mines of the county employ only thirty-seven men.

IOWA GEOLOGICAL SURVEY. PLATE IV.



Geological Section along North river in Warren county.



Geological cross-section along Middle river in Warren county.

NORTH RIVER VALLEY.

Descending North river from the west county line, an exposure of good coal is met with a little over a mile down stream (Linn Tp., Sec. 32, Sw. qr., Se. ¼). As measured by Tilton, the section is:

		FEET.	INCHES.
8.	Sandstone, gray, easily decomposed	1	6
7.	Shale, clayey, blue, jointed	5	
6.	Sandstone, very fossiliferous		7
5.	Shale, clayey, blue, jointed; sandy above		6
4.	Shale, clayey, black		4
3.	Sandstone, nodular, reddish		3
2.	Coal, very good	3	6
1	Fire clay, exposed		4

Two miles northeast of this exposure (Sec. 34, Ne. qr.), a forty-foot shaft was sunk to what is probably the same seam. At this point the bed is three feet in thickness.

Two miles southwest of Norwalk and a half mile north of the river (Sec. 23, Nw. qr., Se. ¼) is the local mine of the Hartshorn and Son Coal Company. The shaft is sixty-five feet deep to a seam thirty-two inches thick. Hoisting is effected by a traction engine attached to a drum. The seam exhibits a dip of one foot in sixty to the north. The roof is an argillaceous shale which requires considerable timbering; the floor is a fire clay that shows some tendency to heave. Two miles southeast of Norwalk, a coal lying a few feet above water level has been reached by shafts and slopes at various points along North river (Secs. 19, 20, 21 and 29, Greenfield Tp.). The seam varies from two to three feet in thickness. The Hawkeye mine now supplies a good grade of coal to the surrounding farmers. Down river (Sec. 22), the coal is found sufficiently far above the river to be reached by drifts.

A few miles southwest of Carlisle, drifts and shafts have reached a thirty-inch coal from the south side of North river valley (Allen Tp., Sec. 8). A bit more than half a mile south of the river three mines are now supplying a local trade. They are located in the upper portions of the valleys of small tributaries to North river, at an elevation of from forty to fifty feet above the level of the river. The seam varies in thickness from thirty inches to three feet. A fairly constant characteristic of the bed is a "sulphur band" of black jack and iron pyrites about one inch thick, which lies near the middle of the coal. The roof is a "slate" of fair stability, although weak in places. The John Gross mine formerly worked a twenty-four foot shaft, but a slope has recently been opened (Allen Tp., Sec. 8, Sw. qr., Sw. ¼). The coal may be seen outcropping here in a ditch near the slope mouth. A few hundred feet southwest is the new Peterson coal bank, a slope 180 feet in length to the coal. A half mile east is the Myers and Farrel shaft, thirty feet in depth (Sec. 8, Se. qr., Nw. ¼). Hoisting is done with horse and gin. Work has been chiefly south and west of the shaft. For 300 feet from the shaft the dip is southwest, then ceases, and finally becomes slightly reversed.

MIDDLE RIVER VALLEY.

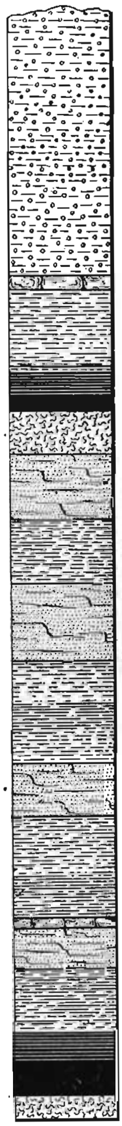
Along the upper course of Middle river, in Warren, little mining has been attempted and a large part of the coal used is taken from beds less than fifteen inches in thickness. There are, however, several places where workable seams are known. Southeast of Spring Hill, a boring made by Earle Brothers near their old shaft furnished the suggestive record given below (Tp. 76 N., R. 24 W., Sec. 9, Nw. qr., Se. ¼). The top of this drilling is twenty-eight feet above the river bed, so that the first seam mentioned in this record is that which is found to pass beneath the river bed close by.

		FEET.
17.	Soil and clay	8
16.	Shale, clayey, blue	6
15.	Sandstone	1
14.	Shale, clayey, dark	1
13.	Coal	1
12.	Fire clay	2
11.	Shale, sandy, hard	13
10.	Shale, clayey	4
9.	Sandstone	1¼
8.	Shale, clayey	12
7.	Shale, clayey, black	5
6.	Coal	2½
5.	Shale, sandy, hard	21
4.	Shale, clayey, red and blue	34
3.	Sandstone, dense	1½
2.	Shale, clayey, black	5
1.	Coal	4

According to Professor Tilton's geological cross-section along Middle river, number 1 of the above record occupies the same horizon as the coal mined at Ford, on the Des Moines river.

Between Earle Brothers' shaft and Summerset, only thin coals have been reported. At Summerset, shafts were sunk sixty to 100 feet to the so-called '''third vein,'' which was four feet in thickness. Nothing has been done at this point for some years, but two miles northeast is a group of local mines working in a seam which lies from fifteen to thirty feet above the low water level of North river. This bed varies in thickness from thirty inches to three feet where worked, and shows persistently, about one foot above its base, an inch or less of iron pyrites. In this, as in its altitude, the seam corresponds closely with the coal worked near Carlisle. It has a slight dip to the south. The roof is a thin layer of black ''slate'' overlain by a thin arenaceous limestone which renders the whole secure, except where the base of the drift approaches perilously near the coal. Sixty feet above the seam now worked is a fifteen-inch bed which has been mined a little. From sixty to forty feet below the seam now worked is a heavier bed, said to be as much as four feet thick in places. Between the two lower seams a thin bed, known locally as the ''lost vein,'' is sometimes present and sometimes absent. Two mines are now supplying a local trade from the seam first described. The Overton mine (Tp. 77 N., R. 23 W., Sec. 33, Nw. qr., Ne. ¼) is taking coal from a shaft recently sunk 125 feet. The Buchanan mine operates a shaft thirty feet deep on lower ground, one mile north (Sec. 28, Nw. qr., Se. ¼). The lower seam was also worked in this vicinity formerly. The accompanying figure illustrates the sequence of strata above the lower coal, which probably lies in the Ford horizon.

Three small mines are now working at and near Ford. Considerable coal has been taken out in the past from a seam which outcrops along the base of the bluff until it comes to an end as it reaches the water level of Middle river, one-fourth mile east of the Clarkson bridge. The stratigraphic relationships of the Ford coal with other seams along the Des Moines river have already been discussed in the chapter on Polk county.



FEET.	INCHES.	
24		19. Drift, yellow sands and variegated clays.
1	1	18. Limestone, blue, fossiliferous.
7		17. Shale, blue, argillaceous.
		16. Limestone, fossiliferous.
	4	15. Shale, black, fissile.
2		14. Coal.
1	2	13. Fire clay.
3	4	12. Sandstone, with nodules of black limerock.
5		11. Shale, gray with streaks of red.
7		10. Sandstone.
8		
10		9. Shale, argillaceous.
5		8. Sandstone.
10		7. Shale, argillaceous.
	9	6. Limestone.
3		5. Sandstone.
6		4. Shale, argillaceous.
2		3. Shale, black, somewhat fissile.
2	10	2. Coal.
2		1. Fire clay (exposed).

Figure 40. Section of shaft at Bennum mine. Summerset.

The Locust Grove Coal Company have a thirty-foot shaft a little less than a mile southwest of Ford (Richland Tp., Sec. 9, Sw. qr., Sw. ¼). Hoisting is by horse-gin; pumping by traction engine. The seam is level and shows a thickness of four feet four inches. A constant feature in it here is the inclusion of a band of black jack about eighteen inches above the base of the coal. The thickness of the band, from eight to eighteen inches, is included in that of the seam as given above. Above the coal is fourteen feet of slate; next higher, six feet of the massive Ford sandstone.

A slope, sometimes called the Red Diamond, is taking out a large pillar left by the old Fordville company in their workings opposite the store at Ford. The roof over this particular piece of coal is not good. The "dirt band" found at the Locust Grove is practically lacking at this point; but more sulphur is present. The old workings are said to extend back nearly a mile from the face of the bluff.

Another slope is being operated opposite the Ford station, where the seam is from three feet to fifty inches in thickness, and shows only a one-inch "dirt band," near the base of the coal. There are no "slips." Rolls in the roof occasionally cut out all or part of the coal. The roof is an infirm black "slate," which may be as much as twelve feet or as little as six inches in thickness, and is capped by the heavy Ford sandstone. The present company, having run 350 feet into the bluff, is heading off part of the old Fordville workings.

SANDYVILLE DISTRICT.

In the southwestern quarter of the county, very little coal has been found and only thin coals have been worked along South river above Ackworth. In the vicinity of Sandyville, east of Ackworth, some two and three-foot coal is known. One mile west of the village, two feet of good coal has been reached by drifts (Union Tp., Sec. 20, Ne. qr., Ne. ¼). Three miles north of the town three coals are shown in the following exposure (Union Tp., Sec. 3, Se. qr., Nw. ¼):

		FEET.	INCHES.
10.	Drift	15	
9.	Shale, clayey, black	2	
8.	Coal	1	
7.	Shale, clayey, gray	4	
6.	Limestone, gray, arenaceous, fossiliferous	2	
5.	Shale, clayey, gray	8	
4.	Coal	3	7

3.	Shale, gray	34	
2.	Coal	1	1
1.	Shale, clayey (exposed to South river)	2	6

A mile south of this exposure, in the valley of a small creek, a three-foot seam was reached by a shaft twenty-four feet deep (Sec. 10, Se. qr., Nw. ¼). A mile northeast of the exposure, a coal from three to three and a half feet in thickness was entered by drifts (Richland Tp., Sec. 35, Nw. qr., Se. ¼). It will be seen that there is considerable workable coal near South river in this region, and it has been left practically untouched. On the north side of South river valley, in Palmyra township (Sec. 5, Sw. qr.), two drillings were carried to the base of the Coal Measures. Only one of these, begun on higher ground than the other, showed coal. The drill record of the latter test is given in full below:

		FEET.	INCHES.
35.	Soil	4	
34.	Clay, yellow, with gravel below	20	
33.	Sandstone, yellowish	11	
32.	Shale, blue	3	
31.	Limestone, fossiliferous	4	
30.	Shale, black	4	
29.	Coal	1	8
28.	Fire clay	8	
27.	Sandstone	4	
26.	Shale, gray	12	
25.	Shale, clayey, black	2	
24.	Coal	1	
23.	Fire clay	3	
22.	Shale, clayey	16	
21.	Shale, clayey, red running to brown, bed of South river	26	
20.	Shale, brown, sandy below	19	
19.	Shale, bituminous	2	
18.	Shale, clayey	14	
17.	Shale, clayey, black	6	
16.	Coal	3	8
15.	Fire clay	4	
14.	Shale, gray with hard bands	10	
13.	Shale, soft, blue, with bands of gravel	27	
12.	Shale, sandy	11	
11.	Sandstone, compact	6	
10.	Shale, bright, with ironstone bands	17	
9.	Shale, clayey, red, blue, and brown	26	
8.	Sandstone, fine-grained	4	

7. Shale, light above, dark below, hard	23	
6. Coal	1	10
5. Fire clay	2	
4. Shale, clayey, black	16	
3. Shale, light, with hard bands	7	
2. Shale, gray, very hard and sandy	12	
1. Saint Louis limestone	38	
Total	367	2

South and southeast of Sandyville, along Coal and Fly creeks and their tributary branches, numerous drifts and slopes have taken coal from thin beds. In almost all cases these seams show thicknesses of less than two feet. Heavier coal could probably be found by drilling.

MILO DISTRICT.

Three miles southeast of Milo, on Flank creek, is a field showing a basin of coal from thirty to forty inches in thickness. The coal is of medium grade, thin bands of pyrite being interspersed through its substance. Two other seams are found at slightly higher levels; they are commonly thin, yet occasionally show as much as two feet of coal. The lower bed is tapped during the colder months by shafts, slopes, and drifts at several points in sections 28, 29, 32 and 33 of Belmont township and in the northern portions of sections 3 and 4, Whitebreast township. The most important of these small mines at the present time is, perhaps, the Heinen drift (Belmont Tp., Sec. 33, Ne. qr., Ne. 1/4), where the bed lies at an altitude of 835 feet above sea level. Mr. Heinen is now pulling pillars and preparing to move to a new location not far up Flank creek, where three feet of coal has been found in a well.

On Otter creek and its tributaries west and southwest of Milo, is a group of small local mines. One mile west of Milo (Otter Tp., Sec. 13, Sw. qr., Sw. 1/4), is the Hollingsworth bank, reached by a shallow shaft. The seam is eighteen inches thick. This mine has been idle for two years, but may be reopened. One mile southwest (Sec. 23, Nw. qr.), Joe Mitchell works intermittently a slope for the local trade. This coal is also thin. The principal mine of the district is the Bayles bank, one mile and a half southwest of Milo. A slope is now being driven in from the valley of a small "ditch" (Sec. 26, Ne. qr., Ne. 1/4), it being planned to use the old shaft as an air course. A seam has been worked by numerous openings in this neighborhood since 1870. It is a fairly clean coal, showing a thickness of from twenty-one to twenty-seven inches. It grows thinner to the west and extends but a short distance east into section 25. In sections 32, 33, and 34 of Otter township and in 5 and 8 of Liberty township thin coals have been feebly exploited at numerous points along the streams.

The coal beds of the Bayles area appear to lie in fairly definite horizons and have, accordingly, been termed by the miners the "first," "second" and "third" veins. The coals, however, are not continuous, but lie in basins of limited extent at levels which approximately correspond. The altitude of the bed chiefly worked at present is about 870 above tide. About thirty feet below and fifteen feet above are other horizons which have yielded only thin coals.

LACONA DISTRICT.

One mile north of Lacona, the Jones mine is operated during a portion of the year. A bed two and a half feet in thickness is reached by a shallow shaft. Farther north, on Wolf creek, and southeast near Whitebreast creek thin beds have been reached at one or two points. Southwest of Liberty Center (Liberty Tp., Sec. 29) a little coal is still taken from a sixteen inch bed during the winter months.

MARION COUNTY

Marion county embraces the northwestern portion of what has proved the most prolific section of the Iowa coal field, and includes some of the best coal basins in the state. Topographically, the greater part of the county is rough, as the result of the excavation of valleys by several important streams, chief among which is the Des Moines river. The topography has affected the coal industry in two ways: it has favored it by affording an easy means of locating and reaching coal beds exposed in the valleys beneath the drift, while it has hindered it by check-ing the building of railroads excepting along a few rather circumscribed lines of travel. A number of railroads do traverse the county; yet their courses are such that they can carry Marion coal only into territory already supplied by fields enjoying the advantage of a shorter haul to the centers of consumption. This is a defect that will be remedied in the course of time.

In the eastern half of the county the base of the Coal Measures lies at no great depth beneath the surface of the county. In fact, the larger streams have cut completely through the Des Moines beds in the lower portions of their courses so as to expose the Saint Louis limestone in the lowlands. Thus, the Des Moines river flows over the limestone as far up the valley as Howell and over an isolated exposure of it just below Rousseau; English creek leaves the Coal Measures just below Flagler; South Skunk river and Thunder, Walnut, and Cedar creeks also uncover the Saint Louis for several miles above the points at which their waters enter Mahaska county on the east. The Coal Measures, therefore, are not very thick in the eastern half of the county, although above depressions in the very uneven surface of the Saint Louis limestone, coal may be found below the level of the basement formation at the outcrops mentioned. Owing to the general dip of the strata to the southwest, the Coal Measures of the southwestern part of the county attain greater depth than do those in the eastern. Few deep drillings have been made in this area, so that only a general idea of the average depth of the surface of the Saint Louis may be offered. At Milo, a few miles from Marion county in Warren, the base of the Coal Measures was reached at a depth of 328 feet, making its elevation above sea level about 609 feet. Borings in Lucas county, on the south, place the Saint Louis at about the same average level in that quarter. Results obtained by borings farther north in Warren county and in Polk do not deviate materially from the figures already given. It is probable, then, that the thickness of the Coal Measures in southwestern Marion seldom exceeds 400 feet and more often approximates 300 feet or less.

Marion county contains in local "swamps" some of the thickest coal in the state. Vertical heights of as much as sixteen feet have been reported from more than one mine, but in such cases the value of the coal is often decreased by the presence of considerable foreign substance or by weakness in the overlying stratum forming the roof. Coal appears to be abundant in all parts of the county; very rarely is a test hole sunk without encountering at least one seam. Nevertheless, the discovery of thick coal in one pocket by no means indicates the presence of a workable field in the neighborhood. The coal lies in isolated basins of lenticular shape, many of them small, and it has been known to thicken and thin with startling rapidity when followed short distances laterally. It is not safe to sink a shaft to any seam until its extent has been accurately determined by a free use of the drill. Such prospecting operations have been actively carried on within the limits of the county and coal rights covering large tracts of land have been reserved by companies now operating in neighboring counties on the east and southeast. When the fields in which these companies are now working approach exhaustion, it is reasonable to suppose that they will turn their attention to Marion. Large sections in the southwestern corner of the county have been neglected, and yet this is the most promising territory of all, since under it the Coal Measures are presumably thickest. The building of a railroad through this area would be followed by rapid coal development.

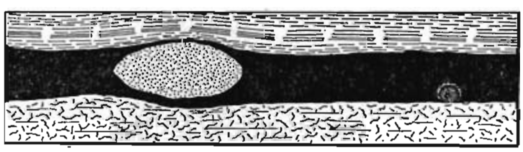


Figure 41. Ironstone mass in coal bed.

Difficulties attendant on mining in Marion are little, if any, greater than in other sections, yet some trouble is experienced from the more than usually large number of "bowlders" often encountered. These "bowlders" are sometimes sandstone concretions, yet much more frequently they are of impure carbonaceous limestone, black on freshly broken surfaces, but whitening after exposure to the atmosphere. "Bowlders" are commonly oval or lenticular in shape and lie with their long axes parallel to the bedding planes of the strata. They often occur in aggregations, leaving large areas perfectly clear. Their favorite position is in the top of the coal, next the roof, and they are apt to be most numerous where the coal is abnormally thick.

Marion has always been an important producer and has shown a steady and consistent gain in output, aside from temporary setbacks. The annual production for 1860 is given in the federal census reports as 1,548 tons; for 1870 as 4,313; for 1880 as 72,550; and for 1890 as 145,180. The output of the last ten years as given in reports of the Iowa and United States Geological Surveys is as follows:

YEAR.	TONNAGE.	YEAR.	TONNAGE.
1898	127,293	1903	324,859
1899	232,351	1904	314,908
1900	209,223	1905	338,812
1901	149,917	1906	372,750
1902	269,724	1907	346,999

The report of the State Mine Inspectors for the year ending June 30, 1908, shows a slight falling off.

Number of mines	20
Number of tons of all grades produced	327,745
Number of men employed	693

Marion now holds sixth place among the coal counties of the state, having recently yielded fifth place to Jasper. The price per ton at the mines is lower here than in other parts of the state, being only about $1.40.

Mining is now most actively carried on in Liberty township. Flagler still ships considerable coal; while smaller mines may be found near Pella, Harvey, Dunreath, Knoxville, and Coalport, and on Whitebreast creek. In the following account brief mention is made of the mines found in operation in September, 1907. Material has been freely taken from earlier reports of this Survey.*

No attempt has been made to correlate the various coal basins, for no regularity in their stratigraphic position has as yet been deciphered. The roughness of the county renders extremely uncertain attempts to assign any particular relationship to coals geographically separated; while the inconsistency in character

*Keyes, Iowa Geol. Surv., Vol. II, pp. 317-340; Des Moines, 1894. Miller, Vol. XI, pp. 169-182; Des Moines, 1901.

of the lower Des Moines strata makes the advisability of such attempts doubtful. The forthcoming publication of detailed topographic maps of the Knoxville and Pella quadrangles by the United States Geological Survey may, perhaps, aid in determining the possible value of future correlation work on a large scale.

DISTRICT NORTH OF THE DES MOINES RIVER.

Morgan Valley. In the northwestern corner of the county two seams, separated by a vertical distance of ten feet, outcrop just above the level of the Wabash tracks. The upper seam, four feet or less in thickness, is capped by a massive sandstone that reveals its close relationship with the Ford horizon. The lower is one foot or less in thickness. Up a ravine near Morgan Valley, a switch track was laid for a distance of three-fourths of a mile from the main line and coal was shipped over it from a mine situated at its extremity. The shaft was forty-five feet deep to a four-foot coal which possesses also the heavy sandstone roof. This mine has been idle for several years. One-fourth mile south (Perry Tp., Sec. 4, Sw. qr., Sw. ¼), beside the tracks of the same switch, brick and tile is being made from Carboniferous clay underlying a twenty-inch seam of coal. The seam outcrops near the bottom of the valley. A compact sandstone roof makes it possible to excavate the clay in broad rooms, with an entry fifteen feet wide at the foot of the short slope. Only the upper ten or twelve feet of clay is utilized, the coal being at first left up for a roof. As the working face advances, the coal is removed and used at the plant.

Along the river, below Morgan Valley, several outcropping seams have been drifted from the sides of the bluffs. These coals are either thin or of limited lateral extent. At Dunreath, however, extensive mining was carried on many years ago. Miller* recognizes the existence of four horizons near this village: the first forty-five feet above river level, the second fifteen feet lower; the third twenty feet beneath the second, and the fourth at low-water level in the bed of the river. All four horizons do not bear coal at any one point. The coal in the lower

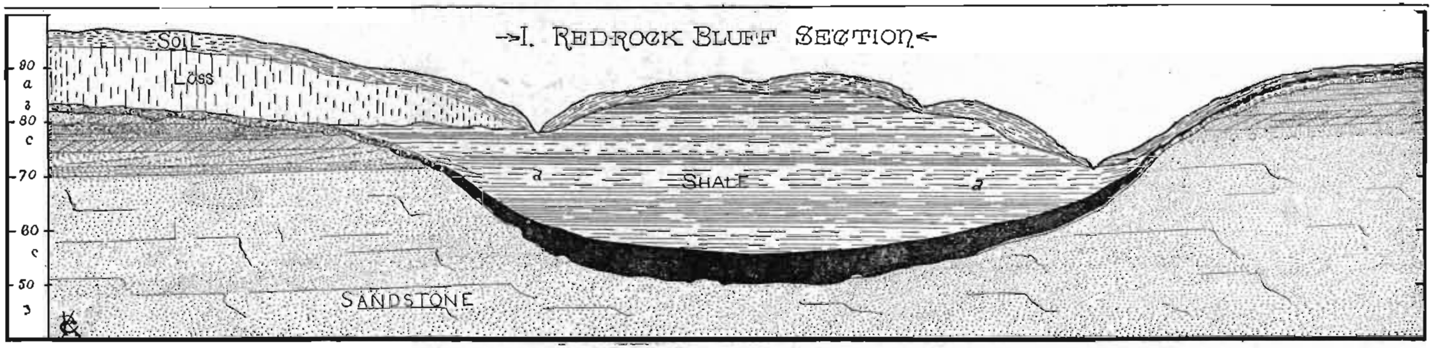
*Iowa Geol. Surv., Vol. XI, p. 176; Des Moines, 1901.

two horizons is thin in most cases. The second seam is the one from which the larger mines of the district obtained their supply, and may be correlated with the coal found occupying a depression in the Red Rock sandstone in the quarry near Red Rock. At Dunreath, the seam is from four to seven feet in thickness. The Black Diamond mine (Red Oak Tp., Sec. 26, Sw. qr., Nw. 1/4) removed the coal from about seventy acres; the Success (Sec. 27, Nw. qr., Sw. 1/4), from approximately forty acres. The upper horizon shows a thickness of two and a half feet where it has been drifted to some extent at its outcrop in the hill south of Dunreath.

The New Dunreath Coal Co., northeast of the village, plans to reopen its shipping mine during the coming winter (Sec. 22, Ne. qr.). With the exception of a few months, this shaft has been idle for two years because of trouble with accumulating water. The shaft, fifty feet deep, reaches what is probably the second Dunreath horizon, in which the coal is here four and one-half feet in thickness. A short spur has been built from the main line of the Wabash railroad. Hoisting is done with a double, geared engine with cylinders 14x20 inches.

Two miles northeast of Dunreath a group of small, local mines have operated intermittently. At the present time Le Grande coal bank is the only producer (Red Rock Tp., Sec. 13, Nw. qr., Sw. 1/4). This is a slope 200 feet long, with a maximum grade of one in three. In excavating the air shaft, six feet of surface material, a small coal "blossom," three feet of fire clay, and forty feet of shale were successively encountered before the thick coal was reached. The seam worked is four feet in thickness and, so far as now known, dips toward the south. Ironstone "bowlders" are freely dispersed through the coal and contingent portions of the roof and underlying fire clay. A "sulphur band," two inches or less thick, occupies a central position in the coal. Whether the seam worked here and those sometimes exploited in neighboring mines are identical is difficult to determine; for a network of small streams has cut deeply into the horizon on every hand.

At the Red Rock quarry, southeast of Dunreath, is the small coal basin already mentioned, and illustrated in the accompany-



Coal bed shown in Red Rock quarry (Miller).

ing sketch. At its point of maximum thickness, this seam shows six feet of coal.

Otley. One mile southwest of Otley is a basin containing coal from four to seven feet in thickness, with an average of five feet. At one time the Otley Coal Company did a shipping business in this field; but now only local mines are operated. The Yukon, or Vriezelaar, mine (Summit Tp., Sec. 21, Se. qr., Se. ¼) has enjoyed a long continuance. The main entry runs east and southeast for a considerable distance, showing at its extremity a slight dip to the east. The roof is a fairly firm shale, showing, as does the coal itself, occasional streaks of pyrites. The mine is entered by a gentle slope 125 feet long, over which cars are hauled by means of a pull-rope attached to a small single engine. About twelve men are employed during the winter. A short space northeast, on the same forty acres of land, is the small Hollingsworth & Rickabaugh slope to the same seam.

Pella. Pella itself lies on a rather level divide on which, over a limited area, the surface drainage is poor. The water sinking through the porous soil has tended to destroy the value of what coal lies immediately under the city; so that all mines now working are situated a few miles from the corporation limits. These mines do no shipping and are not large affairs; yet they do an important wagon trade. Two miles northwest of Pella (Lake Prairie Tp., Sec. 32, Ne. qr., Se. ¼) is the Buwalda mine, where coal is taken from a seam which varies in thickness from three and a half to five feet. In places six feet of coal has been encountered, but in such cases the condition of the overlying "draw slate" made mining impracticable. The shaft was sunk 112 feet, chiefly through sandstone, and is most fortunately placed at the lowest point of the basin. Sandstone forms the roof, except where slate somewhat erratically intervenes between it and the coal. The same coal was mined from a shaft situated one-fourth mile east. It is estimated that this coal pocket contains about 200 acres, less than half of which has been worked out.

The Dieleman Coal Company has a shaft to a seam of similar thickness one mile south of the Buwalda (Sec. 5, Ne. qr., N. ½). In this shaft, which is 104 feet deep, less sandstone and more shale were penetrated. The main entries extend 100 yards north and 150 feet south of the shaft. The seam is undulatory, as is usually the fact in this region.

In the rough country on the border of the Des Moines river valley, south of Pella, seams outcropping in the ravines are occasionally drifted for local use. Several basins containing coal three feet or more in thickness have been located; but very little prospecting has been done and little is known about the nature and extent of the workable coal.

DISTRICT SOUTH OF DES MOINES RIVER.

Swan. Several shipping mines have operated at Swan, in the Des Moines valley near the Marion county line. The town is situated in the midst of a considerable coal field, not yet completely mined out, but abandoned since 1898. Three seams were present, as shown in the following section (Swan Tp., Sec. 18, Sw. qr.), the upper being about twenty-five feet above the level of the railroad track.

SAMPLE DRILLING AT SWAN.

		FEET.	INCHES.
10.	Clay	23	
9.	Coal	2	10
8.	Fire clay	4	
7.	"Slate"	11	8
6.	Coal	3	3
5.	Fire clay	3	
4.	Sandstone	1	6
3.	"Slate"	20	6
2.	Coal	5	6
1.	Fire clay	2	3

Coal Creek. Several small country mines are occasionally worked by slopes and shallow shafts along Coal creek (Pleasant Grove Tp., Secs. 17, 20, and 21). The seam is seldom more than three feet thick. The upper part of the section given below is exposed on the west bank of the creek (Sec. 20, Ne. qr., Nw. ¼).

		FEET.	INCHES.
9.	Surface wash	5	
8.	Coal		6
7.	Fire clay	2	
6.	Shale, light-colored, argillaceous	2	6
5.	Shale, drab, arenaceous	5	6
4.	Sandstone, gray, laminated or massive	3	
3.	Shale, gray, arenaceous	3	
2.	Shale, black, upper 13 feet exposed to water level	30	
1.	Coal	2	6

Red Rock. One mile south of Red Rock, Keyes reports a four-foot coal lying immediately underneath the Red Rock sandstone, twenty feet above river level. This seam is said to have been opened on Teter creek and to be exposed at the ferry at Rousseau.

Whitebreast Creek. Along the upper portion of the valley of Whitebreast creek in Marion county, there is known to be much coal. Owing to lack of transportation facilities, only country mines have been opened. These are located chiefly in sections 24, 26 and 35 of Franklin township, and 19 and 30 of southwestern Knoxville township. The following sequence (Franklin Tp., Sec. 26, Ne. qr., Se. 1/4) is typical.

		FEET.	INCHES.
10.	Drift and loess	5 to 15	
9.	Sandstone, very hard	4	
8.	Slate, gray	8	
7.	Sandstone, yellow, soft	11	
6.	Coal	2	2
5.	Fire clay	6	
4.	"Slate," gray	10	
3.	Coal, at creek level	3	9
2.	Fire clay and black "slate"	60	
1.	Coal	4 to 6	

Number 3 of the above section is the coal usually mined, although some has been taken from the outcrop of number 6. In general, the coal is quite soft.

Gosport. Coal outcrops at several points along English creek in the vicinity of Gosport and has been drifted for local consumption. Where worked, the coal shows thicknesses of three feet and less, and near the outcrop naturally possesses a roof of poor stability. The coal seen along this creek probably belongs to a succession of basins lying in a limited number of horizons. The advent of a railroad would probably cause considerable development work to be inaugurated.

Knoxville. In the northeastern corner of the city of Knoxville, a number of mines were formerly opened to supply the city trade. The coal was about three feet thick on an average, increasing to six feet in a few places. It is said to have lain in a narrow trough running northwest and southeast and overlain by black "slate" and small patches of sandstone.

In the valley of English creek, south and southeast of Knoxville, several local mines have been opened to supply the surrounding country districts and Knoxville. Three miles south of Knoxville is a five-foot coal with a good roof of black "slate." Where reached by slopes, it dips southeastward. Farther east (T. 75 N., R. 19 W., Sec. 20), at least two coals, separated by twenty feet of shale, are known. The lower may be reached from the valley by drifts and is from forty inches to four feet in thickness. Evidences of coal may frequently be detected in descending the creek from this point. Three miles southeast of Knoxville, on English creek, are two coal banks which do an important wagon trade. Of these, the most southerly is the Hayes bank (T. 75, R. 19, Sec. 15, Sw. qr., Nw. 1/4). This is a slope driven east to a six-foot seam which lies about forty feet beneath the surface at the slope mouth. The soapstone roof requires careful watching. The Miller bank is on the opposite side of the creek, one mile north (Sec. 9, Se. qr., Nw. 1/4). A coal varying in thickness from forty inches to six feet is entered by a drift situated about forty feet above the level of the creek. This seam is the one also mined by the English Creek Coal Co., one mile north. It is said that a lower coal has also been found here; but details are not available.

Flagler. The Whitebreast and other coal companies mined out more than 100 acres at Flagler. Since only the best coal was removed, there still remains a fair supply at the village and a few small mines are utilizing it. There are two horizons, both of which have furnished workable coal. The old Whitebreast No. 11 worked in a lenticular basin which thinned rapidly in all directions from a central point where a thickness of fourteen feet is reported. The Knoxville Fuel Company has recently reopened a slope in the hillside, just below the station of the Chicago, Rock Island and Pacific Railroad (T. 75, R. 19, Sec. 3, Ne. qr., Se. 1/4). At present an elevated tramway runs 800 feet from the slope mouth to a tipple beside the Chicago, Burlington and Quincy tracks; but a new opening is planned for the near future. Rope haulage is to be installed shortly. At the slope mouth the seam is only slightly below the entrance; it dips strongly to the north for 300 feet, becomes level for 400, dips north once more for the next 600, and then remains constant in position to the end of the entries. Since the slope opens to the south, water does not drain off naturally, but must be removed by siphoning and pumping. Prospecting in this neighborhood revealed a continuous basin covering at least 500 acres. The coal is quite regularly five feet thick and is overlain by from twenty to forty feet of hard "soapstone" shale. A boring at the Rock Island depot shows that the seam lies forty feet below the railroad; while a trial shaft one mile north of the Knoxville mine shows a continuance of five-foot coal to that point.

On the south side of the Chicago, Burlington and Quincy tracks, opposite the Knoxville mine, a few small slopes are taking coal left in old workings in the lower horizon. The amount to be won in this manner is not great.

One mile west of Flagler, the English Creek Coal Company operates what is commonly known as the "Hawkeye mine," loading on a switch from the Chicago, Rock Island and Pacific (Sec. 4, Se. qr., Se. 1/4). The shaft is fifty feet deep to a seam which varies from three to six feet in thickness, and occasionally cuts out completely for short distances where rolls are present in the roof. The few "bowlders" in the coal do not give much trouble, nor do the slips, or geological faults, which sometimes change the level of the coal as much as three feet. The seam has a strong dip to the south. The mine has a good

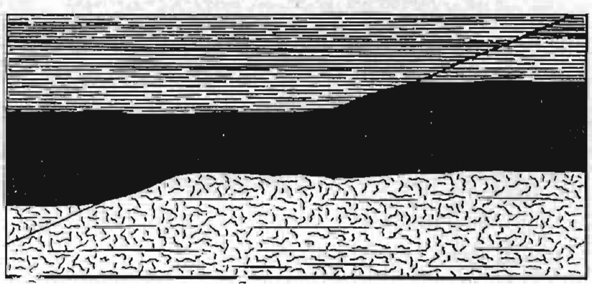


Figure 42. Fault in Hawkeye mine. Flagler.

"slate" roof, separated from the coal by two feet of "draw slate." Hoisting is done with a geared double engine, cylinders 12x18 inches. Three thousand feet of tail rope used for underground haulage are propelled by an engine situated above ground. Much coal has been mined out here, but the company owns a large field where work is now being carried on, one-half mile to the south.

Coalport. At one time Coalport was an important town, supplying coal to the numerous steamboats then plying between the cities located on the navigable portion of the Des Moines river. With the cessation of navigation, mining on a large scale was abandoned and today only one mine is open—a drift in the face of the bluffs beside an abandoned channel of the river (Polk Tp., Sec. 14, Sw. qr., Se. ¼). The coal here is from six to eight feet in thickness, lies fairly level at an elevation twenty-five feet above that of the river, and has as a characteristic feature a four-inch "sulphur band" in its center. Rolls occur, though the coal is never reduced to less than four feet. The coal is soft, but will stand transportation; a little is hauled to Howell and

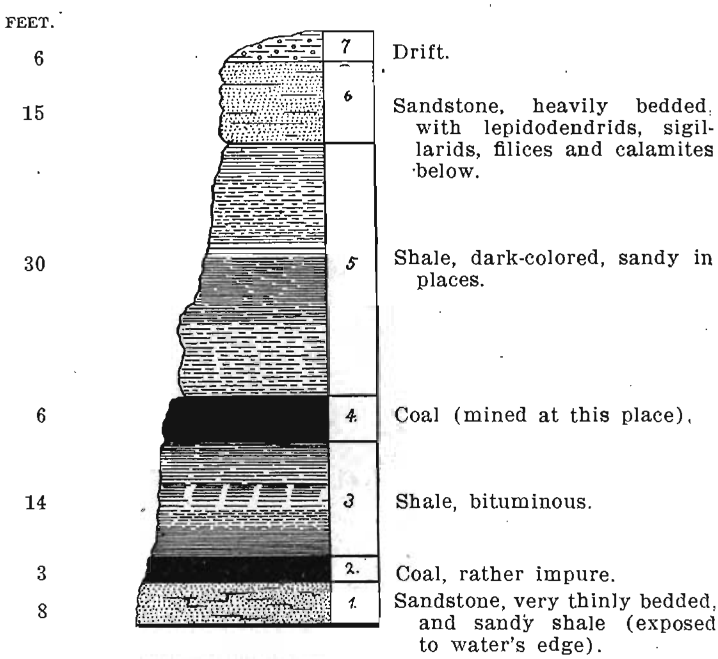


Figure 43. Section at Coalport (Keyes).

shipped from that point. A lower seam is also found here as shown in the accompanying illustration of the section found in the bluff.

Harvey. Workable coal is known near Harvey, both northwest along the Des Moines river and south as far as Walnut creek. Two local mines are now in operation a short distance south of the town. The V. R. Olive bank (Clay Tp., Sec. 9, Se. qr., Se. 1/4) is a hundred foot slope with a thirty per cent grade. The seam is four to six feet in thickness and contains a few pockets of ironstone "bowlders." The roof is eighteen feet and more of a "slate" bearing occasional arenaceous patches. One-half mile southeast is the Lone Star slope (Sec. 15, Nw. qr., Nw. 1/4). The company is now pulling pillars preparatory to moving a short distance to a location nearer the center of the field. This particular basin is said to contain only thirty acres of good coal. With the exception of a few "bowlders" the seam is clean and regular. Both the above mines haul some coal to Harvey for shipment.

The Hawkeye Portland Cement Co., located at Harvey, report that they have prospected 280 acres of land owned by them in section 20, Clay township, and 120 acres in neighboring parts of sections 21 and 28 and have found good coal under the greater part. The seam lies at slightly varying elevations, but is never more than 100 feet below the surface. The borings are said to show from fifteen to fifty feet of soil and yellow clay, forty to sixty of light-colored shale, six to seven and a half of coal, followed by fire clay, sandstone, and a succession of shales to the Saint Louis limestone. Between this area and Everest corporate interests control extensive coal rights on land which they are holding for future development.

Everest. Liberty township, in the southeastern corner of the county, is now the scene of vigorous activity in the mining industry. Everest (Sec. 17) is a new mining camp containing about 200 houses, the homes of employes of the Mammoth Vein Coal Co. The field is a large one and may be expected to turn out much coal. Mammoth Vein No. 5 is a short distance northeast of the camp (Sec. 17, Ne. qr., Nw. 1/4). In point of output it is the largest in the county and ranks well up with the best producers in the state. The average thickness of the seam at this mine is over eight feet; while as much as fourteen and a half feet has been carefully measured at one point and sixteen feet is reported at another. From the foot of the shaft the bed dips gently toward the southeast and rises towards the northwest. The roof is a firm "slate" about eleven feet in thickness. Coal is hoisted forty-five feet from the bed to the surface by a geared double engine with cylinders 12x14 inches. Steam is furnished by four boilers, two of seventy-five horse power each and two of 150 each. The equipment for producing the electric power

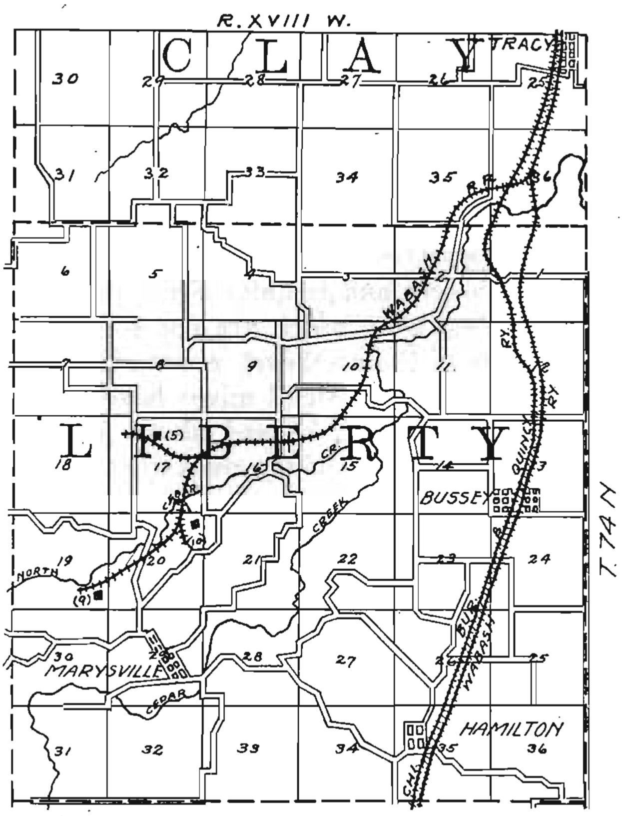


Figure 44. Map showing shipping mines in southeastern Marion county.

used at all the company's mines is located here. At No. 5, electric lighting is used in the main entries and haulage is effected over 2,500 feet of track running northeast and southwest by two class B Goodman motors.

Mine No. 9 of the same company is one mile northwest of Marysville (Sec. 19, Se. qr., Se. ¼). This slope is not yet developed, although entries are completed for 1,000 feet and the mine is ready for work at any time. The coal is from six to ten feet in thickness. Near No. 9, on Mr. Feagan's land, is a small drift supplying a local trade from the same coal bed.

The Mammoth Vein numbers 10 and 11 are a pair of slopes facing one another from opposite sides of a deep ravine (Sec. 20, Ne. qr.). Formerly the two openings were connected across the gulch by an elevated tramway and dumped their product at the same point. A fire so seriously damaged No. 10, however, that it has been temporarily abandoned. Electric power is conveyed across country from No. 5 by cable. One class B motor hauls cars over 3,200 feet of rack-rail track in No. 11, and along the side of the ravine to the tipple. Electric lighting is employed in the main entries. The mine is entered by a slope 400 feet long, with a sixteen per cent grade. The coal averages about five feet in height and is quite clean, except for "bowlders" of impure limestone, which are not a serious source of trouble. The dip is to the northeast, about sixteen feet in 100.

Marysville. A number of small mines have operated in the valley of South Cedar creek, at and above Marysville. The Avery mine, on the south side of the creek near Marysville (Sec. 32, Ne. qr., Nw. ¼), is now taking out some coal for local trade during threshing time and winter. At the end of a slope, 100 feet long and with a grade of one in eight, is found coal six feet in thickness, lying not far from the level of the water in the creek. The dip is southwest and the overlying stratum a sandstone. "Bowlders" of impure limestone occur in sizes ranging from pebbles to rocks three feet in diameter. The basin in which this seam lies apparently covers considerable territory in this region. A tract of land near Marysville has been purchased by one of the large coal companies of a neighboring county.

Hamilton and Bussey. Many openings have been made in the area embraced between Cedar creek and the railroads connecting Bussey and Hamilton. Just southwest of the latter town, there may still be seen the top works erected by the Southeastern Coal Company, which sank 200 feet to a seam from four to eight feet thick, but did not develop the mine farther. There is good coal here, although "bowlders" and thin lenticles of rock in the coal give some trouble. The York Coal Company worked a shaft 164 feet deep half a mile north of town, on the Wabash railroad. The coal here was from three to six feet in thickness and was cut out by rolls in many places. The mine was abandoned one year ago (1906). West and northwest of Hamilton thick coal is found in several horizons; but reliable accounts of the relationships of the various seams cannot be obtained, as little mining has been done for a number of years. The forthcoming publication of a topographic map will enable more exact correlations to be made. The section at the Novelty mine, an abandoned shaft not far north of Hamilton, may be useful for purposes of comparison.

		FEET.	INCHES.
10.	Clay, yellow	20	
9.	Limestone	4	
8.	Sandstone	2	
7.	Shale, gray	60	
6.	Shale, dark gray, fissile	14	
5.	Coal	2	6
4.	Shale, black, fissile	20	
3.	Coal		8
2.	Ironstone "bowlder"	3	
1.	Coal		1

Several shipping mines once operated west of Bussey in coal four feet and more in thickness. The O. K. company mined out nearly 100 acres from slopes and shallow shafts. When the region was visited by the author, only two mines, both small, were in operation. Near one of the former O. K. mines (Sec. 23, Nw. qr., Ne. ¼), is the new slope of the Campbell and Guthrie Coal Company. The seam shows a constant thickness of about four feet; while two thinner coals appear at a slightly higher level. This slope works to the south and opens to the north. A short distance north, in section 14, is the small B. B. mine, worked during the colder portion of the year. Coal is elevated through the thirty-foot shaft by horse and gin. The bed worked is four feet thick and, as usual in this district, contains a few "bowlders" of clay ironstone.

MAHASKA COUNTY

As in Marion county, the coal basins of Mahaska are seldom of large size, though often bearing thick seams of coal. Two causes have operated to limit the fields: (1) pre-glacial and post-glacial erosion have sometimes destroyed the continuity of basins previously quite extensive, and (2) the irregular basement upon which the Coal Measures rest in many cases restricted the original area covered by individual coal swamps by its influence on Pennsylvanian topography. The last statement perhaps requires some elaboration. As discussed elsewhere in this volume, the Des Moines strata everywhere lie unconformably on a strongly eroded surface which, previous to the deposition of the Coal Measures upon it, had been carved into hills and valleys much resembling the present surface of the county. When the region was depressed somewhat below sea level, or tilted so that drainage was checked, deposits of sand and clays were made first in the depressions on the surface and extensive swamps were also formed. The consolidation and compression of these deposits resulted in the formation of the sandstones, shales, clays and coals which today constitute the Coal Measures of Mahaska county. Thus we often find that the coal basins are limited laterally by the resistant calcareous strata that originally formed the sides of the valleys and wide depressions in which the coal plants grew. Continued deposition of sediments eventually buried even the highest points of the basal formation; but subsequent erosion removed much of the higher strata thus formed and again exposed the underlying limestones. In a large part of the northern and eastern sections of the county, where little coal has been discovered, Coal Measure strata remained in only isolated patches, so that the drift was laid down directly on the Saint Louis in many cases. The more important streams later removed both the drift and the Coal Measures from the lower portions of by far the greater part of their valleys.

Although great quantities of coal have been mined in Mahaska county, the productive areas have been confined to a comparatively small portion of the whole region. Mining on a large scale was first undertaken on Spring creek, near Oskaloosa, and

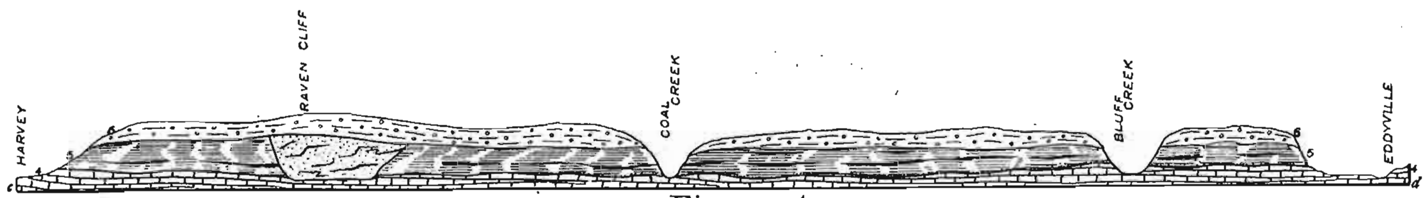


Figure 1.

Figure 2.

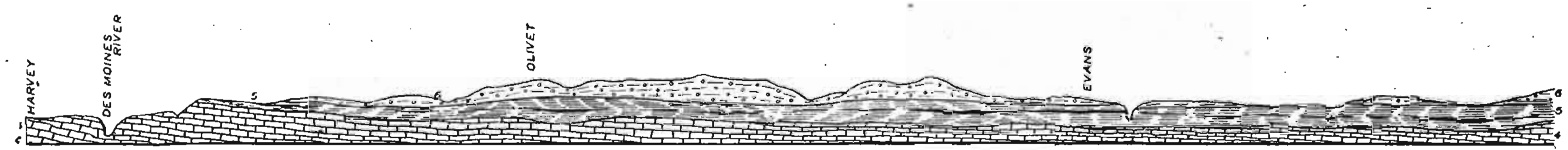


Figure 2.

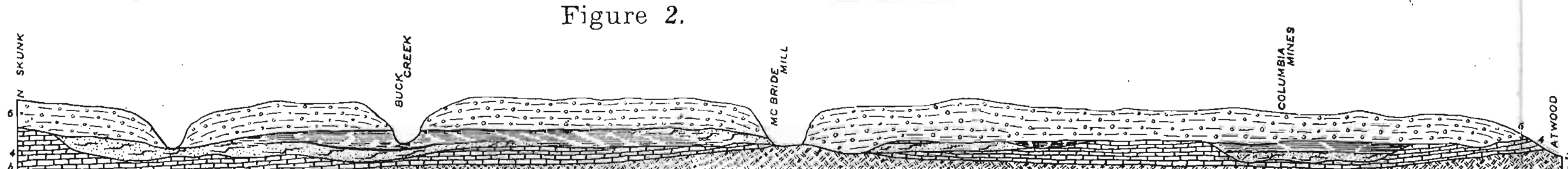


Figure 3.

Figure 4.

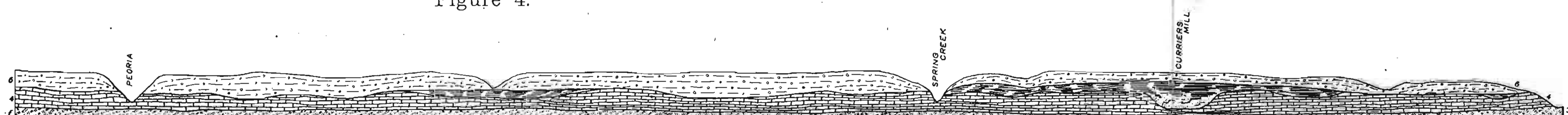
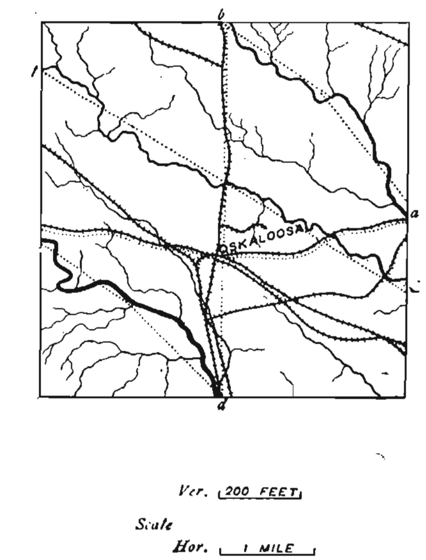


Figure 5.



Geological cross-sections in Mahaska County.

1—Osage stage; 2—Springvale beds; 3—Verdi beds; 4—Pella beds; 5—Des Moines stage; 6—Drift.

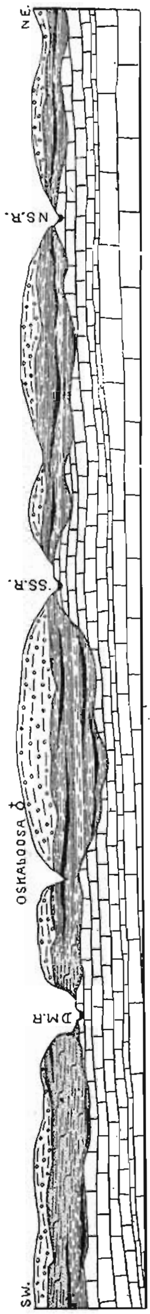


Figure 45. Ideal cross-section in Mahaska county.

in the valley of Muchakinock creek. The coal worked lay in basins of limited extent, separated by areas in which coal was thin or lacking. The succession of strata above and below the coal roughly corresponds in the various fields and the altitude of the coal itself may be placed in several cases between 700 and 730 feet above sea level. It seems probable that the gradual subsidence of the region during Pennsylvanian times was checked at certain periods, sufficiently long to allow quantities of peat to accumulate in depressions on the lowlands.

Production in the Muchakinock valley has been largely replaced by the development of coal beds in the southwestern corner of the county, a fact made possible by the extension of the Chicago and North Western Railway into the latter territory. The coal seams of this area present the peculiarities of those of adjoining fields in Marion and Monroe counties. The basins of coal are lenticular in shape and are not large; the coal is higher than in many parts of the Iowa field, but where thickest often contains aggregations of clay ironstone 'bowlders" distributed "like raisins in a cake." In this region the Coal Measures are found to extend to greater depths than in many other sections of the county, although shafts usually reach the coal at depths of less than one hundred feet.

As a producer, Mahaska has always stood at or near the head of the list of Iowa counties. During the eighties and early nineties she stood pre-eminent, but was passed by Monroe and Polk in 1901, and by Appanoose in 1902. The annual output given by the federal census for 1860 was 3,412 tons; for 1870, 32,550; for

1880, 283,961; and for 1890, 1,056,447. The production published by the Iowa and the United States Geological Surveys for the last ten years is:

YEAR.	TONNAGE.	YEAR.	TONNAGE.
1898	1,292,787	1903	707,459
1899	1,277,248	1904	663,943
1900	1,098,617	1905	714,945
1901	899,618	1906	602,487
1902	549,245	1907	757,778

The State Mine Inspectors report that 772,468 tons were produced and 1,586 men employed by the thirty-five largest mines in the county during the year ending June 30, 1908.

Below may be found a brief description of the various fields and of the mining in progress in August, 1907. The author is under obligations to previous reports of this survey for data respecting the older mining districts.*

Figure 46. Map showing location of mines in southwestern Mahaska county.

DISTRICT NORTH OF SOUTH SKUNK RIVER.

This district appears to contain but few workable basins, although there are doubtless some which remain to be discovered. Considerable prospecting has, however, been undertaken without bringing any positive results. From Peoria east to New Sharon and beyond, and near Barnes City, Indianapolis, and Tioga, persistent search has been fruitless, in many cases not

*Keyes. *Coal Deposits of Iowa*, Iowa Geol. Surv., Vol. II, pp. 340-356; Des Moines, 1894.
Bain: *Geology of Mahaska County*, *Idem*, Vol. IV, pp. 315-380. 1895.

even revealing thin seams. Still, it would be going too far to postulate from evidence so far gained, that northern Mahaska will not in time be the scene of active operations. The only localities in the district which have yielded good coal up to the present time are near New Sharon and Rose Hill.

New Sharon. An area covering a little more than two square miles on the ridge between North Skunk river and Buck creek, about three miles northeast of New Sharon, has furnished coal to a local trade for a number of years. Some large companies have prospected the region, but have apparently considered that their discoveries did not justify the considerable expense incident to the establishment of shipping mines. The Coal Measures are not very thick in this area, as shown by the fact that the St. Louis limestone has been found in the valley of the Skunk only a short distance both above and below the coal field.

Three local mines are now producing, all operating in the same coal. The Williams mine (Union Tp., Sec. 9, Sw. qr., Ne. ¼) is entered by a slope 200 feet long, having a grade of one in three and a half. Entries extend one-fourth mile north, east and west, through coal which varies from two to five feet in thickness. The seam is sharply undulatory and has undergone faulting on a small scale. Nearly a score of old shafts and slopes have been worked on this farm. A short distance west is the Williams Brothers mine (Sec. 8, Se. qr., Ne. ¼) with a slope 400 feet long. The average thickness of the seam here is four feet, while in other respects it has the same charactristics as at the Williams bank. As many as thirty men have been employed here during a few winters; but the output has declined of recent years. Cars are hauled up the slope by steam power. Not far northeast is the Duffus mine (Sec. 9, Nw. qr., Sw. ¼), also a slope using steam haulage. The slope is 220 feet long and has a twenty-five per cent grade. This is comparatively a new mine at which only a few acres have been mined out. The coal averages about forty-four inches in height and shows no faults. A few "bowlders" are present. The following section may be considered typical for the Buck creek district.

		FEET.
7.	Soil and drift	40
6.	"Slate"	2
5.	Limestone	1

4. "Slate"	12
3. Coal	2-5
2. Fire clay	0-6
1. Sandstone	

Southwest of these mines, near the Skunk (Sec. 17, Sw. qr., and Sec. 18, Se. qr.), a seam forty inches thick, but split into two benches by twenty inches of clay, has been drifted a little. It does not appear to be continuous with the Buck creek coal.

Rose Hill. Three miles west and one north of Rose Hill, at Blyth, is the new mine of the Atwood Coal Company (White Oak Tp., Sec. 6, Nw. qr., Nw. ¼). A spur track was run in from the Chicago, Rock Island and Pacific railway in January, 1907, and considerable coal is now being shipped. The shaft is fifty feet deep and a modern steam hoisting equipment has been installed. Walker's lift-rail device is used on the cages for dumping the cars. The operators plan to use a number of Ingersoll-Rand machines underground, both of the shearing and of the undercutting types. The seam is from five to six and a half feet in thickness, with the brightest and heaviest coal in the upper half of the bed. The roof is a dark "slate" which is always strong, while its thickness varies from fifteen to fifty-five feet. About one mile west (Spring Creek Tp., Sec. 1, Nw. qr.) coal believed to be part of the same seam was formerly mined

Six miles east of Blyth, on the east side of North Skunk river, shipping mines were once in operation (Monroe Tp., Sec. 36, Ne. qr.). The basin found here was not of great extent, and in its higher portions possessed only a drift clay roof where the shale had been cut away. The sequence in this area is:

FEET.	
4	5. Shale, dark gray, poorly bedded, often very much broken (exposed).
2	4. Shale, dark-colored, variable thickness.
6	3. Coal, containing some clay ironstone, slightly above river level.
1	2. Fire clay.
15	1. Sandstone, rather massive, ferruginous.

Figure 47. Seam of coal northeast of Rose Hill.

DISTRICT BETWEEN THE SOUTH SKUNK AND DES MOINES RIVERS.

This district for many years produced more coal than any other of equal size in the state, but the chief fields are now exhausted. The Muchakinock valley and the country immediately surrounding Oskaloosa have yielded the most coal, while Black Oak and Cedar townships, forming respectively the northwestern and southeastern extremities of the district, have failed to show good basins. The region is magnificently supplied with railroad facilities and this feature has had much to do with the magnitude of the coal industry within it.

Leighton. A little coal is still taken out for the country trade from the district a mile or two southeast of Leighton, where a seam from three to five and a half feet in thickness has been reached by drifts and shallow shafts. Where the drift approaches dangerously near the coal, mining is precarious, but in many places a firm "slate" above the coal obviates this difficulty. A section of one of the old shafts (Scott Tp., Sec. 12, Ne. qr.) is:

		FEET.
5.	Soil and drift	34
4.	"Slate"	16
3.	Coal	5
2.	Fire clay	6
1.	"Slate"	

Olivet. In 1904, the Rogers Coal and Mining Company took over a small mine near the Olivet station (Scott Tp., Sec. 9, Sw. qr., Ne. ¼) and has been gradually increasing the output. The seam varies from three to six feet in height and is unusually level. It lies 118 feet beneath the surface, at an elevation of about 700 feet above tide. Immediately over the coal is sixteen feet of "hydraulic rock," capped by a compact sandstone. Two coal horizons are known above the one worked. The fire clay forming the floor in the mine has been tested and shown to be of good grade for fire brick and glazed tile purposes. Only four acres of coal have been mined out; the operators report that 314 acres are known to be underlain with good coal and that probably twice as much may be assigned to this basin.

Half way between Olivet and Evans (Sec. 11, Se. qr.) is the small local mine of the Lester Butler Coal Company, open winters and threshing times only. Hoisting is done by horse-gin. The seam is about three feet thick and lies sixty feet under the surface of the country, indicating the possibility of its being in the same horizon as the second seam at Olivet.

Evans. Two miles west of Evans, on a switch running a half mile south from the Chicago, Rock Island and Pacific railway, is shaft No. 4 of the Garfield Coal Company (Scott Tp., Sec. 13, Nw. qr., Se. ¼). This mine was opened in 1905 and has since worked three-fourths mile south and one-half mile west. The company owns 550 acres and leases 200 more, the whole known to be underlain with coal which, however, is thin in places. At the shaft the seam is five feet thick and lies 110 feet beneath the surface. Tail-rope haulage is employed in the south and west main entries. Some of the coal is mined with machines; four cutting and two drilling machines are driven by an Ingersoll air-compressor. Hoisting is by an Ottumwa direct-connected engine, supplied with steam by two boilers of 150 horse power each.

A half mile west of Evans, near Muchakinock creek (Garfield Tp., Sec. 18, Ne. qr., Se. ¼), is the slope of the Clean Coal Company. The slope is 200 feet long; the air shaft forty feet deep. A small haulage engine brings cars to the surface by means of a pull-rope, whence they are propelled over a tramway 200 yards north to a coal switch. This seam averages three to four feet in thickness.

The greater part of the coal contained in the basin between Evans and Garfield No. 4 has been mined out. The basin is a large one; but the actual relationships of its various parts are so obscure that no attempt is made here to define its limits. Coal has been found in at least three horizons, separated from one another by from forty to eighty feet of shale and fire clay. The principal seam is said to have attained a thickness of eleven feet in a few instances. It is roofed by from twenty-five to fifty feet of carbonaceous "slate," and underlain by from three to twenty feet of fire clay. The dip is, in general, to the southwest. Following is the record of a drill hole in section 18 (Sw. qr.).

		Feet.	Inches.
6.	Drift	18	
5.	Shale, gray	8	
4.	Coal	1	
3.	Shale, gray	25	
2.	Shale, bituminous	47	
1.	Coal	6	2

Bolton. Bolton is a mining camp three miles west of Beacon, at the end of a coal spur running north from the Chicago, Burlington and Quincy railway. Here, since 1902, has been located the slope of the Bolton-Hoover Coal Company (Garfield Tp., Sec. 19, Sw. qr., Ne. ¼). The slope extends 150 feet to the coal, which lies seventy feet below the surface and is from four and a half to six feet thick, with an average of five feet three inches. Thirty feet of firm "slate" lies between the coal and the surface drift. Sumps ten feet deep fail to penetrate the fire clay beneath the seam. Sufficient coal is said to exist in this basin to supply the company's mines for ten years to come, although 220 acres have already been mined out. One-half mile southeast of the slope is a pre-glacial channel filled with drift and cutting out the coal over an area 400 yards long and 100 wide. In the mine the haulage rope extends over a mile to the present workings, while the tail-rope runs above ground for nearly a mile and descends into the mine through an old drill hole. Within another year, the company intends to run in another slope 1,200 feet northeast of the one now in operation.

Beacon. Much coal has been taken out on all sides of Beacon and operations have not yet ceased. Quite recently several shipping mines were located on a coal switch running west from the town through sections 27 and 28; but of these only one remains. Slope No. 3 of the Garfield Coal Company is a mile west of Beacon (Garfield Tp., Sec. 28, Ne. qr., Ne. ¼). The seam here has shown as much as six feet of coal, although the average is nearer five feet. This slope, which opens to the south and works towards the north, has been in active operation for three years and its workings are just beginning to break into those of old Garfield No. 1, which was situated between number 3 and Beacon. When the mine was first opened rolls in the black shale roof gave considerable trouble, often cutting down the coal to a thickness of three feet or less; but at present these are only infrequently encountered. Loaded cars are hauled 800 feet from the foot of the slope to the surface by a pull-rope operated by steam power.

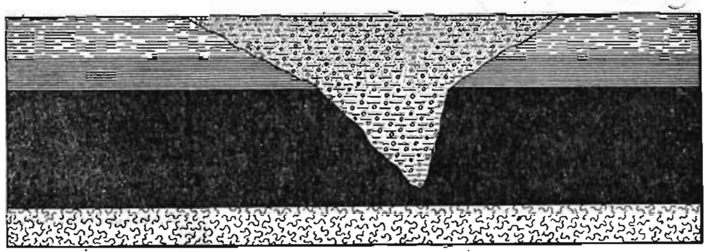


Figure 48. Coal Bed, having small erosive channel filled with drift material.

West of the Garfield (Sec. 21, Sw. qr., Se. ¼) is the small country mine of Toy and Deaver. Very little coal has been taken out yet from a fairly regular four-foot seam. Cars are pulled up the steep slope from the mine by horse and gin.

The succession of strata in the Beacon district is indicated by the following drill record (Sec. 28, Ne. qr., Sw. ¼).

		FEET.	INCHES.
10.	Surface	15	
9.	Sandstone	1	
8.	"Slate," gray	18	
7.	Coal		4
6.	Fire clay		6
5.	"Slate," black	17	
4.	Coal	1	
3.	"Slate," black	26	10
2.	Coal	4	8
1.	Fire clay	2	
	Total	86	4

A lower seam was discovered some time after bed number 2 of the above record had been opened up. It extends from Garfield No. 3 at least one mile west and is reported to be from forty to fifty inches in thickness. It is supposed to be a split from the upper coal, though little has been positively ascertained on this point. The coal worked at Beacon, Bolton, and Evans is very similar in character and is found with a similar association of strata; it may perhaps lie in a series of pockets belonging to the same horizon. This point, however, is of little economic importance, since the general inconstancy of coal beds found in Mahaska and neighboring counties renders the drill the court of first and last appeal when definite information in regard to the occurrence of coal is desired.

A mile north of Beacon (Sec. 22, Ne. qr., Ne. 1/4) is the Ream bank, a small drift taking coal chiefly from old workings. The bed worked varies in thickness from two to six feet. Near the wagon road between Beacon and Oskaloosa are several local mines which do business in a small way. The one nearest Beacon is the Colter mine, formerly the Sowden (Sec. 23, Sw. qr., Nw. 1/4). This is an old mine operating a sixty-foot shaft to a seam five feet in average thickness. The roof is a "slate" which is not always firm. Near the Colter, but on the north side of the Chicago, Rock Island and Pacific cut-off (Sec. 23, Nw. qr., Se. 1/4) is the Raven mine, formerly a shipping concern, but now supplying local trade only. The coal available from the present fifty-foot shaft has been almost exhausted. The seam is three feet thick. A short distance north of the Raven, on the same land, a new slope is being driven into the hillside from the valley of a small stream. The coal is of the same thickness here as at the Raven, and outcrops in an adjacent ravine. Only a small area of coal remains to be won from this opening. Southeast of the Raven, on the south side of the Iowa Central tracks (Sec. 23, Se. qr.), is the Wassenchove mine, reached by a shaft seventy feet in depth. The bed averages four feet and thickens in the "swamps."

Oskaloosa. While there are places under Oskaloosa where coal has been cut away, or is only thin and of poor quality, the greater part of the city is built over a good bed of coal. A number of small mines have been operated in various parts of the city and east and northeast of the corporation limits, on Spring creek. As a typical section for the district, there may be taken the following record of the shaft of a former mine in the southern part of the city (Sec. 24, Ne. qr., Se. 1/4).

	Feet.
7. Drift	60
6. Sandstone	3
5. Shale, bituminous	21
4. "Hydraulic rock"	1
3. Shale, bituminous	18
2. Coal	6½
1. Fire clay	4

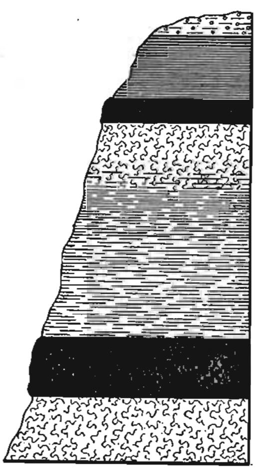
A few small mines are now operating for the city trade. In the northeastern section of Oskaloosa, north of the new cemetery, is the Cunningham mine. The shaft is sixty feet deep to a seam four and a half feet thick. The roof is a thick blue "slate." Just north of the city limits, near the old cemetery, is the forty-foot shaft of the Schultz mine. The work at present is in four feet of coal, although the average for the mine is slightly less. Both the above mines hoist by means of horse and gin. Several local mines are still taking coal from the once productive Carbonado district, but they are small affairs and usually work only during the winter months. Among the more important ones may be mentioned the Barrowman and Oakley mine, three miles northeast of Oskaloosa, and the Davis, one mile east of the same city. The coal at the last named mine varies from five to six feet in thickness and is, perhaps, a continuation of that of the Oskaloosa district and separated from it by pre-glacial erosion. Several hundred acres of coal was left untouched because of the failure of suitable cover between it and the drift.

Muchakinock. For many years the region around Muchakinock, a former mining camp one mile east of Given, produced more coal than any field of similar size in Iowa. Later the mining companies turned their attention a short distance to the north, and finally, having completely exhausted the basin, left for new fields. Coal was shipped over a long coal spur of the Chicago and North Western Railway, chiefly by the Consolidation Coal Company, the largest operator in the district. The coal lies in an irregular area about two and one-half miles east and west by three and a quarter north and south. The area extends but a short distance south and about an equal distance east and west of Muchakinock itself. "The coal does not connect directly with that of the other basins, low coal shales and 'hydraulic rock' occupying its place along the dividing lines. The bed lies at a general elevation of thirty feet above the underlying limestone with fire clay, graduating below into shales, between. An upper coal is usually found wherever the cover is sufficient to have protected it. It varies in thickness from one to four feet, but it is of poor quality and of no value.''*

Below is the record of a drill hole bored from the prairie level near old Consolidation No. 7 (T. 75, R. 16, Sec. 36, Nw. qr.):

		FEET.
6.	Drift	28
5.	Shale, gray, argillaceous	26
4.	Coal, with pyrites	½
3.	Sandstone	3
2.	Shale, bituminous, fairly firm	54
1.	Coal	5
	Total	116½

The only mines now to be found in the district are three small, local banks that are utilizing coal which the exigencies of mining caused the larger companies to pass over. These banks are: (1) the Boggs, one-half mile north of old Muchakinock (Harrison Tp., Sec. 7, Nw. qr., Sw. ¼); (2) the Plum, one-half mile east of Muchakinock (Sec. 7, Sw. qr., Se. ¼); and (3) the Kennebec,



		FEET.
6.	Soil	1
5.	Shale, dark gray, somewhat fissile	3
4.	Coal	1
3.	Fire clay, and clay shale	10
2.	Coal	3
1.	Fire clay (exposed)	3

Figure 49. Bluff near Given.

*Bain: Iowa Geol. Surv., Vol. IV, p. 362; Des Moines, 1895.

one-half mile south of the Plum (Sec. 18, Nw. qr., Se. ¼). Before the Pekay switch was removed, the Kennebec hauled some coal to it for shipment.

Given. West of Given is a small coal area distinct from that of Muchakinock, yet closely related to it. Of former mining in this basin, nothing remains. The exposure shown in the figure may be seen in the bluff near Given.

Half way between Given and Beacon is an area of coal closely related to that in the Muchakinock basin, as may be seen by comparing the Muchakinock section already given with the following record at old Consolidation No. 8 (Garfield Tp., Sec. 34, Sw. qr., Se. ¼):

		FEET.
8.	Drift	18
7.	Shale, gray, argillaceous	32
6.	Coal	1½
5.	Sandstone	4
4.	Shale, bituminous	49
3.	Coal	7
2.	Fire clay, graduating below into gray shale	35
1.	Limestone (Saint Louis)	

With its field of action limited by old workings north and south, the mine of the National Union Coal Company, two and one-half miles south of Beacon (E. Des Moines Tp., Sec. 3, Ne. qr., Sw. ¼), still continues to do a considerable shipping business. Coal is brought to the surface by both a slope and a shaft, the former 100 feet long, the latter thirty-three feet deep. Rope haulage is already in use from the foot of the slope to the surface and is to be extended underground. Undulations in the coal bed are sufficiently pronounced to create heavy grades in the roads. The following average section for this territory shows that pre-glacial erosion has cut out much of the indurated beds found above the coal at old Consolidation No. 8.

		FEET.
5.	Drift	variable
4.	"Soapstone"	12
3.	Shale, black, bituminous	20
2.	Coal	5 to 7
1.	Fire clay	

Pekay. The Pekay and Lost Creek district, from which large quantities of coal have been taken out in the past, may be regarded as the southern representative of the Muchakinock basin and as separated from it by areas of thin coal. The Pekay basin extends from a point a mile southeast of old Muchakinock for a little over three miles in a southeasterly direction. Where normal, the coal is five to six feet in thickness, but in places the bed becomes attenuated. An upper seam, two feet thick and forty or fifty feet above the one worked, has been removed by erosion in all but a few localities. This basin is now nearly exhausted.

One mile south of Pekay, and one-fourth mile east of the Buxton branch of the Chicago and North Western Railway, is the slope of the Western Fuel Company (Harrison Tp., Sec. 29, Nw. qr., Ne. 1/4). This mine is taking out the coal left on the southern border of the old Whitebreast workngs. The seam is here from four to six feet in thickness, clean, and level. Between the coal and the drift is a variable amount of "slate"; at the foot of the slope, where doubtless it has suffered considerable pre-glacial erosion, it is only four feet thick, but farther east it increases to twenty feet. Under the coal is a thick stratum of fire clay. Cars are pulled 150 feet up the gentle slope and one-fourth mile west to the tipple by a large tail-rope engine equipped with a powerful friction clutch. Rope haulage is also employed for a distance of 200 yards in the mine itself. The mine is not yet old, and will increase its output shortly.

One-half mile east (Sec. 29, Ne. qr.) is a fifty-foot shaft operated for the local trade by Gott Brothers. Twenty-five feet of "slate" intervenes between the coal and the drift at this point. Southeast of the Gott mine is the Gray bank and south of that, near the county line, is the Davis. These are small local mines. Small pockets of coal are common near Eddyville and are utilized by a country trade; but none, apparently, are of sufficient size to warrant development on a large scale.

Wright. Three miles northeast of Wright, a coal occupying a position but little above the Saint Louis limestone, has been mined in a small way. A section of the shaft (White Oak Tp., Sec. 16, Sw. qr.) shows:

		FEET.
4.	Drift	30
3.	Shale, bituminous	25
2.	Coal	3½
1.	Fire clay	

A seam in what is perhaps the same horizon has been drifted from the river valley, a mile and a half northeast of the above mine. Both basins are probably of limited extent.

DISTRICT SOUTH OF DES MOINES RIVER.

Southwestern Mahaska was known to contain basins of thick coal some time before any attempt was made to develop large mines in the region. It was not until the lower Muchakinock valley had been worked out that the Chicago and North Western Railway was extended into this territory to open up what has proved to be a very productive area. The adjacent portions of Marion and Monroe counties are also turning out quantities of coal. In Mahaska, individual basins are not extremely large; but the coal is often quite thick. "Bowlders" of an impure limestone, termed clay-ironstone, are sometimes so numerous as to cause considerable difficulty in mining.

Cedar and Coal Creeks. A little mining for local purposes has been prosecuted along Cedar and Coal creeks; but the absence of railroad facilities in much of this territory has retarded development. Four seams of coal of workable thickness have been reported as found in a well about one mile east of the iron bridge over Cedar creek. On South Coal creek, near old Eveland postoffice, is an exposure showing ten feet of impure coal, overlain by twelve feet of shaly sandstone, and underlain by three feet of fire clay (Fig. 50). Drifts have been operated in this coal, but the greater part of the seam is of very poor quality.

Durfee. Durfee is a mining camp of 100 houses situated on the upper part of South Coal creek, at the extremity of a four-mile coal spur from the Buxton branch of the Chicago and North Western Railway. At this point the Rex Coal Company operates a shipping mine (Jefferson Tp., Sec. 19, Se. qr., Sw. ¼). The seam lies 118 feet below the surface at the shaft and varies in thickness from five and a half to thirteen feet, with an average of seven feet. It is so undulatory that some difficulty is experienced in draining the mine; ditches are dug in the higher parts of the entries wherever practicable, yet it is necessary to use three gasoline engines to pump water over the more pronounced "hills" or to the surface. The company controls 700 acres of coal, of which the south and east portions are quite clean. On the north side of the basin a dark impure limestone occasionally comes in to divide the seam into two benches. Rock is so plentiful in this portion of the coal that hand mining is rendered diffi-

Figure 50. Coal near Eveland.

cult and Ingersoll-Rand machines are to be installed as an experiment. Tail-rope haulage is employed for half a mile on the main north and south entry. The top works are modern and well equipped. Power is furnished by four boilers capable of producing a total of 260 horsepower. The handling of the coal is accelerated by the use of Olson automatic cages and a Christy box-car loader. There are three pairs of double engines at this mine, one each for the tail-rope, for the box-car loader, and for hoisting.

Buxton. Number 14 of the Consolidation Coal Company is a new mine still in course of development. The shaft is 133⅔ feet in depth and is located about a mile and a half north of Buxton (Jefferson Tp., Sec. 28, Sw. qr., Ne. ¼). The nature of the seam and its accompanying strata and the type of equipment are much the same as at the other Consolidation mines described in the chapter on Monroe county. At this mine, however, the retreating method of work is to be essayed; entries are to be driven to the boundaries of the property before rooms are turned and work will then be carried back toward the shaft. Progress is retarded by the presence of numerous pyritic concretions and clay ironstone "bowlders" in the coal bed. A Norwalk air-compressor furnishes power for the drills used in driving entries. The all-steel tipple is the latest and best of those erected at the various Consolidation mines and the top equipment is, in general, of the best pattern. The company owns 600 of the 700 acres or more included in this particular basin.

The Crawford Coal Company operates a shipping mine on a short switch from the Buxton branch, about half way between No. 14 and Buxton (Sec. 23, Nw. qr., Se. ¼). The shaft is forty feet in depth and from its foot entries have been driven 2,500 feet south, 400 north, and 400 west. The company expects to work over about 160 acres. Rope haulage is to be installed in the main south entry. A typical section at this point, given from memory by the superintendent, is:

		FEET.
4.	Drift	3
3.	Sandstone	10
2.	"Slate"	27
1.	Coal	4 to 6

Eveland. The Eveland mine is at the camp of that name, one mile northeast of Buxton (Jefferson Tp., Sec. 34, Nw. qr., Ne. ¼). The seam worked is from four to seven and a half feet in thickness, ordinarily showing five feet. Rock in the coal gives little trouble. The roof is of a peculiar type, presenting the appearance of a mass of "bowlders" firmly welded together so as to form a secure cover over the workings. Irregularities in the under surface of this stratum sometimes cut out the top coal. This mine has been in operation five years and has worked one-half mile east and one-fourth mile north and south. The product is loaded on a short spur running west to the Buxton branch of the Chicago and North Western Railway. The basin is a small one. Northeast of the shaft the seam splits, shale coming in between the two benches. At the shaft the coal lies only fifty feet below the surface, but under higher land near by

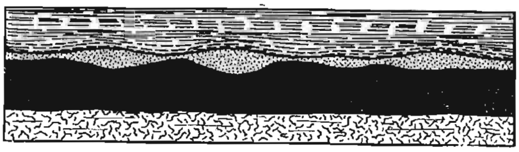


Figure 51. Ironstone band in roof of coal seam, Eveland mine.

a considerable thickness of strata is found between the coal and the drift, as shown in the following record.

	FEET.	INCHES.
4. Sandstone	35	
3. "Slate," gray and blue	45	
2. "Hydraulic rock," very hard	3	6
1. Coal	5	4

Crickett. On the west side of Bluff creek, a little more than a mile north of the Eveland mine, is the shipping mine of the Crickett Coal Company (Sec. 27, Nw. qr., N. ½). The shaft is fifty-four feet deep and was sunk in 1905. Not very much territory has as yet been mined out. The seam worked averages five and a half feet in thickness, although a few rolls in the roof cut out some of the coal under small areas. As in many other parts of this section of the county, "bowlders" are plentiful in places. In working out the coal two shearing machines and a compressed-air drill prove of service.

Lakonta. Two miles southwest of Lakonta and about the same distance east of the Crickett, is the mine of the Greenridge Coal Company (Jefferson Tp., Sec. 25, Ne. qr.). The product is shipped over a switch from the No. 13 spur of the Chicago and North Western Railway. The company leases 280 acres of land, at least 160 of which is said to have been prospected and proven to be underlain by from four to seven and a half feet of coal. "Bowlders" are extremely plentiful in parts of the seam. Where the coal attains its greatest height conditions detrimental to profitable mining prevail, such as an abundance of rock in the seam or, perhaps, a poor roof. As the mine has been in operation only a short time, mule haulage is still found adequate. The electric shot firing system employed gives good results: wires from the top station traverse each main entry, and may be tapped and a current run into the rooms as required. Separate buttons control the firing in each room. The shaft is 100 feet deep; coal is hoisted through it by a geared engine, capable of elevating 700 tons daily. The mine is not now running full capacity and an effort will be made to increase the output during the coming winter.

White City. White City is an attractive mining camp two miles west of Lakonta, on the Buxton branch of the Chicago and North Western Railway. One-half mile north, on a short railroad spur, the Crescent Coal Company has sunk a shaft (Jefferson Tp., Sec. 13, Sw. qr., Nw. 1/4). A large quantity of coal is shipped. The following is a record of a drilling near the shaft.

	FEET.	INCHES.
3. Drift	37	
2. "Slate"	27	2
1. Coal	7	9

A few places in the mine show eleven feet of coal, yet the average height is nearer seven feet. "Bowlders" of sandstone and clay-ironstone are freely distributed through the coal in some localities, leaving others quite free from them. Although the seam may contain considerable rock, the latter is often so easily removed that the working remains good from a miner's viewpoint. The coal bed is sharply undulatory. About 125 acres have already been mined out. There are about 350 acres of coal, usually thick, in basins tributary to this shaft; but the drillings cannot, of course, be depended upon to show how much of this is sufficiently clear of rock to be profitably mined. The equipment of the Crescent mine is modern, and adequate in every respect.

UNION COUNTY

The rocks immediately underlying the heavy drift cover of Union county belong without exception to the Missouri, a stage that may contain seams of coal. These coals are usually so thin, however, that they can be worked with profit only when they occur near the surface and present few obstacles to facile development. Below the Missouri lies the Des Moines, the productive stage of the main Iowa coal field. Its summit probably lies at least 400 feet below the surface in Union county, excepting, perhaps, the northeastern corner, where the depth is less; but as the upper part of the Des Moines is nowhere very productive, horizons of good coal might not exist above a depth of 600 or 700 feet. Moreover, it has not yet been proved that the Des Moines bears coal at any level as far southwest as the region under discussion. It is not probable that prospecting would yield a proper financial return, even though a workable coal basin were finally located.

CLARKE COUNTY

Clarke county is covered by a heavy mantle of drift under which lie beds of Pennsylvanian age. The greater part of the region bears Missiourian strata, thin in the eastern section and 100 feet or more thick in the western; yet where pre-glacial erosion has cut to exceptional depth and in the valleys of the main streams in the eastern and northern parts of the region, the Des Moines is the highest of the indurated formations. The outlook for basins of thick coal near the base of the Des Moines is good, but the depth to which prospects would necessarily be carried in order to reach the best horizons, would make the expense of locating a field quite high. Coal has been mined at Cleveland, in Lucas county, only two miles from Clarke, at a depth of 326 feet. Recent borings at Leon, in Decatur county, revealed good coal horizons at about 500 feet. At both these localities the best coal lies at from 550 to 600 feet above sea level, although other horizons are present nearer the summit of the Des Moines. If coal is to be sought at Osceola or at other points in the central portion of Clarke, borings should be sunk 600 feet in order to reach the coal horizons known to exist on the east and south. Farther west these horizons lie still farther below the surface, both because the elevation of the latter is greater and because of the westerly dip of the formations; but in the deep valleys of eastern and northern Clarke, a depth of 400 feet would probably reach the base of the Coal Measures.

LUCAS COUNTY

The gentle dip to the southwest that is common to the Carboniferous beds in most of the Iowa coal fields lessens greatly in Lucas county, so that the limestones of the Missouri stage appear only in a few places on its extreme western border and the Saint Louis limestone lies closer to the surface than would otherwise be the case. The highest indurated rocks of practically the entire county belong to the lower and more productive division of the Coal Measures and bear coal in considerable quantity. A zone of upper horizons bearing coals of moderate thickness outcrops along Big and Little Whitebreast, English and the various branches of Cedar creek; while lower horizons containing thicker coals have been found in drillings and shafts in the Lucas district, northeast of Chariton, and on Cedar drainage. As in the lower Coal Measures of the region north and east, the coal lies in discontinuous basins along more or less definite horizons. The largest basin so far located contains less than 4,000 acres; while the driller considers himself fortunate if he discovers a thousand acre field in prospecting ten or fifteen miles along the valleys. The shales and sandstones making up the bulk of the Des Moines stage are equally erratic in occurrence, grading into one another laterally with startling rapidity. Even the limestones, which are few and poorly developed, have little persistence and do not serve as horizon markers for the driller or geologist.

In the northeastern part of the county, where prospecting has been actively pursued in recent years, the best coal has been found between 700 and 750 feet above tide, with some between 625 and 700 A. T. It should be remembered in this connection that the level of a continuous bed may vary by forty or fifty feet at neighboring points because of undulations. Since the elevation of the uplands is about 1,040 feet A. T. and the streams have often cut over a hundred feet below the divides, it is evident that the depth to which borings need be carried is by no means prohibitive. The base of the Coal Measures lies at about 611 feet A. T. on an average, though the surface of the underlying Saint Louis calcareous formations is extremely uneven, changing in elevation as much as 100 feet in one mile. On the uplands it is sometimes necessary to drill 200 feet before the drift is penetrated, but commonly 150 feet or less is sufficient.

In the western portion of the county the Saint Louis lies at somewhat greater depth and the best coal is found about 300 feet below the lowlands along Whitebreast creek. Little is known of conditions in the four southern townships, nor has the Mystic coal of the Appanoose-Wayne field been recognized within the county, although it is probably present in the southeastern corner. A deep drill record from section 12 of Benton township fails to show any trace of the Appanoose formation or to bring to light lower coals of workable thickness.

The early production of coal in Lucas county was not large, having been 945 tons in 1860 and 37,284 bushels in 1868. In 1880, however, as a result of the opening of the Whitebreast mines east of Lucas, the county had forged to the front with an output of 126,498 tons and in 1890 the total was still larger, 339,229 tons. Hardly more than a year later, the closing of the larger mines caused a decline that was only checked by the installation of the Whitebreast No. 4 at Cleveland. Recent statistics are:

YEAR.	TONNAGE.	YEAR.	TONNAGE.
1898	6,600	1903	295,554
1899	3,700	1904	189,895
1900	221,922	1905	147,093
1901	216,058	1906	97,147
1902	238,862	1907	105,536

The closing of the Big Hill mine in 1907 and the abandonment of the Cleveland mine early in 1908 left the county without a shipping mine and reduced the output for the year ending June, 1908, to 74,288 tons. As soon as railroad facilities are provided for the northeastern quarter of Lucas, it will again become one of the most important of Iowa coal counties. The following pages contain a brief review of the coal data available in July, 1907.

Cleveland. The Whitebreast Fuel Company of Illinois drilled fifty holes near Lucas, as a result of which the mine now known as Cleveland No. 4, was opened about two and one-half miles southwest of Lucas at Cleveland. The shaft was sunk 326 feet early in 1899, penetrating the following coal horizons.

COAL.	THICKNESS IN FEET.	DEPTH IN FEET.
No. 1	1.5	81
No. 2	1.5	100
No. 3	0.6	122.4
No. 4	0.2	216.6
No. 5	0.9	294.9
No. 6	4.9	318

The basin now mined shallows rapidly to the west, southwest and northwest, extends one and one-half miles southeast of the shaft, and connects through an area of low coal with the Lucas seam on the northeast. The coal varies in thickness from one foot to six feet, but the roof is apt to be of poor quality over the thickest coal. Elsewhere the roof is a fairly firm and thick black fissile shale. Undulations are well marked. Little sulphur and no black jack interfere with the purity of the coal. In the south workings a large erosion channel in which the coal is replaced by shaly clay was encountered and was tunnelled through for several hundred feet before the coal was again found. Electric haulage is employed in the main entries, three eighty horse power motors being in service and one held in reserve. The power is derived from a Brownell engine, with a Milwaukee generator. The pit cars are built of steel alone. Hoisting is done by a double engine with 18x32 inch cylinders. The tower and tipple are of steel construction, erected by the Pittsburg Steel Co. The link-belt shake and screen are used. The automatic dirt dump was made at the mine. This mine has now almost exhausted its territory and will be abandoned early in 1908.

Lucas. In June, 1874, Mr. William Haven and others leased 540 acres of land on Whitebreast creek, two miles east of Lucas, and the next year began drilling operations. Two upper seams were penetrated within 138 feet and after considerable delay due to financial difficulties a lower coal over five feet in thickness was finally found. The Whitebreast Coal Company was organized to work this field and did so by means of three mines between Phillips and Lucas. Until the field was exhausted in 1891 it was one of the most productive in the state. In an endeavor to find more coal the company bored 123 diamond drill holes along a strip of varying width and considerable length trending northeast and southwest from their mines, but no basin of sufficient extent for development on a large scale was located. These prospects covered an area of about twenty square miles, chiefly in Whitebreast valley, and were continued to about 300 feet below the surface level. Of 120 holes, seventy showed less than three feet of coal, twenty-two between three and four feet, twelve between four and five feet, and sixteen over five feet. In one prospect a thickness of seven feet of coal was penetrated, and in another eight feet.

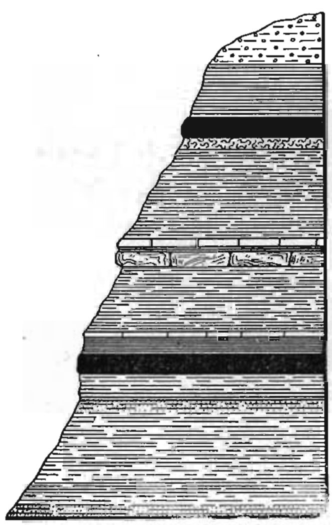
In the Lucas district there are reported to be four coals in addition to one that outcrops in the hillsides. These are said to be as follows:

COAL	THICKNESS FEET.	DEPTH, AVERAGE, FEET.
No. 1.	1 2-3	60
No. 2.	2¼	90
No. 3.	3½ to 5	290
No. 4.	4	330

These coals are not continuous over large areas but appear to lie in basins along fairly definite horizons. It will be seen that they correspond quite well with the coals found in the shaft at Cleveland. Strong undulations rendered the level of every seam somewhat variable. Coal in the second horizon can be profitably worked longwall and is so mined by Skidmore Bros., who are operating a local mine about one mile northeast of Lucas. The third horizon has supplied most of Lucas county coal and is now utilized at the Big Hill mine. The fourth horizon is not definitely known to contain thick coal at Lucas, but is that worked at Cleveland. It is possible, however, that the coal mined at Cleveland and at Lucas lies in the same horizon, since the Saint Louis limestone is encountered not far below the third seam at Lucas.

The Big Hill mine ships over the Burlington from a location not far from the station at Lucas and although of limited extent, this mine has at times produced considerable coal. It is now idle because of trouble with water and for other reasons. The shaft is 290 feet deep to a coal a little over four feet in average thickness. Above the seam is a considerable thickness of sandstone which makes a firm roof but lets in much water. Laterally this rock grades into shale. A thick sandstone is found also at Cleveland between coals Nos. 4 and 5 of the shaft record.

Big Whitebreast Drifts. Coal outcrops at several points in the valley of Whitebreast creek from old Cleveland northeast to the county line and, though usually thin, has furnished limited supplies for purely local consumption. In sections 5 and 8 of Whitebreast township some coal is occasionally taken from a fourteen-inch seam that outcrops near high water level in the creek. The section made by St. John farther down the creek at the old Wheeler Mill is shown in figure 52. At and near the confluence of Big and Little Whitebreast creeks, a rather constant bed of thirty inches outcrops and has been drifted to some extent on Whitebreast and Barker creeks.



		FEET.
12.	Drift	5
11.	Shale, argillaceous, variegated	4
10.	Coal	1½
9.	Fire clay	1
8.	Shale, variegated	8
7.	Limestone, impure, earthy in places	2
6.	Shale, ash colored, calcareous below	6
5.	Limestone, bluish, nodules in places	2-3
4.	Shale, black, bituminous, fissile	1½
3.	Coal	1½
2.	Fire clay	2
1.	Shale, light-colored, sandy in places	10

Figure 52. Section on Whitebreast creek. Six miles below Lucas.

Chariton. An unsuccessful attempt to find thick coal was made near the Chariton river, in the northern part of Chariton. One boring which was continued for 322 feet (Sec. 30, Sw. corner) encountered only two thin coals at 112 and 318 feet respectively. Another drilling struck a small pocket of five foot coal at the depth usual for the "lower vein." A good basin of deep coal was, however, located northeast of Chariton where the mine of the Inland Coal Company is situated. The Inland shaft record is (Lincoln Tp., Sec. 9, Nw. qr., Ne. 1/4):

		FEET.	INCHES.
33.	Soil and drift	34	6
32.	Shale, sandy, light-colored	7	
31.	Shale, sandy, black	11	
30.	Coal, good	2	
29.	Fire clay	5	
28.	Sandstone, dry, light-colored	2	
27.	Limestone		10
26.	Sandstone, dry, light-colored	2	
25.	Shale, variegated	26	
24.	Shale, hard, black	8	
23.	Coal	1	
22.	Fire clay, impure	3	
21.	Shale and limestone	8	
20.	Shale, hard, dark	7	
19.	Coal, not good	1	6
18.	Fire clay	7	
17.	Sandstone	3	
16.	Shale, variegated	10	
15.	Shale, hard, dark	7	
14.	Coal, part bony	1	
13.	Sandstone	2	
12.	Shale, black	1	
11.	Coal		6
10.	Fire clay, with shale	5	6
9.	Sandstone	31	
8.	Shale, dark	10	
7.	Sandstone	2	
6.	Shale, light-colored	6	
5.	Shale, dark	22	
4.	Shale, lighter colored	15	
3.	Coal	7	
2.	Fire clay	3	
1.	Sandstone	8	

The thickness of the lower coal (No. 3) varies considerably. The upper horizons seem fairly persistent, but bear only thin coals. Although the Inland mine has no railroad connections and so supplies only a local trade, it is extremely well managed and is one of the best coal properties in the state. As soon as railroad facilities are provided it will become one of the important mines of the Iowa field.

Little Whitebreast Surface Mines. At numerous places on both sides of Little Whitebreast creek, from section 22 of Lincoln township to section 19 of English, coal has been taken for local consumption from seams outcropping in the valleys. In Lincoln township the establishment of the Inland mine caused the abandoning of most of the work in this upper coal, for it is seldom more than thirty inches in thickness. In English township, also, little mining is now done. Two coals, the upper about eighteen inches and the lower slightly thicker, outcrop here. Sometimes these two seams approach sufficiently close to be mined as one, and again, they may be separated by a distance of fifteen feet or more.

Wild Cat Drifts. Along Wild Cat or English creek and its branches, in sections 11, 12, 14 and 15 of English township, small drifts have been opened during the winter months. The coal mined is in most cases only from fourteen to eighteen inches in thickness and lies only a short distance above the creek bottoms. A mine on W. S. Dungan's land (Sec. 12, Nw. qr.) is said to have worked a thirty-inch bed.

Drifts on Cedar Drainage. Some fairly thick surface coals have been mined for local use in the valleys of Pleasant township, and, since this region is far from any railroad, are of considerable importance to the farming communities. At least three horizons containing discontinuous basins of coal may be recognized, but in the absence of a topographic map no correlation of separated outcrops can be made with any certainty. Reported occurrences of the upper coals along Cedar drainage are noted in the following list. No mines were open when the region was visited in the summer of 1907.

LOCATION.	THICKNESS.	REMARKS.
Lincoln Township—		
Sec. 12, near center........	18 inches....	
Cedar Township—		
Sec. 6, near center.........	14 inches....	Outcrop now concealed.
Pleasant Township—		
Sec. 24, north central......	3 feet........	The Briggs drift. It supplies a large country trade.
Sec. 23, Se. qr., Ne. ¼......	....	A small shaft.
Sec. 21, Nw. qr., Nw. ¼....	....	A small drift on Little Cedar creek.
Sec. 13, Se. qr., Sw. ¼.....	....	The Umbenheuer drift on Big Cedar.
Sec. 12, Nw. qr., Sw. ¼....	3 feet........	A new drift on Little Cedar.
Sec. 11, Sw. qr., Ne.¼......	3 feet........	An old drift on Little Cedar.
Sec. 1, Sw. qr., Ne. ¼.....	3 feet........	A new opening.
Sec. 1, Ne. qr., Se. ¼......	....	The Van Loon mine.
Sec. 2, N. ½..............	....	Abandoned drifts.
Sec. 3, Se. qr., Nw. ¼.....	3 feet........	An abandoned drift.
Sec. 3, N. ½..............	3½ feet....	Top seam, mined by stripping.
	3 feet......	Second seam, drifted.
	....	Third seam, drifted from creek bottom.

Zero. At Zero, on the Chicago, Burlington and Quincy Railroad, a mile and a half west of the Monroe county boundary, a mine was formerly operated by the Creston Mining Company. The shaft was 260 feet deep, with coal five feet in thickness. Where worked the seam was quite irregular, on which account the mine was finally abandoned after several companies had worked out considerable coal.

Deep Coals on Cedar Drainage. The Consolidation Coal Company, Inland Coal Company, and others have for several years been conducting prospecting operations in northeastern Lucas county in an endeavor to find workable basins in the more productive horizons near the base of the Coal Measures. There is little doubt that success has attended these efforts and that only the advent of a railroad in this region is necessary to place Lucas in the front rank of coal producing counties. Mr. Haven of the Inland Coal Company reports the location of five good basins, comprising a total of several thousand acres. The Consolidation Coal Company has purchased the mineral rights of a large tract in sections 9, 10, 15, 16, 17, 20 and 21 of Pleasant township. Coal of an average thickness of four feet eight inches

15

is said to have been found in all holes drilled here on over 2,500 acres of land. The strata are extremely variable, yet the following drill records give some idea of their succession.

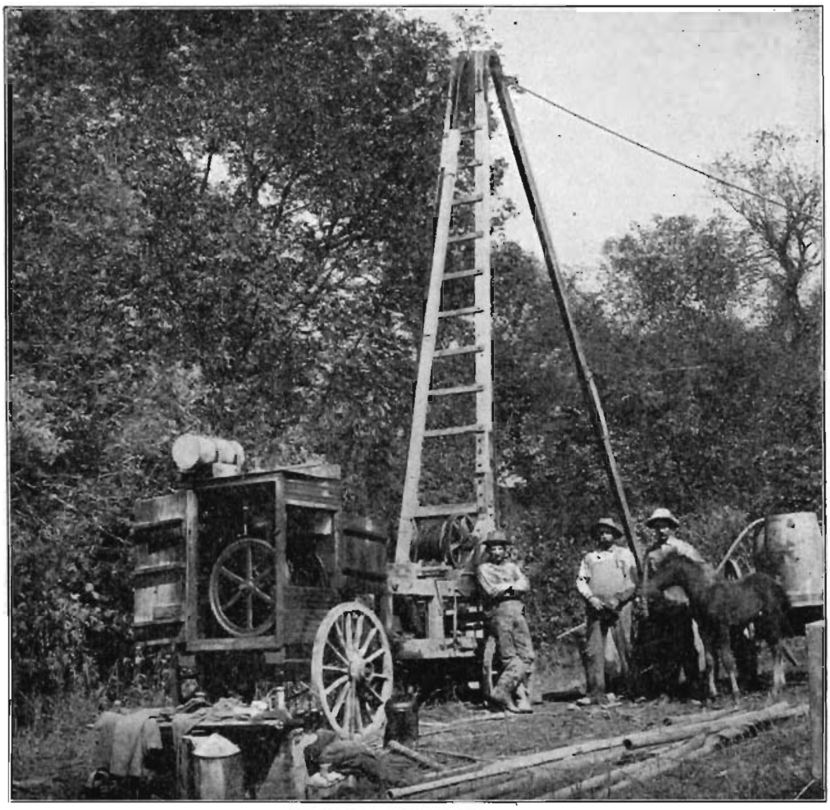


Figure 53. Churn drill of the Consolidation Coal Company, operated by a gasoline engine.

PLEASANT TOWNSHIP, SEC. 15, NE. QR., NW. 1/4.

		Feet.
4.	Clay	15
3.	Shale, light-colored	5
2.	Shale, gray	42
1.	Coal	4
	Total	66

PLEASANT TOWNSHIP, SEC. 16, SW. QR., NW. ¼.

		FEET.	INCHES.
5.	Soil and drift	67	11
4.	Shale	69	11
3.	Shale, gray	80	9
2.	Coal, good	3	10
1.	Coal, dirty	2	1
	Total	224	6

PLEASANT TOWNSHIP, SEC. 17, SE. QR., SE. ¼.

		FEET.	INCHES.
14.	Soil and drift	52	
13.	Shale, light-colored	22	
12.	Shale, dark	5	8
11.	Coal	1	1
10.	Shale, light-colored	19	
9.	Rock (concretion ?)	2	
8.	Shale, dark	4	
7.	Coal	1	4
6.	Shale, light-colored	10	
5.	Rock (concretion ?)	4	
4.	Shale, light-colored	18	3
3.	Coal	1	
2.	Shale	88	
1.	Coal	5	9
	Total	234	1

The unreliable character of much of the coal in the lower horizon is illustrated by six drillings made on J. F. Carson's land in and near section 32 of Pleasant township, which showed that the seam present ranged from six inches to five feet in thickness on a comparatively small bit of land. One of these drill records is:

PLEASANT TOWNSHIP, SEC. 32, NE. QR., SE. ¼.

		FEET.	INCHES.
12.	Soil and drift	125	9
11.	Shale, dark	10	3
10.	Shale, light-colored	3	6
9.	Shale, gray	33	6
8.	Sandstone	2	4
7.	Shale, gray	9	1
6.	Sandstone	2	7
5.	Shale, gray	32	
4.	Rock ("bowlder" in coal?)		10
3.	Coal	1	2
2.	Coal, dirty	1	3
1.	Shale, calcareous	4	9
	Total	227	

MONROE COUNTY

Magnificently served by railroads and lying in a highly productive coal belt, Monroe county has for several years been the most important coal producer in Iowa. The number of mines is not exceptionally large, yet they are with few exceptions the property of companies that are willing and able to risk a large amount of capital in order to obtain a proportionately large return. Prospecting has been systematic and thorough, so that the larger corporations are able to look far into the future when planning the location of their mining camps and mines. As a result, the larger basins of workable coal are being exploited one by one in definite geographic order.

With the exception of a small area of about three square miles in the valley of the Des Moines river near Eddyville and for short distances up Gray and Miller creek, where the Saint Louis limestone outcrops, the entire county is underlain with Coal Measure strata of the Des Moines stage. From a thickness of zero at Eddyville these increase progressively toward the southwest until probably a thickness of about 400 feet is attained in the southwestern corner of the county. Very few test holes are continued to the Saint Louis, a practice which is to be condemned, as thick coals lying near the base of the measures may thereby be overlooked. In section 28 of Bluff Creek township the limestone was reached at a depth of 199 feet; yet two miles north the coal mined descends abruptly into a small basin 283 feet below the surface, a feature probably due to a local depression in the basement limestones. A boring in section 29 of Mantua township found the Saint Louis at 216 feet, while drillings of about the same depth at Hilton and Foster stopped in the Coal Measures. A drill hole put down by the Hocking Coal Company to a depth of 317 feet in section 34 of Troy township encountered at least 272 feet of coal-bearing strata. Coal is reported at 313 feet in section 4, Wayne township.

Notwithstanding the amount of development work that has been done in this county, mining has been confined chiefly to the northern and central portions; while large portions of the southwestern quarter remain practically unexplored. It is in the extreme southwestern corner that the Mystic seam of the

Appanoose-Wayne field is most likely to be found if it be present at all in Monroe county.

Although coal was mined along Bluff, Miller, and Avery creeks, and west of Albia at an early date, the county did not rank among the few best producers until the seventies. As

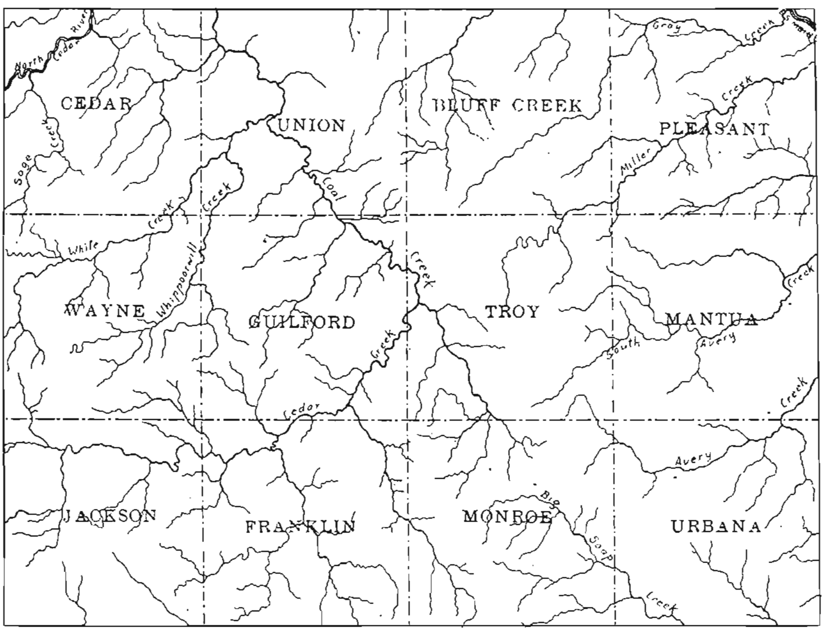


Figure 54. Sketch map of Monroe county.

given in the U. S. census reports, the output for 1860 was 2,756 tons; for 1870, 15,410; for 1880, 181,288, and for 1890, 258,401. With the exception of the period of business depression ending in 1896, the coal industry of succeeding years has advanced steadily and notably. In 1901 the county passed all others and since then has held first place. According to reports of the Iowa Geological Survey, statistics for recent years are:

YEAR.	TONNAGE.	YEAR.	TONNAGE.
1898	584,578	1903	1,768,054
1899	684,004	1904	2,061,877
1900	772,457	1905	2,227,177
1901	1,237,332	1906	2,458,473
1902	1,349,722	1907	2,476,021

During the year ending June 30, 1908, twenty-three mines produced 2,167,061 tons of coal and employed 3,634 men. Whereas in 1883 Monroe was responsible for less than two and one-half per cent of the production of the state, in 1907 she mined over thirty-one per cent of the total.

The status of the industry, so far as known in July, 1907, is sketched in the following pages.*

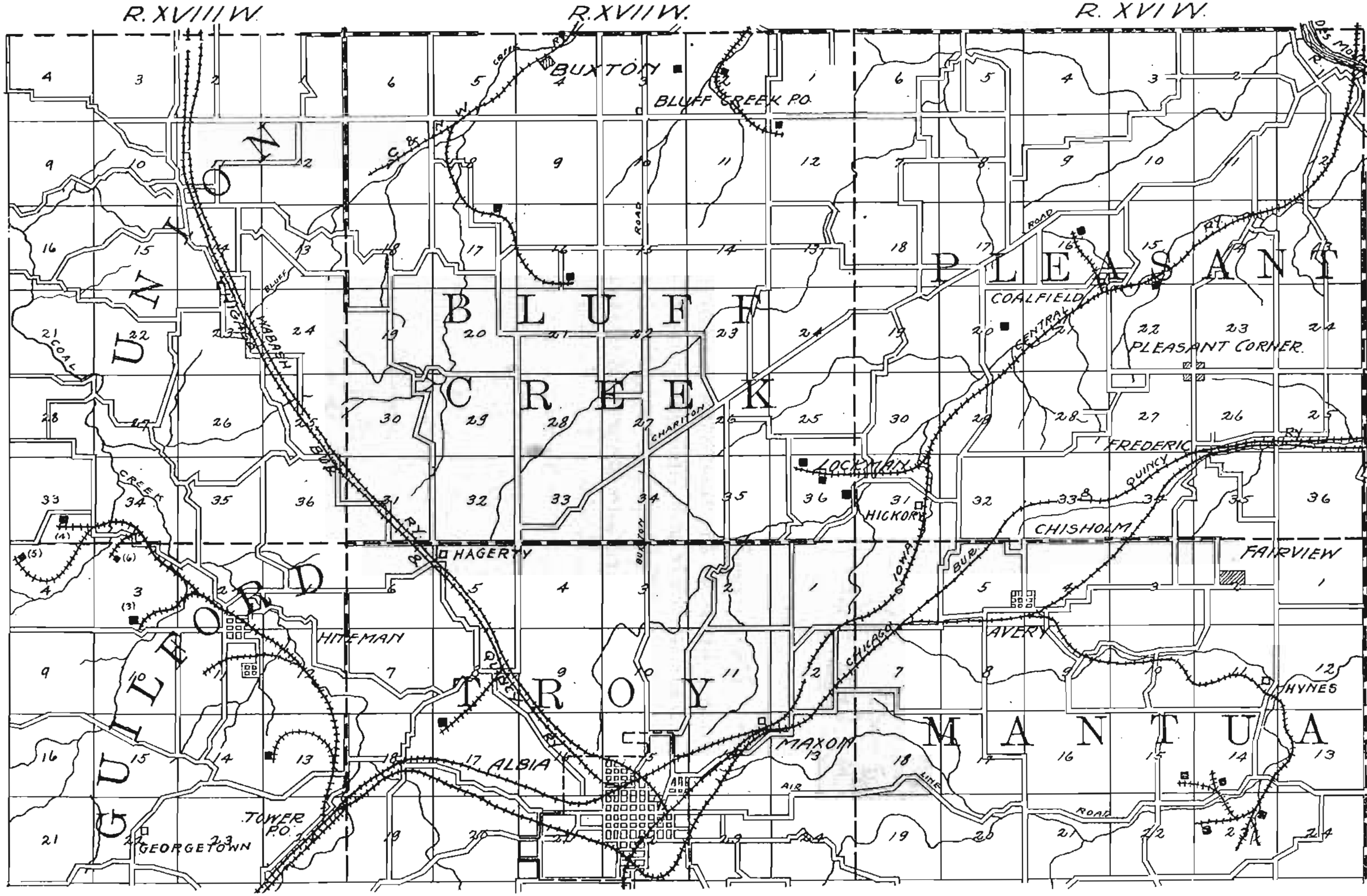
MONROE MINES AND COAL BEDS.

Northwestern Townships. The Consolidation Coal Company has done considerable prospecting in Union, Cedar, and Wayne townships and has located and purchased several basins of coal which will be exploited at some future date. The Consolidation driller reports that coal averaging four feet eight inches was found in over 1,000 holes drilled in a strip one-half to two miles wide along White creek in Wayne township. This area forms part of a continuous basin said to contain 7,000 acres of coal. One of the drill records of a boring in this territory follows (Wayne Tp., Sec. 7, Nw. qr., Se. ¼).

	FEET.	INCHES.
Drift	97	
Shale	26	
Coal		8
Shale, dark	18	6
Rock (sandstone ?)	1	6
Shale, gray	30	2
Coal	4	
Total	177	10

Another basin containing the same average thickness of coal occupies sections 7, 8, 17, and 18 of Union township and adjoining portions of Cedar. It is said to comprise 3,000 acres of coal. A smaller basin of 210 acres is reported from sections 14, 23, and 24 of Union township, south of Lovilia. Coal is also known north of Lovilia, where country mines are occasionally operated. The following record is from section 3 of Union township.

*Acknowledgments for material are due to Beyer and Young: *Geology of Monroe County*, Iowa Geol. Surv., Vol. XIII, pp. 353-433; Des Moines, 1903.



Map showing mines in northern Monroe county.

	FEET.	INCHES.
Drift	30	
Sandstone, buff	3	
Shale, sandy, gray	7	
Shale, blue, light-colored	30	6
Shale, blue, dark	6	
Coal	5	6
Fire clay		6
Total	82	6

Figure 55. View of Buxton from the west.

Buxton. The Consolidation Coal Company was organized in 1875 with headquarters at Muchakinock, in Mahaska county, and was reorganized under the present ownership in 1881. The Chicago and North Western Railway extended its already long coal spur southwestward into Monroe county and the Consolidation headquarters were moved to the new mining camp, Buxton. Buxton is a thriving town containing a population of about 5,000 people, chiefly colored. It possesses a $20,000 Y. M. C. A. building, a large company store, well built houses for the miners, and is, in general, progressive. Special trains carry the men to and from the mines, of which there are five operated by the company. Mine No. 14, situated in Mahaska county, is discussed in another place in this volume. No. 10 lies two miles south of Buxton (Bluff Creek Tp., Sec. 17, Ne. qr., Nw. 1/4), No. 11 about one mile southwest of No. 10 (Sec. 16, Se. qr., Sw. 1/4), No. 12 three miles east and south of Buxton (Sec. 12, Nw. qr., Nw. 1/4), and No. 13 two miles east of the same place (Sec. 2, Nw. qr., Se. 1/4). Within a year Numbers 11 and 13 will be abandoned and Number 15 will be sunk one mile southeast of Number 11.

The coal worked at these mines varies from four to seven feet in thickness, with an average of four feet six inches. Several unworked coal horizons are also known. A section representative of prospects in the territories of Numbers 10 and 13, which are located on the bottom lands, is as follows:

		FEET.	INCHES.
9.	Surface wash and drift	12	
8.	Sandstone	1	6
7.	Clay shale	3	
6.	Shale, dark	6	
5.	Clay shale	10	6
4.	Shale, dark	9	7
3.	Coal	1	8
2.	Shale, dark	62	7
1.	Coal	6	2
	Total	113	

Of the upland prospects, as found at Numbers 11 and 12, the following is about an average.

		FEET.	INCHES.
20.	Drift and loess	25	
19.	Sandstone, gray	29	6
18.	Clay shale	3	6
17.	Shale, dark	3	1
16.	Coal	1	9
15.	Shale, light	10	2
14.	Coal	2	
13.	Shale, dark	3	6
12.	Coal	1	3
11.	Shale, light	32	
10.	Coal		10
9.	Shale, light	21	
8.	Shale, dark	2	4
7.	Coal		6
6.	Shale	15	10
5.	Sandstone	3	
4.	Shale, gray	13	11
3.	Coal	2	
2.	Shale, dark	49	
1.	Coal	5	
	Total	225	3

The roof-shale is fairly firm and the coal is usually uniform in character, though where there are strong undulations it is apt to "pinch out." The company's mining engineer reports a very remarkable occurrence from mine Number 10. At the time the region was visited by the writer this mine was temporarily closed, so that the phenomenon was not personally investigated by him, but the source of information is apparently reliable. It is said that the seam drops nearly 145 feet in a horizontal distance of 800 feet, with good five foot coal continuous throughout the entire distance. A deep depression elongated northeast-southwest and embracing thirty acres, is formed in this manner. The following drill records taken 700 feet apart show the relationships (Sec. 16, Sw. qr., Nw. ¼).

HOLE A.

		FEET.	INCHES.
15.	Clay	13	
14.	Shale, light-colored	42	10
13.	Sandstone	1	6
12.	Shale, light-colored	74	8
11.	Shale, dark, sandy	10	2
10.	Coal		8
9.	Shale, light-colored	42	8
8.	Shale, dark	11	3
7.	Coal	1	8
6.	Shale, light-colored	7	2
5.	Shale, sandy	4	6
4.	Shale, mixed	22	3
3.	Coal	1	
2.	Shale	44	7
1.	Coal	5	11
	Total	283	10

HOLE B.

		FEET.	INCHES.
14.	Drift	24	
13.	Shale, dark	6	7
12.	Coal	1	3
11.	Shale, light-colored	19	10
10.	Shale, dark	3	
9.	Coal		6
8.	Shale, light-colored	7	10
7.	Sandstone	3	4
6.	Shale, dark	5	9
5.	Coal		3
4.	Shale, light-colored	4	6
3.	Coal		7
2.	Shale, gray	51	10
1.	Coal	4	11
	Total	134	2

There is also in Number 10 workings a contemporaneous erosion channel in which shale replaces the coal. The ancient stream ran north or south, and evidently divided into two parts and flowed around a small coal-producing area; for an "island" of fifteen acres of coal is now found in the mine, with a barren strip 360 feet wide on one side and another 150 feet wide on the other. True faults with a maximum throw of five feet each occur in the same workings; while a similar feature is encountered in the main south at Number 11. Pyritic concretions and clay-ironstone bowlders are not especially common, excepting at Number 13. Below are tabulated summaries of the results of mining operations.

MINE NUMBER.	DEPTH OF SHAFT (FEET.)	ACRES MINED OUT.	ACRES IN BASIN, PROBABLE.
10	100	320	640
11	208	260	560
12	182½	220	} 1300
13	100	200	}

At the present rate of working, these basins will soon be exhausted, but the company owns large tracts of coal land farther west, in Monroe and Lucas counties.

The room and pillar system of mining is used, the rooms being turned forty feet and driven 210 feet. Widening out begins after ten feet and coal is obtained by shooting from the solid. At numbers 11 and 12 all the water pumped is used in wetting down the entries. Electric third-rail haulage, for which the current is carried in the rack-rail and returned in the running-rail, is used on all the main entries. Ten gathering motors have also been ordered and will be operated by rack-rail in the entries and by trolley in the rooms. The capacity of the pit cars is from 2,000 to 3,000 pounds, although smaller ones are used on the edges of the basins where the coal is low. Nothing is worked out within 200 feet of the shaft. Forty-five Whitcome cutting machines, the same number of post-drills, and four Norwalk compound air-compressors are in use.

The tipples are all of the same pattern and, aside from that at number 11, of steel construction. Reynolds-Corliss and Litchfield engines are used in hoisting. Loading is facilitated by the use of Olson self-dumping cages and by box-car loaders at numbers 10 and 12. The equipment on top is complete in every respect.

West of Number 13, in an area surrounded by Consolidation holdings, is the Regal mine (Bluff Creek Tp., Sec. 3, Ne. qr., Se. ¼) and the associated mining camp, Frakerville. A five-foot coal is reached at a depth of 164 feet. Entries extend about one-fourth mile east, west, and south to the limits of the 160 acres controlled by the company. Aside from an occasional streak of pyrite the coal is clean, though it is not so good in the north-western workings. Hoisting is by a direct-connected engine and dumping by automatic cages.

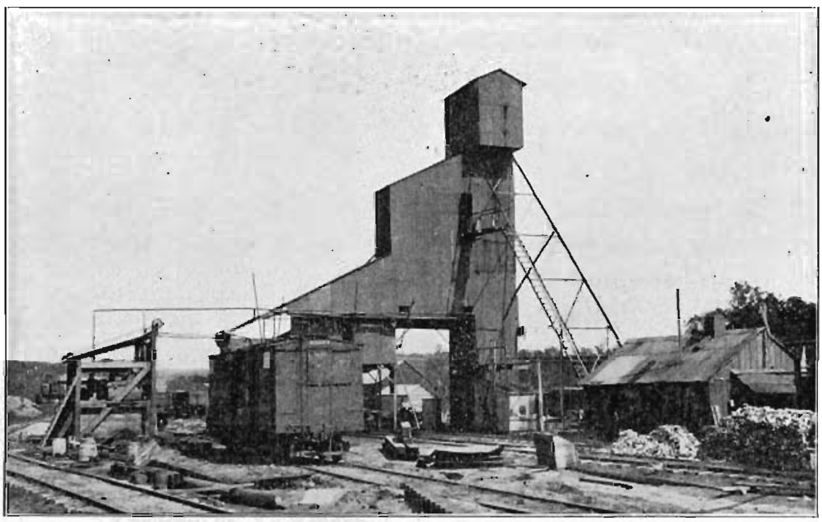


Figure 56. Steel tipple, showing box car loader, Shaft No. 10, Consolidation Coal Company. Buxton.

Coalfield. In the valley of Miller creek are a number of mines, chiefly local, operating in coals that lie not far beneath the surface and are reached by slopes. Near Eddyville the coal basins are found quite near the Saint Louis limestone. Two mines near Coalfield do a shipping business. The Coalfield Fuel Company works a slope on a short spur from the Iowa Central, northwest of Coalfield. Coal from three to four and a half feet thick has been mined across section 9 into section 8. The seam is slightly undulatory and dips, in general, to the southwest. Boden's slope is a short distance southeast of Coalfield and is also a railroad mine. The bed worked bears an average of three feet six inches of coal, dipping strongly to the southeast as far (one-fourth mile) as an entry has been driven into the hill. The coal thins on the south of this territory.

Lockman. The Central Coal Company now operates three shipping mines near Lockman, of which Number 3 is expected to become the best producer. This slope, which lies near the western extremity of the coal spur through the northern portion of section 36 of Bluff Creek township, pitches four and one-half inches to the yard. Wire-rope haulage is effected by means of a double Taylor engine. Slope Number 2 enters the hill not far from the mouth of Number 3. Shaft Number 4, lying one-half mile southeast, is forty-five feet deep and has just been made ready for work. In all three mines from four to five feet of coal is worked, except where local irregularities in the thickness are present. Contemporaneous erosion channels, filled with sandstone, cut out the coal in places. The four-foot coal has been located in many drill holes in sections 25 and 36 of Bluff Creek, section 31 of Pleasant, and section 1 of Troy township, while at least one thinner seam is commonly found in some higher horizon. Following is a representative record from section 25, Bluff Creek township.

		FEET.	INCHES.
12.	Soil and drift-clay	45	
11.	Shale	35	
10.	Sandstone	2	
9.	Shale	12	
8.	Coal		6
7.	Sandstone, gray	7	6
6.	Shale	23	
5.	"Slate"	14	
4.	Coal		8
3.	Shale, dark and fissile below	5	7
2.	Coal	3	11
1.	Fire clay	1	6
	Total	150	8

South Avery Creek. For many years coal has been extensively mined in the valley of Avery creek, in Mantua township. As the areas near Hynes became exhausted, a coal spur was extended southward along the valley of South Avery creek and new mines were opened. The Smoky Hollow Coal Company has been the largest producer in the district and to-day operates two slopes, Number 6 (Sec. 23, Ne. qr., Nw. 1/4) and Number 7 (Sec. 23, Nw. qr., Sw. 1/4). The coal either outcrops in the hillside or is covered only lightly by the drift. It varies from forty to sixty-six inches in thickness and is fairly level except for minor undulations. Prospects over a considerable territory show that the coal is usually present, although somewhat irregular in occurrence. At least one thin coal is commonly found above the bed worked; while in the territories of Numbers 6 and 7, a seam that infrequently shows a workable thickness occasionally comes within six inches of the bed mined, only to be separated from it again by distances of twenty feet or less. A prospect three-fourths mile west of Number 7 disclosed as many as four coals in a vertical interval of forty-five feet. The company has worked chiefly in sections 9, 10, 11, 13, 23 and 24 of Mantua township. The following section may be taken as an average for the district.

		FEET.	INCHES.
16.	Drift and alluvium	20	
15.	Sand and gravel	60	
14.	Clay mixture	20	
13.	Shale, black	14	
12.	Coal		8
11.	Shale, light	13	
10.	Shale, dark	5	
9.	Shale, light	6	
8.	Shale, dark	6	
7.	Coal	1	
6.	Fire clay	3	
5.	Shale, dark	8	
4.	Coal	5	6
3.	Shale, sandy	4	
2.	Sandstone	21	
1.	Shale, gray	2	
	Total	189	2

Mine Number 6 is the best producer, Number 7 not being fully developed. Number 6 workings are nearly a mile and a half from the slope mouth; while Number 7 has worked in about 1,700 feet. Tail-rope haulage is employed in both mines. Two new shafts are now being prepared for future production: Number 8, forty-five feet in depth (Sec. 14, Sw. qr., Se. 1/4), and Number 9, fifty-five feet deep (Sec. 15, Se. qr., Se. 1/4). A spur will be run off to them from the company's main spur between the two slopes.

The White Ash Coal Company has worked a slope for eight years one mile south of Avery. The coal bed varies between three and one-half and six feet in thickness. A local trade is supplied, chiefly in the winter months. A tramway may soon be built to Avery and a shipping trade inaugurated.

Albia. Although numerous shafts have at one time and another been opened just north and west of Albia, especially in sections 8, 9, 10, 17 and 18 of Troy township, only one mine is now in operation in this district. The Star mine, two and one-half miles northwest of Albia (Sec. 17, Nw. qr., Nw. 1/4), has been open seven months in the year for about ten years. The shaft was sunk to a coal forty-four inches to six feet thick. A three-foot seam is said to lie forty feet below the surface at the shaft. The product of this mine is hauled to Albia, and to a switch on the Chicago, Burlington and Quincy railway whence it is shipped.

The Albia Fuel Company has completed the sinking of a shaft one mile south of Albia (Troy Tp., Sec. 28, center of east line). The mine lies on the west side of the Iowa Central tracks, over which the product will be shipped.

Hocking. For a number of years the Hocking Coal Company has mined extensively in and near the valley of Coal creek. Their mine Number 1, at Hocking, was abandoned in 1906. Number 2, southeast of Hocking (Monroe Tp., Sec. 4, Ne. qr., Ne. 1/4), is still in operation, but its output is steadily decreasing and it will also be abandoned in the course of a year or two. Number 3 was sunk in 1905 two and a half miles south of Albia, beside the main line of the Iowa Central (Troy Tp., Sec. 34, Se. qr., Sw. 1/4). It is probable that another mine will be started southwest of Hocking. The coal in all these mines is of the same general character and lies at a depth of 315 feet at Number 3 and 208 feet at Number 2, which is situated on lower ground. It varies in thickness from three and one-half to six feet. Round concretions of sandstone and ironstone are fairly common in the coal and roof-slate and undulations render the floor quite irregular in places, causing maximum variations of twenty-five feet in the level of the bed. The general dip of the strata is toward the south. Where the coal is thickest the underlying fire clay often shows a strong tendency to heave. During the summer months the warm air-currents deposit much of their moisture on the cool sides of the entries and rooms, altering the pyrite and marcasite of the roof-shale so that the latter breaks down somewhat. At Number 3 the coal lies in a trough-like basin trending east and west. On the north it rises and disappears; on the south it rises and thins. The basin is from 1,320 feet to three-fourths mile in width. On the north the roof and bottom become more firm. The following section (Monroe Tp., Sec. 4, Se. qr., Nw. ¼) is representative for the district.

		FEET.	INCHES.
19.	Drift	25	
18.	Shale, light-colored	10	
17.	Sandstone	25	
16.	Shale, light-colored	25	
15.	Sandstone	10	
14.	Shale, light-colored	15	
13.	Rock, hard	2	
12.	Shale, dark	43	
11.	Rock, hard	5	
10.	Shale, light-colored	11	
9.	Sandstone	10	
8.	Shale, light-colored	8	
7.	Coal	1	
6.	Rock, hard	1	
5.	Shale, light-colored	11	
4.	Rock, hard	2	
3.	Shale, dark	92	8
2.	Coal	4	4
1.	Fire clay	1	
	Total	302	

Both mines are well equipped and well managed,—especially Number 3. About 400 acres have been mined out from Number 2 shaft. At Number 3 automatic cages, stokers, and pit-car oilers, and a cleaver breaking device on the pit-cars facilitate the handling of the coal. The fan used is of an improved pattern devised by Mr. John Verner, one of the State Mine Inspectors.

The steel tower is sixty-six feet high to the sheave wheels. Coal is loaded through a curved shoot, a somewhat doubtful method of preventing breakage.

Hilton. The Whitebreast Fuel Company established one of the largest producers in the state at Hilton, two miles south of Hocking Number 3, but closed it in July, 1907. The roof was

Figure 57. Tipple of shaft No. 2, Hocking Coal Company, Hocking.

poor, making it necessary to use many props and to handle considerable dirt. The coal, however, was of fair quality and is not yet exhausted. The record given below is typical of the sequence of strata in this district.

MONROE TP., SEC. 10, NE. QR., NW. ¼.

		FEET.	INCHES.
35.	Drift	71	
34.	Shale, yellow	10	
33.	Shale, gray and clayey	9	5
32.	Coal	1	9
31.	Shale, blue	1	4
30.	Coal	1	1
29.	Shale, blue	25	5
28.	Shale, black	4	
27.	Sandstone, gray	2	
26.	Shale, black	7	

25.	Coal	1	6
24.	Clay shale, light	9	6
23.	Sandstone, hard	6	
22.	Shale, dark	3	
21.	Shale, sandy, light	10	
20.	Shale, dark	6	8
19.	Coal		9
18.	Shale, dark	4	7
17.	Clay shale, light	3	
16.	Shale, dark, banded	7	
15.	Shale, gray	5	
14.	Coal		4
13.	Shale, dark, and light below	17	8
12.	Sandstone	3	
11.	Shale, mixed	7	
10.	Sandstone	2	
9.	Shale, dark	4	10
8.	Coal	1	4
7.	Sandstone, hard	2	10
6.	Shale, dark	36	6
5.	Coal	4	2
4.	Coal, shaly		7
3.	Shale, dark above and light below	5	9
2.	Sandstone	3	
1.	Shale, dark	4	
	Total	283	

Hiteman. For a number of years the Wapello Coal Company has mined extensively in Guilford and Union townships, using as headquarters the attractive mining camp named Hiteman, near the northeast corner of Guilford. The company has constructed a spur from the Chicago, Burlington and Quincy railroad northward to the camp and beyond to their mines. Mine Number 1, immediately south of Hiteman, was abandoned in 1903 because of the long haul of over a mile from the workings to the shaft. Number 2, just north of the town, was never considered a profitable mine and was abandoned in 1901. Number 3, one mile west of Hiteman, and Number 4, three miles northwest of the same place, are still in operation. Shaft Number 3 is located in a basin running east and west and for several reasons was sunk so as to penetrate the lowest point in the basin, although the coal at that point is rather poor and contains much rock. The coal runs no thicker in the basins than on the rises. Haulage on the south side of the mine has recently been materially improved by the installation of a first-motion tail-rope engine and the making of a cut-off that obviates the necessity for two turns in the road, besides shortening the haul. The north workings are approaching depletion. Mine Number 4 is one of the best producers in the state. It was opened in 1902 by a shaft 150 feet in depth through which coal is hoisted by a geared engine with a six foot drum. The main haulage is effected by a first-motion tail-rope engine over roads laid with forty pounds of iron to the yard.

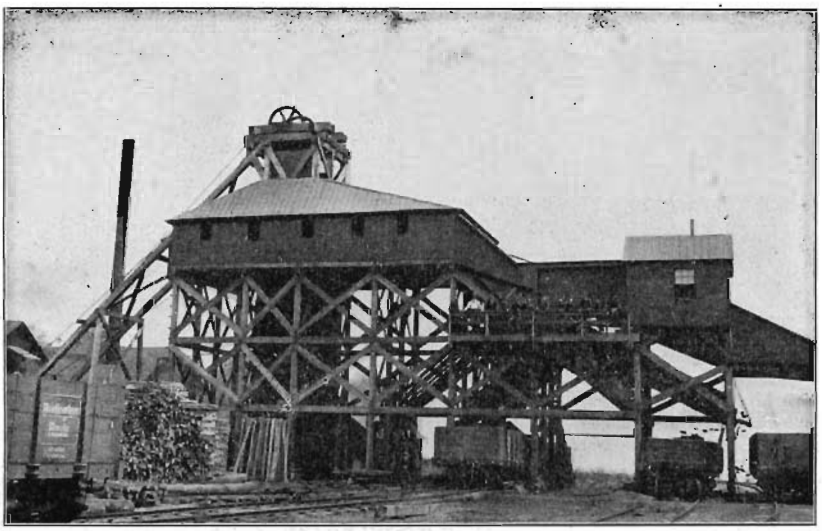


Figure 58. Tipple at shaft No. 3, Wapello Coal Company, Hiteman.

The Wapello Coal Company has operated diamond drills in this district for many years and has gained a complete knowledge of the various coals. Coal from four to six and one-half feet in thickness has been located in sections 1, 2, 3, 5, 9, 11 and 12 of Guilford township and 27, 28, 31, 34 and 35 of Union township. This statement is not meant to convey the idea that one continuous seam covers an extensive area; the strata are variable in thickness and occurence, as in other parts of the main Iowa field. The undulatory nature of the coal beds renders their level quite changeable between neighboring points. In most of the drillings a heavy stratum of dark, fissile shale, from twenty-five to sixty-five feet in thickness, lies immediately above the thicker coal. Where the drift does not extend to this layer, a sandstone is often found next above it, with a thinner coal bed still higher in the series. The following sections illustrate the position of the strata.

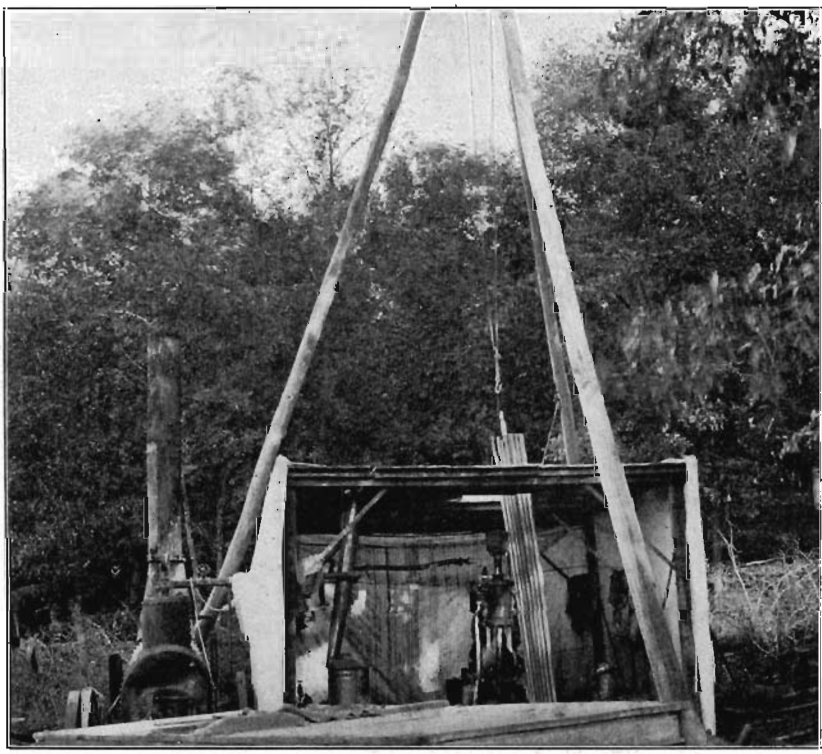


Figure 59. Diamond drill of the Wapello Coal Company.

UNION TP., SEC. 34, SW. QR., NE. ¼.

	FEET.	INCHES.
3. Soil	15	
2. Shale, fissile	60	6
1. Coal	6	
Total	81	6

GUILFORD TP., SEC. 2, NE. QR., SE. ¼.

	FEET.	INCHES.
8. Soil and drift	31	
7. Soapstone shale	8	
6. Shale, fissile	6	6

5.	Coal	1	
4.	Shale, fissile	1	6
3.	Sandstone	4	
2.	Shale, fissile	72	6
1.	Coal	5	
	Total	129	6

Foster. The only mine of importance in the southeastern corner of the county is Number 6 of the Phillips Fuel Company, located one-half mile west of Foster and shipping over the Chicago, Milwaukee and Saint Paul Railway. The bed mined lies 184 feet below the surface and is from four to five and one-half feet thick. Two coal "blossoms" were penetrated in sinking the shaft. A few well-marked geological faults of moderate throw are found in the workings, one of which made necessary the construction of an inclined tunnel sixty feet in length. Some trouble is also experienced from a "squeeze" that is slowly spreading over a part of the mine.

The records of prospect holes in this vicinity are so variable that they form but a slight basis upon which to rest general conclusions. Usually a two-foot "cap rock" is found about four feet above the coal mined, and at least two thin coals occur between it and the surface. Some attempt has been made to correlate a coal which outcrops along Soap creek near Foster and on Avery creek in Urbana township with the Mystic seam of Appanoose county. This bed shows three feet of coal, split into two benches by a thin clay parting as at Mystic, but the beds are of poor quality for fuel purposes and have not been drifted into for many years. There is some evidence of the limestone "cap rock" of the Mystic seam, yet no "bottom rock" has been discovered and neither the limestones nor the coal appear in several borings made south of Foster. Various theoretical considerations lead us to doubt the verity of the suggested correlation.

RINGGOLD COUNTY

Ringgold county is underlain by strata of the Missouri stage, sometimes known as the upper or barren Coal Measures. They are not completely lacking in coal, however, as is shown by the mining now being done in them in the counties on the west.

Nevertheless, such coal beds as have been found in this group of strata are thin and workable only under very favorable conditions. Several hundred feet below the surface of this region the rocks of the Des Moines stage, the true coal bearer of Iowa, may be reached; but the best coal horizons lie near the base of the Des Moines, several hundred feet farther down. Very little deep drilling has been undertaken in this part of the state, so that the exact location of various formations is but imperfectly known. The recent discovery of coal at Leon, at depths of approximately 500 feet below the surface, leads us to conclude, however, that coal may at some future date be found in Ringgold at depths that will be somewhat greater because of the westerly dip of the formations. Considering the depth to which prospect holes must be carried in order to reach the best horizons of the Des Moines, the number of prospects necessary to definitely determine the extent of any basin encountered, and the lack of certain knowledge that thick coal does exist so far southwest, drilling for coal alone cannot at present be encouraged in this county.

DECATUR COUNTY

The indurated rocks found immediately beneath the drift in the greater part of Decatur are of Missourian age, except where the drift deposits extend to exceptional depths. Des Moines strata outcrop only in the valley of Grand river as far north as Terre Haute and in the extreme southeastern corner of the county. The Missouri may carry thin coals of some importance, but is probably practically barren in this region, so that coal must be searched for among the Des Moines beds beneath it, and preferably in the lower portion of the latter, where coal horizons corresponding in stratigraphic level to those mined in Lucas, Monroe, Wapello and other counties may exist. It is not probable that the persistent seam, the Mystic, which occupies a higher level in Wayne and Appanoose counties, preserves its identity as far west as Decatur county. As is well known, the coal of the deeper horizons lies only in basins of limited lateral extent, so that barren prospects are often drilled in the midst of valuable fields. An unsuccessful drilling is not, therefore, an absolute indication that no coal exists in the neighborhood, nor does the finding of thick coal in one hole necessarily mean that a workable field has been encountered, for it may be that the drill has penetrated only a small pocket. The discovery of thick coal does indicate, however, that workable basins probably are present at approximately the same level somewhere in the district.

Bain* cites a few attempts to find coal in this region. At Davis City a boring was carried 212 feet below the Bethany limestone, which outcrops near that point, and penetrated two seams of coal four inches and six inches thick respectively. A boring near De Kalb was unsuccessful. Neither of these two holes were carried sufficiently far to reach the most productive horizons. Mr. C. Woodruff of High Point reported finding three beds of coal respectively one foot, three feet, and four inches in thickness. The hole was located on the highland, approximately 1,125 feet above sea level and was 412 feet in depth.

Recently three interesting borings have been made near Leon. The core of one that was drilled with a diamond drill was examined by James H. Lees, Assistant State Geologist, and his report of the section is given in full below. The thicknesses given for the coals are doubtless smaller than the actual facts, as some material was lost in removing the core.

RECORD OF PROSPECT DRILLING IN PASTURE OF ED. SHARP, IN NW. QR., NE. ¼, SEC. 32, TP. 69, R. 25, LEON.

Altitude at Top About 1050 Feet Above Tide.

NO.		FEET.	INCHES.	TOTAL.
54.	Bowlder drift	23		
52.	Glacial drift	274		300
52.	Glacial, drift	274		300
51.	Sand, with water	5		305
	(Core begins here.)			
50.	Shale, light gray, fine-grained, hard, fractured surface rather rough	3		308
49.	Shale, blue, growing darker below, very fine-grained, fissile, softer than No. 50, fractured surface smooth, soapy	12		320

Geology of Decatur County, Iowa Geol. Surv., Vol. VIII, pp. 296-297; Des Moines, 1898. The reader is referred to this report for a more detailed discussion of the stratigraphy than it is possible to give here.

NO.		FEET.	INCHES.	TOTAL.
48.	Shale, black, rather rough feel, but not sandy, becoming calcareous below; last 3 inches impure coal or carbonaceous shale. Shale for 9 inches above coal very calcareous and fossiliferous, carrying brachiopods	3		323
47.	Clay shale, gray, breaking very irregularly (air-slaked), crumbly, fine-textured, rather soapy, quite calcareous. Occasional small limestone nodules. (Core shows 12 ft. 6 inches.)	16		339
46.	Limestone, or very calcareous shale, gray, responding readily to acid, rough fracture	1	10	340-10
45.	Shale, black, fine-textured, quite smooth feel, noncalcareous, similar to No. 48. Has numerous thin bands blue-gray material, not respondent to acid, evidently shale, also some pyritic nodules, as well as a 3-inch band of gray, rather calcareous shale, similar to No. 46, 6 inches from top	3	6	344-4
44.	Shale, harder than overlying member, rather rough, calcareous, gray, pyritic,. not in definite layers except near bottom, where they are inclined from the horizontal	2		346-4
43.	Shale, typical clay shale, blue, soapy, slightly calcareous	3	6	349-10
42.	Shale, blue, finely sandy, with fine specks of mica, noncalcareous	8		357-10
41.	Shale, blue, fine-grained, fissile, rather soft, noncalcareous, becoming slightly darker below	10		367-10
40.	Shale, brown, very fine and fissile, rather soft, noncalcareous	3		370-10
39.	Shale, similar to above except for blue-gray color, becoming darker below	5		375-10
38.	Shale, gray, finely arenaceous, noncalcareous	6		381-10
37.	Sandstone, gray, very fine-grained, gradation from No. 38	7		388-10
36.	Shale, blue-gray, fine-textured, fissile, noncalcareous; occasional reddish concretions, possibly oxidized pyrite	19		407-10

NO.		FEET.	INCHES.	TOTAL.
35.	Limestone, dark gray, crystalline, with thin streaks of hard, dark gray shale. Transition from shale above seems to be quite abrupt so far as shown by core. Apparently some fossils are present		6	408-4
34.	Coal No. 1, in part hard and firm, in part slaked down to dust (blossom). Impure at top. Transition quite abrupt from limestone above to impure coal. According to driller's record	1	7	409-11
33.	Shale, blue-gray, fissile, some layers slightly sandy, with ironstone concretions; noncalcareous; becoming darker below. Thin films of carbonaceous matter interspersed in upper portion, small mica flakes present	16		425-11
32.	Clay shale, gray, fine-textured, noncalcareous, except for certain thin lenses of gray calcareous material. Becomes darker below, but core shows no gradation into coal.......	4	6	430-5
31.	Coal No. 2, rather better than coal No. 1. Stands air better. First and last 2 inches, impure. Record shows..	1	2	431-7
30.	Clay shale, not so fine as No. 32. Breaks irregularly. Contains small concretions, probably ironstone. (Core shows 2 ft. 6 in.)..................	6		437-7
29.	Shale, blue-gray, strongly calcareous. Contains some fossils..............	2		439-7
28.	Shale, blue, fine-textured, fissile, darker near the base......................	4		443-7
27.	Shale, black, carbonaceous, finely gritty, contains some pyrite	2		445-7
26.	Limestone, dark gray, very fine-grained, hard, apparently nonfossiliferous, responds to acid. Grades both above and below into dark gray calcareous shale		9	446-4
25.	Shale, black, carbonaceous, quite fine-grained, fissile, has numerous thin, small lenses of hard, gray, slightly calcareous shale ⅛-¼ inch thick. In places becomes very carbonaceous.	2		448-4
24.	Coal No. 3, quite solid and hard. According to record..................	2		450-4

NO.		FEET.	INCHES.	TOTAL.
23.	Shale, gray, argillaceous, slightly arenaceous, contains fine black concretions of ironstone. Grades down into No. 22	2	6	452-10
22.	Shale, gray, finely sandly and pyritiferous above, then arenaceo-calcareous, becoming less calcareous and more arenaceous below. Here it becomes bluish and grades into true clay shale, finally grading into No. 21	16		468-10
21.	Shale, dark gray to black, similar to other black shales in general character. Some pyrite and some streaks of hard, gray, noncalcareous shale. Near the base the bed becomes carbonaceous, rather fine, fissile	4	2	473
20.	Coal No. 4, solid and hard. According to record	1	6	474-6
19.	Clay shale, gray, rather rough, noncalcareous; irregular fracture, grades into calcareous shale below	2	6	477
18.	Limestone, hard, dark gray, fine-grained, subconchoidal fracture; considerably broken up and has shale and softer material in interstices		8	477-8
17.	Clay shale, bluish, quite smooth textured, surface of core roughened in places by minute pyrite nodules. Below, the shale contains small black, calcareous concretions. The last 1½ feet becomes darker and grades into calcareous shale, then into brownish, impure coal, then into No. 16	4	6	482-2
16.	Coal No. 5, some parts firm and solid, others slaked and disintegrated into blossom. According to record	2	9	484-11
15.	Shale, black, carbonaceous, with 2 inches of coal blossom at top. Coal has slaked badly, with small, white, feathery crystals		8	485-7
14.	Shale, blue-gray, quite fine-textured for first 2 feet, then becoming slightly more arenaceous for about 2 feet, then argillaceous again and bluish. Pyritiferous locally. Is more fissile near base	8	3	493-10

NO.		FEET.	INCHES.	TOTAL.
13.	Limestone, gray, subcrystalline, rather fine-grained; ready effervescence with acid. Transition from bluish shale above and below is rather abrupt...		9	494-7
12.	Shale, dark gray or bluish, becoming black below	6		500-7
11.	Coal No. 6, not very good quality......	1	7	502-2
10.	Clay shale, dark gray, finely arenaceous; contains some thin films of black carbonaceous matter. Becomes lighter gray below and somewhat more sandy. Shows two limestone bands about 4 inches thick, 6 and 24 inches from base...................	7	6	509-8
9.	Sandstone, light gray, fine-grained, quite hard, contains numerous small specks of white mica. Becomes coarser below	4	3	513-11
8.	Clay shale, dark blue, fine-textured, pyritiferous, becomes black below.....	4		517-11
7.	Coal No. 7, sample used for analysis...	1	6	519-5
6.	Shale, black, fine-textured, fissile......	2		521-5
5.	Coal No. 8, fair quality. Has thin, hard, pyritiferous, calcareous layers above.	1	4	522-9
4.	Shale, dark gray, fine, fissile, becomes lighter and calcareous below, where it shows interlacing veins of iron oxide. Finally grades down into No. 3	3	6	526-3
3.	Limestone, brown, highly calcareous, fine-grained; shows blue clay shale seams	2		528-3
2.	Clay shale, blue, fine-grained. Grades down into sandy shale through 2 feet and thence into No. 1..........	2		530-3
1.	Sandstone, light bluish gray, rather fine-grained, grows a little coarser about 3 feet down, then becomes finer again and rather clayey. To bottom of prospect			554

The Albaugh prospect, a short distance southeast of Leon (Center Tp., Sec. 33, Se. qr.), penetrated 283 feet of drift, and coals as follows:

COAL.	THICKNESS FEET.	INCHES	DEPTH FEET.	ELEVATION ABOVE TIDE.
No. 1	1	11	352	668
No. 2	1	6	397	623
No. 3		10	401	619
No. 4		4	403	617
No. 5	4	6	425	595

The Biggs prospect at Leon was begun on higher ground and continued to greater depth than either of the two drillings just quoted. A churn drill was used, but the record was kept with some care and is given below for purposes of comparison.

LOG OF BIGGS PROSPECT DRILL, SW. COR. SEC. 28, TP. 69, R. 25, LEON.

Altitude of curb about 1120 feet above tide. Now used as city well.

		FEET.	INCHES.	TOTAL.	ABOVE TIDE.
20.	Glacial drift	333		333	
19.	Limestone	2		335	
18.	Coal (No. 1)	1	8	337	783
17.	Soapstone	7		344	
16.	Blue stone	10		354	
15.	Blue soapstone	23		377	
14.	Coal (No. 2)		10	378	742
13.	White soapstone	62		440	
12.	Limestone	4		444	
11.	Black slate	6		450	
10.	Hard soapstone	20		470	
9.	Slate, black	1		471	
8.	Coal (No. 3)	4		475	645
7.	Blue soapstone	33		508	
6.	Limestone, white	7		515	
5.	Soapstone, white	6		521	
4.	Hard white soapstone	44		565	
3.	Coal (No. 4)	4	6	569-6	550
2.	Soapstone	66		635-6	484-6
1.	Sandstone, white	158		793-6	326-6

An examination of these three records shows that a number of coal horizons, some bearing in places coal of workable thickness, lie between elevations of 783 and 527 feet above sea level, with the thickest seams between 550 and 600 feet. While a sufficient number of holes have not been sunk to determine whether a basin of coal that would justify exploration be present at Leon, the results obtained are encouraging as showing that good coal does underlie Decatur county along several horizons. We may look forward hopefully to the time when better market conditions will justify the expenditure of large sums in locating and developing the mineral resources of the region. Chemical analyses of the coals found in the Leon drillings are given in another place in this volume.

The three prospects were drilled in greater part through the drift and the Des Moines. The Missouri has been removed at Leon by pre-glacial erosion, its place being taken by about 300 feet of drift. Since outcrops of Des Moines strata have been identified by Bain at Davis City at an elevation of about 915 feet A. T., the base of the Missouri may be expected to occur above that level in the central part of the county. The highest indurated beds shown in the three records lie at an altitude of 837 A. T., and are evidently, therefore, of Des Moines age, as is indicated also by the character of the beds shown in the sections. Numbers 1 and 2 of the Biggs' log are apparently incorrectly interpreted. Number 2 perhaps, presents a succession of shales with some sandstone, at the base of the Des Moines, and No. 1 a series of limestones, calcareous shales, and sandstones belonging to the Mississippian. This interpretation, which is merely tentative, would make the thickness of the lower, or productive, Coal Measures of the district, 400 or 450 feet in thickness. No coal will be found below the Des Moines.

Recent drilling near Cainsville, a few miles south of the Iowa state line, in Missouri, is said to have revealed some deep coals at that point. The accuracy of the report could not be verified, but the following statement is the one commonly given out.

	THICKNESS		DEPTH.
COAL.	FEET.	INCHES.	FEET.
No. 1	4	4	500
No. 2	2	2	520
No. 3	3	6	525
No. 4	1	6	546

WAYNE COUNTY

In the eastern third of Wayne county is found the western continuation of the Mystic coal and the accompanying strata of the Appanoose formation. These beds and their stratigraphic relationships will be briefly described later in the chapter on Appanoose county. They are found to extend almost unchanged into Wayne county, and the coal is mined at several places in the eastern townships where, however, it is a few inches thinner than at Mystic and Centerville. At Seymour, where the coal is rather extensively mined, the bed is usually little more than twenty-five inches in thickness. A number of local mines are in operation in the vicinity of Confidence in coal about twenty-eight inches high. In tracing the coal west from Seymour it is found to become gradually thinner and poorer in quality; it thins out and even disappears in places, while the roof is sometimes uncertain. In short, there occurs a disappearance of the constant characters the formation possesses in Appanoose county. The results of the only systematic prospecting that has been undertaken within the county are not now available, so that data are somewhat meager; but so far as can be learned the western boundary of the Mystic coal lies a few miles west of a line drawn through Sewal, Harvard, Bridgeport, and Bethlehem. Mr. R. C. Poston of Corydon drilled several holes three miles north of Harvard, on the Vollmar farm (Corydon Tp., Sec. 34). The record of one of these is:

		FEET.	INCHES.
57.	Sand and gravel	35	
56.	Gray drift and sand	96	
55.	Shale, unctuous	5	6
54.	Shale, dark	3	6
53.	Coal (at 140 feet)		3
52.	Shale, argillaceous	10	9
51.	Shale, sandy	6	
50.	Limestone, fossiliferous	3	5
49.	Shale, sandy	10	
48.	Shale, gray	7	9
47.	"Slate"	2	
46.	Shale, gray	1	10
45.	Coal (at 182 feet)		2
44.	Fire clay	4	2
43.	Rock, hard	3	

42.	Shale, sandy	13	3
41.	Sandstone, light-colored	2	
40.	Shale, dark	4	6
39.	Shale, light-colored	4	
38.	Shale, sandy	22	
37.	Shale, gray	21	
36.	Coal (at 256 feet)	1	3
35.	Clay parting		1½
34.	Coal, impure		3
33.	Coal		3
32.	Shale, light-colored	1	
31.	Sandstone, gray	6	
30.	Shale, gray	13	
29.	Shale, dark	2	1
28.	Coal (at 280 feet)	1	6
27.	Coal, impure		2
26.	Shale, light-colored	3	
25.	Rock, hard	4	6
24.	Shale, dark	7	
23.	"Slate"	2	4
22.	Coal (at 298 feet 7 inches)	1	3
21.	Shale, light-colored	1	
20.	Rock, hard	2	6
19.	Shale, sandy	10	
18.	Shale, light-colored	7	4
17.	Shale, dark	1	
16.	"Cap rock"		8
15.	Shale, dark	2	
14.	"White top"		8
13.	Shale, dark, sandy		8
12.	Coal (at 325 feet 8 inches)	1	
11.	Coal, impure	1	11
10.	Shale, light-colored	2	
9.	Shale, sandy	2	9
8.	Sandstone, gray	2	8
7.	Shale, light-colored	1	6
6.	Shale, dark	2	
5.	"Slate"	1	2
4.	Coal, impure (at 340 feet 8 inches)	2	7
3.	Shale, light-colored	1	
2.	Limestone		10
1.	Shale, calcareous	4	1
	Total	349	2

Two other drillings made in the same locality show a general correspondence with the above record, although the inconstancy of strata peculiar to the typical phase of the Des Moines stage is evident. It will be observed that not less than seven thin coals appear in the record given above, not one of which can be correlated with certainty with the Mystic seam. In the other two holes the thin coals, numbers 45 and 54 of the above section, were not encountered. It is barely possible that some of the identifications made by the driller are open to question and that the Mystic coal is present here in workable thickness.

Reports of borings made at Corydon are rather conflicting. Six drillings were made within a mile of the city and it is claimed by reliable men that three feet of coal were found beneath a considerable thickness of drift. No exploitation was attempted. It appears probable that the Mystic seam, if present at all in central Wayne county, lies over 300 feet beneath the general level of the surface.

The average dip of ten feet per mile to the southwest that the formations exhibit in northwestern Appanoose county is doubled from Jerome to Seymour, but appears to flatten out or even to become reversed southwest and west of the latter town. From Brazil westward to Plano an exceptionally strong dip or else a geological fault is also noted, coal being reached at a depth of two hundred feet at Plano. This dip practically ceases between Plano and Promise City. In Wright township the coal lies near the level of the creek bottoms and dips towards the south, with a smaller component in a westerly direction. The northern boundary of the Appanoose formation is to be found in Lucas county, not far north of the Wayne county line.

Some effort has been made to locate workable coal near Promise City. The following drilling was made by the Scandinavian Coal Company on the Hart land, a short distance west of that town.

DRILLING WEST OF PROMISE CITY.

		FEET.	INCHES.
12.	Drift	199	
11.	Coal	1	2
10.	Fire clay	1	
9.	Limestone	1	2
8.	Shale, blue, arenaceous	15	
7.	Shale, blue, argillaceous	4	
6.	Limestone	1	10
5.	Shale, black, argillaceous	3	2
4.	Coal		1

3. Shale, gray	24	
2. Shale, black		8
1. Shale, gray and red	6	
Total	257	1

Number 11 of the above section corresponds very well in position with the lower bench of the Mystic seam found farther east, the upper bench having been removed by pre-glacial erosion. Number 9 then falls into place as the "bottom rock" of the Mystic district. The full thickness of the coal, twenty-six inches, is reported as found on Mr. Sharp's land, two and one-half miles farther west, and on the Lord place, east of Promise City, but sufficient roof is present only in places.

Some attempt was made to find coal in the northwestern section of the county, where practically the entire thickness of the typical facies of the Des Moines is present. Coal seams, often thick, are abundant in these strata, but are seldom even moderately persistent when traced laterally. A drilling begun one-half mile northeast of Humeston was abandoned after the remarkable thickness of 402 feet of drift had been penetrated.

All of the coal mined in Wayne county has been taken from the Mystic seam. The earliest authentic record we have of annual output is that of the State Census of 1865, which gives a total of 9,230 bushels. The federal census cites a production of 155 tons for 1870, 6,000 for 1880 and 17,480 for 1890. Variations in tonnage during recent years are as follows:

YEAR.	TONS.	YEAR.	TONS.
1898	51,550	1903	75,488
1899	60,418	1904	98,879
1900	54,503	1905	112,549
1901	19,478	1906	136,694
1902	64,164	1907	146,901

During the year ending June 30, 1908, the State Mine Inspectors report that 124,465 tons were produced, chiefly by the two shipping mines at Seymour, and that 471 men were employed.

WAYNE COUNTY MINES.*

Confidence. For nearly forty years local mines have been operated in the northeastern corner of the county; yet the total amount of coal taken out is not large, as only local trade has been supplied. At one time and another shafts have been sunk on nearly every section in the eastern third of Wright township. The mines at present open are located chiefly south of Confidence.

The present L. Frye mine (Wright Tp., Sec. 23, Sw. qr., Se. ¼) has been worked for three years. The shaft, located on high ground, is 110 feet deep. A small steam engine is used for hoisting. About fifteen acres were mined out from an old shaft one-fourth mile north. Below the thirty-inch limestone "cap rock," the section at the new mine is:

FEET.	INCHES.	
1		7. Shale, bituminous, fissile.
1	8	6. Coal.
	3	5. Clay parting.
	7	4. Coal.
	½	3. Clayey parting, containing much pyrite.
	1	2. Coal.
1		1. Fire clay, impure.

Figure 60. Coal seam in Frye mine. Confidence.

On the same piece of land, just west of the Frye, is the J. Hayhurst bank. A strong dip to the southwest at this point lowers the Mystic coal fifteen feet between the two mines. At the Hayhurst bank the "cap rock" has increased in thickness to five and one-half feet and the coal to twenty-nine inches. On the south is the Jared bank (Sec. 26, Sw. qr.). The shaft is twenty-eight feet deep and is on low ground. The section here is:

	FEET.	INCHES.
6. "Cap rock"	8	
5. "Clod"		10
4. "Slate"	1	8
3. Coal, with "mud band"	2	5
2. Fire clay	4	
1. "Bottom rock"	5	6

*As found in operation in August, 1907.

The A. H. Hayhurst bank is farther down the creek (Sec. 35, Ne. qr., Sw. ¼). The shaft is thirty feet in depth and the section at its base is essentially the same as that at the Jared bank, although the "cap rock" is reduced to five feet. Below this mine is the E. A. Sipes bank, now operated by Mr. Edwards (Sec. 35, Se. qr., Se. ¼). The seventy-foot shaft is located part way up the valley slope. The thickness of the Mystic seam is from twenty-six to twenty-eight inches. A short distance southeast is the Sims bank (South Fork Tp., Sec. 1, Ne. qr., Ne. ¼). The Mystic coal lies sixty feet below the surface at the shaft and is accompanied by the following strata.

	FEET.	INCHES.
6. "Cap rock"	6	
5. "Clod"		4
4. "Slate"		4
3. Coal, with "mud band"	2	5
2. Fire clay	1	
1. "Bottom rock," about	6	

Four miles west, on South Chariton river, is the Davis bank (South Fork Tp., Sec. 5, Se. qr., Ne. ¼). A shaft low down in the valley reaches the coal at seventy-two feet, but has not been used for some time. There is a local dip to the northwest here. A section at this point shows:

	FEET.	INCHES.
Soil	14	4
Limestone (the "fifty-foot limestone")	5	11
Shale, argillaceous	25	2
Limestone } (the "seventeeu-foot limestone")	1	2
Shale, calcareous } (the "seventeeu-foot limestone")		10
Limestone, impure } (the "seventeeu-foot limestone")	1	10
Shale, mixed	9	11
Limestone	2	5
Shale, unctuous	2	7
Limestone, fossiliferous (the "cap rock")	1	6
"Slate"		11
Coal, upper bench	1	3
Clay parting (the "mud" band)		2
Coal, lower bench		7
Fire clay	1	9
Total	70	2

This section corresponds very well with the generalized section of the Appanoose beds given in the chapter on Appanoose county as typical for the Appanoose field. Some drilling done one-half mile west of Bethlehem failed, however, to reveal workable coal.

Seymour. By far the greater part of the coal mined in Wayne county is taken out by the two mines of the Numa Block Coal Company at Seymour. Mine No. 2 is situated on the north side of the Chicago, Milwaukee and Saint Paul railway, one mile east of the Milwaukee depot at Seymour (Sec. 13, Ne. qr., Sw. ¼). This mine, known as the "Big Jim," has produced more coal during recent years than any other in the Appanoose-Wayne coal field. Working full time it can easily produce 100,000 tons per year. It is equipped with an Ottumwa first-motion hoisting engine, steam dirt dump, Ottumwa box-car loader, and self-dumping cages. The remainder of the equipment is good. The shaft is 202 feet in depth. Mine No. 3, called the "Sunshine" mine, is in the southeastern part of Seymour about one-half mile from the Rock Island station. It loads a considerable output on the Chicago, Rock Island and Pacific railway. The shaft is 240 feet deep, showing that the strong southwesterly dip seen in the mines is continued between Nos. 2 and 3. The lower part of the section in this district, as given by Keyes, is:

FEET.	INCHES.	
1	10	8. Limestone, gray, fossiliferous (exposed).
	6	7. Clay, drab, shaly ("clod").
	10	6. Shale, bituminous, fissile.
1	4	5. Coal.
	2	4. Clay parting.
	9	3. Coal, with an occasional thin clay parting.
1	3	2. Fire clay.
1	10	1. Limestone, thick bedded, gray.

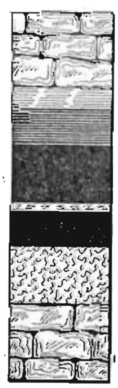


Figure 61. Coal at Seymour.

Four miles southwest of Seymour, is the Carey Brothers mine (Monroe Tp., Sec. 3, Nw. qr., Nw. ¼). A small double engine hoists 140 feet from the pit bottom to the surface. The mine supplies only a local trade and so has worked out only a small area during the four years of its existence. The strata accompanying the Mystic coal are:

		FEET.	INCHES.
6.	Limestone	1	
5.	Shale	1	
4.	"Slate"		7
3.	Coal (upper two inches impure)	1	4
2.	Clay parting		3
1.	Coal		10

About two miles northwest of the Carey is the Winger mine (Walnut Tp., Sec. 29, Sw. qr., Ne. 1/4). The shaft is 145 feet in depth. Hoisting is done by a small single engine. The limestone "cap rock" occasionally rests directly on the coal; elsewhere "slate" intervenes as shown in figure 62.

FEET.	INCHES.	
3		6. Shale, black, fissile, grading into 5 below.
1	2	5. Coal.
	2	4. Clay parting.
	8	3. Coal.
2	6	2. Fire clay.
3		1. Limestone, gray.

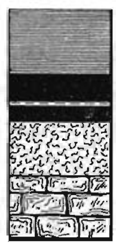


Figure 62. Bed of Winger mine. Harvard.

Between Sewal and Harvard is the Slack mine, now operated by Mr. Blue (Jackson Tp., Sec. 22, Se. qr., Se. 1/4). The shaft is 165 feet deep and hoisting is done by horsepower gin. In places in this mine the coal is absent, in others as much as twenty-six inches occurs. From four to eight inches of "slate" separates the "cap rock" from the coal.

A shaft has recently been sunk one and one-half miles east of Harvard (Sec. 14, Ne. qr., Nw. 1/4), where it is claimed as much as twenty-six inches of coal is known to occur. The mine is idle at present, owing apparently to a weak roof and an unreliable coal seam. Sufficient work has not yet been done here to determine the exact nature of the coal bed.

APPANOOSE COUNTY

Appanoose and Wayne are unique among Iowa coal counties, inasmuch as they contain a coal bed which is continuous over a considerable area and yet forms part of the Des Moines stage. With the exception of the few places where erosion channels have removed it, this coal, known as the Mystic seam because of its typical development at Mystic, appears to be present under the entire western half and more of Appanoose and adjoining portions of Wayne county on the west and the state of Missouri on the south. Moreover, it is not alone the Mystic coal which possesses the feature so anomalous for the Des Moines, of continuous and uniform deposition over an extensive area. The strata associated with the coal are remarkably similar at widely separated points, so that Bain* in his study of the county was led to distinguish the entire assemblage as the Appanoose formation, a sub-stage of the Des Moines terrane. The appearance of persistent strata, including bands of limestone, is far different in character from the typical Des Moines facies as found in other parts of the Iowa field, and represents deeper sea conditions of deposition more nearly like those which governed the growth of the Missouri stage. The Appanoose formation lies in the upper portion of the Des Moines in a region where the latter possesses a greater thickness than is found in Lucas county, for example, where nearly the entire series from the base of the Missouri to the top of the Saint Louis is present. The Appanoose beds represent the transition stage from the shallow water conditions governing the deposition of the lower Des Moines to those of the upper Des Moines and of the Missouri. A somewhat similar assemblage of strata, with rather persistent limestones and coal horizons, has been traced through parts of Madison, Dallas and Guthrie counties and has been assigned to late Des Moines time. A conglomeratic member at the summit of the Appanoose formation serves to separate it to a limited extent from the beds that formerly overlay it. The strata mentioned as occurring in the more northerly counties are evidently also the result of a transition from the extremely unstable conditions of sedimentation prevalent throughout earlier Des Moines time to relatively more stable relationships of land and sea.

Several layers of limestone, shown in the sections given below, act as markers for the Mystic coal wherever it occurs. The names applied to them locally—the "floating rock," "fifty-foot

*_Geology of Appanoose County_, Iowa Geol. Surv., Vol. V, pp. 363-438; Des Moines, 1896. The writer is indebted to this report for much information in regard to the geology of the region. Acknowledgments are due also to Mr. John Verner, Mine Inspector for the first district, for data concerning several mines and for courtesies extended.

limestone," "seventeen-foot limestone" or "little rock," the "cap rock," and the "bottom rock"—indicate succinctly their stratigraphic position with respect to the coal. While these rock bands are not of exactly the same thickness or at exactly the same distance above or below the coal in all sections of the field, the differences noted at widely separated points are minor ones. The Mystic seam itself is also remarkable in preserving unchanged certain characteristic features wherever it is found. It is split into two benches by a thin layer of clay known as the "mud band," and usually also bears a second and thinner clay seam, termed the "dutchman," below the first. While the coal bed varies somewhat in thickness from point to point, the variations are merely a matter of inches. Bain gives the following generalized section for this field.

		FEET.	INCHES.
17.	Limestone, gray, subcrystalline, the "floating rock"	2-4	
16.	Shale, argillaceous, color variable	12-30	
15.	Limestone, heavy ledges, the "fifty-foot limestone"	4-10	
14.	Shale, argillaceous, blue and red	14	
13.	Shale, arenaceous, frequently sandstone	8	
12.	Shale, argillaceous, blue to gray	10	
11.	Limestone, somewhat variable in thickness, the "seventeen-foot limestone" or "little rock"	1-3	
10.	Shale, sometimes gray, frequently bituminous and pyritiferous	7	
9.	Limestone, sometimes gray and coarsely subcrystalline; sometimes fine-grained, bituminous, and grading into shales above and below; the "cap rock"	2-4	
8.	Shale, usually bituminous and known as "slate," occasionally in part soft and clay-like, then known as "clod;" at times, heavy and homogeneous, nonfissile, in which form it is known as "black bat"	1-3	
7.	Coal, upper bench, usually	1	8-10
6.	Clay parting, "mud band"		2-3
5.	Coal, lower bench, usually		8-10
4.	Clay parting, the "dutchman"		½
3.	Coal, frequently not so pure		2-3
2.	Fire clay	1-6	
1.	Limestone, the "bottom rock"	3	6

The deepest shaft in the county is that of the new Scandinavian mine at Plano. Owing to the considerable thickness of the drift here, the "fifty-foot limestone" is not present.

SHAFT RECORD OF SCANDINAVIAN NO. 2.

		FEET.	INCHES.
8.	Drift	159	
7.	Shale, arenaceous	7	
6.	Shale, argillaceous, blue and brown	8	
5.	Limestone, fossiliferous	3	
4.	Shale, blue	11	
3.	Shale and "cap rock"	8	
2.	"Slate"	1	9
1.	Mystic coal	2	5
	Total	200	2

In the Cincinnati district, which is rather distant from the type area, the "seventeen-foot limestone" is often called the "nineteen-foot limestone" and sometimes lies immediately beneath a thin "blossom" of coal. The "cap rock" may be as much as eight feet in thickness, but is very variable and may be altogether lacking. The "clod" is from six inches to a foot thick and is accompanied by six to eight inches of "slate." Especially toward the south the "cap rock" may rest directly on the coal. The coal is twenty-eight to thirty-four inches thick, occasionally slightly more. The underlying fire clay is from eighteen to twenty-four inches in thickness. The "bottom rock" is infrequently absent. "Slips" and erosion channels disturb the continuity of the coal bed at several points. East of Cincinnati, at Exline, and southeast, at Coal City, the Mystic coal shows local augmentation in thickness. Following is the record of a drilling made on the east line of the lease of the Thistle Number 2, a short distance east of Cincinnati. The Mystic coal is slightly below its normal thickness in this record.

SECTION EAST OF CINCINNATI.

	FEET.	INCHES.
Soil and drift	64	
Shale, green	2	6
Limestone	3	2
Shale, light-colored	1	
Shale, argillaceous, gray	11	4
"Cap rock"		7
Shale, blue	1	6
"Slate," black		10
Coal	1	4
Clay parting		5
Coal		10
Fire clay		10
Total	88	4

The Appanoose beds dip, in general, to the southwest at the rate of about ten feet per mile. This dip is far from universal, however, if limited areas be considered; for local anticlines and synclines disturb the symmetry of the inclination. Thus, although from Mystic to Jerome the dip is nearly normal, from Jerome to Seymour it is almost doubled. Also the coal at Plano lies nearly at the same elevation as that at Exline, Cincinnati and Seymour, and is surprisingly lower than that at Jerome or Brazil. In the southern half of the county the dip, however, veers to about ten feet per mile toward the south; while the western component is often absent or even reversed. Brazil, Numa, Cincinnati, and Exline lie on a broad low anticline which interrupts the general southwesterly dip. In the absence of a topographic map of the region and because of the lack of agreement between the datum planes of the profiles of the various railroads, absolute determination of the altitudes above sea level of the coal in various mining districts is rendered impossible. Owing to the general dips to the south and southwest, the lowermost beds of the Appanoose formation outcrop at the surface along a line that corresponds, roughly speaking, with the course of the Chariton river. North and east of this line the Mystic coal does not exist except, perhaps, in isolated outliers.

There is little doubt that workable basins of coal exist at levels stratigraphically lower than that of the Mystic seam, but it is not likely that there are other beds as continuous and persistent over large areas. Because of the presence of so reliable and easily mined a coal as the Mystic, the location and development of lower horizons is necessarily a matter for the somewhat distant future. In spite of the millions of tons of coal that have been taken from the Appanoose formation, only a narrow strip on each side of portions of the lines of railroad has been mined out. Great quantities of coal still remain untouched in the Mystic seam. Rumors of the presence of lower coals at Rathbun, Mystic, and Moravia have been circulated recently and are apparently authoritative, especially as regards the Rathbun district. Some attempts to locate new fields have been made in the eastern part of the county, in the typical phases of the Des Moines terrane. A boring at Unionville was abandoned after 200 feet of drift had been penetrated. Four borings made upon the plain near Udell found coal at a depth of about 175 feet. There is a possibility that this is the Mystic seam, though direct proof of this is lacking. The Mystic outcrops and is mined at the mouth of Snort creek, not far westward. Fresh drillings are to be undertaken at Udell in the near future. Several drillings were made between Sedan and Dean. Mr. Hanson of Dean reports that the following sequence was penetrated in a core boring headed near the Sedan station, about four feet above the level of the railroad tracks.

BORING AT SEDAN.

		THICKNESS		DEPTH	
		FEET.	INCHES.	FEET.	INCHES.
43.	Soil and drift	74		74	
42.	Coal	2	5	76	5
41.	Fire clay	2		78	5
40.	Soapstone shale	21		99	5
39.	Coal		5	99	10
38.	Fire clay	3		102	10
37.	Shale, dark, with limestones	16		118	10
36.	"Slate," black	10		128	10
35.	Shale, clayey, white	29		157	10
34.	Coal	1	10	159	8
33.	Shale, black	3		162	8
32.	Soapstone shale	30		192	8
31.	Coal	1	10	194	6
30.	Sandstone	7		201	6
29.	Shale, blue	5		206	6
28.	Coal		9	207	3
27.	Shale, gray	9		216	3
26.	Shale, sandy	16		232	3
25.	Shale, black	4		236	3
24.	Coal		7	236	10
23.	Shale, clayey, blue	2		238	10
22.	Coal	2	3	241	1
21.	Shale, blue	5		246	1
20.	"Conglomerate"	1		247	1
19.	Coal	2	10	249	11
18.	Soapstone shale	7		256	11
17.	Shale, gray	4		260	11
16.	Shale, blue	2		262	11
15.	Coal	1	3	264	2
14.	Shale, gray	5		269	2
13.	Shale, blue	20		289	2
12.	Sandstone	14		303	2
11.	Shale, blue	18		321	2

10.	Coal	2	10	324	
9.	Fire clay		8	324	8
8.	Coal	2	1	326	9
7.	Shale, blue	9		335	9
6.	Coal	2	4	338	1
5.	Fire clay	7		345	1
4.	Shale, gray	13		358	1
3.	Shale, blue	2		360	1
2.	Soapstone shale, white	17		377	1
1.	Limestone (probably Saint Louis)	5		382	1

Three other holes bored along the line of the Keokuk and Western railway between Sedan and Dean, showed essentially the same strata as far as they went, but were discontinued at 300 feet or less. A deeper hole one mile south of Sedan, near the Iowa Central railway, failed to find thick coal in the lower horizons. It will be noticed that in the above record no less than twelve coal horizons are shown. This may be taken as an index of the possibilities of the typical Des Moines strata in Appanoose county, though it must not be forgotten that coal in these horizons is apt to be pockety.

In the Sedan record, the Saint Louis limestone was reached at an altitude of approximately 443 feet above tide, Cairo datum. This indicates that an average dip of eight feet per mile is maintained from Ottumwa, where the highest Saint Louis outcrops lie at 680 feet A. T., southwest to Sedan. It is thought that the limestone was reached in a well at Centerville at 600 feet, an altitude corresponding very well with that of the same formation in the Sedan boring. Any of the strata lying between the Saint Louis and the drift may be safely considered to be possible coal bearers.

All the mines in the county work the Mystic seam. Owing to the slight depth at which the seam may be found in many places and to the lack of any necessity to prospect thoroughly lands about to be developed, a great number of shafts have been sunk and local mines are too numerous to mention. The presence of a firm limestone "cap rock," of the thin "mud band" in the center of the seam, of but little water, of an abundance of good clean coal at moderate depths, and of easy railroad communication render mining peculiarly easy and profitable. Although the coal averages but thirty inches in height, a large proportion of the total present can be won by the longwall methods to which a majority of the mines have changed. The amount of coal won per acre is, therefore, high in proportion to the thickness of the coal. The properties of the Mystic coal will be found described in another place in this volume. In point of production, the county has advanced steadily until it now ranks third in the Iowa field. It will continue to hold its high position for many years to come. In 1860 Appanoose produced 1,438 tons; in 1870, 6,709; in 1880, 59,160; in 1890, 285,194. Statistics for more recent years are given by reports of the Iowa Geological Survey as follows:

YEAR.	TONNAGE.	YEAR.	TONNAGE.
1898	608,165	1903	893,021
1899	633,899	1904	872,920
1900	734,698	1905	875,248
1901	868,967	1906	1,101,595
1902	771,363	1907	1,123,407

During the year ending June 30, 1908, 1,107,806 tons were produced and 4,026 men were employed by ninety-one mines. Of these, sixty-two were railroad mines, fifteen shipping over the Keokuk and Western railway, twelve over the Chicago, Burlington and Kansas City, nine over the Chicago, Rock Island and Pacific, twenty-four over the Chicago, Milwaukee and Saint Paul, two over the Iowa Central, and one over the Iowa and Saint Louis. Of the larger mines, thirty-three used the room and pillar method and forty-eight the longwall. There is no practical limit to the coal in sight; only the inadequacy of the market and a scarcity of men limits operations.

In the following pages may be found mention of all shipping mines in operation in July, 1907, and of the principal local mines. Numbers in parentheses refer to the positions of certain mines on the accompanying map.

APPANOOSE COUNTY MINES.

Independence Township. Owing to a lack of railroad facilities rather than to the absence of workable coal, only small local banks exist in the extreme northwestern corner of the county. Aside from a slight decrease in the thickness of the lower bench, the coal mined is in all respects similar to the Mystic seam as typically developed, and lies only a few feet above the level of the major streams. Among the principal coal banks in operation may be mentioned the Fenton (Sec. 20, Sw. qr.), the Mosly (Sec. 30, Sw. qr.), the Phillips (Sec. 30, Se. qr.), and the new Young mine near Griffinville.

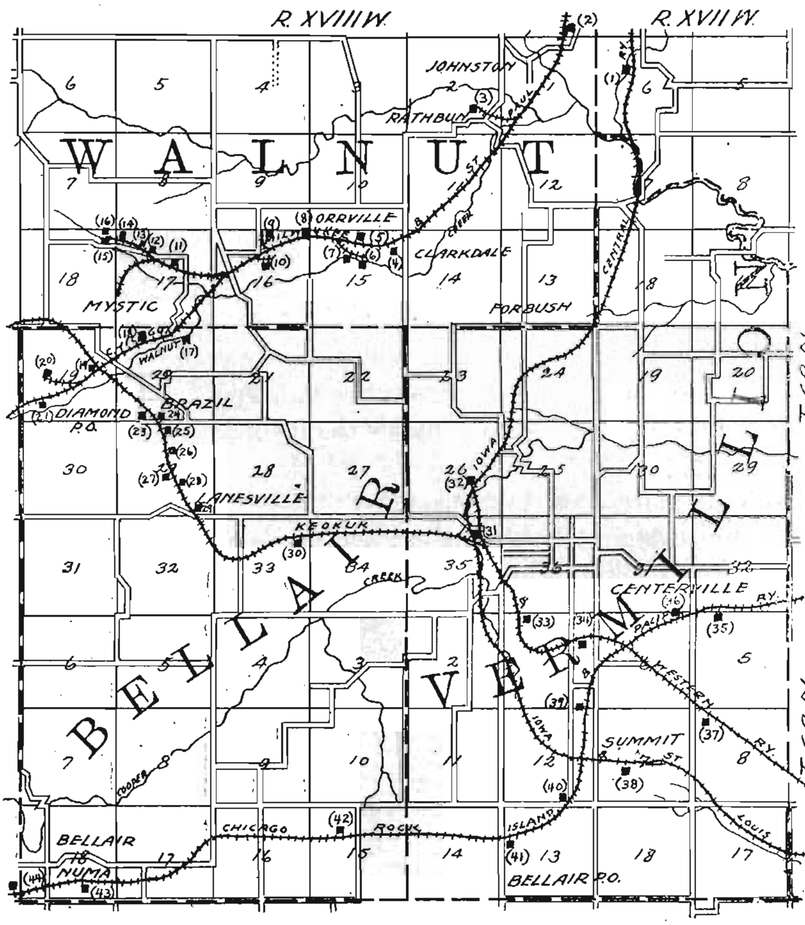


Figure 63. Map showing shipping mines in central Appanoose county.

Moravia. Three miles east of Moravia a shallow shaft is now being sunk. Small banks have been essayed in this area at successive intervals, but have led short lives because of the softness of the coal and the frequency of "slips" and "washouts." The seam present shows the usual thin clay parting, but is not so thick as farther southwest and apparently lacks the overlying limestones characteristic of the Mystic coal. Nevertheless, it is possible that an outlier of the Appanoose beds exists here. A lower coal, about which no definite information could be obtained, is said to be present also.

Rosebrook. At Rosebrook, a new station on the Iowa Central, is the new mine (1) of the Sunnyside Coal Company, with a shaft eighty-two feet in depth (Douglas Tp., Sec. 6, Nw. qr.). It has been worked only 150 feet east and west of the shaft, and apparently lies on the eastern border of the Appanoose formation. A local mine is worked by Wm. Henry from an eighteen-foot shaft on the same farm on which the Sunnyside is located. One-half mile south is another small bank.

Darbyville. The Unity Block Coal Company (2) operates a slope at Darbyville (Walnut Tp., Sec. 36, Se. qr.), but is not putting out much coal at present. Natural drawbacks on the east and an old mine on the west have retarded development. This mine loads on the Chicago, Milwaukee and Saint Paul railway. The Mystic coal lies a few feet below the level of the river at this point.

Rathbun. The Star Coal Company mine at Rathbun (3) is located on a short spur from the Chicago, Milwaukee and Saint Paul railway (Walnut Tp., Sec. 2, Se. qr., Sw. ¼). This is one of the best equipped longwall mines in the county. In the northern portion of the Walnut creek coal field the Mystic coal comprises:

	INCHES.
Coal	16-18
Clay	2-4
Coal	14

At Rathbun and other points on Walnut creek a lower horizon with coal from four to five feet in thickness is reported on good authority. Its depth could not be definitely ascertained, but appears to be about 100 feet greater than that of the coal now mined.

Clarkdale. The Mystic Block Number 5 (4) is located at Clarkdale (Walnut Tp., Sec. 15, Ne. qr., Se. ¼), two miles east of Mystic. The shaft is seventy feet in depth. A substantial

Cleveland Iron Works hoisting engine, mounted on fifteen-foot foundations, is in use.

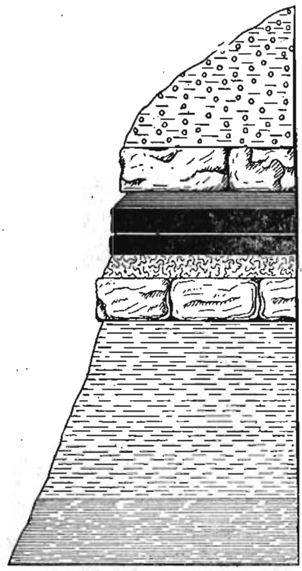
The Interocean Coal Company operates its mine No. 6 (5) one and three-fourths miles east of the Mystic station (Sec. 15, Ne. qr., Nw. 1/4). The shaft is seventy-five feet deep. A local dip of the coal bed to the southeast causes the north end of the workings to be left quite dry. Both the Interocean and the Mystic Block Number 5 load on the main line of the Chicago, Milwaukee and Saint Paul railway.

A short distance south of the last mentioned mine is the Elgin and Barret (6), a slope mine reached through the old workings of the Iowa Block Coal Company. The slope mouth is located on the south side of Walnut creek, so that cars must be carried over to the tipple on the north bank on a long trestle. Formerly coal was very extensively worked at this point.

The Beggs Coal Company has a fifty-foot shaft (7) a few rods west of the last mine mentioned and on the same short spur from the Chicago, Milwaukee and Saint Paul railway. Hoisting is done by horse gin and only three or four acres have been mined over. In this district there is a local dip to the southeast, which amounts to about one foot in one hundred in the Beggs workings.

Mystic. One mile east of the Mystic station is the slope of the Winnifred Coal Company (8), situated on the north side of the Chicago, Milwaukee and Saint Paul tracks. This mine is known as the "Lady Mary" and has been intermittently worked for about fourteen years. The company intends to install tail-rope haulage from the bottom of the slope to the tipple.

The Mystic Block Coal Company Number 12 (9) is on the "reservoir switch" in the eastern section of Mystic. The slope and main roadway extends about one-half mile under the hill to the north. The coal lies a few feet below the level of the tracks. A shaft is to be sunk some time in the future and the slope abandoned. The output of Number 12 ranks among the best in the district. Between this mine and the "Lady Mary" is a wide pre-glacial channel, running off to the northwest and cutting out considerable coal.



		FEET.	INCHES.
10.	Drift	12	
9.	Limestone, heavily bedded gray, fossiliferous	2	10
8.	Shale, bituminous, fissile	1	
7.	Coal	1	6
6.	Clay parting		2
5.	Coal, with some pyrite near base	1	
4.	Fire clay	1	6
3.	Limestone, heavily bedded, fossiliferous	2	10
2.	Shale, gray, clayey	11	
1.	Shale, blue, clayey (exposed to water level)	4	

Figure 64. Bluff on Walnut creek. Mystic.

Peerless Number 6 (10) is a mine of considerable extent, entered by a drift located on a short spur running southeast from the main line near the Mystic station. Tail-rope haulage is employed and an Ottumwa box-car loader facilitates the handling of the product at the tipple. The strata here show a slight dip to the north of about four inches in a hundred feet. Peerless Number 3, a slope just east of Number 6, is now shut down and its output will in future be pulled out through another opening not yet decided upon.

A railroad spur a mile and a half in length runs west from the main line at Mystic up the valley of a small creek, and on and near it are located a number of mines. The easternmost of these, on the Klondike switch, is the Mystic Block Number 29 (11), termed also the "Klondike mine." It has a shaft opening fifty feet deep, located in the northwestern part of Mystic, about one-fourth mile from the station. No work was done here from March to July, 1907. Two Lee electric mining machines, which have been employed with success in some longwall mines, were formerly used here, but are not now in service because of there being too little face for two machines and too much for one, and because the purchase and transmission of electric power from another mine proved to be expensive.

One-fourth mile northwest of the mine last mentioned is the slope of Acken Number 1 (12), situated on the north side of the spur previously mentioned. The slope has lately been re-timbered. Number 2 of the same company (13) opens by a twenty-five foot shaft a short distance west of Number 1. The output has been small, but is now increasing. Number 1 and Number 2 really constitute a single mine, as the face is continuous between the workings of each and both can be acceptably ventilated by a fan placed at Number 2 air shaft.

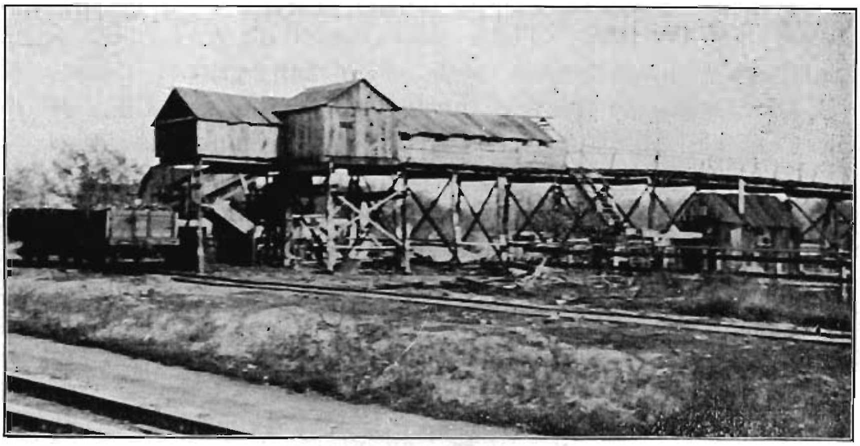


Figure 65. A type of tipple at the smaller mines.

Less than half a mile farther up the switch is mine Number 2 of the Peerless Coal Company (14). The product of the near-by Number 1 now goes out through Number 2 shaft and the two mines are ventilated as one. Number 1 workings are to move down to a new face while Number 2 mines at both its own face and the one formerly used by Number 1. Two Lee electric mining machines have been employed and another is to be installed.

At the end of the spur mentioned above as running west from Mystic are the three openings of the Mystic Coal Company. Number 3 (15) is a slope lying a short distance west of Number 2, which has a shaft opening. The workings of the two mines were recently connected, so that coal can now be taken out through either opening. Mystic Number 1 (16) is a small slope on the north side of the railroad spur, between the other two openings of the same company. Its territory is limited by an erosion channel that cuts out considerable coal in a strip oriented northeast and southwest.

On the main line, about half way between Mystic and the Keokuk and Western crossing, is the drift of the Egypt Coal Company (17). The opening is located on the south side of the creek, so that a long trestle has been constructed on which to carry the coal across the stream to the tipple. As in other mines, some trouble is experienced in obtaining men, and as a result work is rather intermittent. Tail-rope haulage is employed on the trestle. The company controls coal rights sufficient to supply territory to the mine for many years to come.

A short distance west of the Egypt, on the opposite side of the Chicago, Milwaukee and Saint Paul tracks, is Peerless Number 5 (18) also known as "The Twins." Dirt is pulled out by an electric tail-rope system through a slope on the side of the railway track opposite the thirty-five foot hoisting shaft. A neat brick engine house contains a Corliss engine, tubular boilers producing 125 horsepower, and a Siemens and Halske dynamo that supplies power for the tail-rope and the three Lee electric mining machines used in the workings.

The "Keokuk and Western" or "Baker slope" (19) is a small mine situated in the southwestern angle made by the crossing of the Keokuk and Western and the Chicago, Milwaukee and Saint Paul railroads. It operates only during the fall and winter.

Diamond. The Mystic Block Number 22 (20) is a new mine one-fourth mile west of the main line of the Chicago, Milwaukee and Saint Paul Railway, on the "22 switch." The shaft, which is seventy-five feet deep, has been in operation three years. The Mystic coal lies essentially level here. A double hoisting engine with a four-foot drum is utilized for hoisting. The tipple and other top works are well equipped.

The Mystic Block Number 21 (21), on the south side of the Chicago, Milwaukee and Saint Paul tracks at Diamond, is a slope mine. It has not been in operation for over a year because of the difficulty experienced in housing miners for both it and Number 22.

About one mile southwest, on the south side of the main line, is the shaft, eighty feet in depth, of the "Juckett" mine (22), leased by the Big Jo Coal Company. It employes few men but turns out a not inconsiderable output. Hoisting is effected by means of a Rochester engine. This mine, formerly operated by F. H. Juckett, changed hands in June, 1906.

Harkis. The Big Jo Number 1 lies on the south side of the tracks at Harkis, somewhat more than a mile southwest of the Juckett (Johns Tp., Sec. 35, Ne. qr.). The shaft is eighty feet deep and the tower forty feet high. There are separate buildings for the engine house, blacksmith shop, office, store room, fan house, and barn. A Rochester double hoisting engine is used. About 150 acres have been worked out. The coal seam exhibits a gentle dip to the southwest, and contains some "black bat." In this district the upper limestones have been removed in places by pre-glacial erosion.

Jerome. One-fourth mile east of the Jerome station, on the north side of the main line tracks, is the shaft of the Consumers Coal Company. This mine works on half time during half of the year and produces considerable coal during the winter months. An Ottumwa geared hoisting engine is used. The tower is but eighteen feet high, but is soon to be raised and improved. The Mystic coal lies 125 feet below the surface at this point. About eighty acres have been mined out.

Plano. Mine Number 2 of the Scandinavian Coal Company is located on the south side of the Keokuk and Western tracks, a short distance west of the station at Plano. The shaft, a section of which is given on a previous page, is the deepest in the county, being 200 feet from the surface to the base of the coal. Owing to the great thickness of the drift, chiefly clay, considerable difficulty was experienced in timbering substantially the upper portion of the shaft. The Mystic coal is of essentially the same character here as at Mystic and Centerville, though very slightly thinner (twenty-eight inches). A modern equipment has been installed and 320 acres are under lease, north and south of the railroad; but as yet the property has not proved very profitable owing to an inadequate demand for the coal and to the difficulty of securing men. South and east the bed is nearly level; it rises towards the north and somewhat toward the west also. No "slips" or "faults," or other checks on mining have been encountered. Hoisting is done with an Ottumwa first-motion engine.

Brazil. A number of mines are located between Brazil and Centerville, on the Keokuk and Western railway, now part of the Burlington system. A few yards north of the Brazil station is the Walnut Block mine (23), entered by a drift. The coal lies about six feet above the level of the railroad tracks and is twenty-eight inches in thickness. Mining has been carried about three-fourths mile under the hill to the south and west. The main roadway is now in course of improvement.

On the east side of the Keokuk and Western, three-eighths mile south of the Brazil station, is the Phoenix drift (24). The coal dips to the southeast as far (one-half mile) as work has been carried in that direction. On the north the so-called "nineteen-foot rock" outcrops, while the coal may be seen in the small valleys of the neighborhood. The main road in the mine runs north, with side roads to the west. A sixty-horsepower Ottumwa engine furnishes power for the tail-rope employed.

The Centerville Block Number 5 (25) is an old slope mine, a short distance south of the Phoenix. This mine produces more coal than any other loading on the Burlington system in this county. The main road is one-half mile long and tail-rope haulage is in use. The coal is nearly level. A tramway crosses the railroad tracks to a covered way in which pit cars may be stored. Part of the product is dumped into engine chutes for locomotive consumption.

About one-fourth mile south of the slope last mentioned is the Tipton Co-operative drift (26). About forty acres have been mined out and little coal is left within the territory. Not much work is being done at present. The Mystic seam is here thirty inches thick, with a dip to the east. Under the low lying land the roof is too poor to allow of profitable exploitation.

The Peacock slope (27) is on the west side of the Keokuk and Western, about one-half mile south of the Brazil station. The slope is 100 feet long, with a drop of four inches to the yard. Eighteen acres of the 160-acre lease have been mined out. The equipment is light. At this point the Mystic coal dips, in general, to the east and is slightly undulatory.

Not far from the Peacock is the Oriental Number 1 slope (28). The slope mouth is on the east side of the Keokuk and Western tracks while the top works are on the west side, the two being connected by a way running under the railroad. Tail-rope haulage is employed. The workings have been carried in nearly 2,000 feet. The company has 320 acres under control. The Mystic coal lies about forty feet beneath the level of the railroad tracks, and shows slight and variable dips.

Lanesville. The Perfection Block mine (29) is on the east side of the Keokuk and Western, at Lanesville (Bellair Tp., Sec. 29, Se. qr., Se. ¼). The shaft is seventy-two feet in depth. A large area of old holdings have been mined out here, but the company controls 160 acres of untouched land on the west.

About one mile southeast of the Perfection Block, on the south side of the Keokuk and Western tracks, is the shaft of the Sunshine Coal Company (30). Coal is hoisted 130 feet from the seam to the surface by a two-horse gin, but a more modern equipment will soon be installed. The dip is to the south.

Centerville. The Centerville Block Number 3 (31) is situated at the junction of the Keokuk and Western and the Iowa Central, loading on both lines. This is the old "Relay mine" and has a shaft opening 107 feet in depth. The present workings are at a considerable distance from the shaft. Six Legg and Harrison machines and a Norwalk air-compressor assist in keeping up the output. In the "Relay mine" has been encountered one of the heaviest dips found in the county; in a distance of 1,944 feet the coal rose thirty-six feet. Following is a section of the Mystic coal as it appears in this territory.

	INCHES.
Top coal	21
Clay parting	2
Bottom coal	11

The Centerville Block Number 9 (32) is about one-half mile north of Number 3, on the west side of the Iowa Central. The shaft is seventy-two feet deep, the upper twenty-two feet being drift. Six Harrison and Legg machines and a Norwalk air-compressor are in use in driving entries and turning rooms. A measured section at the bottom of the shaft showed:

		FEET.	INCHES.
11.	"Cap rock"	1	6
10.	"Clod"		7
9.	"Slate"		7
8.	Coal	1	6
7.	Clay		2
6.	Coal	1	½
5.	Clay and pyrite, the "Dutchman"		1
4.	Coal		1½
3.	Fire clay	1	2
2.	"Bottom rock"		10
1.	Shale, soft, sandy		

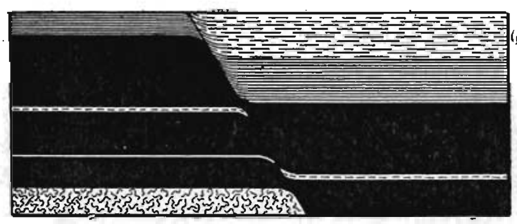


Figure 66. Fault in Centerville Block No. 9. Centerville.

On the Keokuk and Western, in the southern part of Centerville, is the seventy-foot shaft of the Anchor Mine Number 1 (33). A steam hoist and fan are employed. It has proved difficult to properly ventilate the north workings. About forty acres have been mined out.

The Scandinavian Number 1 (34) is in the southeastern portion of Centerville, on the south side of the Keokuk and Western railway. The coal lies about 100 feet below the level of the railroad. Under various names this mine has been worked twenty-five years and has exhausted 300 of the 340 acres controlled. Three rather large geological faults have been encountered. The first was found many years ago in driving south and east from the shaft, and it appears to have caused considerable displacement of the strata. The second is a trough fault which has lowered a section of the coal bed twenty-eight feet. The fault plane lies north and south and probably joins that of the first fault near the water works. A third fault, running southwest and northeast, has a rather uncertain relationship. As the zone of disturbance is approached the coal is found to be badly broken and to rise sharply.

A large number of local shafts operate within and near the Centerville city limits to supply the local trade. They are small affairs, usually hoisting with horse and gin, and do but little work during the warmer months of the year. The chief producers are the Centerville Block Number 8, Citizens, White Oak, Woodlawn, North Hill, Koontz, Trio, Rock Valley, Star, Smith, Sears and Wright. The coal mined at these banks differs in no essential respect from the Mystic seam as typically developed elsewhere.

About one mile east of Centerville, on the Chicago, Rock Island and Pacific railway, is the Centerville Block Number 10 (35), known also as the "Raven mine." Coal is reached at a depth of 130 feet. The drift is quite thick here, being ninety feet at the shaft, while the "cap rock" is only one foot in thickness and the "bottom rock" is also thinner than usual and is underlain by sandstone. A short distance west of Number 10 and connected with it is the Centerville Block Number 1, the old "Diamond mine" (36). The haul necessary here is more than a mile. Six Harrison and Legg machines and a Norwalk air-compressor are used in the workings. The tipple at Number 1 has recently been improved and revolving screens are used at both mines.

On the Keokuk and Western, a little over a mile southeast of Centerville, is the Dewey mine (37). This is one of the good producers of the district and hoists by means of a geared engine.

The Manufacturer's Coal and Coke Number 30 (38) lies on a short spur from the Chicago, Rock Island and Pacific railway, about one mile southwest of the Dewey. A neat mining camp of twenty-five houses is situated here. The Mystic coal is thirty-one inches thick at this point and lies in a shallow basin that dips from all directions toward the shaft. A short distance from the latter the north entry encountered a pre-glacial channel which had cut out the roof, but not the coal, for a distance of over 400 feet north and south. A drift-clay filling containing leaf impressions and bearing water lies directly on the coal. The same channel was found also north of the west entries; while on the east it lay farther east the farther south the workings were carried. The channel appears, therefore, to have a curvilinear course and to bear off towards the southeast. An attempt will be made to penetrate it with an east entry.

The Center mine (39) loads on the Chicago, Rock Island and Pacific railway, about one-half mile south of Centerville. The shaft is 136 feet in depth to the Mystic coal, which varies in thickness from thirty to thirty-five inches. 200 acres are under lease.

The Anchor Coal Company has worked out fifty acres from its mine Number 2 (40), one mile south of the Center and on the north side of the Chicago, Rock Island and Pacific railroad. Coal of the usual character is found here at 155 feet.

Bellair. Anchor Number 3 (41) lies on the opposite side of the same railroad, at Bellair. Drift extends down to the "fifty-foot rock," which was struck at a depth of ninety feet. The "cap rock" is only six inches thick at the hoisting shaft, but shows three and one-half feet at the air-shaft. As a general rule in this mine the "cap rock" is thin, but the "slate" immediately above the coal is sufficiently tough to insure safety in mining. Above the firm "slate" is softer shale. About eighty acres have been mined out, most of the product going to Kansas and Nebraska.

Two miles west of Bellair is the Prairie Block mine (42). The shaft was sunk 160 feet to the Mystic seam in 1904 and later a small group of houses was constructed. A lease of 560 acres is owned by the company. The coal presents essentially the same features as at Centerville.

Numa. The Numa Block mine (43), one-fourth mile east of Numa, is the largest producer in the county, although work was checked this year by a fire that destroyed the top works in March, 1907. Thirty to thirty-two inches of coal lie 150 feet below the surface. "Slips" and "black bat" give a little trouble. Two hundred acres are under lease and more will be added.

Just west of Numa station is the Centerville Block Number 2 (44). This is an old mine from which about 300 acres have been worked out. Tail-rope haulage is employed. The shaft is 150 feet deep and the tower forty-five feet to the sheave wheels. The Mystic coal is here thirty-two inches in thickness.

The Walnut Grove mine (45) is immediately north of the cemetery north of Numa, where a gin-shaft sixty-four feet in depth is operated. Although the mine is a mile from the railroad, a portion of the product is hauled to Numa and shipped. The coal is thirty inches in thickness, and without perceptible dip. The "cap rock" is exceptionally thick in places. Small "slips" and some "black bat" have been encountered.

Exline. The Iowa Block mine is one-fourth mile east of the station at Exline (Caldwell Tp., Sec. 32, Ne. qr., Nw. 1/4), on the north side of the Chicago, Burlington and Kansas City railway. The Mystic coal is here 150 feet below the surface, is thirty-six inches thick, and exhibits a southerly dip with a small eastern component. Near the shaft small pre-glacial channels filled with clay, and "slips" are numerous, but in the northwestern part of the workings are less plentiful. Both the channels and the fault planes are commonly oriented northeast and southwest. The throw of the faults is seldom greater than is necessary to bring the roof "slate" down to the level of the "Dutchman."

The old Royal slope, about two miles east of Exline (Sec. 34, Ne. qr., Sw. 1/4), is resuming work after a long idleness. Water gives so much trouble it is doubtful if much of an output will be attained.

The two mines of the Exline Coal Company are situated about three-fourths mile southwest of Exline (Sec. 31, S. 1/2), on the east side of the Chicago, Burlington and Kansas City railway. At Number 2, the mine nearest the Exline depot, the coal lies about 130 feet below the railroad tracks. A considerable territory is controlled by the company. A large so-called "fault" which is at least eighty feet in width at a point about 600 feet northwest of the shaft is found at Number 2 mine. Numerous small "faults" and one of undetermined extent run northeast and southwest at a high angle to the first mentioned and still further limit the territory as it is at present known. Some, at least, of these features are due to true geological faults.

A local mine, the White Oak, operates about one mile northwest of Exline. A little of the product is carted to the railroad and shipped.

Cincinnati. Less than a mile east of Cincinnati (Pleasant Tp., Sec. 3, Se. qr.) are the three mines of the Thistle Coal Company. Mines Numbers 1 and 2 open on the north side of the Chicago, Burlington and Kansas City by shafts 115 and 100 feet, respectively, in depth and about one-fourth mile apart. Number 3 shaft is 147 feet deep and lies on the south side of the railroad. All these mines have steam hoisting apparatus and are, in general, well equipped. The coal is about thirty-four inches thick in all and bears the relationships to other strata shown in the section given on a previous page. An old erosion channel, 100 feet wide and running southeast and northwest, has cut out the coal on the east side of Number 2 workings. The company intends to tunnel through it to the east where the seam again makes its apparance at its former level. The channel apparently winds in a broad, sweeping curve; for it, or a very similar one, has removed the coal on the southeastern side of

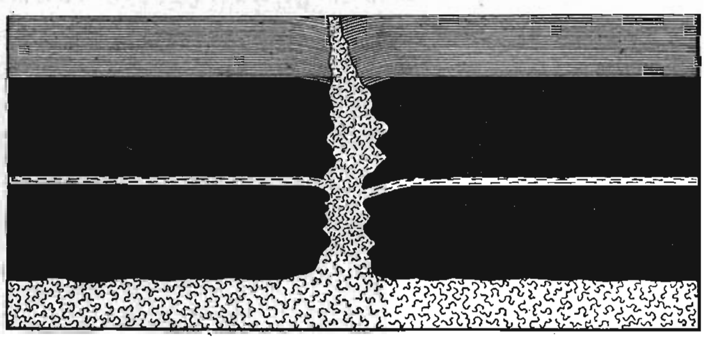


Figure 67. Fissure in seam at Thistle No. 1. Cincinnati.

Number 3 workings and was reached by the Appanoose while working south and by the old Streator (Sec. 9, Ne. qr., Se. 1/4) while driving east. Mines which were working up from Mendota struck the south side of the channel where it again swings back to an irregularly east and west course. In the hollow of the curve, between the barren areas found by the Thistle and the southern mines, the coal bed reappears.

In the southeastern corner of Cincinnati is the old Appanoose mine, now owned by the Mendota Coal and Mining Company. The Albert mine, about one mile southwest, on the west side of the railroad (Sec. 9, Ne. qr., Nw. ¼), is now operated as mine Number 2 of the same company. Number 1 shaft is 180 feet in depth; Number 2, 102 feet. The seam exhibits no noticeable dip and is divided as follows:

	INCHES.
Top coal	18
Clay parting	2
Bottom coal	12

The "cap rock" is from two to eight feet in thickness, the "bottom rock" nothing to five feet, the fire clay between the latter and the coal two feet. Between the two mines is a "washout" running southeast that has never been penetrated by tunnels.

A short distance north of Cincinnati (Sec. 4, Ne. qr., Ne. ¼) is the shaft, 112 feet deep, of the Domestic Coal Company. A two-horse gin effects the hoisting. About half of the product is hauled to the railroad and shipped; the rest is sold locally. A few small "slips" appear in the strata. The "cap rock" is sometimes lacking, yet the "slate" next the coal remains tough and forms a fairly safe roof.

An equal distance west of Cincinnati (Sec. 4, Sw. qr., Ne. ¼), the Armstrong mine now ships coal over a short spur from the Chicago, Burlington and Kansas City railway. The coal dips to the south eighteen inches in 100 feet near the shaft and then continues at a uniform level. It lies 139 feet beneath the surface at the shaft. Here, also, the "cap rock" is lacking in places, but is present in others.

The Consolidated Block is a slope on the west side of the Chicago, Burlington and Kansas City railway, one and one-half miles southwest of Cincinnati (Sec. 9, Se. qr., W. ½). The coal bed is nearly level and averages thirty-two inches in thickness.

Half a mile southwest of the Consolidated Block, on South Shoal creek, is the mine of the Cincinnati Coal and Mining Company (Sec. 16, Nw. qr., Nw. ¼). This is a slope 300 feet long to the coal. The product is pulled over a long tramway to the railroad.

Coal City. The top-works and slope mouth of the Manufacturers Coal and Coke Number 10 are in Missouri; but the air shaft and slope bottom are on the state line and all the coal mined is in Iowa, near Coal City. Loading is done on a switch from the Iowa and Saint Louis railway, a part of the Burlington system. A gravity slope brings pit cars to the top of the tipple and returns empties. The Mystic coal often shows a thickness of forty-two inches in this district, the upper bench taking the increase. It seems probable that the Appanoose formation extends only a short distance north of the state boundary, for drillings made one mile northeast and one mile east of the slope just mentioned failed to locate the Mystic coal or the limestones characteristically accompanying it.

PART III

COAL DEPOSITS OF SOUTHEASTERN IOWA

KEOKUK COUNTY

Keokuk county lies on the eastern border of the main Iowa coal field and contains only about eighty-five square miles of coal measures, of which the greater part is connected on the west and south with the Mahaska and Jefferson county fields respectively. With the exception of the eastern tier of sections, Prairie and Washington townships are underlain by Des Moines strata. There is also a similar but smaller area extending from west to east across central Warren township, and another in the southwestern quarter of Benton. A projection from the Jefferson county field is found in the southernmost sections of Richland township. Several small Des Moines outliers, each less than a square mile in extent, are scattered over the remainder of the county.

The relationships of the Des Moines to the underlying and overlying formations have been described elsewhere in this volume. Suffice it to say here that the results of the periods of erosion which preceded and followed the deposition of the Coal Measures are particularly conspicuous in regions which are situated, as Keokuk is, on the attenuated margin of the Des Moines outcrop. Wherever Coal Measures are found within the limits of the county, they are of slight thickness and usually lie in depressions in the Saint Louis limestone. As a consequence, the coal basins are often limited laterally by limestone walls. Again, the unequal erosion which immediately preceded the deposition of the drift scoured deep valleys in even these Coal Measures that it did not completely remove; so that in many cases we find coal seams cut into and seriously damaged by channels filled with unconsolidated clay and sand.

In spite of the facts which conspire to reduce the value of Keokuk coal basins, the county achieved and maintained for many years, one of the leading places among Iowa coal fields. The Coal Measure strata present necessarily belong to the first group deposited upon the subsiding limestone surface, and it is this lower section of the Des Moines which has proved most productive in the southern part of Iowa. Conditions seem to have been particularly favorable to coal formation during the earliest stages of Pennsylvanian time, and thus it is that the thin layer of Upper Carboniferous rocks found in parts of Keokuk county contains some thick coals that have proven of great value. The What Cheer district has been the chief producer and it was not until the beginning of the present century that its standing as a large mining field began to be seriously impaired. At the present time only local mines, located chiefly near What Cheer, are in operation, and it seems probable that the county will never again regain its former prestige.

In 1860 Keokuk produced 472 tons of coal; in 1870, 3,400; in 1880, 49,350. The United States Census of 1890 registers an output of 455,162 tons, and places Keokuk second only to Mahaska among Iowa coal counties. The following statistics from reports of the Iowa Geological Survey show the gradual decline during recent years.

YEAR.	TONS.	YEAR.	TONS.
1898	251,145	1903	63,945
1899	336,065	1904	41,512
1900	227,727	1905	16,460
1901	366,915	1906	17,144
1902	160,401	1907	27,716

The average price per ton at the mines in 1907 was about $2.29, a high figure.

The State Mine Inspectors report for the year ending June 30, 1908, a production of 11,900 tons from the five principal mines. Thirty-five men were employed. The mines cited below include those in operation in August, 1907. Data as to earlier operations have been taken from former reports of the Survey.*

*Keyes: *Coal Deposits of Iowa*, Iowa Geol. Surv., Vol. II, pp. 357-366; Des Moines, 1894.
Bain: *Geology of Keokuk County*, *Idem*, Vol. IV; pp. 255-311; 1895.

What Cheer. For many years the What Cheer district was one of the most important producers in the state. Occupying as it did an important strategical position for marketing its output, the field was energetically developed and almost completely exhausted. In their haste to achieve quick results, however, the large companies operated in a rather wasteful and extravagant

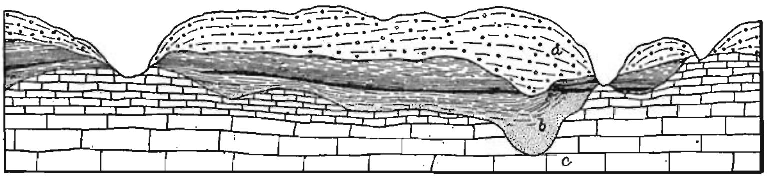


Figure 68. Ideal cross section through the What Cheer district from Rock creek to the North Skunk river.
a—Drift. b—Coal Measures. c—Saint Louis.

manner, taking only the best coal and leaving untouched areas which offered minor obstacles to profitable development. Thus it is that numerous small mines have done a good business while taking out coal left in larger workings and selling it to supply the large local demands. Several local mines are also now engaged in opening up small areas heretofore unleased.

Only one coal horizon is known in the What Cheer field, although the elevation of its different basins varies within rather wide limits. The conditions under which the coal was deposited were much the same as those sketched for the region on the west in the chapter on Mahaska county. The size of individual basins is limited by that of the depression in which the coal swamps formed, and by subsequent erosion. In many places ridges of the underlying Saint Louis limestone project above the level of the beds mined and at other points the coals are abruptly cut off by Pennsylvanian erosion channels filled with consolidated sediments, or by pre-glacial channels filled with drift. In and around What Cheer are fifty or sixty square miles underlain by Coal Measures, but it is more than likely that all the coal which could be handled in a large way has already been removed. The region has been thoroughly prospected and a considerable portion of it proved barren. In several cases coal has not been worked because of the absence of a suitable cover between the mineral and the surface drift. Where mining has been undertaken, a "slate" usually less than fifty feet in thickness, constitutes the sole representative of Coal Measures younger than the coal. There are undoubtedly many small basins of good coal left in this field and these will furnish supplies for small local mines for many years to come. The mines in operation in August, 1907, are briefly mentioned below. They hoist, in most cases, with horse and gin and do little work in summer.

In the southeastern corner of What Cheer (Sec. 10, Se. qr., Sw. ¼) the Karston Brothers' shaft was sunk forty-two feet to the coal in 1906. The seam here varies rapidly in thickness, yet commonly shows from five to six and a half feet of coal. A "fault" has been encountered 100 yards north of the pit bottom and has not as yet been penetrated. This feature and old workings in adjacent territory greatly limit the fuel supply available at this point. Above the coal is a bare six feet of "slate" that is more compact than that in much of the district.

Near the plant of the Volunteer Brick and Tile Co. is a mine which supplies it with fuel (Sec. 10, Se. qr., Se. ¼). A steam hoisting outfit elevates the cars forty feet from the seam to the surface. The coal mined shows an average of four and a half feet in thickness, with a maximum variation of one foot. North of the shaft the margins of two closely related seams overlap. Prospecting now being done north of the mine shows a northerly dip of fourteen feet in seventy yards.

One-half mile north of the Volunteer, the shaft of Armstrong Brothers' mine (Sec. 10, Ne. qr., Se. ¼), sunk in 1903, penetrated the following strata.

	FEET.	INCHES.
3. Drift	63	6
2. "Slate"	30	
1. Coal	4	6
Total	98	

On the western edge of what Cheer (Sec. 9, Nw. qr., Se. ¼) is the new mine of the Creamery Coal Co. The coal has been removed on the north and east by older mines; while in other directions the seam rapidly becomes attenuated. The available area is thus limited to a few acres. The shaft record is reported as:

		FEET.
3.	Drift	16
2.	"Slate," soft	4
1.	Coal	6

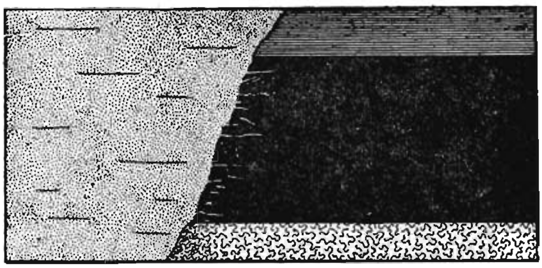


Figure 69. "Fault" in What Cheer coal.

Lee Brothers' mine is in the north-central part of section 3, one mile northeast of What Cheer. Five-foot coal is being worked here, in an area left in the midst of old workings. This company operates a steam hoist and hauls half of its product to the railroad for shipment. A section one-fourth mile west of the shaft gives:

		FEET.
3.	Drift	90
2.	"Slate"	45
1.	Coal, bony	4 to 6

Northwest of the Lee mine and about one mile east of the village of Coal Creek, is the Maxwell, a shaft mine which reaches a five-foot coal at a depth of about sixty feet. One-half mile west is the Ladd mine in the same or a closely related seam.

Delta. Delta itself lies in a region of Mississippian outcrop; but shales and sandstones of Des Moines age are found within a half mile due south and also a short distance north. Two miles north a small country mine takes a little coal from a thin seam. One and a half miles southeast of Delta (Warren

19

Tp., Sec. 14) is a small area of Coal Measures in which from four to five and one-half feet of coal has been found. The seam lies at an elevation of about 712 feet above sea level and is mined during the winters by slopes and shallow shafts which migrate perennially. The quality of the coal is good, but the quantity is limited.

Sigourney. A group of three small Coal Measure outliers lying two miles northeast of Sigourney has furnished small quantities of coal. Up to 1897 some mining was carried on in the northwest quarter of section 25. Coal was taken from the central part of section 24 at a later period and perhaps some pillar and crop work may be done during the coming winter. (1907-8.) The shafts in this outlier have been from twenty-four to seventy-eight feet in depth and have seldom been operated for long periods. The coal bed is three to four and one-half feet thick, and has a weak and thin roof of "slate" or, over the best coal, sandstone. Some coal is still left in this vicinity, yet a high market price is essential to its profitable exploitation.

Several years ago an attempt was made to open a twenty-two inch seam included in a very small Coal Measure area four miles east of Sigourney.

FEET.	INCHES.	
1		3. Shale, black, fissile.
3	6	2. Coal, no partings.
1		1. Fire clay (exposed).

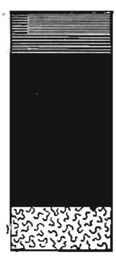
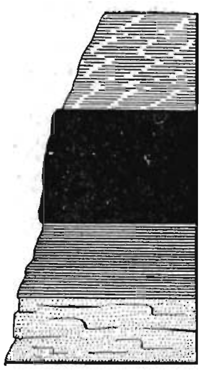


Figure 70. Coal bed at Rowley mine. North of Sigourney.

Richland. What is probably the northern extension of the Jefferson county Coal Measures occupies about nine square miles of territory south and west of Richland. Coal has been mined for the local trade at several places in the southeast corner of Richland township (Secs. 31 and 32) and the last opening, the Snider, was closed quite recently. The coal is found in a single horizon lying about eighty feet below the uplands and occurs, apparently, in small pockets. Water and an inadequate roof usually limit the life of a mine to a single winter, so that numerous openings may be found on a single piece of land. Commonly, less than ten feet of weak, gray shale intervenes between the coal and the overlying drift, rendering close timbering necessary. The coal bed varies between three and five feet in thickness.

WASHINGTON COUNTY

Aside from an extension of the main Iowa coal field occupying less than two square miles in the extreme southwestern corner, only a few small outliers of the Coal Measures are known to occur within the limits of Washington county. Before preglacial erosion had denuded the surface of the region, Des Moines strata undoubtedly occupied a larger area than at present, yet it is open to question whether the entire county was ever covered by the Pennsylvanian sea or whether sediments of this period were deposited in isolated basins. Four Pennsylvanian outliers, covering a few hundred acres each, rest upon Mississippian formations. One of these is in section 27 of Clay township, another in sections 4 and 5 of Brighton; while two others may be found in Highland, one in section 21 and the other in adjoining corners of sections 26, 27, 34 and 35.



	FEET.
5. Shales, argillaceous	3
4. Coal	3½
3. Clay	2
2. Sandstone, ferruginous, partially exposed	?
1. Limestone, Saint Louis (exposed)	10

Figure 71. Coal near the old Liebig mine. Verdi.

Although practically nothing has been mined for many years, at least two Coal Measure areas have proved slightly productive. The deposits northwest of Verdi are composed chiefly of coarse-grained, ferruginous sandstone, with a few feet of intercalated shales and the coal bed shown in the accompanying figure. Several diggings were at one time located near here (Brighton Tp., Sec. 5, Ne. qr., Ne. ¼). On Whiskey Run (Highland Tp., Sec. 34, Ne. qr.) a thin coal seam occurs and has been mined a little. It varies in thickness between six and twenty-two inches, is covered only by drift and apparently rests on clay. A report that Coal Measure sandstone existed near Wassonville led to the sinking of an eighty-foot shaft at this point, but with the exception of some bituminous shales probably of Kinderhook age, no coal beds were found.

The only collection of mining statistics in which mention is made of Washington county is contained in the State Census for 1866, when a production of 4,000 bushels was reported and for 1868, when 160 bushels were produced. While additional Coal Measure outliers may be located in the future, the exploitation of any coals that they may contain is more likely to result in financial loss than in profit. Sums so far expended in prospecting and mining have been greater than those gained from the sale of the coal won.

LOUISA COUNTY

Coal Measures that were at one period deposited over a large part of Louisa county, either in independent basins or in more or less continuous sheets, have been almost completely removed by the intense denudation which the region subsequently underwent. A few small outliers, covering 400 acres or less each, still remain, the largest being in the west bluff of the Iowa river in adjoining corners of sections 16, 17 and 21 of Union township. It bears some dark shale, a grayish white sandstone, and a few inches of coal. Small areas showing similar strata were discovered in section 13 of Elm Grove township; while twenty feet of Coal Measure sandstone were penetrated in wells in sections 20, 21 and 28, a short distance southwest. This sandstone has been found in various parts of the county, chiefly as narrow dike-like aggregations in crevices of the underlying Mississippian limestone.

The only recorded output of coal for the county is that of forty bushels for 1862. At least two of the outliers have yielded minute quantities of fuel, but little hope for profitable exploitations can be held out for any portion of the county. In some cases money has been wasted in the exploration of bituminous shales of Kinderhook age and therefore barren. A few concealed outliers, which should be looked for principally in the western townships where erosion has been least active, may perhaps be found beneath a covering of drift, yet even should they contain coal the roof would be weak and the product mined of poor quality.

WAPELLO COUNTY

As is the case with most of the counties that are traversed by the Des Moines river, Wapello has been a consistent producer of coal for a long period of time. Most of the coal mined lies at no great depth beneath the surface and the Coal Measures themselves are not thick, being, perhaps, only 250 feet at a maximum and in by far the greater part of the county considerably less. The Saint Louis limestone, which lies immediately beneath the coal-bearing rocks, outcrops in the valley of the Des Moines from the northwestern corner of the county to the mouth of Sugar creek, below Ottumwa, and reappears once more about one mile below Eldon. In these sections of the valley the Des Moines stage is lacking under a strip of territory about one mile in width. In the valleys of the principal tributaries in the northwestern quarter of the county the limestone appears for a distance of several miles back from their points of union with the master stream; in North Avery creek it may be found nearly as far west as the Monroe county line. Outcrops of the same formation have also been reported from Cedar creek, near the Mahaska boundary, and in the northern tier of sections of Competine township.

Mining in Wapello county has been confined almost entirely to the immediate neighborhood of the Des Moines river and its principal tributaries, for it is only in those districts that good outcrops of the Coal Measures are found. In the northeastern and southwestern portions of the county, the covering of drift effectually conceals the indurated rocks; yet there is little doubt that basins of workable coal do exist under the highlands away from the Des Moines valley and that these will be exploited at some future period when the areas now known have become exhausted. Wapello coal basins are, however, of limited extent, as are those in most of the Iowa field, seldom underlying more than a few hundred acres in continuous seams. Only thorough prospecting can, therefore, be successful, and for every drilling that penetrates thick coal several may be barren. The discovery of a seam of workable thickness in one prospect does not prove that a workable pocket has been found, for another

Figure 72. Unconformity between the Saint Louis limestone, 1, and the Coal Measure shales, 2. The shales rest on the uneven and weathered surface of the limestone. At the old quarry on the Des Moines river, three miles above Ottumwa.

hole a few hundred feet distant may give quite different results. Coal is not entirely unknown in those areas where but little development has been undertaken. For example: a few small country banks have been opened in Green township, and near Ormanville two seams outcrop, the upper three feet thick and the lower eighteen inches. Prospecting on Cedar creek revealed some good coal, although north of it, near the Chicago, Milwaukee and Saint Paul railway, nothing came to light. A well in section 12 of Pleasant township penetrated 222 feet of Coal

Measures, including three and one-half feet of coal at a depth of 135 feet. The record of this well is:

		FEET.
13.	Drift clay	60
12.	Sand	3
11.	"Soapstone"	15
10.	Shale, gray	30
9.	"Soapstone"	20
8.	Shale, black, carbonaceous	7
7.	Coal	3½
6.	Shale, blue	15
5.	"Soapstone"	10 to 15
4.	Shale	8
3.	"Soapstone"	10 to 14
2.	Shale, black	100
1.	Limestone (Saint Louis) alternating with thin layers of blue "sandstone"	182

During the early history of coal mining in Iowa, Wapello ranked first among the counties in point of production for a number of years. As long ago as 1857 there were mines near Kirkville and Dahlonega, in the river bluffs four miles below Eddyville, and along Bear creek four miles west of Ottumwa. In 1860, Wapello's annual production was 17,062 tons, nearly three times that of Jefferson, the next in rank. Later on the chief mining districts were one mile south of Dudley, on Middle Avery creek, where a four-foot seam lay fifty feet above the Saint Louis limestone; at Happy Hollow (Center Tp., Sec. 8), in a five-foot coal; near Keb (Richland Tp., Sec. 33) where the coal was more than four feet thick, and especially at Alpine, two miles below Cliffland. In 1870 the output was 31,630 tons, but the county had fallen to fifth place as a producer. During the next decade Happy Hollow continued to produce, and for a number of years prior to 1890 extensive mines were operated just south of Kirkville. In 1880, 67,555 tons were mined; in 1890, 359,199. Production during recent years has failed to advance; statistics gathered by the Iowa and federal geological surveys are as follows:

YEAR.	TONS.	YEAR.	TONS.
1898	252,484	1903	382,398
1899	316,460	1904	379,560
1900	270,330	1905	303,360
1901	249,880	1906	243,256
1902	340,579	1907	258,651

During the year ending June 30, 1908, Wapello turned out 244,214 tons of coal and ranked seventh among the coal counties. Twenty mines were in operation, employing a total of 559 men. According to the best available data, the county has produced about 8,700,000 tons during the period since mining first began. Since about 3,200 tons per acre are usually to be won from a four-foot seam in this area, over 2,700 acres have been deprived of at least their best coal. The coal remaining untouched and largely undiscovered may safely be taken to be many times that mined out.

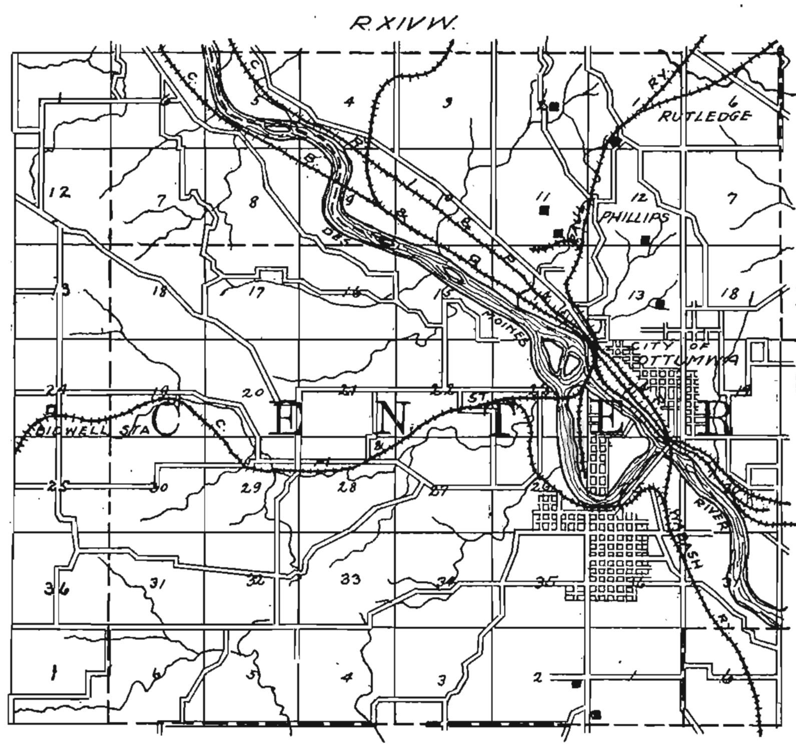


Figure 73. Map showing mines in central Wapello county.

The progress of recent development to August, 1907, is sketched in the following pages. Considerable material has been taken from previous reports of this Survey.*

*Keyes: *Coal Deposits of Iowa*, Iowa Geol. Surv., Vol. II, pp. 383-393; Des Moines, 1894. Leonard: *Geology of Wapello County, Idem*, Vol. XII, pp. 439-499; 1902.

Eddyville. Local mines have been operated since the earliest settlement of the region in the vicinity of Eddyville in Wapello, Monroe, and Mahaska counties; but the coal basins appear to be quite limited in extent. The workings of one shipping mine, No. 9 of the Consolidation Coal Company, were situated chiefly in Wapello county, two and one-half miles east of the town (Columbia Tp., Sec. 3), where a four-foot seam lies near the surface. Local mines are still worked intermittently in this district.

Kirkville. Until 1890 large shipping mines were operated just south of Kirkville by the Wapello Coal and Mining Company and subsequently local banks utilized the same seam. Only two small mines are now located in the vicinity. One mile south of Kirkville is the George Knight bank, where a new shaft was sunk early in 1907 near that of the old Davis Coal Company (Richland Tp., Sec. 18, Ne. qr.). The bed worked lies fifty-five feet below the surface, averages four feet in thickness, and is strongly undulatory with a general dip to the south. About ten feet of "slate" capped by a thick sandstone overlies the coal. A mile and a quarter east of the Knight is the Waddle mine (Sec. 16, Nw. qr.). The shaft is 120 feet deep to a coal that runs quite uniformly about five and one-half feet in thickness. The bed possesses a good "slate" roof, and shows undulations equal in amplitude to the height of the coal. Three low seams were encountered in the new air shaft above the one worked. About twelve acres have been mined out at this point. Small mines once operated about two miles south of the Waddle (Sec. 20, S. ½, and Sec. 28, N. ½) are no longer in existence. Prospecting near here yielded negative results.

Keb. For many years there was at Keb one of the largest mines in the county. Two coals are present, the upper having a quite uniform thickness of about four and a half feet and the lower averaging a few inches more. The distance between the two seams is about twenty feet, though it varies considerably and is in places only three to four feet. The upper seam has a clay parting one to six inches thick and lies about sixty feet beneath the surface.

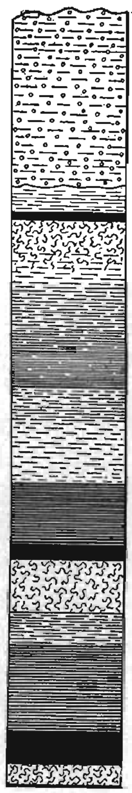
Good coal has been found in some prospects between Keb and Rutledge, but is cut out in many places by erosion channels.

About a mile southeast of Keb, near the center of section 2, the Standard Coal Company is supplying a local trade from a sixty-foot shaft sunk in 1904. Only two acres of the forty-acre lease have been mined out, aside from some that was tapped about twenty years ago. An upper seam is eighteen inches thick, while the bed worked lies forty-five feet lower and is four feet six inches thick. The latter is quite regular in occurrence, except where small "rolls," six feet or less in width, sometimes cut the coal down to as little as one foot.

Rutledge. The Phillips Fuel Company has operated large mines north of Ottumwa, chiefly in section 12 of Center township, for twenty-five years. Three seams are recognized in this area, the lower two being workable in places. A general section of the strata is shown in figure 74, the record of the shaft of old Phillips No. 4. Prospecting carried on a short distance west of No. 4 showed that the coal beds became quite inconstant in that direction, but on the north the second seam is economically important.

Phillips Number 5 is one-fourth mile northeast of old Number 4, at Rutledge, a station on the Chicago, Milwaukee and Saint Paul railway. At this point the second seam is worked, as its thickness is from thirty to forty-four inches and it is less cut into by Carboniferous erosion channels than is the third. At the present time, however, a large barren area is giving considerable trouble in Number 5 workings and its width and orientation are being determined. There are 2,700 feet of tail rope on the main north entry. The shaft is 140 feet deep, its mouth being but a few feet above the level of the railroad tracks at the station. Hoisting is done by a first-motion Ottumwa double engine, cylinders 18x32 inches, supplied by five boilers having a total available horse-power of 375. The tipple is so arranged that lump and nut may be loaded in one car while another is receiving slack. It is said that thirty-five per cent of the coal mined is graded as slack.

Phillips No. 7 is about one mile southeast of Number 5 and works the seam formerly utilized at No. 4. In portions of No. 7 workings the second and third seams run close together and are mined as one; but in such situations the rock is usually poor and a weak roof often makes it necessary to leave up all or part of the higher coal. The third seam presents numerous irregularities, such as old erosion channels running in all directions. The shaft of the mine is 110 feet in depth. The Phillips Fuel Company ships most of its product north, little being sold in Ottumwa.



FEET.	INCHES.	
20		11. Drift, soil and clay.
3		10. Clay shale, white.
	6	9. Coal.
31		8. Fire clay and clay shale.
7		7. Shale, dark, bituminous.
1	6	6. Coal.
6		5. Fire clay.
4		4. Shale, light-colored.
10		3. Shale, dark, somewhat fissile.
4		2. Coal.
2		1. Fire clay (exposed).

Figure 74. Section of shaft of Phillips No. 4. Ottumwa.

Ottumwa. The Spring Hill mine is located within the city limits, near the northern boundary and on a tributary of Harrow's branch. There are two seams of coal, the upper three and one-half and the lower four feet thick. The lower seam is reached at a depth of forty feet and lies not far above the Saint Louis limestone. The latter outcrops along the creek less than three-quarters of a mile below the shaft.

The Black Diamond mine, now operated by the Roseland Coal Company, is one and one-third miles northwest of the Spring Valley, near the plant of the Ottumwa Brick and Construction Company. Two seams of coal have been mined, and usually where one thins out the other grows thicker. The upper averages forty inches and the lower four feet and more. A tramway 900 feet long carries the loaded cars from the sixty-foot shaft to a short spur from the Chicago, Milwaukee and Saint Paul railway, the motive power being by a tail-rope operated by a separate haulage engine. Hoisting is done by steam power. The mine has shipped large quantities of coal, but at present is turning out only a few tons per day and has nearly exhausted the available coal in its territory.

A short distance from the Black Diamond is the Clover Hill mine, operated by the Ottumwa Brick and Construction Company, which consumes about one-half the product. Some coal is shipped and the remainder is sold in the city. The top seam lies at a depth of thirty-two feet at the shaft and is two feet thick; while the coal worked is twenty-six feet lower and varies from four and a half to six feet, with an average of five feet. The company reports that entries have been driven 2,000 feet east, 3,000 north, 1,000 south and 2,000 west and from them an area of about forty acres has been mined out. Sufficient coal remains to supply the mine for at least three years more. The bed shows a barely perceptible dip to the south. A tramway 2,600 feet long runs due south from the shaft to the railway spur mentioned above. The tipple has two chutes with hopper scales for local use and one with track scales for weighing the product shipped. A steam hoist is used. The sequence of strata near the shaft is:

	FEET.	INCHES.
6. Drift	14	
5. Soapstone shale	5	4
4. Shale, dark	9	4
3. Coal		6
2. Shale, gray	8	6
1. Coal	6	
Total	43	8

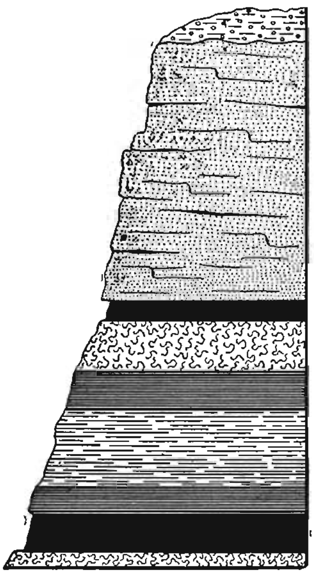
South Ottumwa. Slightly more than a mile south of the southern corporation limit of Ottumwa, two mines are operating to supply the city trade. Two seams, only the lower of which is workable, are present and are separated by no great vertical interval. South of the mines is an area of coal land of unknown extent, but drilling done less than a mile east, west, and north showed that in those directions the seam is badly cut up by barren strips. Of the two mines, that nearest the city is the slope of the Star Coal Company (Tp. 71 N., R. 14 W., Sec. 2, Se. qr., Ne. ¼). The slope is 450 feet in length, with a twenty per cent grade. A short tramway extends north from the slope mouth to the wagon road and cars are hauled by tail-rope a distance of nearly half a mile from the interior of the mine to the tipple. The seam worked is from four to five feet in thickness. About twenty-five feet above it in the air shaft is a fourteen-inch coal. Southwest of the Star is the Dempster mine (Sec. 1, Sw. qr., Sw. ¼), opened in 1906. The mine is now in course of development. The gin hoisting shaft penetrated the following strata, as reported by Mr. Dempster.

	FEET.	INCHES.
6. Soil and drift	12	
5. Blue clay	30	
4. "Slate" with thick rock band	35	
3. Coal (thirteen inches in air shaft)		3
2. "Slate"	11	6
1. Coal	4	4
Total	93	1

One mile east (Keokuk Tp., Sec. 6, Sw. qr.), coal was formerly mined. A seam four and one-half feet thick lies 130 feet beneath the surface, while five feet above is an equally high seam. The Saint Louis limestone outcrops at a level fifty feet above this coal in the bed of the river at Ottumwa, two miles north, cutting off the Coal Measures in that direction.

Sugar Creek. Mining on a small scale has been undertaken at numerous points on Sugar creek and its tributaries, east of Ottumwa (Secs. 21 and 22), and some is still taken out there, as well as in the river bluffs near the creek mouth, by strippings and by small local mines which lead a desultory life. At the old Colgan mine, about one mile below the debouchure of Sugar creek (Tp. 71, R. 13, Sec. 4, Ne. qr.), the following section was obtained.

		FEET.	INCHES.
7.	Sandstone, massive, cross-bedded	50 to 60	
6.	Shale, black		6
5.	Coal	1	2
4.	Fire clay and argillaceous shale	15	
3.	Coal	2 to 3	
2.	Fire clay and black shale	1 to 10	
1.	Coal	4½ to 5½	



		FEET.
9.	Soil	2
8.	Sandstone, coarse grained, massive, yellow and brown	20
7.	Coal, rather slaty	1½
6.	Fire clay	4
5.	Shale, very dark, bituminous, somewhat fissile and dark below	3
4.	Shale, gray, argillaceous	6
3.	Shale, black, bituminous	2
2.	Coal	3
1.	Fire clay (exposed)	1

Figure 75. Bluff in Sugar creek. East of Ottumwa.

Bidwell. East of Bidwell station and about three miles west of Ottumwa (Center Tp., Sec. 20), the Bear creek mine shipped coal from a bed four and one-half feet in thickness. The seam outcrops in the valley and lies only about thirty feet above the Saint Louis limestone. This mine is not now in operation, but may possibly be reopened. At Bidwell, eight prospect holes were put down and apparently good coal was found. A prospect shaft was sunk one-half mile northwest of the station and the coal rights of the surrounding territory were purchased; but the matter has been dropped, perhaps to be taken up again later. It is said that there are several hundred acres of coal here, from four to five feet thick and about 118 feet below the lowlands. If this information is correct, development of this basin may be expected at no distant date. A drilling on the Sweeney farm, near the Bear creek mine, is reported to have penetrated the strata listed below. No workable coal was encountered in this particular boring and the depth to which the Coal Measures extend is surprising, though not at all improbable.

DRILLING BY PHILLIPS FUEL COMPANY.

		Feet.
11.	Clay and sand	75
10.	"Slate," hard, blue	20
9.	Coal	½
8.	Fire clay	4½
7.	Sandstone, compact	6
6.	"Slate," gray	50
5.	Rock, blue, hard	3
4.	"Slate," black	10
3.	Rock, blue, hard	5
2.	"Slate," black	3
1.	Sandstone, gray	4
	Total	181

Willard. The Appanoose mine, which did a shipping business at Willard for many years (Polk Tp., Sec. 33, Nw. qr., Ne. ¼), is now definitely closed. The shaft was ninety feet in depth to a four-foot seam, with an upper rather bony coal about ten feet higher. The bed worked was strongly undulatory, dropping forty feet in 1,800 south of the shaft and rising an equal amount in 2,200 toward the west. Contrary to the usual occurrence in such cases, the coal thickened toward the rise, while in descending toward the lower part of the basin on the east and south the seam ran out against an erosion channel filled with compact argillaceous material for a width of 350 yards or more. Two miles east of the mine, ten out of eleven prospect holes showed coal which was three and a half feet at a maximum. Sixty holes were drilled within a radius of two miles from the mine; coal was found in some of the tests, but appeared to be pockety and somewhat erratic in occurrence. Prospecting was also done between Willard and Blakesburg, but was not followed by exploitation. In Bear creek valley as a whole the coal presents the aspect of a succession of extensive seams greatly cut up by old erosion channels. Prospectors differ as to the material in these so-called "faults" and it is probable that both contemporaneous and pre-glacial water action has played a part. In the majority of cases, perhaps, drift replaces the coal.

One and a half miles northwest of Willard, on South Avery creek, local mines are intermittently worked. The Newell mine (Sec. 29, Nw. qr., Ne. 1/4) opens by a fifty-foot shaft to a three-foot coal which outcrops in the bed of the stream. Hoisting is done by means of a steam equipment.

Eldon. Two miles east of Eldon (Sec. 25, W. 1/2) are two local mines, those of C. D. Sharp and W. McIntosh. These work a seam which is three feet six inches in thickness and lies about sixty feet below the surface. In Eldon itself are several small local banks, among which may be mentioned the Kern, Kelley, and Burns. The coal is reached by shallow shafts and shows only from twenty to thirty inches of coal. The roof of dark "slate" is usually adequate. Coal is also sometimes mined a bit over one mile west and northwest of town. An Eldon company recently drilled nearly fifty holes near Eldon, but are not yet prepared to publish the results. In most places they found at least a top seam of eighteen inches to three feet and a lower of six inches to two feet. Every boring penetrated one or more coals, of various thicknesses. It is said that some good coal land was located back from the railway but that near it nothing encountered justified exploitation.

Laddsdale. At Laddsdale, on the Davis county line, a shipping mine is operated by the Anchor Coal Co., also known as the Eldon Coal and Mining Company; on a short spur of the Chicago, Rock Island and Pacific Railway (Tp. 71, R. 12, Sec. 32, Sw. qr., Sw. 1/4). This is mine number 2 of this company, No. 1, which was situated one-fourth mile west, having been abandoned. The shaft is sixty-eight feet in depth and the altitude of its mouth is given by the company as 620 feet above sea level. The coal mined is of good quality for steaming purposes, being used in the railroad chutes at Eldon. Rolls in the roof and slips with a maximum displacement of eight feet are fairly common in the workings and the beds exhibit frequent changes of level. Entries have been driven 3,000 feet northwest and southeast and 600 feet southwest and northeast. The old workings of Number 1 have now been headed, so that work will progress more rapidly in the future. Grades are so arranged in the entries that one mule can haul ten-car trips. A number of prospect holes drilled in sections 31 and 32 of Washington township at distances of 150 to 200 feet apart reveal that inconstancy of individual strata and rapidity of change in the appearance of the coals which is so characteristic of the Des Moines beds in the southern part of the Iowa field. Following are two sample drill records from this area.

LADDSDALE SECTIONS.

A.

		THICKNESS IN FEET.	DEPTH.
24.	Drift	12	12
23.	Clay shale, gray and blue	13	25
22.	Sbale, black	3	28
21.	Shale, sandy, gray	6	34
20.	Clay shale, blue	10	44
19.	Coal	1	45
18.	Clay shale, gray and blue	24	69
17.	Sandstone	1	70
16.	Shale, black, carbonaceous	3½	73½
15.	Coal	3	76½
14.	"Rock"	1½	78
13.	Clay shale, gray and blue	14½	92½
12.	Coal	1½	94
11.	Clay shale, gray and blue	6½	100½
10.	Shale, sandy, blue	2	102½
9.	"Rock," soft, blue	1½	104
8.	Coal	1 1-3	105 1-3
7.	Fire clay	2 2-3	108
6.	"Rock" (limestone ?)	5	113
5.	Shale, sandy, blue	6	119
4.	Clay shale, blue and gray	16½	135½
3.	Coal	2½	138
2.	Fire clay	2	140
1.	Clay shale, light blue	12	152

B.

20.	Drift	20	20
19.	Clay shale, blue	5	25
18.	Sandstone	5	30
17.	Clay shale. blue and gray	33½	63½
16.	"Stone" (limestone ?)	2	65½

		THICKNESS IN FEET.	DEPTH.
15.	Clay shale, gray and blue	6½	72
14.	Coal	1	73
13.	Clay shale, gray	12½	85½
12.	Coal	1½	87
11.	Clay shale, gray and blue	18	105
10.	Coal	2	107
9.	Clay shale, blue	26	133
8.	Shale, sandy, gray	5½	138½
7.	Clay shale, blue and gray	19½	158
6.	"Cap rock"	½	158½
5.	Coal	2¼	160¾
4.	Clay shale, gray and blue	8	168¾
3.	Shale, sandy, blue	8	176¾
2.	Sandstone	5½	182¼
1.	Limestone (Saint Louis ?)	1½	183¾

Two beds of coal were encountered in several of the holes at approximately the same depth, namely at seventy-two and 103 feet respectively, but varied considerably in thickness. At about 135 feet another seam was found in some drillings, and at 158 feet still another. Besides the four mentioned, other seams were struck at different depths in the various holes, no less than seven being penetrated in one boring and only three in one only 200 feet distant. If reservations be made for the irregularity of the beds, the following may be given as a summary of the coals in the territory of mine Number 2.

BED.	THICKNESS. FEET.	INCHES.
Top seam (often replaced by drift)	3	
Second seam (may be worked later)	3	
Third seam (now being worked)	3	10
Fourth seam (now being worked)	4	2
Bottom seam	2	6

JEFFERSON COUNTY

Since Jefferson county lies on the eastern margin of the Iowa coal field and Mississippian limestone outcrops in the valleys of its principal streams, it is not to be expected that the Des Moines will show any great thickness within its borders. Coal Measures form the youngest of the indurated rocks under the greater part of the county's surface; yet their greatest thickness, where deposited in depressions in the irregular surface of the underlying Saint Louis, is probably little more than 200 feet. Their average is considerably less than this figure in all the townships, but is most in the southwestern section of the county, as shown in the accompanying plat prepared by Udden.

PLAT OF ESTIMATED AVERAGE THICKNESS OF THE DES MOINES IN THE SEVERAL TOWNSHIPS OF JEFFERSON COUNTY (IN FEET).

Polk 20	Black Hawk 15	Penn 30	Walnut 10
Locust Grove 80	Fairfield 75	Buchanan 20	Lockridge 40
Des Moines 50	Liberty 50	Cedar 20	Round Prairie 20

"It should be remembered that the figures given are estimates and that since both the upper and the lower limits of the formation conform to ancient erosion contours there are apt to be great local variations in its development. It is believed that the maximum development of the formation will not exceed three times the figures given, while at the same time it is known that excepting Fairfield and Locust Grove townships, the minimum limit is zero; that is, the Coal Measures have been entirely removed at some point in nearly all the townships."*

The Coal Measures have been removed from a small area in the northwestern corner of Polk township; from the greater

*Udden: *Geology of Jefferson County*, Iowa Geol. Surv., Vol. XII, pp. 355-436; Des Moines, 1902. Material has been taken from this report for the succeeding pages of this chapter without further acknowledgment, and also from Keyes: *Coal Deposits of Iowa*, Iowa Geol. Surv., Vol. II, pp. 393-402; 1894.

part of the region north of Walnut creek, as far west as Veo; from the valleys of Skunk river, of Rocky branch, of Turkey creek, and of Rock creek; from the valley of Cedar creek, as far west as section 29 of Cedar township; and from several small areas in various parts of the county where local elevations of the Saint Louis prevail. The most productive coal basins are located at the base of the Des Moines, near its contact with the Saint Louis. The points where mining has been undertaken have in almost all cases been in the valleys of the numerous water courses; while the upland region is virtually unexplored by prospectors. Systematic search with the drill on the divides, especially on those that lie near known productive valleys, would undoubtedly result in the proving of workable basins heretofore unknown. The boring of merely a few holes would as undoubtedly result in failure; for Jefferson county coal appears to be extremely "pockety" and barren areas are apparently numerous. It might be necessary, therefore, to continue the search over considerable territory before the coveted basins were found. Those townships in which the Coal Measures are thickest offer the greatest opportunity for locating coal in one or more of numerous horizons present; yet the best horizon seems to be contained in the base of the formation, which can be reached by shallower drillings in those localities where the Coal Measures are more attenuated. Consideration must also be given to the fact that where the measures are thin, the roof over the coal is apt to be insufficient for extensive mining.

Owing to the early settlement of the region and to the appearance of coal in outcrops in the deeper valleys, coal mining in Jefferson county began at an early date in the history of the state. In 1860 its production, 6,143 tons, was second only to that of Wapello, and it retained a high position as a producer throughout the following decade. In 1870 the output had not increased, being 5,300 tons, though the statistics for 1880 show an advance to 46,150 tons. Succeeding years witnessed a gradual decline due to the closing of the larger mines at Perlee, until in 1890 only 8,123 tons were reported. According to reports of the Iowa and United States Geological Surveys, recent production has been:

YEAR.	TONS.	YEAR.	TONS.
1898	1,025	1903	6,447
1899	3,700	1904	9,810
1900	3,650	1905	3,379
1901	1,248	1906	3,744
1902	10,284	1907	4,000

The present output is quite small, not more than 2,000 tons annually, and only a few mines are in operation, even during the winter months. A summary of our present knowledge in regard to Jefferson coal may be found in succeeding pages.

County Line. Coal is known to occur along Black creek and its tributaries, two miles south and southeast of County Line and further down the creek. Seams ranging from three feet to five feet six inches have been reported in sections 20, 29, 30 and 32 of Des Moines township as well as in portions of sections 28, 21 and 33. The coal lies at shallow depths and usually possesses a shale roof, which is gray above and grades downward through black, fissile "slate" into bony coal. Small mines have been operated at various points along the streams, yet there has been little apparent endeavor to locate coal by prospecting under the higher lands, where it may reasonably be expected to occur.

Libertyville. Near Lick creek, about three miles south of Libertyville, is a small area from which coal has been taken for many years. Mines in the southwest quarter of section 29 and the northeast of 31 have partially exhausted their territory and have been abandoned; but the J. C. Buchanan bank still works during the colder months of the year in the southeast quarter of section 30. The present shaft, sixty feet in depth, has been flooded by recent heavy rains, so that it may become necessary to excavate new openings for the next season's work. The seam worked is three feet thick, and is overlain with a black, calcareous and fossiliferous shale. The coal bed is not undulatory and dips gently to the west. A fourteen inch coal is reported to lie nine feet above the lower seam and to remain quite constant in thickness over considerable territory. The thicker basin is, however, more limited in extent; for Saint Louis limestone outcrops in the creek on the west and drilling a short distance north and east of the Buchanan mine failed to locate the workable bed.

In the immediate vicinity of Libertyville, wells and prospects have penetrated barren strata. Several years ago Mr. Albert Gardner operated a shaft forty feet deep near the bank of Cedar creek, three miles east of Libertyville (Liberty Tp., Sec. 15, Ne. qr., Ne. ¼). The seam mined lies eighteen feet below the creek bed. A general section of the Coal Measures based upon several explorations in this territory, is as follows:

GENERAL SECTION OF THE COAL MEASURES IN THE NE. QR. OF SEC. 15.

		FEET.
9.	Limestone, concretionary	1-5
8.	Shale, gray	5
7.	Coal	0-3
6.	Fire clay	0-4
5.	Sandstone, hard, gray	0-5
4.	Shale	30
3.	"Slate"	1-3
2.	Coal	3
1.	Fire clay and shale	7

Not far from the old shaft mentioned above, a slope with a fall of nine inches to the yard was recently opened on the land of Mr. Bishop. Since prospecting operations had shown a good seam of coal in this vicinity and the slope encountered a mere "blossom," it was conjectured that an erosion "fault" had removed the better part of the coal. Acting upon this supposition, the parties interested then sank a ninety foot shaft on the neighboring hill with the intention of directing the work from it toward the slope; but as the shaft passed through only a similar "blossom," work was abandoned. A top seam of poor coal was seven inches thick in the shaft and twenty-two in the slope. Evidently only small basins have been located in this vicinity. On the north, the Saint Louis limestone outcrops in the lowlands of much of section 10 and the eastern part of section 9.

Fairfield. Essentially the only mining now conducted in Jefferson county is by a few coal banks on Cedar creek three miles due south of Fairfield, which supply the local country trade and haul some coal to Fairfield. As they work during the winters only and have the simple horse-power equipment characteristic of mines of their class, their output is not large. The Bates and Spratt Coal Company have a mine a few rods south of Cedar Creek, just south of the bridge on the Fairfield-Birmingham wagon road (Liberty Tp., Sec. 24, Ne. qr., Se. ¼). The seam is variable in thickness, ranging from two to five feet, and contains three grades of coal which are classified as such by the miners because of slight differences in practical heating and steam-producing qualities. The shaft is forty-seven feet deep and the coal lies at about the same elevation as the river bed. From five to twelve feet above the lower coal is a thin bed, fourteen to eighteen inches in thickness at this point. As shown by the following section, measured one-half mile northwest, and by other outcrops, it is a fairly persistent horizon.

EXPOSURE ON CEDAR CREEK.

		FEET.
7.	Drift	4
6.	Sandstone, buff, soft and shaly	4
5.	Shale, argillaceous, dark blue	10
4.	Coal	5-6
3.	Fire clay	4
2.	Shale, dark	8
1.	Sandstone (exposed)	1

Coal in a horizon slightly higher has also been found in this vicinity. A short distance above the Bates mine is the sixty-foot shaft of the Fairfield Coal Company (Sec. 24, Ne. qr., Sw. ¼). The coal at the two mines is essentially similar, and forms part of the very base of the Coal Measures. One-

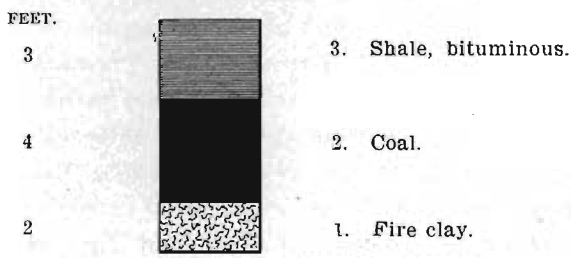


Figure 76. Coal bed at Bates & Spratt mine. Fairfield.

half mile southwest (Sec. 24, Sw. qr., Ne. ¼) a drift has been driven into four feet of coal in the right bank of a tributary of the Cedar. Above it is a black fissile shale about nine feet thick and then a sandstone. Some explorations have been made in this territory and the elevations of the coal seams were found to be quite variable; changing as much as forty feet in less than a quarter of a mile. Coal has been mined at several points within a mile below the Bates bank, in the valley of the Cedar.

A mine was formerly situated at the old Reed mill, near the Burlington railroad bridge across Cedar creek, two miles southwest of Fairfield (Sec. 3, Se. qr.). The sequence shown in the north bluff is:

		FEET.
7.	Shale, gray	25
6.	Coal	1
5.	Sandstone, brown	1-5
4.	Shale, black	1
3.	Coal	1
2.	Fire clay and shale	10
1.	Coal (near the level of the creek bed)	3

In the northeast quarter of the same section, prospecting has recently been prosecuted on the land of Robert Ratcliff, north of the Libertyville road. Here the lower coal, the one formerly worked at the mill, has thinned to half its former height; while the thickness of the top seam is increased to sixteen inches, and of the second seam to thirty inches. The coal in the upper beds is of good quality and may be developed at no distant date.

Another old mining district is located two miles west of Fairfield (Fairfield Tp., Sec. 27, Nw. qr., and Sec. 28, Ne. qr.). The principal coal seam occurs at depths varying from thirty to ten feet below the bottom of the streams, is from three to three and a half feet in thickness, and is overlain with a black shale containing large septaria. In this region, thin coals are frequent and some basins of workable extent and thickness probably remain undiscovered. Well records in both the southern quarters of section 28, Fairfield Tp., are said to show a thick seam of coal at about 160 feet below the upland level. One of the thin coals of this district is excellently well exposed in the north bank of the Cedar (Fairfield Tp., Sec. 32, Nw. qr.). This seam, which is here eighteen inches thick and thins laterally is shown in the lower part of the illustration (Fig. 77).

Perlee. Perlee was at one time the center of the most extensive mining undertaken in Jefferson county. Until early in the eighties, the Jefferson County Coal Company and the Washington Coal Company took out considerable coal; later companies possessed less capital and operated on a smaller scale, while what mining has been done within recent years has consisted in working out the crop coal and in pulling pillars in old workings. On the Courtney land in section 27, Penn township, coal was hoisted through a shaft forty feet deep for two

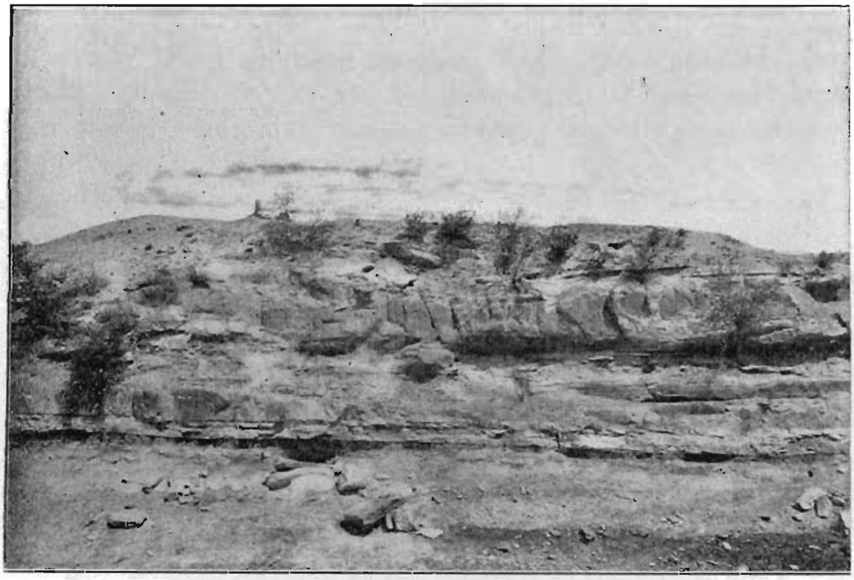


Figure 77. Exposure of Coal Measure strata in the north bank of Cedar creek, section 32, Fairfield township.

years. The seam was four feet in thickness and the pocket still bears some good coal. Some coal also remains west of the Washington mines in section 32. Patches left unused by the Jefferson mines, a mile east of Perlee, were worked quite recently and the district in the immediate vicinity of Perlee is now pretty well exhausted. Most of the old coal banks have been located in sections 26, 27, 32, 33 and 34 in a seam which lies at about the level of South Walnut creek and but a short distance above the limestones underlying the Coal Measures. The latter formation is not of great thickness in Penn township, not much exceeding 100 feet at its maximum and being entirely lacking in much of the northern section. The Saint Louis appears in the valley of the lower parts of the various branches of Walnut creek near the scene of former mining operations. The principal seam worked lies in a series of pockets in a narrow and irregular basin about three miles long and a mile or less wide, covering altogether less than one square mile in an area trending northeast and southwest. Where utilized, the coal averaged three to four feet in thickness and was overlain with from six to eight feet of strong "slate," graduating upward into a thick shale. In places, however, the roof has been cut out and replaced by drift, while locally the seam itself has been removed by pre-glacial erosion. Shafts sunk to the principal pockets ranged from forty to one hundred feet in depth. The sequence of strata is illustrated in the accompanying figure of the section at one of the shafts operated by the Washington Coal Company, whose mines were in sections 32 and 33.

The following section of the indurated rocks in one of the Jefferson shafts near the Perlee station (Penn Tp., Sec. 33, Ne. qr., Sw. 1/4), shows a general correspondence with those in the Washington territory.

		FEET.
5.	Shale, gray and clayey above, becoming black and fissile below	13
4.	Coal	3
3.	Fire clay, grading downward into gray clay shales	14
2.	Shale, highly bituminous and coaly in places	3
1.	Fire clay (exposed)	1

Brush Creek. For nearly fifty years mining has been intermittently prosecuted along Brush creek, in section 27 of Lockridge township. A considerable area near the center of the section has already been mined out. The seam worked is at a level slightly below that of the creek and is somewhat, though not seriously, disturbed by horsebacks and faults of small throw. One of the latest mines to be operated in the district was that of the W. G. Smith Coal Company, the shaft of which penetrated the following strata:

		FEET.
6.	Drift	54
5.	Shale	1
4.	Fire clay, yellow	3
3.	Shale, black	9
2.	"Slate," black	20
1.	Coal (thirty feet below level of creek)	4½

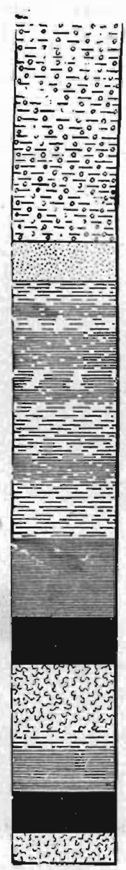


Figure 78. Section of shaft of Washington mine. Perlee.

On the south side of the shaft is a fault with a down-throw of five feet to the north; the fault plane dips north 32 degrees and trends west 15 degrees S. The Smith Coal Company was expanded into the Big Four Coal Company, a steam hoisting plant was installed, and an effort made to develop the mine on a large scale; but after the burning of the shaft in 1906 operations were suspended. The quality of the coal was good, while the roof was firm in places, yet water entered in large quantities and gave considerable trouble. A shaft fifty feet deep was sunk one-fourth mile northeast by Mr. Smith and was worked on a small scale. One room was opened under the creek bed and indications that the seam extended northward were verified when a shaft was excavated in section 22 (Se. qr., Se. ¼).

More than one coal horizon appears in this district, as shown by the section of the old McGregor shaft, west of the Big Four mine, which is given below (Sec. 27, Sw. qr., Nw. ¼).

		FEET.
10.	Drift	10
9.	Clay shale	3
8.	Shale, blue	8
7.	Coal	2
6.	Fire clay	2
5.	Shale and "slate," bituminous	25
4.	Coal, with a thin seam of pyrite	4¾
3.	Fire clay	3
2.	Shale, green	8
1.	Hard black rock with shells (St. Louis ?)	1

Coal has also been mined in section 36 of Lockridge township, where a shaft twenty-five feet in depth reached a seam forty-two inches in thickness. The latter consisted of eight inches of a tough cannel coal above, thirteen inches of ordinary bituminous coal, then three inches of fire clay, and below this eighteen inches of bituminous coal. After working a few seasons, the mine was abandoned because of water.

HENRY COUNTY*

Not more than twenty square miles in Henry county are underlain with Coal Measures, and the deposits are extremely thin where present. The greater part of this area forms merely the attenuated edges of more important Des Moines outcrops

*A complete description of the Coal Measures of this county has already been published by Savage: *Geology of Henry County,* Iowa Geol. Surv., Vol. XII, pp. 284-288; Des Moines, 1902.

in Jefferson county on the west and Lee on the south, while the remainder lies in small isolated patches. Before the prolonged period of erosion which intervened between the last retirement of the waters of the sea from this region and the invasion of the Pleistocene ice sheets, it is probable that Des Moines strata covered Henry county to a depth of many feet. Before the deposition of the drift, however, stream action and surface wash had removed all but that portion of the Coal Measures which lay in a protected position in depressions of the underlying calcareous formations, or which was situated at a distance from the area of most energetic erosion.

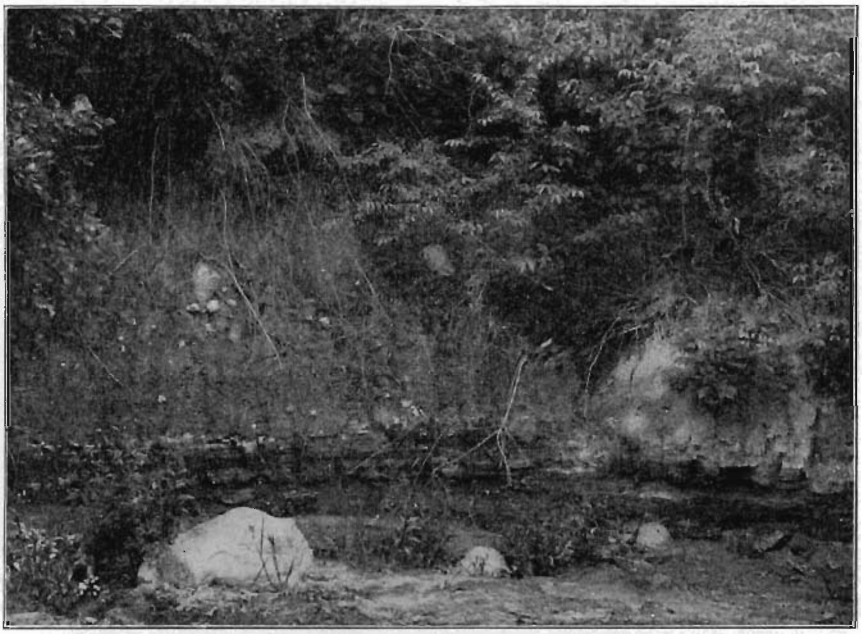


Figure 79. An exposure of coal in section 5 of Salem township. The coal bed is immediately overlain by drift.

Coal Measures may be found along the western boundary of the county in a strip less than one mile wide and about fourteen miles long extending from the southwestern corner of Salem township to a point north of the Chicago, Burlington and Quincy railroad. A similar narrow strip lies east and west along the greater part of the southern border of the county; while a few small outliers are erratically placed in various parts of the southern six townships. The strata constituting the outcrops consist chiefly of yellow and brown sandstones with intercalated shales; although a few coals have been discovered and will be mentioned more in detail below.

Before the advent of several lines of railroad caused cheap fuel to be brought to every door from neighboring counties and from other states, some mining was undertaken; but nothing has been done for a number of years. In 1862, 100 bushels was taken out; in 1866, 10,035 bushels; in 1868, 20,300 bushels; in 1875, 120 tons, and in 1885, 196 tons.

Rome. West of Rome, near the Skunk river, a coal that has been mined in the past outcrops in the sides of neighboring ravines. The following is the section as reported by Keyes.*

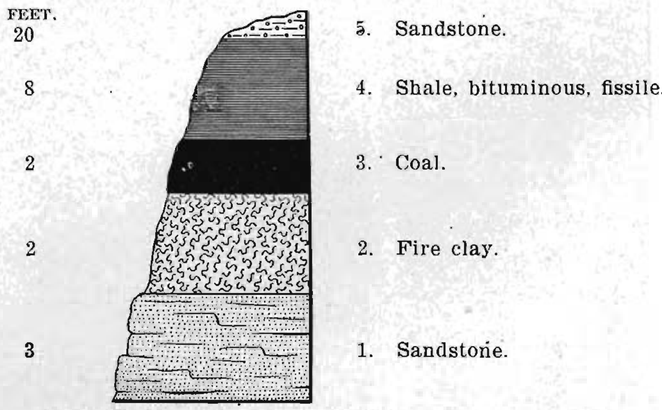


Figure 80. Outcrop west of Rome.

Salem. Four miles north of Salem, in section 5 of Salem township, rocks forming part of a small Coal Measure outlier outcrop at several places in a small ravine. Among these strata is a coal bed, as shown in the section given below.

		FEET.
3.	Gravels and bowlder clay	3½
2.	Layer of soft sandstone grading downward into a narrow band of shale	4
1.	Bed of impure, earthy coal, rather soft and crumbling easily	3

A few rods farther down the stream there is an outcrop in which the coal is of better quality and is slightly thicker. The

*Iowa Geol. Surv., Vol. II, p. 481; Des Moines, 1894.

coal is harder and contains less earthy matter than that of the above section, but is immediately overlain by the bowlder clay. Twenty rods north of the latter exposure, the Saint Louis limestone appears twenty-five feet above the level of the coal. One mile to the north, the opposite side of this limestone ridge is reached and a bed of coal very similar to that described may be observed in a stream valley in the central portion of section 32, Tippecanoe township. The seam is overlain by ten inches of shale, capped by four feet of soft sandstone. The coal is three feet in thickness and was formerly drifted for a distance of two or three hundred feet into the hill.

Coal is exposed in the wagon road five miles directly east of Salem and has formerly been mined. The Coal Measure outlier of which it forms a part is, however, a small one and all the workable part of the seam appears to have been removed.

DAVIS COUNTY

Although containing strata which have proved in neighboring counties the most productive in the state, Davis has as yet produced but little coal. That this state of affairs is due to factors other than the absence of workable coal basins, there can be but little doubt. Most of the county is covered by an exceptionally heavy mantle of glacial drift that effectually masks outcrops, and in only a few places have streams cut down to the indurated rocks beneath. It is significant that where exposures of the Coal Measures have been laid bare, coal beds have in many cases been discovered and there is reason to think that numerous basins exist in unprospected portions of the region. It is not likely that these are of great lateral extent, for the only persistent seam in the Des Moines stage of southern Iowa, the Mystic coal, probably fails to reach as far east as Davis county and the other coals of the lower Measures are more or less pockety in nature. Extensive prospecting is the only means of locating good coals, and this will be least expensive where the overlying drift is most feebly developed. In this respect the valleys of the northern tier of townships are most favorably situated.

The Coal Measures attain considerable thickness within the limits of the county, and the basal Saint Louis limestone outcrops only in the northeastern corner of the county, near the Des Moines river. A few drillings have been continued to the limestone in other sections: At Laddsdale it was reached at 183 feet, near Carbon at 225 feet and at Bloomfield, as reported by Keyes,* at 230 feet. At Sedan, in Appanoose county, the Saint Louis lies 382 feet down, at an altitude of 443 feet above sea level. The very uneven surface of the Saint Louis renders the depth at which it may be encountered in even adjacent prospects rather variable, yet it has a fairly consistent dip to the southwest of about eight feet per mile from the outcrop mentioned above to the Missouri state line.

Davis has never been a large producer and mined as much coal in Civil War days as during many recent years. Federal Census reports show that 577 tons were mined in 1860, 1,080 in 1870, 5,500 in 1880 and 3,825 in 1890. Recent production is given by the Iowa Geological Survey as follows:

YEAR.	TONS.	YEAR.	TONS.
1898	391	1903	2,160
1899	3,100	1904	543
1901	1,364	1907	1,300
1902	3,633		

During the year ending June 30, 1908, an increase was noted, due largely to developments at Carbon. The output was then 4,364 tons and the number of men employed, thirty-three. Below is brief mention of mines in existence in August, 1907.

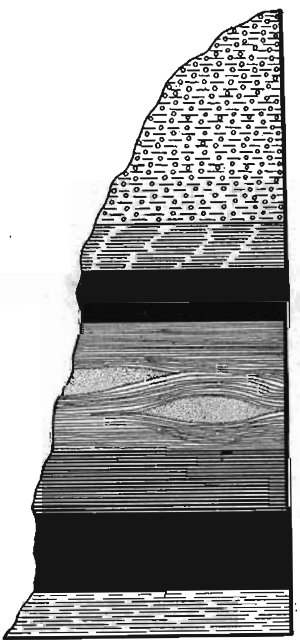
Carbon. The only shipping mine in the county is the drift of the Soap Creek Coal Company. The drift mouth is situated one-half mile west of the station at Carbon, coal being conveyed over the intervening distance on a long tramway. This is a new mine at which but little work has been done. The coal is about three feet thick, including a two-inch clay parting which lies about four inches above its base. Beneath the coal is from two to three feet of fire clay, and above is a "soapstone" shale which forms rather a weak roof. The dip is to the south and west. A seam with a good roof, but only eighteen to twenty-six inches in thickness, outcrops fifteen feet below the one worked. Considerable prospecting has been done near Carbon and the

*Coal Deposits of Iowa, Iowa Geol. Surv., Vol. II, p. 424; Des Moines, 1894.

parties interested report that the seam mined there underlies an area of ten square miles and that the lower coal mentioned above extends from three miles south of Carbon north into Wapello county. In one prospect seven feet of coal was found at a depth of 112 feet.

Two and one-half miles southwest of Carbon, in section 10 of Soap Creek township, is the small Wagner bank, operating in a twenty-two inch seam lying well above the creek level. Farther southwest is the Shanley drift in two feet of coal.

Three miles southeast of Carbon a four-foot coal underlies at least one square mile of territory. Other seams are also known. The old Dunn mine (Lick Creek Tp., Sec. 8, Nw. qr.), on the north bank of Soap creek, worked in five feet of coal about



	FEET.	INCHES.
7. Drift	10	
6. Shale, bituminous	2	
5. Coal	2	6
4. Shale, bituminous, with bands and nodules of clay iron-stone, graduating below into next	6	
3. Shale, firm, black, fissile	3	
2. Coal	3	6
1. Fire clay, gray, shaly in part	2	

Figure 81. Bluff on Soap creek near old Brown Cannel mine. Carbon.

thirty-five feet above the creek level. The coal appears to thin out rapidly up the stream. A thick coal bed on the opposite side of Soap creek was once utilized by the Brown Cannel Coal Company. No mining is being done in this district at present.

Floris. Borings at Floris itself have revealed no coal, although one was carried to a depth of 210 feet. One-half mile northwest of the town, however, is an exposure of two coals on Soap creek (Lick Creek Tp., Sec. 15, Ne. qr.). The lower seam lies at the water level and is two feet thick. It is separated from the upper, which is three feet in thickness, by fourteen inches of shale and sandstone. These two beds coalesce to form a four to six-foot seam that has been worked a trifle at the old Howard shaft, situated not far from the outcrop. Pre-glacial depressions filled with drift probably interfere greatly with the continuity of the bed.

A number of quite small country banks, open only in winter, are operated along Salt creek, northeast of Floris. Two coal seams are commonly recognized here and lower coals are also present. The first seam is three feet and less in thickness and, because of its slight depth beneath the surface, often possesses insufficient cover. The second seam lies at the water level of Salt creek, about twenty-five feet below the first. It shows a thickness of from four to four and one-half feet, and is often overlain by black shale and a band of compact sandstone that makes a fair roof where well developed. The Hastings bank (Salt Creek Tp., Sec. 8, Se. qr., Nw. ¼) and the Clark, one-half mile west, work the second seam. The Dye mine (Sec. 8, Ne. qr., Nw. ¼), and the near-by Fite and Fayne banks, work the first seam.

Considerable mining has been done at Laddsdale, on the Chicago, Rock Island and Pacific Railway just north of the Wapello-Davis county line. Some, at least, of the coals described in the chapter on Wapello county as found there probably extend southward into Davis county. There are rumors that a shipping mine will be opened south of the county line, if the railroad can be persuaded to bridge Soap creek.

Troy. One and one-half miles east of Troy, just over the line in Van Buren county, Mr. Lunsford intends to sink a shaft in the near future. The strata found here are briefly mentioned in the chapter on Van Buren county.

Lunsford. Until the recent caving of the shaft caused it to be abandoned, a local mine was operated in the valley of Fabius creek, one-fourth mile north of the Missouri line. The drift is 200 feet thick at this shaft. An eighteen-inch coal lies 226 feet beneath the surface and a seam thirty-eight inches thick was mined at 260 feet. Entries were driven eighty-five feet east, fifty feet west, 260 feet south, and 270 feet north. The coal thickened slightly to the north and west. The upper seam was found in a boring one and one-fourth miles northeast of the shaft, but no attempt was made to reach the thicker bed.

VAN BUREN COUNTY

Van Buren county lies on the eastern margin of the coal field and is quite generally underlain with Coal Measure strata. These deposits are commonly, however, rather attenuated and are far from continuous over the entire region, being absent in the immediate vicinity of the Des Moines river and lower Chequest creek and in the eastern portion of Harrisburg township. There are also numerous areas under the uplands where the drift rests locally upon the Saint Louis limestone in preglacial depressions. In some sections the Coal Measures may be characterized, therefore, as being merely outliers on the border of the main field. The coal basins so far discovered have been quite small and the mines have been located chiefly in the Des Moines valley and in the northern tier of townships. The mantle of drift in the southwestern half of the county has tended to completely conceal the indurated rocks and to prevent the discovery and development of the coals which probably underlie limited areas in that region. A basin of unknown extent is soon to be opened near the Davis county boundary and Chequest creek, and coal has been mined near Farmington, along Bear creek, and in thin beds near Keosauqua. Aside from these districts development has been confined to the region north of the Des Moines river.

In spite of the fact that most of the coal mined has always been used locally and that the coal basins utilized have not been of great extent, the early settlement of the county soon led to the development of outcropping coals. Thus in 1860 the annual production amounted to 4,252 tons, a sum exceeded only in Wapello and Jefferson counties. From this period to the present, the annual output has varied from 1,000 to 45,000 tons. The tonnage of recent years, according to statistics gathered by the Iowa Geological Survey, is as follows:

YEAR.	TONS.	YEAR.	TONS.
1898	6,605	1903	12,361
1899	7,385	1904	8,005
1900	12,108	1905	6,192
1901	12,572	1906	12,137
1902	14,819	1907	15,374

The State Mine Inspectors' report shows for the year ending June 30, 1908, an output of 17,518 tons from eight mines. Sixty-six men were employed.

In the following pages of this chapter, the coal areas so far as known in August, 1907, are discussed in more detail.*

Business Corners. About a mile north of Douds, three horse-gin mines supply the local trade and the railroad chutes at Douds and ship small quantities of coal to Keosauqua, Fairfield, Eldon, and other points. The coal of this district lies in pockets that differ but little in character, and averages about three and a half feet in thickness. A thin stratum of fire clay is found under the coals of the chief horizon; while from four to twelve feet of black bituminous shale, with intercalated bands of impure limestone forms the roofing material. Small basins appear to be quite numerous in the northwestern section of the county.

The present Ratcliff mine is entered by a shaft sixty feet deep adjacent to that of the former G. W. Findley bank (Village Tp., Sec. 14, Se. qr., Se. ¼). The thickness of the seam worked remains quite constant at three feet eight inches, except at the west line of the lease, where it was five feet at the point at which work ceased. About ten acres have been mined out in strips extending to the north and west lines of the lease. In running north from the old Ratcliff shaft, a short distance south of the present mine (Sec. 23, Ne. qr.), the seam went to the rise until it dropped six feet along a fault plane, and then pitched downward at such a steep gradient that it was deemed advisable to sink a new shaft at the present location in order

*Acknowledgments for material are due previous reports of this Survey—Keyes: *Coal Deposits of Iowa*, Vol. II, pp. 429-434; Des Moines, 1894, and Gordon: *Geology of Van Buren County*, Vol. IV, pp. 197-254. 1895.

to avoid the heavy haul toward the south. On the south side of the old workings the roof was insecure; while west of the former shaft no coal was found in a well sixty-four feet in depth.

The mine of the Findley and Sons Coal Company is situated near the center of section 14, where the coal is found to vary from forty inches to four feet in thickness. The bed is cut out in places and the plan of mining is to follow around the edge of the barren strips instead of tunneling through them. The shaft is sixty-six feet in depth and the coal lies but slightly below the bed of a neighboring water course. Recent drilling revealed forty acres of good coal tributary to the shaft. Three six-inch coals with local thickenings are found above the bed worked. The A. M. Felmelee mine is a short distance northwest of the Findley (Sec. 14, Nw. qr., Se. ¼). The fifty-foot shaft was sunk in 1906 to coal which shows from three to four feet in thickness. It was intended to work from this shaft about thirty acres, of which less than two have been mined out. The bed dips northeast. On the south side of the territory the coal was deemed too soft and the roof too weak for profitable exploitation.

The sequence of strata in the northern portion of section 14, where mining operations have been conducted in the past, is shown in the following:

		FEET.
13.	Clay	10 to 11
12.	Shale, black, bituminous	11
11.	Coal	½
10.	Fire clay	2
9.	Shale	3 to 4
8.	Limestone, black	1
7.	Coal	1
6.	Fire clay	2
5.	Shale, gray, with limestone masses	4 to 6
4.	Coal	3 to 4
3.	Fire clay	4
2.	Concealed	8
1.	Shale, blue, in well starting about twelve feet below the coal	22

The following section of the strata at the old Findley mine near Business Corners (Village Tp., Sec. 24, Ne. qr.) shows as close a correspondence with the preceding record as can be expected in so irregularly stratified a stage as the Des Moines.

		FEET.	INCHES.
12.	Concealed	20	
11.	Shale, blue, argillaceous	10	
10.	Coal		6
9.	Shale, arenaceous, with plant remains		10
8.	Coal		6
7.	Shale, becoming more argillaceous below	3	
6.	Coal		6
5.	Sandstone, with plant remains	1	
4.	Fire clay	2	
3.	Shale, black, fissile above, more compact below; the basal portion containing lenticular masses of black, calcareous rock	5	
2.	Coal, sometimes partially cut out by the lenticular masses ...3 to	4	
1.	Fire clay	2	

Prospecting in section 13 revealed a continuation of the coal at the Ratcliff mine and this may be developed at no distant date. Some coal has been taken out on the Hinkle land in section 10, southwest quarter, and a little mining is still prosecuted intermittently. In the northeast quarter of the same section a coal outcropping in a higher horizon than any yet considered occurs not far below the plain level. An exposure in a branch at this point is:

		FEET.	INCHES.
12.	Shale, black	8	
11.	Coal	3	
10.	Clay seams		2
9.	Coal		8
8.	Fire clay	4	
7.	Concealed	30	
6.	Shale, black, bituminous	8	
5.	Limestone, black, compact		2-10
4.	Shale, black, fissile	2	
3.	Shale, black, argillaceous	2	
2.	Coal	1	6
1.	Fire clay	1	

A three-foot coal bed is known to be present south of the river, near Selma (Village Tp., Sec. 20), about seventy-five feet above the Saint Louis limestone. It has been worked in a small way. A small coal bank is located just south of the county line, on Lick creek (Lick Creek Tp., Sec. 6, Ne. qr.), where a shaft not quite fifty feet deep reaches a three-foot seam. Another coal horizon is present, but seldom bears workable coal. This coal is found also in section 5 and north on Lick creek in Jefferson county. Farther south (Sec. 17, Ne. qr.) the Mathias bank produces a little coal, but only a few rooms have been worked out. The section yielded by an opening on the hillside is:

	FEET.	INCHES.
7. Drift	37	
6. Coal		7
5. Limestone, brown	2	9
4. Limestone, blue	1	3
3. Shale, black, with limestone "bowlders"	2	
2. Coal	3	
1. Fire clay	15+	

In boring for coal at Birmingham, the following record was obtained, the location being at the station of the Chicago, Burlington and Quincy Railroad, altitude 758 feet above tide.

	FEET.	INCHES.
14. Soil	2	
13. Clay, yellow	?	?
12. Sand, fine, white		4
11. Sandstone, gray	13	8
10. Coal	1	2
9. Shale, black	4	10
8. Shale, red, sandy	10	
7. Shale, black	4	
6. Coal, impure	1	
5. Shale, gray	1	2
4. Limestone, black, bituminous		10
3. Coal, impure	5	6
2. Shale	10	
1. Limestone, white	12	

The seams encountered were not regarded as workable here. Coal has been mined for local use, however, about two miles southwest of Birmingham and also three miles south and west, where a slope is now being reopened by Mr. Buckmaster (Lick Creek Tp., Sec. 25, Nw. qr.). The coal at the latter bank is three feet and less in thickness and is roofed by a black shale capped with impure sandstone. In the northeastern corner of the county, in Cedar township (Secs. 13, 14, 23 and 24), small quantities of coal were taken out for a number of years, though nothing beyond pulling pillars and some superficial drifting has been done recently. An exposure (Sec. 14, Nw. qr.) shows the following stratigraphical arrangement:

	FEET.	INCHES.
7. Shale, black, fissile	1	6
6. Sandstone, ash-gray, irregularly indurated	1	
5. Coal, with lenticules of sandstone	2	
4. Shale, black, fissile, calcareous		10
3. Fire clay	3	
2. Concealed	5	
1. Limestone—in creek bed (St. Louis)		

Locally this coal thickens considerably, for most of the coal is irregular in occurrence. On the south, in section 23, three feet of coal is separated from the underlying Saint Louis by only three feet of fire clay. A top coal is often present, separated from the lower by a short vertical interval. Not more than sixty acres have been worked out in Cedar Township.

Bentonsport. The C. Manning bank is now doing a good business three-fourths mile northwest of Bentonsport in what is evidently a small outlier of Coal Measure strata (Sec. 35, Nw. qr.). A slope and entry have been driven in about 900 feet to a seam which bears from three to three and one-half feet of coal and lies about fifty feet below the general level of the country. This coal does not extend far east of the wagon road through section 35, but in the south half of section 26 is an area of about 100 acres in which coal from eighteen to thirty-six inches thick appears to be quite generally present.

Northeast of Bentonsport, on a small branch of Honey creek (Harrisburg Tp., Sec. 20, Sw. qr.), is the A. R. Gardener bank. Two coals are found here, the upper being the one mined. It is two feet ten inches in thickness, free from impurities or irregularities, and roofed by five feet of heavy "slate." About seven rooms have been worked out and the pillars brought back to the entries. The lower seam was reached in two borings eighty rods north of the mine, where it lies twenty feet below the upper and is four and one-half feet thick. East of the mine 150 yards the lower seam shows only one foot of coal; while the upper possesses no roof. Farther east, on Honey creek, the lower seam again thickens and has been mined by stripping.

The Whitmore bank is two and one-half miles south of the Gardener (Bonaparte Tp., Sec. 5, Ne. qr.). Horse and gin hoist the coal through a shallow shaft. Work was abandoned on the north side because of a miner's "fault." The sequence of strata at this mine is shown in figure 82. The fire clay under the lower coal is said to rest directly on the Saint Louis limestone.

FEET.	INCHES.		
2		10.	Drift.
1	5	9.	Shale, dark blue.
	5	8.	Coal.
2		7.	Fire clay.
	11	6.	Shale, drab or brown.
1	6	5.	Shale, dark, fissile.
1	8	4.	Coal.
	1	3.	Clay parting.
1	2	2.	Coal.
2		1.	Fire clay.

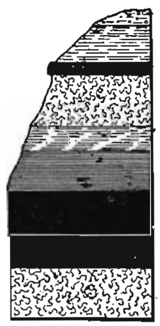


Figure 82. Seam at Whitmore mine. Bonaparte.

Mr. Whitmore worked out a basin seventy feet wide and of unknown elongation north and south in a small outlier in section 3, Bonaparte township. The coal varied between thirty and fifty inches in thickness and had a safe roof of "slate" over the part worked only.

Coal areas of limited extent are present in the valley of Bear creek, on the south side of the river, near Bentonsport. These basins appear to be in depressions of the Saint Louis limestone, and to be somewhat irregular in occurrence. The only mine now in operation is the small Bradford drift on a tributary of Bear creek, at which point the average thickness of the coal is thirty inches, with pockets of greater height. The dip of the seam is to the northwest, and near the drift mouth the coal lies about seven feet below the level of the stream valley. The roof is a "slate" of satisfactory strength except where one pre-glacial erosion channel, four feet in width, occurs. One-fourth mile north of the mine the limestone outcrops well up in the creek valley, cutting off the Coal Measures. Three small seams of coal are reported from the center of section 12, and coal also has been found in the upper part of the river bluffs below the debouchure of Bear creek. At the old Boyer mine (Henry Tp., Sec. 3, S. ½), which has not been worked for five years, the following section occurs.

		FEET.	INCHES.
5.	Coal		6
4.	Sandstone, white, very compact, called "clod," sometimes changing to black shale	6 to 12	
3.	Coal	3	
2.	Fire clay		3 to 4
1.	Sandstone	?	

Another coal bank is to be opened one mile west of the Boyer.

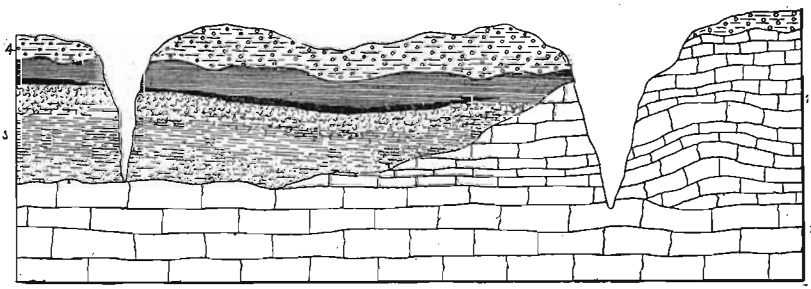


Figure 83. Section at Farmington showing Coal Measure deposits resting in depression in Saint Louis limestone. 1 and 2, Saint Louis limestone. 3, Coal Measures. 4, Drift.

Farmington. Several coal basins of limited extent occupy depressions in the Saint Louis limestone in the vicinity of Farmington. Each coal bed is usually underlain by fire clay and sandstone, but this sandstone occasionally fails, and then the coal rests directly upon the limestone. In some cases the fire clay and sandstone occur at the center, but wedge out at the edges of the basin. The following represents the succession as shown by drill records in a coal district, number 4 being the only workable horizon.

		FEET.	INCHES.
17.	Drift clays	80	
16.	Shale, black	6 to 10	
15.	Sandstone, gray, coarse-grained	1	8
14.	Coal	1	2
13.	Sandstone		8
12.	Coal	1	

11.	Fire clay and shale, bluish	5	
10.	Shale, blue	15	
9.	Shale	2	6
8.	Coal		6
7.	Sandstone		3
6.	Coal		1
5.	Sandstone	1	8
4.	Coal	4 to 5	
3.	Fire clay	0 to 3	
2.	Sandstone	0 to 6	
1.	Limestone (Saint Louis)	1+	

The Cahill Coal Company is operating a seventy-eight acre lease one mile northeast of Farmington (Sec. 25, Sw. qr., Sw. ¼). A seam from three to five feet in height lies sixty-five feet below the surface at the shaft. This pocket has been worked for a long period of time and is now almost exhausted. Hoisting is done with horse and gin, as at all the mines of the district. The larger portion of the output is consumed locally, although some is shipped to neighboring towns. North of the Cahill is the Knott mine, which supplies a local trade from a steep slope 100 feet in length. Very little of the product is shipped. On the Mannhart land, a pocket of twenty acres of coal is known, varying in height from forty to fifty inches.

A short distance southeast of Farmington is the 135-acre lease of the Hessler Coal Company. The shaft is seventy-five feet deep, and is located near the tracks of the Kansas City railroad (Sec. 1, Ne. qr., center of S. ½). The top of the seam worked is fairly level, but the surface of the underlying fire clay is uneven, causing the coal to exhibit changes in thickness from twenty-two to thirty-seven inches. Mr. Hessler reports that the entire lease is known to be underlain with coal and that it thins toward the north. A local trade is supplied. The bed worked and a seven-inch coal thirty feet higher outcrop in a neighboring creek and coal has been found as far west as the railroad. The interval between the two coals is bridged by "slate" and a little fire clay. Five shafts have been sunk at various times to this basin.

The Blue Jacket mine is a local bank about one mile west of the Des Moines river, near the Missouri line. Where worked the bed is four to five feet thick and coal is said to be present under a large part of the lease of 105 acres. The shaft is forty feet in depth.

Troy. In Van Buren county, one and one-half miles east of Troy, Mr. Lunsford reports that a coal area has been found by drilling and that a shaft will soon be sunk. A boring headed on low ground encountered twenty-two inches of "slate" above an eight-inch coal at a depth of twenty-five feet, followed by sandstone, "soapstone" and "slate" to a depth of forty-five feet, where five feet of coal overlain by a hard, gray cap-rock was reached. Essentially the same strata were found in a hole drilled one-fourth mile distant. Years ago a small slope was worked in this district.

LEE COUNTY

The Coal Measures which covered Lee county at one period were, as a result of crustal movements, subjected to more severe erosion than were those of the region lying within the main part of the Iowa coal field, and were in greater part washed away before the drift was laid down upon them. There are within the limits of the county today only remnants of Des Moines strata left in the form of isolated outliers. Many of these are, nevertheless, of rather large size. The main body of outliers is in the northern and western sections of Lee county and is an offshoot from the Iowa field; but there are near Keokuk a few very small areas which are structurally more closely related to

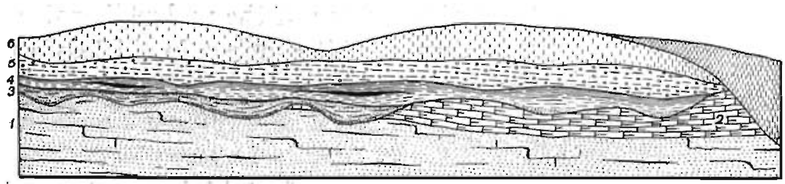


Figure 84. Unconformity of Coal Measures and Saint Louis limestone. Sonora quarry.

the Upper Carboniferous of the Illinois basin. In all parts of the county these beds are greatly attenuated and consist chiefly of a compact brown sandstone which commonly forms the basal member of the Des Moines in southeastern Iowa. In every case this stratum rests unconformably on Saint Louis limestone.

Coal Measure sandstone resting unconformably on Saint Louis limestone. Keokuk.

Owing to a lack of many coal seams of workable thickness and to the general absence of a good roof over those coals that do exist, Lee county has never been and never will be a great producer. Considerable coal has been taken out for local consumption, however, and some is still mined during the winter months. The mines are seldom permanent, often operating from new openings each season, and on account of the nature of the roof only narrow work is attempted. As examples of the production for early years may be cited the annual output of 315 tons in 1860, 10,650 bushels in 1868, and 500 tons in 1880. The tonnage during recent years is negligible. Complete accounts of the occurrence of Coal Measures in Lee county have been published by Keyes* and have been drawn upon for material in the following detailed statement of the present status of the county as a coal field.

Cedar and Harrison Townships. With the exception of sections 28, 31, 32 and 33, the western half of Cedar township is probably underlain by Coal Measures. Similar beds appear in southwestern Harrison, but in neither township has workable coal been reported.

Van Buren, Charleston, and Des Moines Townships. The Harrison area is continued through Van Buren township as an irregular strip parallel to the Des Moines river and occupying fully one-half of the surface of the township. At Croton about fifteen feet of the basal sandstone caps the bluffs; while farther north and west, near Farmington, in Van Buren county, considerable coal has been mined near the Lee county limits. A narrow tongue of Coal Measures is continued into section 31 of Charleston township and into sections 1, 6 and 7 of Des Moines. In none of these three townships, however, has coal of economic importance yet been located.

Marion Township. Parts of two Pennsylvanian outliers occur in Marion township. One of these occupies the entire northeastern portion north of a line drawn at an average distance of one mile north of the Burlington railroad. A half mile east of Saint Paul some mining has been done in a desultory fashion in a thin seam that is extremely irregular in occur-

***Coal Deposits of Iowa*, Iowa Geol. Surv., Vol. II, pp. 484-489; Des Moines, 1894. *Geology of Lee County, Idem*, Vol. III, pp. 305-408; 1895.

rence. Another thin coal outcrops beneath several feet of black shale and light-colored clay less than a mile south, in the bed of a small ravine. In the south-central part of the township lies the north end of another outlier. In the south half of section 33 some mining has been conducted in a three-foot seam of coal which will be mentioned later.

Pleasant Ridge Township. Coal Measures may be found in practically all of this township except the southern tier of sections. The chief openings in this district have been made on Sutton creek, six miles northwest of Denmark, where coal has been mined by both strippings and drifts. One of the principal mines was the old Morris drift (Sec. 16, Ne. qr., Ne. ¼) from which some coal has been hauled to West Point during several winters: The seam was seldom as high as twenty-five inches. Almost nothing has been taken from this land for many years. Two miles east, a thin seam has been worked in a similar manner. An outcrop near the road in section 14 (Ne. qr., Nw. ¼) shows the section in the accompanying figure.

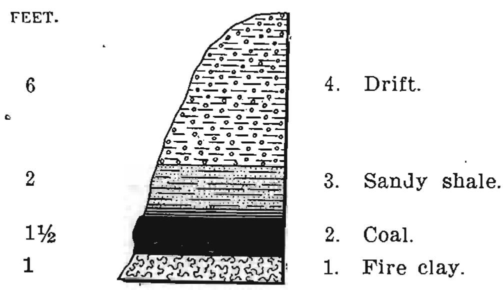


Figure 85. Outcrop northwest of Denmark.

This seam has an appreciable dip to the west and may possibly thicken in that direction. Coal may be present under much of the land lying between the two creeks near which the outcrops just mentioned occur, yet the tenuity of the seam and the weakness of the roof over it would hardly justify development.

Franklin and West Point Townships. The southern extension of the outlier in southern Marion township covers the older indurated rocks of the greater part of Franklin township between the Keokuk and Northwestern railway and the valley of Sugar creek. On both sides of the creek in section 4, Franklin township, shafts and drifts as well as strippings have taken out considerable coal for local consumption. There are rumors that the seam may be reopened on a somewhat larger scale than before. The coal is from three to three and a half feet in thickness, dips to the west and south, and has a poor roof, as shown by the following section of an outcrop in the vicinity.

		FEET.
5.	Drift	3
4.	Shale, bituminous	1
3.	Coal	3½
2.	Fire clay, arenaceous	2
1.	Shale, arenaceous (exposed)	3

One mile southeast, a few openings have also been made. The limestone underlying the Coal Measures is exposed in the creek bottom and bears the relationship to the coal bed revealed in the sequence given below.

		FEET.
5.	Drift	10
4.	Coal	2
3.	Fire clay	2
2.	Sandstone, soft	5
1.	Limestone, coarse, fossiliferous (St. Louis)	2

Between Sugar creek and West Point is a small Coal Measure outlier covering about six square miles. Two miles southwest of West Point (Franklin Tp., Sec. 12), and in adjacent areas, some mining was undertaken in a bed of coal which seldom exceeds one foot in thickness. More recently a lower seam, showing the thickest coal yet found in the county, was uncovered by a washout in the bed of a small stream. This coal lies four feet and more below the seam formerly mined and is about the same distance above the Saint Louis. It varies between three and four feet in thickness. In 1906, Mr. Peitz sank a shaft to this bed (Sec. 12, Se. qr., Nw. ¼) and now takes out considerable coal during the somewhat widely separated periods when the mine is working. He kindly furnished from memory the following shaft record.

		FEET.
9.	Soil and drift	9
8.	Sandstone	4
7.	Coal, upper seam	1
6.	Fire clay	5
5.	Coal, lower seam	3 2-3

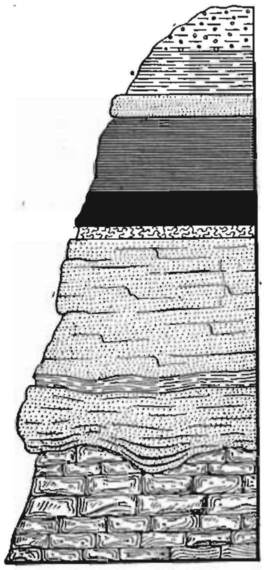
The strata below the lower coal have been exposed in a neighboring well.

		FEET.
4.	Fire clay, fine-grained	4
3.	Limestone (Saint Louis)	2
2.	Sandstone	20
1.	Limestone	

Jackson and Montrose Townships. Separated from the outliers previously enumerated by a low anticline which brings the Keokuk and Burlington beds to the surface, there are in southeastern Lee county three small Coal Measure tracts, each about one square mile in extent. The most northerly of these is just west of Galland, in Montrose township, on the crest of the bluff. So far as known, it contains no coal. The other two outliers are immediately north and west, respectively, of Keokuk, on the summit of the bluffs. Near Rand Park, north of the city, a very little coal was taken out by means of drifts many years ago. The section in this vicinity is:

		FEET.
6.	Drift	20
5.	Shale, dark	6
4.	Coal	1½
3.	Fire clay	½
2.	Sandstone, brown, coarse-grained	10
1.	Limestone, brecciated (Saint Louis)	8

In the southwest corner of the city, above Nassau slough, operations have also been attempted on a small scale. The coal is of good quality, but lacking in quantity. The sequence of strata at the summit of the bluff is illustrated in figure 86.



		FEET.
8.	Drift	2
7.	Shale, blue, argillaceous (exposed)	2
6.	Sandstone, ferruginous, irregularly bedded	1
5.	Shale, dark, fissile, many small concretions	3½
4.	Coal, thickening slightly northward	1½
3.	Fire clay	½
2.	Sandstone, variable in thickness, with irregular bands of clay shale, resting unconformably upon the next	10
1.	Limestone, gray, compact, brecciated (Saint Louis formation)	5

Figure 86. Top of bluff on Mississippi river at Nassau slough. Below Keokuk.

DES MOINES COUNTY

Upper Carboniferous strata are very poorly developed in Des Moines county, the greater part of those which were originally deposited having been removed by pre-glacial erosion. Only those Coal Measure rocks which lay in deep channels carved in the more resistant surface of the Mississippian formations remain in place at the present time, and these are entirely confined to the southwestern corner of the county. The most extensive deposits of Coal Measures lie in two small outliers on either side of Long creek, about two miles north of Augusta, at which point a thick buff to brown sandstone rises in bold cliffs. No coal has been found associated with this outcrop. Another area of Des Moines beds occurs in the extreme southwestern part of the county, about three miles and more southwest of Danville station, where they constitute outliers which extend a short distance into the southeastern corner of Henry county. Shale and a thin seam of coal accompany the sandstone in several parts of this area; but aside from the shale clays, nothing that can be considered of economic importance has been located. Coal Measures do not cover a total area of more than six square miles in Des Moines county.

The relationships of the Des Moines beds to the drift and to the older indurated rocks are illustrated in the accompanying cross-section along Skunk river. In this sketch, the numbers represent the following formations: 1 is the Kinderhook; 2 and 3, the Lower Burlington; 4, the Upper Burlington limestone; 5, the Montrose cherts; 6, the Keokuk; 7, the Warsaw shales; 8, the Saint Louis limestone; 9, the Saint Louis marls; 10 and 11, the Coal Measures.*

It is probable that the Coal Measures are not quite so continuous or so extensively developed as shown in this section. They should appear only in the central and western districts, as heretofore described. The general relationships of the various formations, however, are correctly portrayed.

*Keyes: *Geology of Des Moines County*, Iowa Geol. Surv., Vol. III, p. 428; Des Moines, 1895.

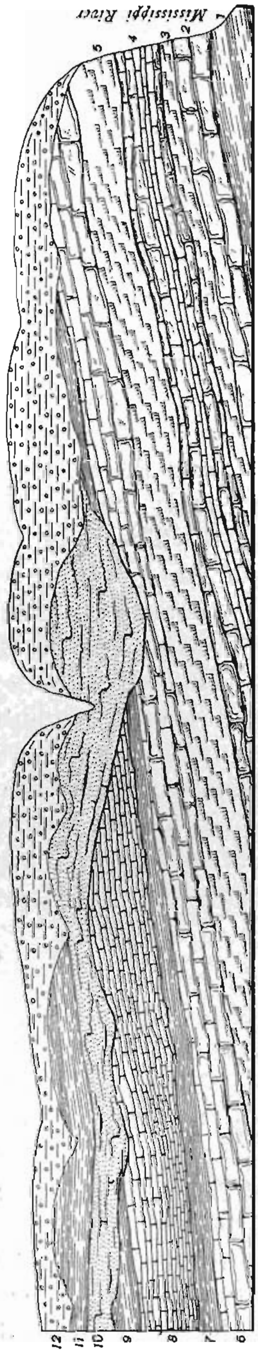


Figure 87. Cross-section along Skunk river.

PART IV.

COAL DEPOSITS OF EASTERN IOWA

GRUNDY COUNTY

A tongue of Lower Coal Measure strata projects eastward from the main Iowa coal field into the western half of Shiloh township and the northwestern corner of Melrose township of Grundy county, but no mining has been done within the limits of the district. The Eldora field, once quite productive, lies only a few miles west of the west county line and the absence of natural exposures in Grundy renders it probable that outliers of the Des Moines remain undiscovered beneath the upland surface; yet, nevertheless, it is not likely that extensive coal basins will ever be exploited in this region. The Coal Measures are probably thin where present, and the coal which they may possibly contain of poor quality. While prospecting operations would hardly yield legitimate returns, the incidental discovery of coal in well diggings may at some future time result in the development of coals of local importance.

LINN COUNTY

Of beds of Des Moines age that formerly covered a large part of Linn county only a few small outliers have survived the ravages of pre-glacial erosion. Of these Coal Measure areas, the best known lie between Cedar Rapids and Marion in sections 11 and 12 of Rapids township and consist chiefly of beds of ferruginous sandstone similar to those found in the Carboniferous outliers of neighboring counties. On West Otter creek Coal Measure sandstone and some coal are reported from section 19 (Nw. qr.) of Otter Creek township, where black bituminous shale was reached at a depth of only six feet from the surface. The probabilities of finding workable coal seams in Linn county are very slight.

JONES COUNTY

A thin deposit of sediments was probably laid down over nearly the whole of Jones county during the Pennsylvanian period, but has since been almost completely removed by preglacial erosion. Loose fragments of Coal Measure sandstone, derived from an undiscovered ledge in the neighborhood, were found in a ravine in Fairview township (Sec. 24, Se. qr.) and were associated with clays derived from Des Moines shales. A bed of pebbly, ferruginous sandstone, probably of similar age, occurs three miles northeast of Oxford Junction. There are probably other small outliers of Coal Measure strata concealed beneath the surface cover of drift and loess, but it is not likely that these contain coals of even local importance.

JACKSON COUNTY

Although situated far from the main portion of the Iowa coal field and subjected to intense erosion after the formation of the Des Moines stage, the territory embraced by Jackson county contains a few remnants of Coal Measure strata. Since no coal has been found associated with these, however, and the prospect for finding workable beds is exceedingly small, these deposits are of little importance as fuel producers. Many of these Carboniferous outliers occupy channels in the Niagara limestone and they consist chiefly of sandstones with some shale. They are found in Monmouth, Brandon, Maquoketa, and Fairfield townships in isolated basins covering a few acres each. One of them, in section 13 of Maquoketa township, bears as much as fifty feet of coarse-grained sandstone. The largest individual basin is probably the crescent-shaped sandstone area on the south side of Beaver creek, south of Monmouth, which extends interruptedly for a distance of more than two miles in a southwest-northeast direction.

POWESHIEK COUNTY

The outer border of the main body of Iowa Coal Measures traverses Poweshiek in a somewhat irregular line running through or near Grinnell, Jacobs, Montezuma and Tilton. At any point south and west of this line it is possible that coal may exist, but north and east of it only the calcareous strata of the Mississippian formations outcrop. Up to the present time almost no workable coal has been found within the limits of the county, a condition due in part to a considerable thickness of drift which has discouraged prospecting, and to the active mining in neighboring counties which has produced a like effect by lessening the urgency of the market. Nevertheless, it is entirely conceivable that good coal basins will be located at some future time when an increased price for fuel renders the necessity for its discovery more pressing. The What Cheer district in Keokuk county, for many years one of the largest producers in Iowa, is located but a short distance from Poweshiek county and lies on the edge of the main Iowa field under conditions corresponding with those existing in this region. Coal is also mined near New Sharon in Mahaska county, almost on the south Poweshiek line, and in Jasper county, at no great distance from the west line. One of the unfortunate features to be considered, however, is that the base of the Coal Measures is found above the water level of Skunk river in places and that the drift probably extends down to the same level in numerous instances, thus cutting completely through the coal bearing strata.

In the late sixties some mining was done near Buck creek and Skunk river, in the southern margin of the county, and a production of 100 bushels is recorded in state census reports taken in 1866 and 1868. Since that period a little work has been undertaken from time to time in a desultory fashion. The old Watson drift in section 36 of Sugar Creek township, near the Iowa Central bridge over the Skunk, was driven several hundred feet into the hill on the south bank of the river. Recently attempts to utilize it were renewed, the entry being lengthened toward the northwest; but the bed dipped so strongly in the same direction that water entering the mine could not be easily removed. Moreover, the coal was from fifteen to twenty inches thick only.

No coal has been reported from the many wells, some over 200 feet in depth, that have been sunk in southwestern Poweshiek, though in some at and near Searsboro and elsewhere thin seams were encountered. Prospecting for coal between New Sharon and Searsboro failed to show anything but thin coals. On what was formerly the McIntyre farm, two and one-half miles south of Montezuma (Jackson Tp., Sec. 19), several prospect holes were sunk and the discovery of a four-foot coal was reported. No exploitation was attempted and apparently no other drillings were made in the neighborhood. If this report is correct, prospecting operations along the line of the Rock Island Railroad south of Montezuma might prove profitable.

IOWA COUNTY

Although the What Cheer coal field, formerly one of the most productive in the state, lies at no great distance from Iowa county, the Coal Measures have been removed by pre-glacial erosion from most of the region now under consideration. Only a few independent outliers that cannot be considered of economic importance remain of once extensive deposits of Des Moines strata, and these contain practically no coal. The principal area of Pennsylvanian beds occurs in the northeastern part of the county, on the north side of the Iowa river valley. It embraces an elongated basin of coarse-grained, cross-bedded sandstone less than a mile in width and extending from Knapp creek in Johnson county westward to a point about three miles beyond the Iowa-Johnson boundary line.

JOHNSON COUNTY

Blocks of coal have been found in or immediately beneath the drift in Washington township and elsewhere in Johnson county; while Coal Measure outliers are known at several points. There are, however, but two noteworthy areas of Des Moines strata. One covers a few hundred acres in sections 2 and 3 in the northern part of Iowa City, occupying an old valley that was more than eighty feet in depth and consisting of shale and sandstone with a coal "blossom" one-half to an inch in thickness. The second Coal Measure outlier is a narrow elongated body lying along the north side of the Iowa river valley from Knapp creek west into Iowa county. It contains sandstone with some sandy shale. It is extremely unlikely that coals of even local importance will be found in this county.

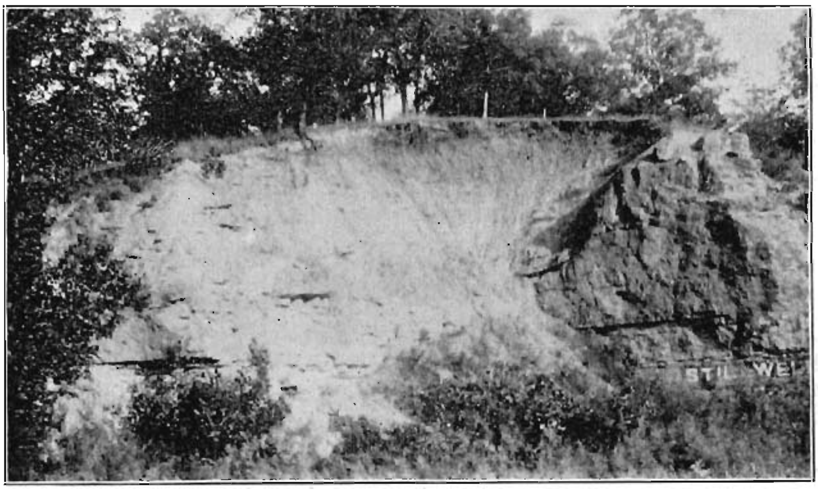


Figure 88. Contact of Carboniferous with Devonian strata at the Sanders quarry north of Iowa City. The heavy ledges at the right are Devonian limestones; the rapidly weathering talus-forming beds at the left of the limestone are Upper Carboniferous sandstone. There is here seen a portion of the rocky cliffs that marked the right side of a pre-Carboniferous valley.

CEDAR COUNTY

Although essentially no coal has been laid bare in Cedar county, a few isolated areas of Coal Measure sandstone are known. These are only a few acres each in extent and cannot be considered of economic importance except for building purposes. Two such areas exist on Clear creek, in sections 28 and 29 of Pioneer township. Others occur near Rock run in sections 21 and 22 of Center township; on Rock creek in section 25 of Rochester township; and in the northeast quarter of section 1, near the town of Rochester. While the future may reveal other outliers, any coal that they may contain will be of slight significance.

CLINTON COUNTY

This county contains only a few scattered remnants of the Coal Measures and they are very limited in extent. Certain clays, silts, and sands in crevices and caverns of Niagara limestone are of Pennsylvanian age, as are also some outcrops of sandstone found in the northeast corner of Bloomfield township, on a small branch of Deep creek near Charlotte, and in sections 7 and 18 of Sharon township. A small outlier was explored by a well in Welton township (Sec. 33, Nw. qr.) where the following strata were penetrated.

		FEET.
5.	Yellow and blue clay	50
4.	Quicksand	20
3.	"Slate," with thin coals in lower part	17
2.	Sand, white	12
1.	Limestone, yellow	4

Number 1 of the above is Niagara limestone, Number 2 a disintegrated Coal Measure sandstone grading upward into Number 3. Any coal bed found in this county will be of such limited lateral extent and lie so near the loose surface formation that it cannot be worked with profit.

MUSCATINE COUNTY

Muscatine contains the western portion of a large Coal Measure outlier that is in reality part of the Illinois coal field, from which it has been separated only by the recently formed valley of the Mississippi river. This Pennsylvanian tract possesses a width of from two to five miles and occupies much of the high-lying area reaching back from the border of the narrow valley of the Father of Waters. Its western extremity lies about three miles west of the city of Muscatine; its eastern is found in Scott county. In all, perhaps seventy-three square miles are covered by the Muscatine portion; although, because of the rapid rise of the underlying formations towards the north, it becomes greatly attenuated on the outer margin. As in the main section of the Iowa field, the materials of which the Des Moines strata of Muscatine county are composed consist chiefly of sandstones, shales, fire clays and coals, with local developments of conglomerates, and with a few thin limestones, and these varieties grade laterally from one to another with remarkable suddenness. Unlike the Des Moines of the main Iowa field, which in all cases rests upon Mississippian rocks, the Coal Measures of this area lie upon the Devonian.

Although coal has never been found in quantities of economic importance in this county, considerable amounts have been taken out for local use. The coal basins are of limited extent, contain coal of rather poor quality, and are usually quite low.

Figure 89. Basal conglomerate of the Des Moines, in the left bank of Montpelier creek, near the bluff of the Mississippi. Photo by Calvin.

What mining is now done is confined to small country banks that are in operation only during the winter months to furnish fuel for the immediate neighborhood. Before the better basins were mined out and improved transportation facilities brought coal from other states into direct competition with the local product, the coal industry was of relatively greater importance. Production during the early days of the county's settlement has been recorded as follows: for 1860, 1,785 tons; for 1865, 49,089 bushels, for 1870, 2,492 tons. These figures compare favorably with the outputs of other sections of the state at the same periods.

Muscatine. The Coal Measures of the county have been ably described by Professor Udden. In speaking of the occurrence of coal at the city of Muscatine, he writes:* "In the northwest part of the city, near the adjoining corners of sections 26, 27, 34 and 35, a sandstone fifteen feet thick lies at an elevation of at least 125 feet above the river. Under the sandstone there is a small seam of coal, which appears in a creek southeast of the crossing of Logan and Cedar streets. In going up the main branch of Papoose creek the Coal Measures make their first appearance a short distance above the junction of Star and Cedar streets." At this point one foot of coal again appears under a considerable thickness of sandstone and has been worked on a small scale a short distance north.

Hall describes the following section from the mural escarpment fronting the river at West Hill.

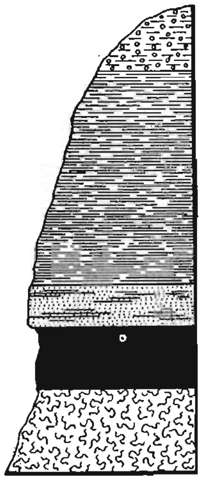
		FEET.
8.	Thin-bedded sandstone, with shaly layers	19
7.	Massive sandstone, with large concretions	10
6.	Seam of coal or shaly coal, with under clay	4
5.	Shaly sandstone, with shaly partings	8½
4.	Thin-bedded sandstone, with shaly partings	5
3.	Heavily bedded sandstone	6
2.	Green shale	3
1.	Distance to level of river (covered)	20

The coal seam (number 6 of the section) is not very regular, but is divided into several smaller areas toward the river. To the west a short distance it becomes more regular and attains a thickness of thirty inches to three feet. A little farther westward it thins out entirely. From Muscatine east to Pine creek, coal, usually thin, has been drifted from the river bluffs at various places. Keyes† gives the section shown in figure 90 from the old Hoor mine, three miles east of Muscatine (Sweetland Tp., Sec. 30, Ne. qr.) and suggests the possibility of operating other mines here to advantage.

Wyoming Hill. Within recent years some coal has been taken from the Nettlebush mines near Wyoming Hill (Sweetland Tp., Sec. 27, Ne. qr.). The seam is about twenty-two inches in thick-

**Geology of Muscatine County,* Iowa Geol. Surv., Vol. IX, p. 304; Des Moines, 1899. This report has furnished considerable material for the present chapter.

†*Coal Deposits of Iowa,* Iowa Geol. Surv., Vol. II, p. 477; Des Moines, 1894.



		FEET.
6.	Drift	3
5.	Shale, bluish, argillaceous	10
4.	Sandstone, rather compact, becoming much thicker elsewhere	2
3.	Coal	3
2.	Fire clay	4
1.	Hidden to river level	30

Figure 90. Coal at Hoor drift. East of Muscatine.

ness and is reached by drifts from the side of a ravine, about 120 feet above the level of the river. The coal is said to be of good quality and to possess a fairly strong roof of soapstone and "slate."

Montpelier Township. Thin coal beds have occasionally been mined at several places in this township; but in no case can the coal deposits be considered of much importance. In the bluff not far west of the mouth of Pine creek, coal has been taken from a bed lying 120 feet above the river. Above it is a black limestone, in part concretionary. At the point where the middle branch of Pine creek crosses the line between sections 7 and 8, a coal is found resting upon the Cedar Valley limestone and overlain by eight feet of shale capped with sandstone. At this same horizon coaly deposits are found at various places in the middle and east branches of Pine creek and on Lowrys run, Robinson creek and Montpelier creek.

SCOTT COUNTY

The Muscatine Upper Carboniferous outlier extends eastward a little over seven miles into Scott county, where it exhibits its richest phase. In spite of the fact that only about twenty square miles, or less than one-fourth of the total area covered by the tract is situated in Scott, this county has been and is today a much more consistent producer than its neighbor on the west. Practically the whole of Buffalo township and much of Rockingham are underlain by Coal Measures; while the northern boundary of the outlier is found a short distance north of the south line of Blue Grass township. The characteristics of the Muscatine outlier in Scott county and its relationship to other forms are essentially the same as are those of its western extremity, already described. Several small Pennsylvanian outcrops have been recognized in other parts of Scott. "Le Claire township includes a valuable outlier whose shales are worked at Island City, and another lies deeply buried beneath the drift in the northwestern part of the township. Carboniferous deposits are reported in well records near Eldridge. They outcrop near the western and northern limits of the county, in Cleona and Liberty townships. About Davenport there are no quarries which do not show pockets of Carboniferous sandstone or shale. So many are these outliers that it is not difficult to believe that well nigh the entire county once lay beneath the Carboniferous sea, and was covered with a continuous veneer of its offshore silts."*

So far as coal deposits are concerned, the smaller outliers are of little significance. They commonly represent merely surface irregularities of the old pre-Pennsylvanian land, such as channels, pits and crevices, which were filled with scourings from adjacent lands when the region was first depressed beneath the Upper Carboniferous sea. During the profound erosion which followed the re-emergence of the land from the waters, these deposits were protected and preserved by virtue of their position between compact rock walls.

Thin seams of coal are found in the outlier at Black Hawk and Island City; but it is only on Stillwater creek, west of Buffalo, and near Jamestown, north of the same village, that systematic mining has been undertaken. Of late years production has tended to decrease, owing to the exhaustion of the main "swamp"; yet a few new areas are being opened up and will continue to furnish coal for a limited number of years. Only a local trade is supplied, no railroad connections having been estab-

*Norton: *Geology of Scott County,* Iowa Geol. Surv., Vol. IX, p. 463; Des Moines, 1899.

lished. The local demand is, however, considerable, and some coal is hauled as far as Davenport. Competition of Illinois coals has always been a detrimental factor. Coal has been mined in Scott county nearly sixty years; a glimpse of the progress of the industry may be obtained from the statistics quoted. In 1865, a production of 82,730 bushels is recorded by the state census. Federal census reports show that 17,325 tons were mined in 1870; 14,500 in 1880; and 9,446 in 1890. Figures given in the reports of the Iowa Geological Survey for later years are as follows:

YEAR.	TONS.	YEAR.	TONS
1899	7,348	1903	12,653
1900	28,728	1904	10,724
1901	13,857	1905	6,772
1902	10,358		

For the years ending June 30, 1906, 1907, and 1908, the State Mine Inspectors published these data.

YEAR.	TONS PRODUCED.	MEN EMPLOYED.	NUMBER OF MINES.
1906	860	12	3
1907	2,500	4	1
1908	2,750	30	3

Jamestown. Professor W. H. Norton visited the Jamestown district in 1897 and shortly afterwards published the following succinct description:* "The seam worked by the Jamestown mines lies in a trough about two miles long and 200 yards wide, trending from northwest to southeast, and reached at a depth of about ninety or 100 feet from the surface. In the center of this "swamp" as it is termed, the coal has a thickness of from four to six feet, but it thins as it rises to either side of the trough; where it lies some ten feet higher than in the center. In the James mine (Buffalo Tp., Sec. 3, Sw. qr., Sw. ¼) it is worked on each side for 100 yards from the central axis, and at this distance it is reduced to a thickness of two and one-half feet. The trough rises from each end gently toward the center. Thus, at the James mine, the dip is toward the northwest at the rate of eight feet in 300 yards. Slight faults, rolls, and pinch-outs occur on each side of the axis, with the down throw on the swamp side, but nowhere do these seriously interfere with

*Op. cit., p. 494 *et seq.*

mining. The farthest point toward the northwest to which this seam has been traced is Blue Grass township, Sec. 33, Se. ¼, where coal two feet thick is said to have been found, but to be unworkable because no roof overlies it. At the Williams mine (Buffalo Tp., Sec. 11, Nw. qr.) the swamp sinks to the southeast.

South of Jamestown there is an area where the coal is said to be in a comparatively flat and uniform seam. It has been mined on the farm of Mr. Charles Rowan, Buffalo Tp., Sec. 10, W. ½, about eighty feet from the surface. Several seams, two and three inches thick, occur above the one mined. Wells show that the coal is underlain with fire clay sometimes to a depth, as is reported, of twenty-five or thirty feet, and at from 175 to 200 feet from the surface the drill passes into Devonian limestone. Towards the northwest coal is reported one and one-half miles south of Blue Grass, Buffalo Tp., Sec. 8, Nw. qr., where a well record gives it a thickness of twenty-one inches at a depth of 114 feet from the surface."

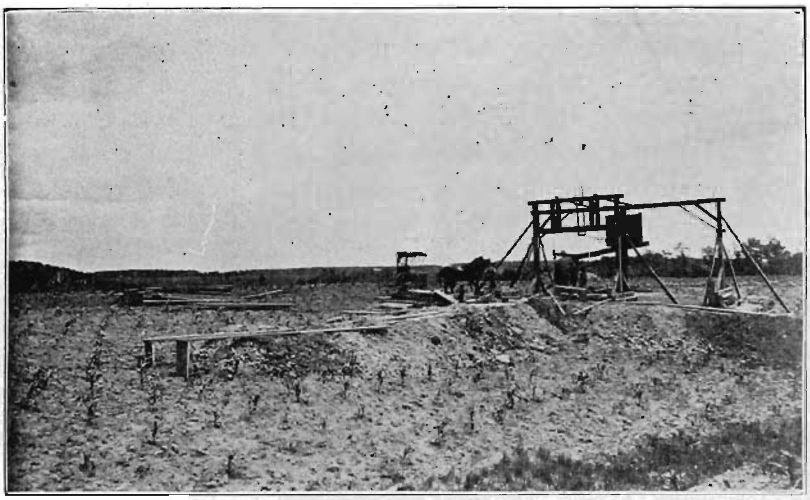


Figure 91. Sinking a shaft near Buffalo; showing the equipment of the Scott county mines.

Late in the summer of 1907 but one mine was working in the main trough described above, and the small mining camp formerly at Jamestown had been almost completely removed. The James Buckmeyer mine, until recently worked by Frank Winfield, is taking coal from the eastern edge of the trough a short distance southeast of Jamestown, in section 11. The seam was found to terminate rather abruptly at each end of the "swamp" and is now rapidly approaching complete exhaustion. At the Buckmeyer mine the seam is only two feet four inches in thickness and lies fifty-two feet below the surface at the shaft. The dip is toward the west and south. A small single engine is utilized for hoisting purposes. The sequence of strata in this area is shown by the following section of an old shaft near the present mine (Buffalo Tp., Sec. 11, Nw. qr.).

	THICKNESS.	DEPTH.
8. Glacial clays	48	48
7. Soapstone	4	52
6. Sandstone, white	2	54
5. Shale, blue	5½	59½
4. Sandstone and shale	41½	101
3. Shale, slaty	1	102
2. Coal	3	105
1. Fire clay	2	107

The McCullough Brothers' mine is a slope to what is apparently a small separate basin, although other coal areas are found near it. The slope mouth is in the bottom of a hollow, a mile northwest of Buffalo (Sec. 16, Ne. qr., Sw. ¼), and is very little above the level of the seam, since the latter lies nearly at the level of the floor of the small ravine in which the slope is situated. The coal varies in thickness between thirty inches and three feet. The bottom of the "swamp" is located 100 feet west and ninety feet north of the slope mouth and is the focus towards which the seam dips from all directions. South of the wagon road that crosses the center of section 16, Buffalo township, a little coal is taken out during the winter by Mr. Kaucher from a seam similar to the one worked by the McCullough Brothers. In this vicinity, a well record shows two coal horizons (Sec. 16, Se. qr., Se. ¼).

	THICKNESS.	DEPTH.
9. Yellow clay	20	20
8. Soapstone	25	45
7. "Slate"	2½	47½
6. Coal	½	48
5. Fire clay	2	50
4. Shale	20	70
3. Coal	2½	72½
2. Fire clay	1	73½
1. Limestone (Devonian)	66½	140

Stillwater Creek. At one period, the district near Stillwater creek was an active producer for local trade. Mr. Webster has recently taken out some coal, yet the field is now practically deserted. The coal lies in small "swamps," is from two to four and a half feet thick, and lies at varying depths below the stream levels. As is usual with Scott county basins, the dip differs radically at different points, the seams inclining towards the centers of the "swamps." The roof commonly consists of a thin layer of bituminous, fissile "slate," overlain by an argillaceous shale of lighter color. The under clay is hard and arenaceous, often approaching in constitution an arenaceous shale, or even a sandstone.

Island City. An outlier of Coal Measures at Island City, in Le Claire township, which occupies an area about one square mile in extent, contains small pockets of coal. It lies in a channel cut in Niagara limestone, a little more than a mile wide where transected by the trench of the Mississippi, and more than 200 feet deep. The sequence of strata above and below the coal found is well illustrated in the following sections described by Professor Norton.

RECORD OF WELL OF MR. SARGENT, LE CLAIRE TP., SEC. 5, SE. QR.

CURB, 700 FEET A. T.

		THICKNESS FEET.	DEPTH FEET.
9.	Soil	7	7
8.	Shale, blue	67	74
7.	Sandstone, gray	10	84
6.	Shale, dark	10	94
5.	Cap-rock, dark	3	97
4.	Coal	5	102
3.	Fire clay	12	114
2.	Shale	105	219
1.	Limestone at		219

OLD EXPOSURE AT CLAY PIT OF LE CLAIRE BRICK AND TILE COMPANY, ISLAND CITY.

		THICKNESS FEET.	DEPTH FEET.
7.	Loess and till, unmeasured		
6.	Cannel coal	2	2
5.	Potter's clay	4	6
4.	Coal	1	7
3.	Fire clay	4	11
2.	Shale, gray	2	13
1.	Shale, black, to bottom of pit	20	33

Cleona Township. In addition to several small unimportant Carboniferous outliers in Lincoln, Sheridan and Liberty townships, there are a number in Cleona township, in one of which a small pocket of coal has been discovered.

WELL RECORD, CLEONA TOWNSHIP, SEC. 4, SW. QR.

	THICKNESS. FEET.	DEPTH. FEET.
4. Pleistocene deposits (drift)	144	144
3. "Slate"	1	145
2. Coal	1	146
1. Limestone at		146

PART V

COAL DEPOSITS OF WESTERN IOWA

POCAHONTAS COUNTY

Des Moines strata may probably be found under the drift and Cretaceous rocks of the southern part of Pocahontas county, but they are not thick and are considerably cut up by pre-Cretaceous erosion. Nevertheless, it is not at all impossible that coal basins of local importance may at some future time be located in this area. Prospect holes should be continued to the Mississippian limestones that underlie the Coal Measures. The Cretaceous itself contains a few lignites of slight economic importance.

PLYMOUTH COUNTY

It has long been a question whether the Coal Measures of Des Moines age extend beneath the drift and Cretaceous rocks of the northwestern portion of the state and, if they do, whether they contain workable coal basins. Without doubt Des Moines rocks were originally deposited for a considerable distance west of Webster, Greene, and Guthrie counties; but these may have been largely removed during the long interval of erosion previous to the Cretaceous period. Moreover, we cannot be certain that coal producing conditions prevailed over much of the region during Carboniferous time. Explorations so far made seem to indicate that only isolated outliers of the Coal Measures underlie the Cretaceous. Even should Carboniferous coal be located, only thorough prospecting can determine whether or not a workable basin be present. Several deep holes have been put down in the region—at Sioux City, Ponca (Nebraska), Hull, Sanborn, and Cherokee—with negative results, although they were sunk far below the level of any possible coal. Two drill records at Le Mars indicate that Cretaceous strata continue down to the basal gneiss, but a third hole penetrated a five-foot coal at 381 feet that may, perhaps, be part of an outlier of Des Moines age. Analyses show it to be of better grade than the lignites found among Cretaceous strata. A complete discussion of the coal possibilities of the region has been published by Bain.*

CALHOUN COUNTY

The highest indurated rocks of this county belong to the Cretaceous system and contain in places thin beds of lignites that are of practically no economic value under present conditions. The eastern limit of Cretaceous strata lies along a north and south line situated about two miles west of the eastern boundary of the county. East of this line the highest indurated rocks are of Des Moines age and may contain valuable basins of coal similar to those of the Fort Dodge field. In the greater part of the county it is necessary to drill through a considerable thickness of drift, as well as through the Cretaceous, before the bituminous coal horizons are reached, and this fact, together with the uncertainty of finding workable coal at any given point in the Des Moines strata and the uncertainty that a thick coal when found is of sufficient lateral extent, have deterred prospecting operations. Some prospecting has been done within the limits of the county; but the results obtained are too indefinite to be cited here.

GREENE COUNTY

The highest indurated rocks in the two eastern tiers of townships of Greene county are of Lower Coal Measure age; farther west the eastern edge of the Cretaceous intervenes between the drift and the Des Moines. Little deep drilling has been undertaken in the western area, yet such as has been done appears to show that the thickness of the Cretaceous is not great and that the considerable thickness of Coal Measures lying beneath it is a legitimate field for prospecting. According to Professor

*_Geology of Plymouth County_, Iowa Geol. Surv., Vol. VIII, pp. 361-365; Des Moines, 1898.

T. H. Macbride bituminous coal has been reported by those sinking pipe for deep wells, in the following localities:

Tp. 85, R. 32, Sec. 28.
Tp. 84, R. 32, Secs. 1, 7 and 18.

The seams ranged from twelve to twenty-two inches in thickness and the depths quoted are from 150 to 175 feet. Since Cretaceous sandstones outcrop at depths of about 100 feet in the neighborhood of these wells and well-drillers claim that holes 160 feet deep go sixty feet in yellow sand, the amount of Carboniferous deposits above the coal cannot be great. Deeper prospects might reveal coal horizons bearing thicker coals. In prospecting care should be taken not to mistake the thin and valueless lignites of the Cretaceous for Carboniferous bituminous coal. It is possible that this mistake may have been made in the case of the wells just cited.

Aside from the unexplored coal bearing series beneath the Cretaceous, the possibilities of the Des Moines outcrop in the eastern section of the county are as yet far from exhausted. The once prolific field near Angus and Rippy may be only one of several similar areas; for extensive prospecting has not been attempted in much of the county. Recent developments in Boone county show that exploration beneath the uplands, where no natural outcrops occur, may lead to the discovery of profitable basins. Drilling is now in progress between Dana and Grand Junction. Some drilling has been done near Jefferson, and Mr. Carpenter, of the Big Five Coal Company of Moingona, reports an apparently workable three-foot coal within four miles of that city.

Though at present not ranking as a large producer, Greene county stood higher in the list before the abandoning of the larger mines of the Angus district. The earliest recorded production of coal was 1,200 bushels in 1866. Little was done until about 1880, when 8,559 tons were mined. The year 1885 witnessed an increase to 89,587 tons and 1890 a decline to 51,438 tons. The lessened output for recent years is shown in the following table:

YEAR.	TONS.	YEAR.	TONS.
1898	12,920	1903	24,296
1899	13,289	1904	28,213
1900	17,044	1905	20,058
1901	16,450	1906	19,816
1902	11,573	1907	16,289

During the year ending June 30, 1908, six mines produced 22,226 tons and employed seventy-five men.

In the following pages may be found brief mention of Greene county mining districts.

Grand Junction. An eighteen-inch coal is quite general in the vicinity of Grand Junction, but is mined at only one point. Just north of the town (Sec. 33, Sw. qr., Sw. ¼) is the plant of the Goodwin Tile and Brick Company, where a shaft 140 feet in depth reaches the coal seam above mentioned. Beneath the coal is a considerable thickness of fire clay, only three feet of which is utilized. Above the coal are about two feet of black jack overlain by from twenty inches to twenty-five feet of blue argillaceous shale which, together with the fire clay, is used in making brick and tile and forms the principal product of the mine. The coal seam is strongly undulatory, with a maximum difference of twenty-five feet between the levels of the bottoms of the troughs and the crests of the rises. As a whole the bed

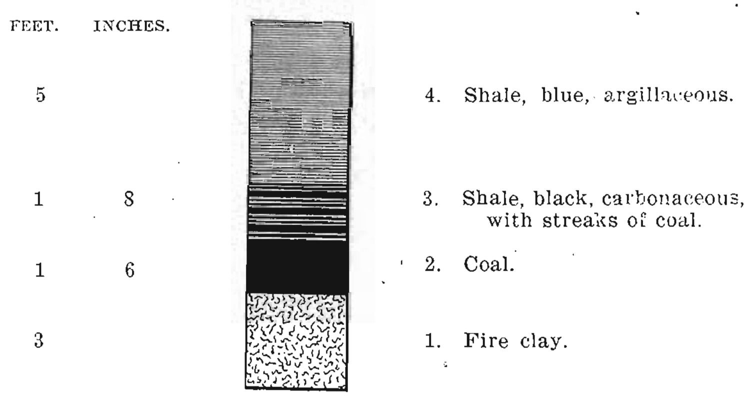


Figure 92. Coal bed in Goodwin mine, Grand Junction.

is regular in occurrence and free from obnoxious impurities. About twenty-three acres have been mined out during a long period of working, the fuel product being used chiefly in firing the kiln at the clay plant.

Prospecting is now being done on the E. S. Hillman land, one mile west and three miles north of Grand Junction. Workable coal is reported from all but one of the several holes bored, but more drilling remains to be done before definite statements can be issued.

Rippey. Formerly a four-foot coal was mined at a depth of 125 feet a short distance east of the Rippey railroad station, but nothing is now done at this point. The center of the mining industry of Greene county now lies three miles south of Rippey, where three mines supply an important local trade. A number of years ago extensive mining was in progress in this area, as numerous old dump heaps attest. The sequence of strata is shown in the following drill record furnished by Craig and Dawson of Fort Dodge (Washington Tp., Sec. 26, Nw. qr.).

		FEET.	INCHES.
31.	Clay	96	
30.	Shale, argillaceous, light-colored	4	
29.	Shale, fissile, black	3	6
28.	Coal	2	6
27.	Fire clay	1	6
26.	Shale, argillaceous	9	4
25.	Shale, fissile, black	1	
24.	Sandstone, hard	4	10
23.	Shale, fissile, dark	1	
22.	Sandstone, hard	8	
21.	Shale, dark	27	
20.	Shale, sandy, soft	2	
19.	Fire clay		6
18.	Sandstone, soft	1	6
17.	Shale, black	2	
16.	Sandstone, soft, and shale	6	8
15.	Coal, good	4	4
14.	Fire clay		10
13.	Sandstone, soft	4	
12.	Fire clay, sandy	7	
11.	Shale, fissile, dark	1	
10.	Coal		2
9.	Fire clay, sandy	5	4
8.	Shale, dark, and sandstone	3	
7.	Sandstone	4	8
6.	Shale, argillaceous	19	4
5.	Hard bands		5
4.	Shale, argillaceous, white	1	6
3.	Hard bands		5
2.	Shale, argillaceous, oily	4	
1.	Sandstone, hard	11	2

The thick coal, number 15 of the above section, appears to lie at a higher level than that now mined in adjoining territory. It may tentatively be correlated with the "lower vein" of the Angus area farther east; while the coal now worked perhaps lies in the horizon of the "middle vein" or the "niggerhead." Of the three mines now working south of Rippey, the Keystone is the most important (Sec. 27, Ne. qr., Ne. ¼) and is relatively well equipped. A part of its product is hauled to Rippey and Dawson for shipment, the remainder is sold locally. At eighty-six feet the shaft reaches a coal that varies in the mine between three and six feet in thickness and is of good quality. No other seam is thought to exist under this land, as a well 230 feet deep on the same farm failed to penetrate thick coal.

A short distance northwest of the Keystone, the Buckeye Coal Company reaches coal lying at about the same level by means of a shaft 103 feet in depth (Sec. 22, Se. qr., Se. ¼). The bed contains from four to five feet of coal overlain by four to twelve inches of black jack and underlain by a few feet of fire clay over a hard sandstone basement. In places the fire clay is filled with geodes bearing calcite crystals. The roof proper is a thick black shale, which, with the other beds, dips east of northeast. In the workings, which are east of the shaft, faults have occasionally changed the level of the coal one foot or less.

The shaft of the Snake Creek Coal Company is situated east of the Buckeye, on the same piece of land (Sec. 22, Se. qr., Se. ¼). It is 141 feet deep, making the elevation of the coal seam much lower than at the Buckeye shaft, although the workings of the two mines are connected. The coal averages four and a half feet in this mine and dips to the northeast. About three rooms are affected by a large sandstone mass enclosing bits of coal, probably the result of Pennsylvanian erosion. The Snake Creek is the only plant in the district operating a steam hoist.

Angus. Some years ago Angus was the center of a very important coal industry extending over territory embracing portions of Boone, Dallas and Greene counties. Many large mines were operated and mining was vigorously prosecuted until a large portion of the field was exhausted. So little is now being done in this region that it is difficult to ascertain the exact relationships of the various coals, but the following statement is probably approximately correct. Generally speaking, there are four coal horizons, though all of these seldom bear coal at any one point and rarely is more than one workable from a single shaft. The uppermost seam, known as the "riding vein," is very erratic in its appearance and is twenty-two inches or less in thickness. The second bed is best developed westward toward the Coon river and is known from the "bowlder" roof often overlying it as the "niggerhead." A characteristic section of it is:

	FEET.	INCHES.
5. "Bowlder" roof		
4. Black jack		6
3. Coal, with streaks of black jack	2	
2. Coal, good	1	6
1. Fire clay		

Below the "niggerhead" is the "middle vein," also with considerable black jack, and below that the "lower vein." Each of the lower three seams may run as high in thickness as four or five feet.

The only mine now open in the Angus district, aside from the banks south of Rippey already mentioned, is that of the McElheny Coal Company (Tp. 82, R. 29, Sec. 36, Ne. qr., Ne. ¼). A local trade is supplied from a gin shaft seventy-five feet in depth. The bed mined is four to four and one-half feet in thickness, and is gently undulatory. Streaks of pyrites appear irregularly, but most commonly about six inches from the base of the coal. Both the "middle" and the "lower" seams are said to be present here, separated by a variable, though slight, vertical interval that is bridged by a micaceous sandy shale and fire clay. The "lower" coal gives out on the south, where the higher seam overlaps it. The thickness of the "middle vein" varies greatly, often in short distances.

CARROLL COUNTY

At only one point in Carroll county have rocks of Carboniferous age been found to outcrop and these are somewhat doubtfully referred to that system. Throughout the remainder of the county the Coal Measures are covered not only by a great thickness of drift—from 100 to 200 feet on an average and in places as much as 500 feet—but also by about 100 feet of the Cretaceous in the eastern portion of the county and by 200 feet or more of the same rocks in the western portion. Owing to the fact that the contact surface between the Cretaceous and the Des Moines is extremely irregular in level, the depth at which the latter may be reached cannot be exactly postulated for any given area. The Carboniferous outcrop referred to above lies about one mile southwest of Carrollton (Newton Tp., Sec. 1, Sw. qr., Ne. ¼), on Middle Coon river, and consists of an unknown thickness of gray, sandy shale covered by about three feet of brown fine-grained limestone.

The limestone outcrop greatly resembles certain rocks belonging to the "Middle" Coal Measures of Guthrie, Dallas and Madison counties, so that we may tentatively conclude that there are present in Carroll county several hundred feet of Des Moines strata that may possibly bear basins of thick coal and are therefore suitable for exploration with the drill. Since the lower part of the Des Moines is the most productive in other parts of the state, it would be best to continue test holes not only through the drift and Cretaceous, but also for some distance into the Coal Measures, thus making the expense of prospecting considerable. Even after thick coal has been penetrated in one prospect it would be necessary to drill on all sides of it in order to determine the lateral extent of the coal basin found. The horizon of the coals mined farther east probably lies about 170 feet below water level at Coon Rapids. Whether or not prospecting in this county would yield results is an open question, but the strategical position of the region for marketing its fuel product would make the discovery of coal within its borders particularly remunerative. Prospecting should be undertaken only by companies prepared to expend a large amount of money and to weather many preliminary disappointments; for coal, if present, will not be in continuous beds over an extensive territory, but will be in more or less independent basins, as is the case in the mining counties on the east. For a more complete discussion than it is possible to give here, the reader is referred to that published by Bain.*

Geology of Carroll County, Iowa Geol. Surv., Vol. IX, pp. 97-101; Des Moines, 1899.

GUTHRIE COUNTY

The western three-fourths of Guthrie county is underlain by the Cretaceous, a system that in some parts of the United States carries heavy deposits of coal, but in Iowa bears only thin pockets of lignite. The surface rocks of Penn and the southeastern portion of Beaver townships belong to the Upper Pennsylvanian, or Missouri, a stage which is coal bearing to a limited extent, but not at all in the lowest portion, which is all that is represented in Guthrie county. The Lower Pennsylvanian, or Des Moines, stage immediately underlies the drift in Richland, Cass, and eastern Jackson townships, and it is to this that we must look for important coal deposits. As will be mentioned farther on, many of the principal streams of the county have cut down through the overlying formations so as to expose the Des Moines in the bottoms of their valleys. Neither the Cretaceous nor the Missouri is very thick in this region; so that to reach the Des Moines it would not be necessary to drill any great distance through overlying formations. The elevation above sea level of any given horizon in the Des Moines varies within only narrow limits in different parts of the county.

According to Bain* the Des Moines strata of Guthrie and neighboring counties fall naturally into four groups: (1) Shales, predominantly sandy, characteristically free from coal, with an occasional development of arenaceous limestone. The thickness of this group varies from forty to 100 feet and decreases rapidly from Stuart north. (2) Shales, sandstones and limestones, with three coal horizons. This group is characterized by the great persistence of its individual members. (3) Sandstone and sandy shales with the Redfield coal at the base. (4) A lower series of shales, sandstones and thicker coal seams characteristic of the greater portion of the Des Moines formation.

The coals now being worked within the county may be all classed with group (2) and belong to one of the three coal horizons, termed in descending order, the Lonsdale, Panora and Marshall coals. All three horizons have been recognized at Panora: the Lonsdale as a thin bed in the top of the hills, the Panora as a seam twenty feet above the river, and the Marshall

*Iowa Geol. Surv., Vol. VII, p. 443; Des Moines, 1897.

as the coal at present worked and lying thirty feet below the river. What is probably the representative of the Marshall horizon has been extensively worked by a group of mines at Fanslers, eight miles farther up the Middle Raccoon river. The coal here does not correspond well in its characteristics with the lower bed at Panora, yet stratigraphically it appears to occupy the same position. The coal mined north of Stuart on Deer creek is found only a short distance below the base of the Missouri and is either the Lonsdale or a seam not far below that horizon. The limestones and one of the sandstones belonging to group (2) are indeed remarkably persistent from outcrop to outcrop along the streams; but it seems probable that early geologists placed too much emphasis on the persistency of the coals. It is true that where coal is found it can often be readily assigned to one or another of the three horizons quoted, yet mining operations show that the continuity of the coal between two points apparently in the same horizon has its limits and that these limits are not always wide ones.

Almost no deep prospecting has been attempted in Guthrie and several reasons may be advanced for this state of affairs. As already indicated, it is necessary in order to reach the lower Coal Measures under much of the county to first drill through the barren Cretaceous or Missouri rocks. While the strata are not very thick beneath the valley lowlands, the additional expense entailed has discouraged prospecting. Then, too, even where the highest indurated rocks belong to the Des Moines the drift is often thick. This is especially the case in the otherwise attractive territory north and east of the Middle Raccoon river. To obtain the best results prospect holes should be carried into group (4), the lower division of the Des Moines; for it is in this that the heaviest coal beds may be expected. To locate such beds would demand drilling to depths of between 250 and 450 feet, according to the altitude of the surface at the head of the bore. A few of these coals have already been discovered in isolated prospects which will be given later; but the additional work necessary to prove a field has not been undertaken.

Guthrie has never ranked as a large producer. The mines have been, and are, small, local affairs, usually with horse-gin hoists. The life of individual shafts is in general not long, but as soon as one is abandoned, another is sunk in the same field, so that the total production of the county suffers little loss. In 1860 the output was 289 tons with a value of $550.00. The production became 12,675 bushels in 1866 and 24,500 bushels in 1868. The production for later years has not varied between very wide limits. According to the reports of the Iowa Geological Survey, the figures for 1902-1907 are as follows:

YEAR.	TONS.
1902	2,300
1903	4,708
1904	9,149
1905	15,413
1906	12,063
1907	13,840

The report of the State Mine Inspectors for the year ending June 30, 1908, is:

Number of mines	10
Amount of coal of all kinds produced	13,143
Total number of employes	104

The value of the product is relatively high, as the average price per ton at the mines ($2.61 in 1907) is higher than in any other mining county in the state.

In the description of the various fields given below, geological data and accounts of former mining localities now abandoned or idle are freely drawn from former reports of this Survey by Keyes* and Bain.† Those interested in a fuller exposition of geological phenomena are referred to the author last named.

NORTH RACCOON DRAINAGE.

Jamaica. Near Jamaica, in the extreme northeastern corner of the county and on a small creek which joins the north branch of the Raccoon river in Dallas county, the Greenbriar Coal Company has operated for more than nineteen years. A seam which averages two feet four inches in thickness lies at a depth of about seventy feet. The longwall plan of working is employed,

*Coal Deposits of Iowa, Iowa Geol. Surv., Vol. II, pp. 243-253; Des Moines, 1894.
†Geology of Guthrie County, Iowa Geol. Surv., Vol. VII, pp. 413-487; Des Moines, 1897.

mining being done in the underlying fireclay. Natural ventilation is considered sufficient and hoisting is with horse and gin. Above the coal are forty-seven feet of black "slate" which makes a fairly good roof. Three miles east of here, near Dawson, in Dallas county, three workable coal horizons have been recognized and may be found described in their proper place in this volume.

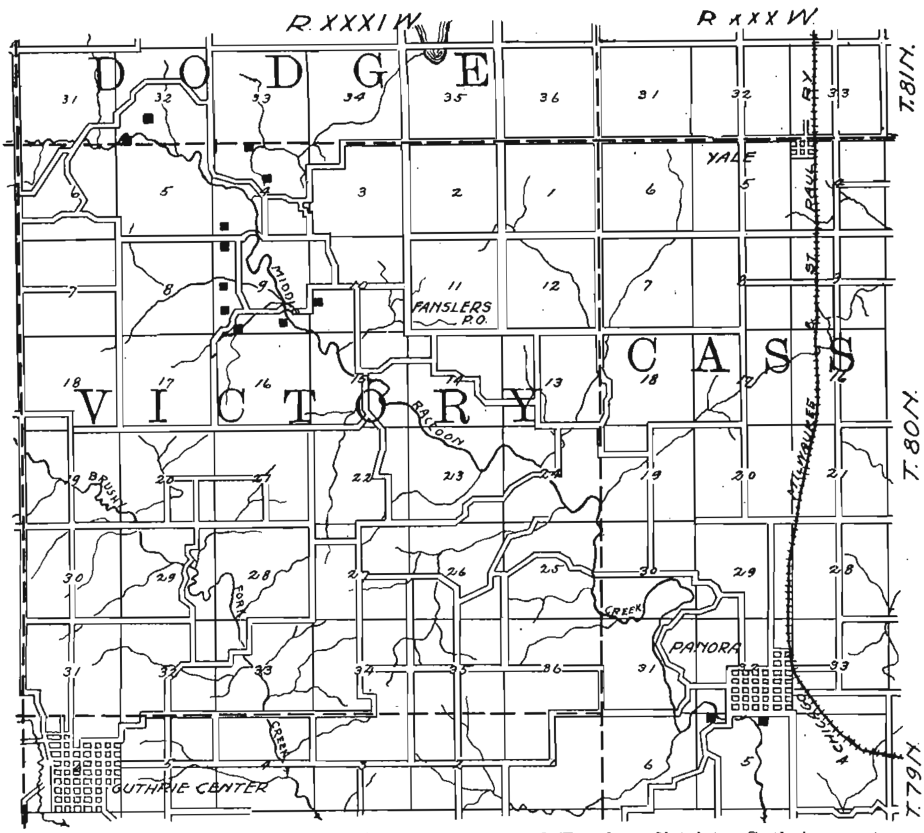


Figure 93. Map showing mines in the Panora and Fanslers districts, Guthrie county.

Very probably the coal at the Greenbriar lies in the same horizon as one of the beds at Dawson. The coal near Rippey, in Greene county, and Angus, in Boone, may also possibly have some stratigraphic connection with it. The fact that a number of holes put down for gas and water in Richland township have passed through no coal should not discourage further prospecting.

FEET.	
3+	3. Shale, black, fissile (exposed).
2 1-3	2. Coal.
2	1. Fire clay (exposed).

Figure 94. Coal bed at Greenbrier mine, Jamaica.

MIDDLE RACCOON VALLEY.

Bayard. Throughout most of its course in the county, the Middle Raccoon river has cut entirely through the overlying cover of Cretaceous rocks and exposed in the bottom of its valley the coal bearing strata of the Des Moines formation. Most of the Guthrie mines are situated along this stream at and above Panora. The highest point on the river at which Coal Measures outcrop is southwest of Bayard at the western edge of section 24, Orange township. Near here in the early days, drifts and slopes reached a seam eighteen inches thick, lying about two feet above the river. Later shafts were sunk to a lower bed twenty-eight feet below the water level. For a distance of about five miles down the river, drifts have been run in from both sides of the valley to the upper seam just mentioned. At the old Wales bank (Highland Tp., Sec. 33, Ne. qr.), this bed lies twelve feet above the river and is sixteen to eighteen inches thick, while between it and the base of the Cretaceous are at least twenty-seven feet of Des Moines strata. Near here, on the opposite side of the river, the following section has been measured just above the water level.

	FEET.
5. Incoherent reddish sands	10
4. Yellow and blue shale	3
3. Black and gray calcareous shales	1
2. Coal	1-1½
1. Blue shales	

A dip in a northeasterly direction of ten inches in a hundred feet carries the top of the Coal Measures beneath the level of the

Raccoon beyond the point at which the road leading due south from Bayard crosses the stream, and they do not reappear for a distance of about two miles down the river. After they do again come to the surface they may be found in the bottom of the valley at all points lower down the Raccoon.

Fanslers. No mining was being done in the district described above during the month of September, 1908, but near Fanslers a number of shafts were being made ready for the winter trade. All supply only a local trade and hoist coal by means of the primitive horse-gin. Longwall is the plan of work used. Mines have been operated in this district for a long period, but they change hands frequently and the location of the shafts is shifted every few years. They are idle in summer and each produces from 200 to 500 bushels a day in fall and winter. The location of the coal banks open in the early fall of 1908 is as follows:

NAME OF BANK.	LOCATION.	DEPTH OF SHAFT, FEET.
Sipe Brothers	T. 80 N., R. 31 W., Sec. 10, Sw. qr., Nw. ¼	80
Middleton or Black Diamond	T. 80 N., R. 31 W., Sec. 9, Se. qr., Se. ¼	116
Scott	T. 80 N., R. 31 W., Sec. 9, Sw. qr., Sw. ¼	96
Mansell	T. 80 N., R. 31 W., Sec. 9, Sw. qr., Sw. ¼	110
Butler and Gibson	T. 80 N., R. 31 W., Sec. 9, Sw. qr., Nw. ¼	67
Renslow	T. 80 N., R. 31 W., Sec. 9, Nw. qr., Nw. ¼	87
Hughes & Son	T. 80 N., R. 31 W., Sec. 4, Sw. qr., Sw. ¼	66
Thomas	T. 80 N., R. 31 W., Sec. 4, Nw. qr., Se. ¼	115
King	T. 80 N., R. 31 W., Sec. 4, Nw. qr., Ne. ¼	70
Clark	T. 81 N., R. 31 W., Sec. 32, Sw. qr., Ne. ¼	70
Coe	T. 81 N., R. 31 W., Sec. 32, Sw. qr., Sw. ¼	70

All the mines are working the same vein, in which practically all former mines have operated. A possible exception may have been the old Thomas bank (T. 80, R. 31, Sec. 6, Ne. qr.), which opened a pocket three feet thick. The thickness of the coal at the present mines is remarkably uniform: the Middleton and Sipe banks show about two feet while the others are content with a few inches less. A variation of more than two inches in any one mine is rare. The bed is quite constantly characterized by a so-called "sulphur band," usually merely a streak of impure coal, or black jack, from a half to two inches thick, lying about six inches above the base of the coal. Often this streak is sufficiently carbonaceous to burn with more or less difficulty, but in some mines it is replaced by hard calcareous or sandy rock containing lenses of iron pyrites which occasionally constitute the major part of the band. Calcite in transparent films along cleavage cracks and in thicker bands commonly horizontal in position is present in all parts of the seam, yet not in sufficient quantity to interfere with the quality of the coal. Occasionally clay seams run through the coal in branching dendritic streaks in such number as to cause a disagreeably large yield of ash on burning, and in a few cases they are so abundant as to destroy the value of small portions of the bed. There is a general southerly dip which is rather erratic, being as much as ten feet in three hundred at the Sipe bank, but inconspicuous at others.

Above the coal is a four-inch layer of "draw slate." This is a compact, calcareous rock which comes down with the coal on mining and is sometimes rendered hard and firm by great numbers of shells of brachiopods of the species characteristic of the Des Moines stage. Above the "draw slate" is a succession of shales, very carbonaceous at their base. Generally a thin coal bed, eighteen to twenty-two inches thick, is found about forty feet above the one worked. Although it does not appear to be universally present, its absence may often be accounted for by pre-glacial erosion. The seam has not been commercially important because of its poor roof and the softness of the coal. At the Mansell bank a seam not usually present in this region is reported. It is said to lie fourteen feet above the coal mined and to be three feet thick. It is the intention to run a slope up to it from the present workings. Two and a half miles above the Mansell, at the old Scott bank (T. 81, R. 31, Sec. 31, Se. qr., Sw. 1/4), two coals have also been reported, as shown in the following section.

Panora. Between Fanslers and Panora, a little mining has been intermittently attempted along the Middle Raccoon. About half way between the two points (Victory Tp., Sec. 24, Nw. qr., Se. 1/4) the old Clark mine at one time supplied a local trade. Farther south on the west side of the river (Sec. 25, Sw. qr., Ne. 1/4) a shaft was sunk twenty feet in 1892, to a bed eighteen to twenty inches thick. There was a clay bottom and a roof of thin, black, fossiliferous shale. Clay seams were frequent and rolls not uncommon. Still farther south, on the same side of the river (Cass Tp., Sec. 31, Nw. qr., Se. ¼), coal was taken by means of a shaft from a thin seam which lies fifteen feet above water level. The seam probably occupies the horizon of what has been termed the Panora coal.

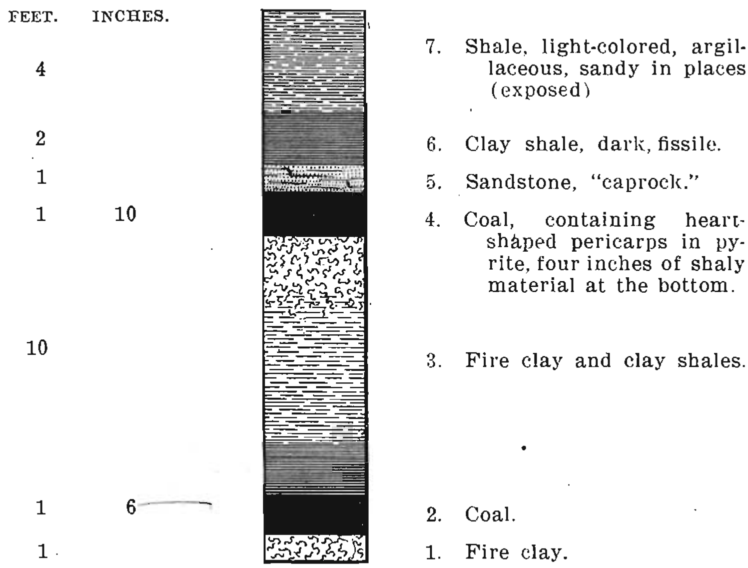


Figure 95. Section of former Scott shaft, Fanslers.

At the present time two mines are producing coal in the Panora district and both are located near the town. On the west side of the river, just north of the wagon bridge leading southwest from town, is the Reese shaft, now, after nearly twelve years of service, worked by the Lord and Love Company. Twenty to twenty-five feet above the river is a thin coal, probably lying in the Panora horizon. The strata found in the Reese shaft afford a section from about this horizon down to that of the coal now mined, thirty feet below water level.

REESE SHAFT SECTION.

		FEET.
9.	Drift	6
8.	Limestone	1
7.	Argillaceous shale, red	7

6.	Shale, soft	2
5.	Sandstone, white to gray, with flakes of mica	30
4.	Bituminous shale, fossiliferous, becoming a cannel coal below	10
3.	Coal	1 2-3
2.	Fire clay	8
1.	Sandstone	10+

The fire clay forming the bottom in the mine is rather soft, so that its thickness of from eight to ten feet at this point tends to cause "squeezes" in the workings. The thickness of the coal at the present face is less than in the shaft section quoted, being quite uniformly sixteen inches. Clay seams in bands and branching streaks sometimes become so plentiful as to destroy the value of parts of the coal bed and in all places they give much trouble. The seam is fairly free from "sulphur," however. Longwall is the plan of working, the present face being west and north of the shaft. The output is hoisted by means of horse and gin.

On the opposite side of the river, adjacent to the plant of the Pentycost Brick and Tile Company in the southern part of Panora, is the O. K. mine. It is a shaft 100 feet deep with coal quite uniformly eighteen inches in thickness. Eight acres have been worked out longwall without revealing any particular dip. Mining is done here at the rate of about one acre a year, and, since anything but a very short haul pays poorly in such a thin bed, this shaft will probably be abandoned within another year. A horse and gin are found sufficient to hoist the coal for the merely local trade supplied. The fire clay bottom heaves slightly, but on this side of the river the sandstone lies only two feet below the coal and checks any serious trouble. A "sulphur band" very much like that in the Fansler coal previously described divides the coal bed proper from the clay. Above the bed is from two to four inches of "draw slate" which comes down with the coal. Above this is a black shale roof which requires little attention. The upper, or Panora, coal was not noticed in excavating either the hoisting or air shaft, but the horizon is represented in the neighboring clay pit by two feet of very carbonaceous shale. In former days some drifting was done into the Panora coal at favorable points in this district.

Farther down the river, at the mouth of Bays branch, where a few small mines were once located, the following section of the Panora and its associated strata is exposed in a bluff.

		FEET.
7.	Drift	4
6.	Limestone, impure	3
5.	Shale, dark drab	8
4.	Limestone, impure, bituminous	½
3.	Shale, black, carbonaceous	1½
2.	Panora coal	1
1.	Shale, light-colored and variegated, exposed	10

Practically the same section was found directly opposite Panora.

Half way between Panora and the Dallas county line (T. 79, R. 30, Secs. 16 and 21) several small mines were operated during the nineties. The seam, where reached by the drifts and shallow shafts, was from twelve to twenty inches thick. Clay seams gave trouble locally. A coal of very pockety nature was occasionally encountered at a slightly lower level. Traces of old drifts and dump heaps may be seen farther down the river. Near the county line, two miles southwest of Linden, Dallas county, a seventeen-inch seam was at one time opened by several mines (T. 79, R. 30, Secs. 36 and 25). The coal was divided into three benches by two thin bands of soft argillaceous shale. A similar seam has been found a short distance east, in Guthrie county.

BRUSHY FORK VALLEY.

Aside from the lower mile of its course and one isolated area in Seeley township, Brushy Fork flows over Cretaceous rocks. These are in no place very thick, so that it would be unnecessary to drill to any great depth below the bottom of the valley before reaching the coal bearing strata of the Des Moines stage. About six miles southwest of Bayard (T. 80, R. 32, Secs. 5 and 6), the same low anticline which causes the Carboniferous to be brought to the surface along the Middle Raccoon river above Rocky Bluff makes an exposure of the same rocks on Brushy Fork. Des Moines strata may be traced in the valley for a distance of a mile and a half or more and in this territory a thin seam has been mined now and then by means of shallow shafts. The coal corresponds in level to that mined on the Middle Raccoon south of Bayard.

WICHITA CREEK VALLEY.

For a distance of two and a half miles above the junction of Brushy Fork and Wichita creek, Carboniferous strata outcrop in the valley of the latter stream, but beyond that point finally disappear under the Cretaceous system. Coal is occasionally removed during the winter months at the upper end of the outcrop, about two miles below Guthrie Center. The bed is eighteen inches thick and lies about ninety feet below the surface. A bed perhaps representing the same horizon was found at a depth of 132 feet in a drilling made just south of the Raccoon, one mile west and a half mile north of the courthouse at Guthrie Center. This bed was said to be twenty inches thick, while a second seam four feet and five inches thick, with a roof of soft white clay, was found sixty-five feet below it. About five feet below the second seam a third bed, associated with black clay, was reported. The first forty feet of the boring passed through drift, the next forty-four feet through a soft sandstone, probably Cretaceous in age. While no records could be procured of the other borings which confirm these statements, the information was obtained from apparently reliable sources.

RACCOON VALLEY.

The South Raccoon proper has cut down to the Carboniferous rocks along its entire course; above Dale City through the Cretaceous and below that village through the Missouri. Near Dale City, the following drilling made by John Lonsdale & Sons revealed several coals, the more important being at 264 and 318 feet.

DALE CITY SECTION.

		FEET.	INCHES.
69.	Drift	12	
68.	Shale, red, blue and brown	19	
67.	Sandstone, light gray	3	
66.	Shale, gray	11	7
65.	Shale, gray, dark	10	7

64.	Coal		2
63.	Fire clay		4
62.	Shale, with impure coal in alternate layers	1	10
61.	Yellow stone		1
59.	Shale, dense, gray, with traces of coal	4	9
59.	Shale, dense gray, with traces of coal	4	9
58.	Sandstone	1	4
57.	Shale, blue	4	
56.	Shale, dark gray	14	4
55.	Sandstone, white	6	6
54.	Shale, blue	2	
53.	Limestone		2
52.	Shale, yellow	1	4
51.	Limestone		9
50.	Shale, gray		3
49.	Limestone		9
48.	Shale, blue	2	
47.	Limestone	1	4
46.	Shale, brown	2	
45.	Shale, blue, black at bottom	3	7
44.	Limestone, gray, very hard		10
43.	Slate, black	2	
42.	Coal		4
41.	Shale, light blue	15	
40.	Shale, brown	2	6
39.	Shale, variegated	7	
38.	Shale and limestone in thin layers	3	4
37.	Shale, variegated	8	
36.	Shale, blue	25	3
35.	Shale, yellow	1	9
34.	Limestone, buff		4
33.	Shale, gray, blue-black at bottom	6	8
32.	Coal	1	4
31.	Shale, blue fire clay at top	6	10
30.	Limestone, gray	1	8
29.	Sulphur band		2
28.	Sandstone, fine-grained	11	
27.	Limestone, very hard	3	1
26.	Sandstone, white	2	6
25.	Shale, variegated	4	9
24.	Sandstone, gray	7	2
23.	Shale, gray	3	9
22.	Sandstone, gray	3	9
21.	Shale, blue-gray	10	10
20.	Shale, gray	23	
19.	Coal	2	6
18.	Fire clay		6
17.	Shales, light and gray	17	10
16.	Sandstone		8
15.	Shale	1	3

14.	Limestone, brown	2	
13.	Shale, dark	1	2
12.	Black stone		2
11.	Slate, bluish black	5	8
10.	Sulphur band		1
9.	Shale, blue	1	5
8.	Shale, blue and gray fire clay at top	17	8
7.	Coal	3	4
6.	Shale	1	6
5.	Coal	1	
4.	Shale		8
3.	Coal		10
2.	Shale, light and dark	17	5
1.	Shale, dark blue	2	

Two miles below Dale City attempts have been made to mine the Lonsdale coal, but no systematic work has been inaugurated.

BEAVER CREEK VALLEY.

Coal Measures are exposed in the valleys of Beaver creek and its main tributaries as far west as section 33 of Beaver township, three miles above Glendon. A thin seam, probably the Marshall, was formerly exposed on Spring branch (Tp. 78, R. 31, Sec. 3, lot 12). A lower bed, said to be two feet six inches thick, was once worked at a depth of 100 feet and a bed four feet six inches thick was reported sixty to seventy feet still lower. Farther up Spring branch and on Beaver creek west of Glendon, thin beds have been occasionally tapped by small drifts and shafts.

DEER CREEK VALLEY.

A coal which is probably the Lonsdale has been mined along and near Deer creek at several points. Two horse-gin mines were being opened for an important local trade in September, 1908. The smaller of the two is located one mile west and one and a half miles north of Stuart (Penn Tp., Sec. 19, Se. qr., Ne. ¼), in the deep valley of Deer creek. The bed, worked longwall, is here from twenty-two to twenty-six inches thick. The circular face is about 500 feet in circumference. Under the coal is a hard, dry fire clay and above it three feet six inches of black, bituminous shale overlain by soapstone. The shaft is 110 feet deep.

A half mile or more north (Sec. 18, Se. qr., S. ½), on the north branch of Deer creek, is the shaft of the Deer Creek Coal Company. The seam here is quite uniformly two feet in thickness and dips steadily about one foot in twelve to the south. The same face, about 2,000 feet of which has been opened, has been worked for ten or twelve years, but the present shaft, fifty-eight feet deep, has been in existence only two years. The coal is of good quality and yields a fair proportion of lump. The roof is sandstone in some parts of the mine and "slate" in others. Where there is a "slate" roof, the seam is usually rather dirty. This mine is being rapidly placed in condition to supply a large local trade. The same coal has been opened at other points in this vicinity. At the old Lonsdale mine, one-half mile west of the Deer Creek, the bed worked lay thirty feet below the base of the lowest Missouri limestone and was only twenty inches thick. Two thin clay bands separated the seam into three benches.

STUART.

Near Stuart, thick seams have been somewhat doubtfully reported as found in drillings made for water. The following record of a boring made by the Stuart Prospecting Company on the Savage and Dosh farm should, however, be fairly accurate.

STUART SECTION.

		FEET.	INCHES.
40.	Drift	4	
39.	Sand, water vein	4	
38.	Drift, water vein	145	9
37.	Sand	6	
36.	Drift	16	
35.	Sand, water vein	3	9
34.	Limestone		3
33.	Sand shale, light; pyrite bands	92	
32.	Clay shale, light	3	
31.	Limestone, fossiliferous		8
30.	Shale, blue		10
29.	Limestone, fossiliferous	1	2
28.	Shale, blue	5	
27.	Limestone		8
26.	Shale, black	1	2
25.	Coal		6
24.	Shale, bituminous		11

23.	Coal		10
22.	Shale, light	3	
21.	Sandstone	8	
20.	Shale, blue, red and brown	31	
19.	Clay shale, light	5	10
18.	Black shale	4	
17.	Rock, gray		7
16.	Black shale	2	8
15.	White shale	6	
14.	Black shale	2	
13.	Blue clay shale	3	
12.	White clay shale	4	
11.	Blue sand shale	6	
10.	Red clay to brown clay	35	9
9.	Gray sand shale	4	
8.	Brown clay shale to red and blue clay shale	14	
7.	Blue clay shale	29	
6.	Black shale	1	8
5.	Coal		4
4.	White clay shale	3	
3.	Blue clay shale	10	
2.	Blue sand shale with water vein	29	
1.	Limestone, blue	1	
	Total	490	4

AUDUBON COUNTY

Cretaceous deposits underlie practically the whole of Audubon county beneath a heavy cover of drift. Little is definitely known of the deeper formations; yet it is probable that the most productive facies of the Coal Measures, the Des Moines stage, may be found directly under the Cretaceous in the northern portion of the region; while in the southern part rocks of Missourian age occupy that position. In the northeastern section of the county the Des Moines can probably be reached at a depth that does not prohibit prospecting, for strata of that age outcrop along Middle Raccoon river in Guthrie county only five miles east of the Audubon boundary, and again near Carrolton six miles north of Audubon. Since the lower part of the Des Moines is usually the most productive, it would be advisable to continue prospect holes some distance into the lower Coal Measures. In the greater part of Audubon county workable coal horizons lie at such great depths that prospecting cannot be encouraged under present conditions of the Iowa fuel supply.

ADAIR COUNTY

Under the drift of the greater part of Adair county are rocks of upper Coal Measure, or Missourian age; but in the western third of the region these are covered by Cretaceous strata of no great thickness. Only thin coal seams have ever been discovered in the Missouri, so that it is not a promising field for deep prospecting; while the Cretaceous of Iowa carries only lignites that are not of economic importance. Beneath the Missouri, however, are the more abundantly coal bearing beds of the Des Moines, presenting several hundred feet of strata that may contain at any point basins of coal of limited lateral extent. Throughout the greater part of the county the depth to which prospecting would necessarily be carried in order to reach the best coal horizons appears to be prohibitive under present conditions; yet in the valleys of the northern and northeastern portions, the Des Moines can be found nearer the surface. Thin coals have been reported from the northeastern section and parties are now preparing to prospect it.

Thin coals, belonging probably to the Missouri stage, have been encountered at several points near Bridgewater. Mr. James Hendry reports the following record of a drilling made on the highland near his residence (Washington Tp., Sec. 8, Ne. qr., Sw. ¼).

	FEET.
Soil and drift	164
Sandstone	18
Rock, hard	1
Shale, fissile, dark	?
Coal	1¾

The thicknesses of the coal and the roof "slate" are in some doubt, although twenty-one inches is thought to be approximately correct for the former. Other drillings made on the lowland within one-half mile of the above prospect found the coal split into thin beds separated by layers of shale.

Near the residence of Henry Rose, two miles north of Bridgewater (Jackson Tp., Sec. 29, Ne. qr.), a coal two and one-half feet in thickness was claimed by the driller to have been penetrated at a depth of 290 feet in boring for water. A well sunk for Henry Hyda, about five miles east of Bridgewater (Summerset Tp., Sec. 31, Se. qr.), reached a thin coal seam at about 300 feet.

A number of prospects were made near Fontanelle with doubtful results. A number of residents emphatically state that good coal five feet or more in thickness was encountered 380 feet below the level of the railroad track, near the Fontanelle station; while others just as emphatically declare that no coal was found. The Craig and Dawson Coal Company of Fort Dodge drilled in the creek bottom, about one mile below Fontanelle, to a depth of 409 feet. The record of this prospect shows a coalless alternation of the Missouri shales and thin limestones to the bottom of the hole, indicating that workable coal horizons, if present, must be looked for at still greater depth.

The only coal mined recently within the limits of the county was taken from a depth of about 260 feet, six miles directly south of Adair, in the northwestern corner of the region under consideration. A roof of bituminous shale covered a two-foot

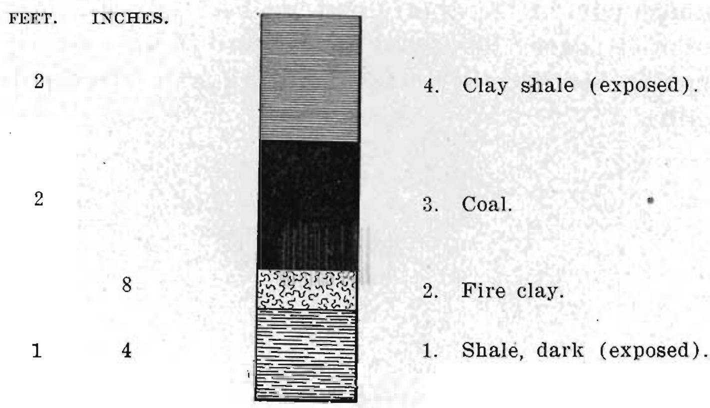


Figure 96. Coal bed south of Adair.

coal bed. A local mine was operated more or less continuously for about fifteen years until accumulating troubles with ventilation and other difficulties caused it to be closed. It may, perhaps, be again opened.

CASS COUNTY

Like many of its neighbors, Cass county offers few exposures of the indurated rocks beneath the drift, so that our knowledge of the stratigraphy of the region is limited. The Cretaceous is present except in the valley of the Nishnabotna river as far up as Atlantic and in the southeastern half of Noble township and the western portion of Edna. Where the Cretaceous is lacking, the beds immediately beneath the drift are Missourian. In a deep well drilled at Atlantic the top of the Missouri was reached at 125 feet and the base of the Des Moines at 850 feet, showing that 725 feet of Coal Measures exist at that point. While coal may possibly occur in any part of the Coal Measures, the thick seams are found in other parts of the state well toward the base, and it is not known that coal producing conditions prevailed as far west as Atlantic during even lower Coal Measure time. The chances for finding thick coals at practicable depths in Cass county are, therefore, not particularly bright.

The coal mined in counties south of Cass extends into the southern part of the county and has been mined to some extent north of Briscoe. This coal is discussed in another part of this volume in the chapter on the stratigraphy of the southwestern counties.

PART VI

COAL DEPOSITS OF SOUTHWESTERN IOWA*

The mines of the southwestern field, including Adams, Taylor and Page counties, are all in the Upper Coal Measures, the Missouri stage. The coal worked is the Nodaway seam although a bed six to fifteen inches thick and known as the Linquist or Nyman coal has been worked in a very small way in Page county. The Nodaway seam is very persistent, both in its extent and its thickness. While its area is not fully determined the fact that it is mined at New Market and Henshaw in western Taylor county; at Nodaway, Carbon and Briscoe in western Adams, and at Clarinda, Shambaugh and Coin in Page county shows that it underlies a very considerable area. It is also worked extensively at many points down the Nodaway river in Missouri. Its thickness varies from sixteen to twenty inches and its quality is quite uniform over large areas. It is considered by Professor Calvin to be a submarine deposit. This conclusion is based on its large areal distribution, its practically unvarying thickness and other characteristics and the manner in which the coal is interstratified with marine sediments. The stratigraphic relationships are discussed at length by Dr. Geo. L. Smith in another part of this volume.† The map accompanying Dr. Smith's report shows the line of outcrop of the Nodaway coal.

The following table shows the figures of coal production in this field during 1908.

County	Tons	Value	Average price per ton	Average No. men employed	Average No. days worked
Adams........	17,492	$42,235	$ 2.47	83	141
Page..........	11,364	31,993	2.82	59	124
Taylor........	15,833	33,881	2.12	67	211

*Notes on some of these mines were contributed by Dr. S W. Beyer. The descriptions were written by the Assistant State Geologist.

†"The Carboniferous Section of Southwestesn Iowa."

As to the possibilities of finding coal at greater depth in these regions it is not at all likely that any will be discovered except by prospecting very far below the bed worked. Even then it is problematical whether the strata which are most productive farther east will be found to be coal bearing in this section of the state. A hole was drilled at Carbon in Adams county with a core drill to a depth of 873 feet but without finding a trace of coal. The strata penetrated were chiefly calcareous shale, limestone and sandstone. Other prospects are described in Dr. Smith's report.

TAYLOR COUNTY*

Coal has been worked in Taylor county for over forty years. The earliest mining, so far as known, was carried on near Henshaw in the bluffs of the East Nodaway river. Mines have been operated in this vicinity more or less intermittently until quite recent years. These mines have never been of more than local importance and since there is no railroad within six or eight

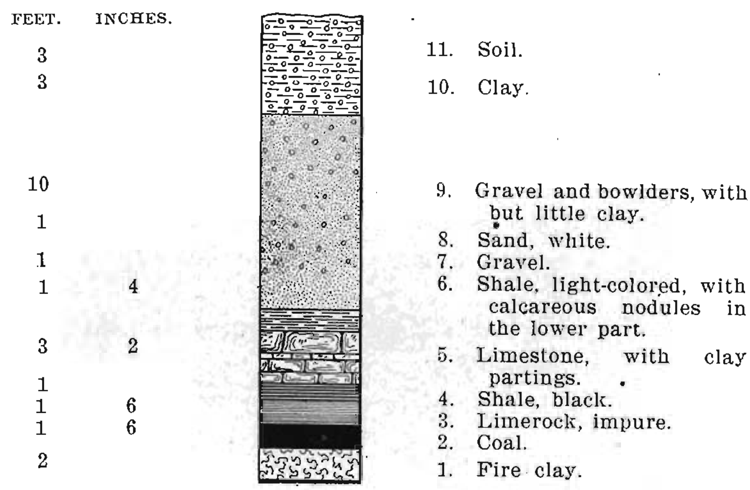


Figure 97. Section at Beynon shaft, near Henshaw.

miles the output has been marketed in the district where produced. Some coal has also been taken out a few miles farther south, east of Hawleyville, Page county. Figure 97, the section

*Keyes: *Coal Deposits of Iowa,* Iowa Geol. Surv., Vol. II, pp. 457-461. 1894.

of a mine which was one of the important producers of the district will give an idea of the strata present. This mine was opened about 1887. Some of the openings were drifts in the bluffs while others were shafts of depths ranging from twenty to eighty feet.

At present mining in Taylor county is confined almost entirely to the vicinity of New Market. Mines were opened here for local use in 1883 and since then the district has gradually increased in importance until it is one of the leading producers in the southwestern counties. At present (1909) three mines are operated the year around while three others are worked during the winter.

About one mile east of New Market, on the Chicago, Burlington and Quincy railroad, is mine number 1 of the Campbell Coal Company. The coal is reached by a shaft 150 feet deep. It is about eighteen inches thick and is fairly even and flat. The roof is composed of black or gray shale and "cement" or "bastard" rock. It is generally fairly good, especially where formed by the black slate. The section is given by Dr. Smith in his paper which will be found elsewhere. The mine does not make much water, except for the drip at the shaft. Mining is carried on here, as in other mines of the district, in the bottom, since this is fairly easy to remove. The system used is long wall and the coal works fairly easily. Owing to the thinness of the seam the roadways are blasted out of the bottom with dynamite and are gradually heightened by the falling of the roof during the summer. Haulage is effected below entirely by men as it is not practicable to make the roadways high enough for mules.

Ventilation is by furnace as in nearly all the mines of the Nodaway seam. These mines do not require much air and so are generally in better condition than is possible in larger mines. Natural ventilation usually suffices during the winter and is relied on entirely in some of the smaller mines. The Campbell mine is one of the farthest in of any working the Nodaway seam. The average miner will get out about two tons of coal per day. At present miners are paid 4½ cents per bushel in summer and 5 cents in winter. Wheelers receive about 1¼ cents per bushel, or 25 to 37½ cents per ton, for loading and pushing. The cars used will hold 800 to 1200 pounds. The capacity of the mine is from 400 to 600 bushels per day. Campbell Number 2 is used only as an air shaft. In time it may be used as a producer since the company owns twenty-five acres of coal contiguous to it.

About one-fourth of a mile east of the Campbell property is the mine of the Union Coal Company, formerly owned by Tomlinson and Pace, and originally opened by Benjamin Anderson. There have been three shafts sunk here, but only one of these is being used at present. The section at the most westerly of the Anderson shafts may be taken as typical of all the others in the vicinity. Numbers 2 to 6 are given in the cut.

FEET.	INCHES.	
2		6. Limestone, bluish.
2		5. Shale, black, bituminous, with nodules of impure limestone.
1	10	4. Coal.
1	8	3. Fire clay.
	8	2. Sandstone, soft, somewhat clayey.

Figure 98. Seam at Anderson shaft, New Market.

		FEET.
10.	Soil and drift clay	20
9.	Sand and gravel	2
8.	Clay, tough, dark gray	24
7.	Shale, light gray	80
	2 to 6 given in figure 98.	
1.	Shale, bluish, with thin layers of limestone	12

The mine is located on the Chicago, Burlington and Quincy and does a shipping business. Horse power is used for hoisting and in all essentials the mine is similar to the Campbell. The coal is 150 feet deep and one of the shafts is utilized for air and escape purposes.

One-fourth mile west of the Campbell mine is that of the New Market Coal Co. formerly owned by Wm. Browning, and also located on the Burlington. The equipment of this mine is very simple and is similar to that of the others in the district. The coal seam and associated strata show the features common to the district. The mine is 156 feet deep.

Besides these three shipping mines there are three small mines about two miles east of New Market, north of the railroad, but without connections with it. These were put down by Wm. Welsh, N. Easter and John Carmichael. They are operated only during the winter. The coal and the methods and equipment used for working it are similar to those found elsewhere. Some difficulty has been experienced here on account of water.

Mining is done in the New Market district either under the royalty plan or by purchase of coal rights. In the former case the amount paid is one cent per bushel while under the latter system about $30 per acre is charged. All the mines of the county are nonunion. It is quite difficult to get miners to work the mines on account of the low vein. Otherwise a much larger production would be maintained.

PAGE COUNTY*

Professor White mentions the fact that coal was mined in Page county as early as 1866.† The bed worked, he states, was the same as that worked in Adams and Taylor counties, and was opened up near Clarinda. This has been the center of mining in this county ever since. The principal mine in operation at present is that of Johnston and Company, about three miles west of town. This is a shaft mine, 185 feet deep, and is the only one in the district which uses steam power. It is equipped with a small vertical hoisting engine, with mine car and wagon scales and has storage capacity provided for 500 tons. Arrangements at top and bottom are very simple. The mine is quite dry, save for the drip at the shaft. The seam varies from sixteen to twenty inches with an average of about seventeen. It is fairly uniform in character and thickness, and the bottom is quite even. The long wall system of mining is employed here

*Keyes: *Coal Deposits of Iowa*, Iowa Geol. Surv., Vol. II, pp. 453-456. 1894.
*Calvin: *Geology of Page County, Ibid.*, Vol. XI, pp. 397-460. 1900.
†C. A. White: *First and Second Annual Report of Progress of the State Geologist*, p. 50, Des Moines, 1868.

as in all the mines of this district. The coal is undercut from twelve to twenty inches, the mining being done in the bottom shale. This is rather more difficult to mine than is that at New Market. Nearly all the dirt is disposed of below. The height of the roadways is increased by taking up the bottom and this along with the other waste material is used to build pack walls for the protection of road- and air-ways.

All tramming is done by hand as the entries are too low for mules. Cars of ten bushels capacity are used. Only lump coal is produced. There are no facilities for grading or cleaning the coal except by hand picking. The capacity of the mine when in full operation is about forty to fifty tons daily.

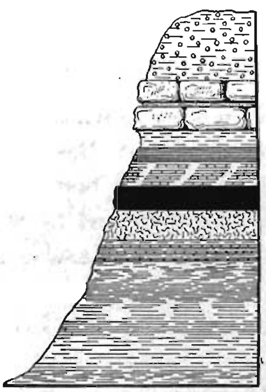
As with the New Market mines so here also the mines are non-union. Miners are paid from 5½ to 6 cents per bushel, wheelers receive 1½ cents per bushel, day men at bottom receive $2.00 to $2.25 and those on top about $2.00 per day. The royalty paid varies from ¾ to 1½ cents per bushel. The usual royalty is one cent. All of the coal is sold and consumed locally and most of it is hauled to Clarinda. The delivery charge is two cents per bushel. None of the Page county mines have railroad connections.

The Van Arsdall, or Swisher and Maley, mine is located about two miles south of west of Clarinda. The present shaft is 146 feet deep and is equipped with horse hoist. The old shaft was 135 feet deep. The coal and the methods of securing it are similar to those of the Johnson mine. The full daily capacity of the mine is from twenty-five to forty tons, depending on whether or not the horses are relayed on the gin. The coal stands storage fairly well. The storage capacity is somewhat less than that of the Johnson mine. Ventilation is effected by furnace as in all the mines of the Clarinda district.

The equipment of the mines in the Nodaway seam compares favorably with that of similar mines over the state. The safety devices in use conform in character to the requirements of the law and the operators keep their mines in good working condition. Second openings have been made at all the larger mines and are kept in available order. The natural conditions also are conducive to the safety of the miners and hence serious or fatal accidents are of rare occurrence.

There are two other mines about two miles southwest of Clarinda, the Berry and the Wingert mines. The equipment and general conditions about the mines are about the same here as at the Van Arsdall mine. The underclay is more difficult to cut in the Berry mine than in those mentioned previously.

Mining was carried on a number of years ago at the Shambaugh mill, about two miles southeast of Clarinda. Drifts were carried into the bluffs on the east side of the West Nodaway river (East River Tp., Sec. 7, Se. qr., Nw. ¼) and considerable coal was taken out. This locality has been abandoned for years.



		FEET.	INCHES.
9.	Drift	4	
8.	Limestone, in two layers, gray, compact	3	
7.	Shale, light-colored	1	
6.	Shale, bituminous		9
5.	Limestone, impure, fragmentary	1	6
4.	Coal	1	6
3.	Fire clay	1	8
2.	Shale, light-colored, with calcareous nodules	1	
1.	Shale, light-colored (exposed)	8	

Figure 99. Bluff at Shambaugh Mill, on West Nodaway river, Clarinda.

There has been considerable activity in the neighborhood of Shambaugh, six miles south of Clarinda. Some of the openings here were slopes and some were shafts. Twenty-eight or thirty years ago Samuel Pinkerton, William Aiken, William McLean and others were operating the principal mines in the county. Later the seat of operations moved to Clarinda and in recent years Shambaugh has not been a producer.

About three years ago the Coin Coal Company sank a shaft at Coin. This is the deepest mine on the Nodaway seam, which it reaches at 230 feet. Steam power is used for hoisting and a jet furnishes ventilation. This is the only mine in southwestern Iowa using this method of furnishing air.

Northwest of Clarinda about ten miles, in the valley of the Middle Tarkio river, coal was mined a number of years ago on the land of Charles Linquist (Fremont Tp., Sec. 24, Nw. qr., Nw. ¼). The coal was first discovered at the base of a low hill near the river. Tunneling was attempted, but here the "cap rock" was too badly weathered to form a good roof. A shaft was then sunk to the seam, which is from six to eighteen inches thick. Several thousand bushels were taken out, but owing to the unsatisfactory conditions it has not been exploited extensively. It is underlain by a fire clay and has as a roof a three-foot band of limestone with intercalated shaly partings. Above this come the materials of the drift. This is the Linquist coal, called also the Nyman, from the locality of that name near by. It lies 185 feet or more above the Nodaway vein.

FREMONT COUNTY*

Fremont county occupies the southwest corner of Iowa and is underlain over its entire extent by the strata of the Missouri stage. A heavy mantle of drift and loess conceals the bed rock over most of the county and good exposures are confined to the bluffs of the Missouri river and to the vicinity of Hamburg and Riverton.

A phenomenon unique in Iowa geology, in the shape of a fault with an upthrow to the north of over 300 feet, brings some of the deeper strata of the Missouri stage to the surface in northwest Fremont county.† Along the bluffs of the Missouri river southeast of Bartlett (Scott Tp., Sec. 14 and 23) a bed of coal outcrops which shows a thickness of ten to eighteen inches. This rests upon fire clay and has a roof of blue or gray shale. These features, together with its associations, ally it with the Nodaway coal and Dr. Smith, who has made an extensive study of this part of Iowa, has no hesitancy in declaring it to belong with that seam.

About four miles south of this outcrop, two miles south of Thurman, coal was found in a prospect shaft. It was fourteen inches thick and rested upon shale with a six-inch band of lime-

*See on the geology of Fremont county Keyes: *Coal Deposits of Iowa*, Iowa Geol. Surv., Vol. II, p. 452, 1894. Udden: *Geology of Mills and Fremont Counties*, Iowa Geol. Surv., Vol. XIII, pp. 126-182. 1903.

†On this fault see the chapter below by Dr. Smith.

stone forming the cap rock. Dr. Smith identifies this with the Nyman coal, and as it presents the same features that are shown by the seam in Page county the correlation may be accepted as certain. Between this locality and the one north of Thurman, therefore, lies the fault which has caused this displacement and has brought the Nodaway coal above the level of the Nyman seam.

A seam of coal is seen in a creek valley about two miles east of Hamburg, in the southwest part of the county, at a locality known as McKissicks Grove. It is here less than a foot thick, is underlain by shale and has a soft limestone roof. It has also been penetrated in several wells and prospects, where a thickness of fifteen to twenty inches is reported a few feet below the base of the drift. This coal also is considered by Dr. Smith to be the Nyman coal.

Several attempts at exploration of these coal beds have been made, but nothing satisfactory seems to have been accomplished. The coal near Hamburg is said to be of good quality and its nearness to the surface makes exploitation easy. It is possible that some workable pockets may be found and utilized. Its thickness is locally equal to that of the coal mined in Page county to the east but since it lies above the general level of the eroded surface of the Coal Measures it must be discontinuous and hence exploration is bound to be attended with a great deal of uncertainty. The Nodaway coal seems to be of inferior quality and the steep dip of the strata away from the fault soon carries it far beneath the surface. Summing up all the conditions it does not seem probable that prospecting either of the beds will ever be attended with any degree of success.

MILLS COUNTY

Mills county, like Fremont to the south, has a heavy deposit of loess and drift overlying the indurated rocks. These latter belong to the Missouri stage, with the exception of a little sandstone of Cretaceous age in the northeastern part of the county. No exposures of coal are known, and as has been stated before, the Nodaway coal soon disappears to great depth and is of inferior grade. The Nyman coal may be found under conditions similar to those existing in Fremont but nothing is known of this.

MONTGOMERY COUNTY*

Montgomery, like its neighboring counties, has a deep covering of drift over the uplands, and hence the rock exposures are confined to the water courses. These have, however, cut into the indurated rocks to a larger extent than is true farther west. A considerable portion of the county is covered by Cretaceous sediments which now extend as long tongues or outliers over the uplands, but have been eroded from the stream valleys. Beneath all of these lie the strata of the Upper Coal Measures. These are known to carry one or two thin seams of coal, one of them the Nodaway vein. The relationships of the other seam, which Lonsdale states was reported to be six inches thick and about 100 feet above the Nodaway vein, do not seem to be very clear.

The Nodaway seam has been known and worked in the northeastern part of the county for many years. The principal opening in this region was the Westrope mine. (Douglas Tp., Sec. 1, Se. qr., Sw. 1/4). The vein was at one time exposed

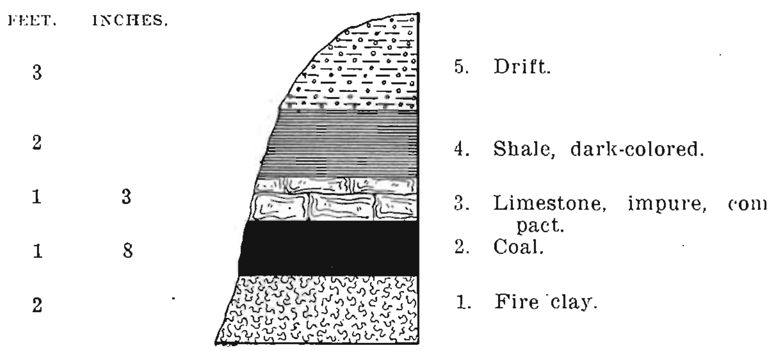


Figure 100. Coal bed at old Westrope mine.

in a small runnel opening into the West Nodaway. The coal has an average thickness of about nineteen inches. As early as 1857 slopes were driven into the hillsides and a considerable

*See Keyes: *Coal Deposits of Iowa,* Iowa Geol. Surv., Vol. II, pp. 443-445. 1894. Lonsdale: *Geology of Montgomery County, Ibid.,* Vol. IV, pp. 402-408, 446-448, 1894. Lonsdale does not seem to have been aware of the identity of the Nyman coal and confuses it with the Nodaway.

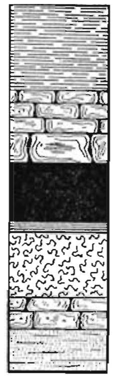
amount of coal removed. From 1875 to 1880 mining was here carried on quite extensively for this region. At one time as many as fifteen men were employed at the mine, the daily output being upwards of 400 bushels or nearly sixteen tons. Since 1881 no mining has been undertaken at this locality nor elsewhere within the county. It will be noticed that in the section given above the usual shale roof of the Nodaway vein is separated from the coal by a bed of limestone. This phenomenon seems to be more common in the northern part of the area occupied by the Nodaway coal than in Page and Taylor counties, although there are several phases, from heavy bedded limestone through thin limestones and shales to thick shales.

ADAMS COUNTY*

The Upper Coal Measures underlie all of Adams, but in the northwest one-third of the county they are overlain by the strata of the Cretaceous. There has been only one bed of coal found in the county, the Nodaway, and this is exposed and mined only in the west one-third. A short distance east of Carbon, probably not over one-fourth mile, the roof thins out and the coal becomes soft and worthless. It does not extend much farther. Carbon has always been the center of the greatest activity and Adams has, during most of the years for which figures are available, been the leading producer of southwestern Iowa. As early as the days of the Civil War coal was being mined in the banks of the Middle Nodaway near Carbon, and the industry has been prosecuted to the present day. It is probably making a conservative estimate to say that over 350,000 tons have been removed; a very considerable quantity when it is recalled that the vein averages only sixteen inches in thickness, that there is not a railroad mine in the county and that until two or three years ago no coal was ever shipped by rail from any of the mines in the county.

Mines have also been operated for about thirty years near Briscoe. Some of these shafts were from sixty to ninety feet deep. At the Plowman shaft (Lincoln Tp., Sec. 2, Nw. qr., Nw. ¼), a section of which is given below, the coal was found at twenty-six feet.

*Keyes: *Coal Deposits of Iowa.* Iowa Geol. Surv., Vol. II, pp. 445-450. 1894.

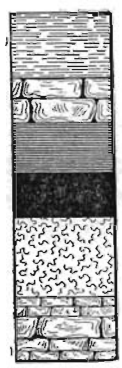


FEET.	INCHES.	
2		7. Shale, gray, clayey.
1		6. Limestone, gray.
1	4	5. Coal.
	3	4. Shale, finely laminated. bituminous.
1	6	3. Fire clay.
	8	2. Limestone, thin bedded.
1		1. Shale, sandy in part.

Figure 101. Coal bed in Plowman shaft, Briscoe.

At present one mine is being worked here, that of H. K. Demirjean. This is a shaft mine 119 feet deep and uses horse hoist. Ventilation is effected by furnace and an escape shaft five by six feet is provided. All the mines of this vicinity have shown about the same thickness of coal and a similar sequence of strata. The absence of the roof shale and the consequent juxtaposition of the coal and the cap rock is worthy of note.

The early mines of the Carbon district were located west of town, for the most part along the river. At present these are all abandoned and operations are being carried on by shafts located north and south of town. The accompanying section will give an idea of the strata encountered in this district.



FEET.	INCHES.	
2		6. Shale, light gray, clayey
1	5	5. Limestone, fossiliferous.
1	6	4. Shale, bituminous, fissile.
1	6	3. Coal.
2	6	2. Fire clay.
2		1. Limestone (exposed).

Figure 102. Vein at old Syfert and Jones mine, Carbon.

The mine of Jones, Smith and Tindall is located about one-fourth mile south of the village. The shaft is 110 feet deep, five by nine feet in area and with two compartments. The cages are very simple and without safety devices. Horsepower is used for hoisting and a manilla rope is used instead of the customary wire rope. The plant is equipped with wagon scales but as the mine has been open only since April of the present year (1909) mine car scales have not yet been installed. An average output of 500 bushels per day can be maintained during the busy season, from September 1st to April 1st. Storage sheds of 4,000 bushels capacity will be provided. The coal has a uniform thickness of eighteen inches and lies fairly flat. It is essentially nonpyritic and can be stored for several months even during the summer season. At present most of the work being done is confined to entry driving. Twenty to twenty-five miners will be employed.

The shaft of J. F. Ruth, one-half mile northeast of Carbon, was opened in March of 1907. It is sixty-five feet deep to the coal and this and the equipment used for handling it are essentially the same as those of the Jones mine, except that the cages are supplied with covers and safety catches. Mine car scales are in use and storage capacity for 500 tons is provided. The mine is fully opened up and for the present season thirty men are employed. The capacity is about twenty tons per day although as much as forty tons is raised at times.

The mine of J. F. Wild is just being sunk. It is located on the north edge of town a third of a mile southwest of the Ruth mine. The shaft will be seventy feet to the coal and it is hoped to have the mine opened up ready for the winter's trade.

The Houck mine No. 2, near Carbon, was operated last winter by Wild and Barker, but a cave-in in the shaft has put an end to operations.

About five miles northwest of Carbon is the village of Eureka, north of which several mines have been operated. The earlier ones were slopes and the later ones shafts. A considerable amount of coal was removed but in recent years not much has been done here. At present the only mine which is open is the Dixon or Houck shaft, which is being operated by McKee Brothers during the present season. The shaft is thirty-five feet deep and during the winter season ten or more men are employed. The capacity of the mine is about twelve tons.

Coal from the Carbon mines finds a ready market in the vicinity while some is hauled by team to Corning and even as far as Massena, Red Oak and Lenox, distances of twenty and twenty-five miles.

A comparatively new field has been opened up within the last few years near Nodaway in the southwest corner of the county. As early as 1903 James Spargur operated a mine near here and at present two mines are being worked.

One mile northwest of town is the shaft of Daugherty and Son, 102 feet deep. It has been operated since 1905 and at present eight to twenty miners are employed. The coal here is similar to that at Carbon, but is somewhat lighter, especially where it thickens. A dip of four feet per 100 to the southwest aids the pushers in getting the cars to the shaft. Mine car and wagon scales are provided and hoisting is effected by a double engine which operates a single three-foot drum by friction clutch. Power is supplied by a vertical boiler. The shaft has but one compartment and at present the cage is without cover or catches, although these will be provided. No storage sheds are provided and the surplusage over local needs is shipped on the railroad, chiefly to Villisca and other nearby towns. This is not profitable, however, and is resorted to chiefly to keep the miners in steady employment. Last winter the shipments averaged a car per week. The proprietors own the coal rights to eighty acres adjacent to the shaft.

One-fourth mile northwest of the Daughery shaft is that of Frederick Weil. This is a double compartment opening five by ten feet in diameter and 124 feet deep and is operated by a one-horse gin. The coal here runs from fourteen to twenty-four inches, with an average of eighteen or less. Fourteen men are employed at present, but as many as twenty are used in the winter. This and the Daugherty mine are generally run all summer to supply the small demand. The daily capacity of the mine is about twenty tons, all of which is consumed locally.

At both of these mines the succession of strata is the same. Overlying the clay is a black, somewhat fissile shale which grades laterally into a gray shale, called by the miners the bastard. It is slightly more crumbly than the black shale, but either one makes a good roof. The thickness varies from eighteen to thirty inches. Above it is the "cap rock," a bed of limestone one or two feet thick. Below the coal is a "fire clay" perhaps two feet thick and underlying this the "bottom rock," about the same thickness.

Mining in the Adams county mines is comparatively safe and accidents are very rare, owing to the thin seam, the method of working the mines and the uniformly good roof.

The coal is mined exclusively by the long wall plan and work is done in the underclay. About four inches is taken out and the cut is made from twelve to eighteen inches deep. The coal is too soft to allow the use of powder. In most of the mines all the coal is taken out, even that around the shaft. Here cribbing is resorted to in order to support the roof. No mules are used in any of the mines as the roof is too low. Man-power is used for bringing the coal to the bottom. The cars used will hold from eight to fifteen bushels, their capacity depending on the height of the roadways and the ability of the pushers. In order to give the necessary height to the entries and the roadways two or three feet of the underclay is taken up, usually down to the bottom rock. Roadways are driven every forty feet off the entries and each miner, or in some cases two miners working together, cuts out twenty feet on either side of the road.

In the Carbon district miners are paid seven cents per bushel and hire or do their own wheeling. In the Nodaway mines the diggers receive six cents, or seven cents for cutting the rib, and wheelers are paid a cent a bushel. Coal sells for ten cents per bushel at the mines. Although it stands storage quite well it will lose about twenty-five per cent in weight. The operators work on the royalty plan and pay on the average one-half cent per bushel.

The equipment is very simple at all the mines, the Daugherty mine being the only one with steam hoisting apparatus. In former years the workings were extended only a short distance from the shaft or slope mouth and were then abandoned and new openings made. Recently, however, better methods have been instituted; separate air shafts and manways have been installed and the equipment has steadily improved. Nevertheless, it is not practicable to run entries more than about 300 yards as the distance becomes too great for men to push the coal. Ventilation is effected during the summer by means of stoves in the bottoms of the air shafts. Natural ventilation suffices during the winter. All the mines are dry except near the shaft. With the exception of those of the Nodaway district the mines are idle during the summer, but in winter they are taxed to their capacity, and indeed, beyond. At times as many as 175 men have been employed in and around the mines.

FUEL VALUES OF IOWA COALS

BY

F. A. WILDER

ANALYSES OF IOWA COALS

BY

JAMES H. LEES AND A. W. HIXSON

FUEL VALUE OF IOWA COALS

BY FRANK A. WILDER

WITH ANALYSES OF IOWA COALS

BY JAMES H. LEES AND A. W. HIXSON

CONTENTS

CHAPTER II

THE FUEL VALUE OF IOWA COALS

The following chapter gives the results of chemical and physical tests, carefully made at large expense to the national government, to show the fuel value of Iowa coals; and to determine how to handle them in order to obtain from them the greatest efficiency.

The state of Iowa, with individuals and companies engaged in coal mining within the state, contributed in various ways to this fund of information with reference to the nature of Iowa coals.

To the engineer who wants to post himself on Iowa coals, the complete presentation of the tests as made in the following tables will be considered natural and necessary, though the casual student of the subject might get along with a more condensed statement.

Care was taken to make the tests typical, and though they actually stand for coals from certain mines, they probably represent rather correctly the coals of the state and their behavior under various conditions, except where note is made to the contrary.

The tests were made under an act of congress approved in 1904, providing for the analysis and testing of the coals and lignites of the United States, in order to determine their fuel value and the methods that should be employed to obtain from them the greatest efficiency.

The testing plant was established at St. Louis in connection with the Louisiana Purchase Exposition, and was under the supervision of the United States Geological Survey.

A very complete plant was established with all desirable apparatus and machinery for making both chemical and physical tests on coal and lignite.

A particularly valuable feature of the tests is found in the fact that coals from all portions of the United States were brought together and tested under identical conditions by disinterested persons.

For the first time, therefore, opportunity was given to compare the coals of America and to determine their relative value.

If the prices of coals are taken into calculation, and the fuel values used which are set forth on the following pages it will be found that there is no excuse for importing expensive eastern coals into the Mississippi Valley, except for domestic and metallurgical purposes.

Moreover the possibility of briquetting Iowa coal and putting it in an especially attractive form for domestic use, is plainly brought out.

The Iowa Geological Survey co-operated effectively with the National Survey in connection with these tests.

The state survey selected the mines from which the coal for testing should be taken, and in doing so, endeavored to select points that might be regarded as typical for the state, and points, moreover, which would long be producers.

It was felt that the tests should represent as large an area as possible, and that the results obtained should have weight for a considerable period of time; in-as-much as the tests were expensive and could not readily be duplicated.

The Iowa Geological Survey selected and secured the donation of five cars of coal from as many important mines; and secured from the railroads the free transportation of four cars of this coal from the mine to the testing plant. The State Survey paid the freight on the fifth car.

The coals that were tested are presented in the table below, and on the following pages they will be referred to by the numbers here shown.

NAME OF SAMPLE	OPERATOR	MINE	LOCATION	GRADE OF COAL	NAME OF BED
Iowa 1....	Anchor Coal Co., Ottumwa, Iowa	No. 2	Laddsdale, Ia.	Over ¼ inch screen.	Middle bed.
Iowa 2....	Mammoth Vein Coal Co., Hamilton, Ia.	No. 5	Liberty Twp., Marion Co., Ia.	Run of mine.	Big vein.
Iowa 3....	Gibson Coal Mining Co., Des Moines, Ia.	No. 4	Near Altoona, Polk Co., Ia.	Over ⅛ inch screen.	Third vein.
Iowa 4....	Centerville Block Coal Co., Centerville, Ia.	No. 3	Centerville, Appanoose Co., Ia.	Over 1⅜ inch screen.	Lower bed.
Iowa 5....	Inland Fuel Co., Chariton, Ia.	No. 1	Chariton, Lucas Co., Ia.	Run of mine.	Lower bed.

Mr. Savage, at that time Assistant State Geologist, in company with Mr. Groves, who represented the United States Geological Survey, secured the mine samples, and supervised the loading of the cars. The report of Mr. Savage, made in Bulletin No. 2, Iowa Geological Survey, is quoted at this point:

From each of the mines from which a car of coal was shipped to be tested, two samples were taken for chemical analysis. These samples were obtained from points in the mine quite widely separated. They were cut from the full section of the working faces of the seam mined at the time the car was loaded, and were immediately sent to the St. Louis laboratory by mail in air-tight cans. The two coal samples that were collected at the mine for chemical analysis are referred to in the tables which follow as "mine sample A" and "mine sample B" respectively.

As each car load of coal, sent to the plant for testing, was unloaded at St. Louis, a third sample was taken for chemical analysis which represented the coal actually contained in the car to be tested. This sample is designated in the following tables as the "car sample".

As the coal was distributed to the testing divisions samples were taken at frequent intervals, quartered down, and analyzed. In this way at least six separate samples from each car of coal were obtained at the plant, and two at the mine.

Quotations are freely made on the following pages from Professional Paper 48, of the United States Geological Survey, in which all the tests of the St. Louis plant are presented, and from which the tables showing results of tests are taken.

DESCRIPTION OF MINES AND SAMPLING METHODS

IOWA NO. 1.

Operator.—Anchor Coal Company, Ottumwa, Iowa.

Mine.—Mine No. 2, located at Laddsdale, Wapello county, Iowa, on Chicago, Rock Island and Pacific Railroad.

Coal bed.—In Wapello county the coal beds lie at no great depth below the surface. The middle bed in this mine is found at a depth of 58 feet, and what is called the third seam at a depth of 70 feet. The coal beds vary greatly in thickness in this region, but in the majority of places in which they are now worked they range from 3 to 5½ feet.

Two sections were measured on each bed and the variations are shown in plate X. The detailed sections are as follows:

Sections of coal bed in mine No. 2, Anchor Coal Company, Laddsdale, Iowa.

MIDDLE BED.				THIRD BED.			
SECTION A.		SECTION C.		SECTION B.		SECTION D.	
	Ft. in.		*Ft. in.*		*Ft. in.*		*Ft. in.*
Coal	2 11	Coal	3 10	Coal	2 3	Coal	4 5

Samples for chemical analysis.—Two samples for chemical analysis were obtained in this mine. Sample A is from the middle seam and sample B is from the third seam. These samples were taken at the points where sections A and B, noted above, were measured. The samples were obtained in the usual manner by making cuts across the face of the coal from roof to floor, so as to obtain coal from all parts of the bed. The samples were then crushed and quartered down until about a quart of crushed coal remained of each sample. The samples were then packed in airtight galvanized-iron cans and mailed to the laboratory at the testing plant.

Character of car sample.—Two grades of coal were loaded in the car for testing. In one end of the car was placed coal that had been passed over a 1¼-inch screen and in the opposite end of the car was loaded the material that had passed through the same screen. These grades together were in the proper proportion to constitute run-of-mine coal. This coal is all from the middle bed. The lower bed is not developed sufficiently to furnish much coal. The coal was loaded in an open coal car, which was shipped on October 17 and was received at the testing plant November 1, 1904.

Mining methods.—Mining is done on the room-and-pillar system. The coal is shot off the solid and hauled to the foot of the shaft by mules.

IOWA NO. 2.

Operator.—Mammoth Vein Coal Company, Hamilton, Iowa.

Mine.—Mine No. 5, located in Liberty township, Marion county, Iowa, on the Wabash Railroad.

Coal bed.—There are at least six well-defined coal beds in Marion county. These are nearly all well exposed in the bluffs of the Des Moines river. The coal beds of this county are among the most extensive of central Iowa. The seam worked in No. 5 mine is known locally as the Big Vein. The thickness and character of the bed are shown graphically in plate X, and also by detailed sections A and B. Section A was measured in the fifth west entry on the south side of the mine and section B was measured in the third west entry on the south side of the mine. The sections are as follows:

Sections of coal bed in mine No. 5, Mammoth Vein Coal Company, Marion Co., Ia.

SECTION A.	Ft.	in.	SECTION B.	Ft.	in.
Coal	2	11	Coal	1	3
Sulphur and shale	0	1	Sulphur	0	2
Coal	1	3	Coal	3	11
Sulphur and shale	0	6			
Coal	2	6			
Total	7	3	Total	5	4

Samples for chemical analysis.—Two samples were cut in this mine for analysis. Sample A was obtained from the place where section A was measured and sample B from the place where section B was measured. These samples were obtained by making cuts from roof to floor, exclusive of the large partings, which are thrown out by the miner in loading the coal. These samples were carefully crushed and quartered down to about quart size and mailed to the chemical laboratory at the testing plant in air-tight galvanized-iron cans.

Character of car sample.—The car for testing purposes was loaded with run-of-mine coal. Many large sulphur balls are found in this coal, but these were mostly picked out in loading the coal. The coal was loaded in a gondola car, which was shipped from the mine October 23 and received at the testing plant November 23, 1904.

IOWA NO. 3.

Operator.—Gibson Coal Mining Company, Des Moines, Iowa.

Mine.—Mine No. 4, located near Altoona, Polk county, Iowa, on the Chicago, Rock Island and Pacific Railroad.

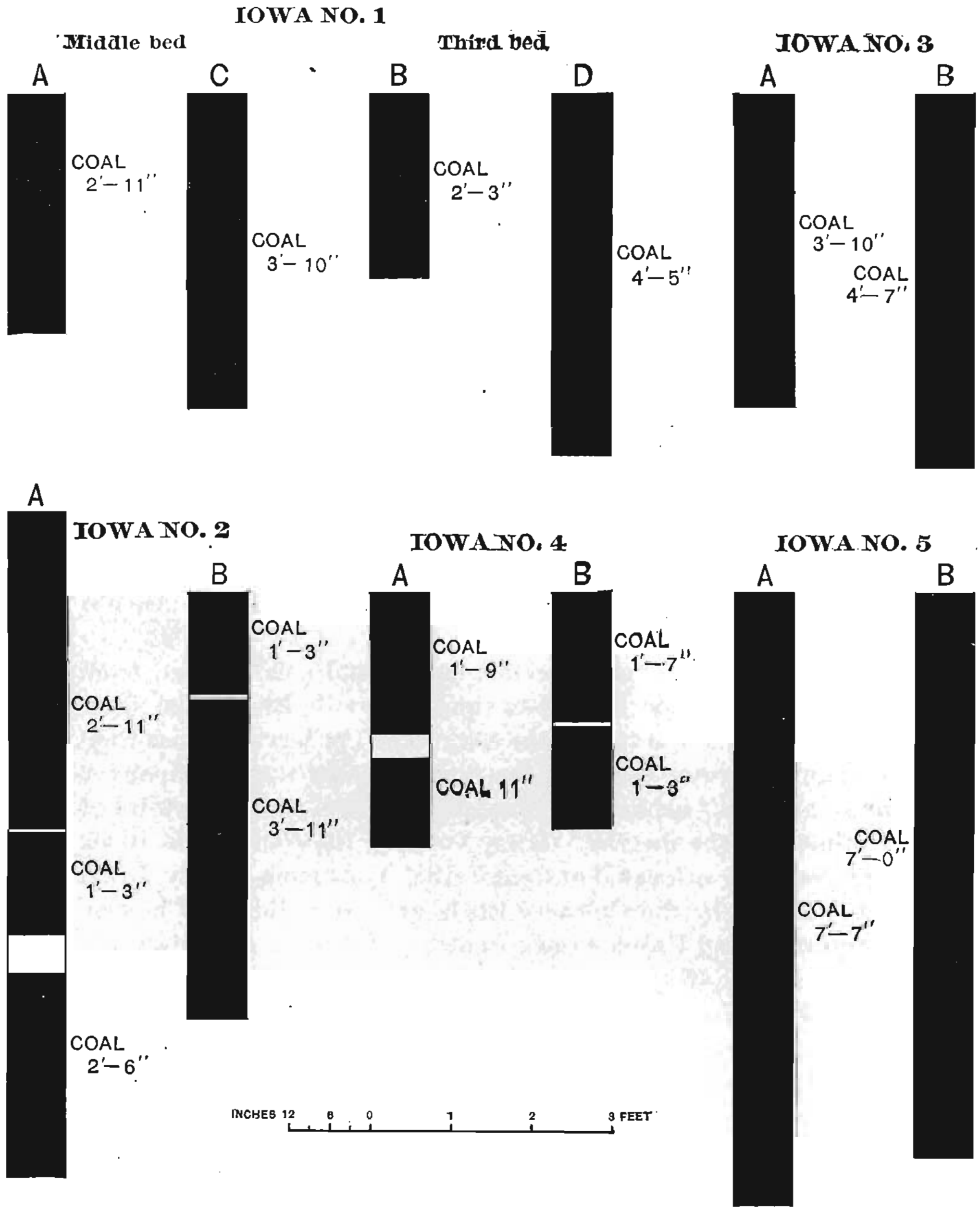
Coal bed.—Polk county has long been one of the most important coal-producing counties in the state. In this county three seams of coal are recognized. They are commonly called "first," "second," and "third" seams. These are the workable seams, and they have associated with them other beds that are not of workable thickness. Mine No. 4 is on the third seam. Two sections of this coal are shown graphically in plate X. Section A was measured in the ninth north entry and section B was measured in the main west entry. These sections are as follows:

Sections of coal bed in mine No. 4, Gibson Coal Mining Co., near Altoona, Iowa.

SECTION A.	Ft. in.	SECTION B.	Ft. in.
Coal	3 10	Coal	4 7

Samples for chemical analysis.—Two samples were cut from working faces of the mine to furnish material for chemical analysis. Sample A was obtained at the place where section A was

IOWA GEOLOGICAL SURVEY. PLATE X.



Sections of Iowa coal beds, from which coal for the St. Louis tests was taken.

measured and sample B at the place where section B was measured. These samples included all parts of the bed, and were obtained in the usual way, by cutting channels from roof to floor. The original bulk of the samples was reduced by crushing the pieces of coal to a uniform size and quartering down to about one-eighth of the original. These final samples contained about a quart and they were mailed in hermetically sealed galvanized-iron cans to the chemical laboratory.

Character of car sample.—The coal for testing was run into the car over a bar screen with five-eighths inch bars set 1⅜ inches apart. This constitutes lump coal and was selected, as run-of-mine coal is not shipped and the smaller sizes of coal and slack contain an abnormal amount of sulphur. The coal was loaded in an open coal car, which was shipped from the mine October 25 and received at the testing plant November 12, 1904.

IOWA NO. 4.

Operators.—Centerville Block Coal Company, Centerville, Iowa; Scandinavian Coal Company, Centerville, Iowa; Anchor Coal Company, Centerville, Iowa.

Mines.—These operators combined to send a car of coal from their district, and decided upon the Centerville Block Coal Company's mine No. 3 to supply the coal. The Centerville Block Coal Company operates 6 mines, the Scandinavian Coal Company 2 mines, and the Anchor Coal Company 3 mines, making a total of 11 mines for the district. Mine No. 3 of the Centerville Block Coal Company is located at Centerville, Appanoose county, Iowa, and is served by the Chicago, Burlington and Quincy; Chicago, Rock Island and Pacific; Iowa Central; and Chicago, Milwaukee and St. Paul Railways.

Coal bed.—In the Appanoose county district the coal bed which is being mined has a wide geographical extent, covering nearly all of Appanoose county and parts of the adjoining counties of Iowa and Missouri. In the reports of the Iowa Geological Survey this coal bed is called the Mystic coal. At Centerville it is found at a depth of 125 feet, rising gradually to the north and east. At the mine from which the sample was obtained the coal is reached at a depth of 110 feet. Sections of the coal bed are shown graphically in plate X. Section A was measured in the first room off the sixth east entry, and section B in the first room off the sixth east entry off the main south entry. The sections are as follows:

Sections of coal bed in mine No. 3, Centerville Block Coal Co., Centerville, Iowa.

SECTION A.	Ft.	in.	SECTION B.	Ft.	in.
Coal	1	9	Coal	1	7
Fire clay	0	4	Fire clay	0	1
Coal	0	11	Coal	1	3
Total	3	0	Total	2	11

Samples for chemical analysis.—Two samples were obtained in this mine for chemical analysis. Sample A was obtained at the place where section A was measured and sample B at the place where section B was measured. The samples were obtained by making a cut from roof to floor, including everything except the fire-clay parting. These samples were crushed and quartered down to about one-eighth their original bulk and mailed to the chemical laboratory at the testing plant in sealed metal cylinders.

Character of car sample.—The coal shipped for testing consisted of about 35 tons of lump and about 4 tons of fine coal. The lump coal was that which passed over a bar screen with 1⅜-inch spaces, and the fine coal was that which passed through this screen. The slack, which was not included in the carload, was screened off through a five-eighths inch screen. The coal was loaded in a gondola car and shipped from the mine October 28 and was received at the testing plant November 14, 1904.

IOWA NO. 5.

Operator.—Inland Fuel Company, Chariton, Lucas county, Iowa.

Mine.—Inland No. 1, located in secs. 4, 5, 8, and 9, T. 72 N., R. 21 W., fifth principal meridian. At present the mine has no railroad connection.

Coal bed.—Two general coal horizons have been recognized in Lucas county, one near the surface and the other about 250 feet below. The Inland Fuel Company is working on a coal bed at the lower horizon, and reaches the coal by a shaft 250 feet deep.

The thickness of the coal bed, as determined by four measured sections, is 7 feet 4 inches, 7 feet 9 inches, 7 feet 7 inches, and 7 feet. Two of these sections are shown in plate X. The bed is irregular, being disturbed to some extent by horsebacks. The thick coal lies in local basins or swamps, and therefore does not extend for a great distance. The roof consists of black shale and the floor of about 3 inches of shale overlying sandy fire clay.

Samples for chemical analysis.—Two samples were taken in this mine for chemical analysis. Sample A was obtained in room 33, off the second north entry, and sample B was obtained in room 8, off the first east entry on the south side. They were obtained by making cuts across clean faces of the coal bed, from roof to floor. The coal so obtained was pulverized and quartered down until two quart samples were obtained, which were placed in galvanized-iron cans, sealed air-tight, and mailed to the chemical laboratory for analysis.

Character of car sample.—The carload sample for testing purposes consisted of run-of-mine coal. As the mine has recently been opened it has no railroad connection, and the coal had to be hauled 6 miles in wagons. The rehandling probably produced considerable slack, but since all coal was crushed at the plant before tests were made, this probably had little effect. The coal was loaded in a gondola car which was shipped from the mine October 31 and was received at the testing plant November 10, 1904.

CHEMICAL ANALYSES OF IOWA COALS

Mr. Savage, in the report already referred to, summed up the results of analyses and heat unit tests as follows:

A careful comparison of the above tables shows that the average per cent of sulphur contained in the Iowa coal samples is 4.67, and the same figures represent the per cent of sulphur in the coals of Missouri. The average amount of ash present in the Missouri samples is a little less than that in the Iowa coal samples. The six samples of Illinois coal contained on the average a slightly smaller per cent of sulphur than the coal of Missouri and a somewhat larger percentage of ash. It would seem that for domestic purposes the coal of these three states should rank about equal in value.

It will be noticed, also, that the calorific value of the Iowa coals compares very favorably with the coals of Missouri and Illinois, yielding on the average 6,144 calories and 11,066 British thermal units.

Results of steam tests show equivalent evaporation from and at 212 degrees as ranging from 7.02 to 7.50 pounds per pound of dry coal.

No thorough experiments were made on washing Iowa coals, but small lots of each sample were washed preparatory to making a test of their coking qualities. In all cases the results showed a notable reduction of ash and of sulphur, and it seemed probable that washing could be done to advantage in many parts of the Iowa field.

Coking tests were made on all samples of Iowa coals, but with indifferent success. In some cases no coke was produced; in others coke of fair quality was made. In all cases the coke was high in sulphur, which, of course, would preclude its use in an iron furnace, but it might be used in other ways.

No gas-producer tests were made during the regular work on Iowa coal, but later a run was made on the coal from Marion county. The test was not entirely satisfactory, as the quality of the gas varied greatly from time to time, but no clinkers formed in the producer, and it is probable that better results could be obtained on a second trial of this coal. Its high percentage of sulphur was a detriment, but it is probable that this can be eliminated with more careful work.

The figures on page 466 show that to produce 1 electrical horse-power hour with this coal in the producer required 1.73 pounds of dry coal, whereas under the steam boiler it required 4.95 pounds to produce the same result, a gain in efficiency for the producer of 186 per cent. As this coal ran nearly 17 per cent of ash in the car sample, the great advantage of using it in the producer plant will be apparent, and these results seem to open the way to the much better utilization of Iowa coals.

CHEMICAL ANALYSES OF IOWA NO. 1 COAL.
(Lump and fine coal from mine No. 2. Received from Anchor Coal Company, Laddsdale, Iowa.)

	Mine sample No. 1	Mine sample No. 2	Car sample	Sample from boiler test*	Sample of coal from coke test, washed coal	Coke sample, washed coal†
Laboratory sample number......	1270	1271	1347	1357	1356	1371
Loss of moisture on air drying—per cent	7.90	8.00	3.20	2.30	4.30	8.60
Analysis of air-dried sample:						
Proximate—						
Moisture ....per cent..	3.74	4.43	5.21	6.54	8.92	2.11
Volatile matter........do....	41.96	40.52	31.76	33.86	37.53	1.79
Fixed carbon..........do....	42.89	41.65	46.51	40.83	42.84	77.01
Ash ....do....	11.41	13.40	16.52	18.77	10.71	19.09
	100.00	100.00	100.00	100.00	100.00	100.00
Ultimate—						
Hydrogen ....do....	-------	-------	4.61	-------	-------	-------
Carbon ....do....	-------	-------	61.80	-------	-------	-------
Nitrogen ....do....	-------	-------	.97	-------	-------	-------
Oxygen ....do....	-------	-------	10.90	-------	-------	-------
Sulphur ....do....	5.12	5.42	5.20	6.54	4.82	4.25
Ash ....do....	-------	-------	16.52	-------	-------	-------
			100.00			
Calorific value determined, calories	6,843	-------	6,329	-------	-------	-------
Calorific value determined, B. T. U.	12,317	-------	11,392	-------	-------	-------
Calorific value calculated from ultimate analysis—calories......	-------	-------	6,230	-------	-------	-------
Calorific value calculated from ultimate analysis—B. T. U......	-------	-------	11,214	-------	-------	-------
Phosphorus in coke............	-------	-------	-------	-------	-------	.051
Analysis corrected to sample as received:						
Proximate—						
Moisture ....per cent..	11.35	12.07	8.24	8.69	12.84	10.53
Volatile matter........do....	38.65	37.28	30.74	33.08	35.91	1.63
Fixed carbon..........do....	39.49	38.32	45.02	39.89	41.00	70.39
Ash ....do....	10.51	12.33	16.00	18.34	10.25	17.45
	100.00	100.00	100.00	100.00	100.00	100.00
Ultimate—						
Hydrogen ....do....	-------	-------	4.81	-------	-------	-------
Carbon ....do....	-------	-------	59.82	-------	-------	-------
Nitrogen ....do....	-------	-------	.94	-------	-------	-------
Oxygen ....do....	-------	-------	13.40	-------	-------	-------
Sulphur ....do....	4.72	4.99	5.03	6.39	4.61	3.89
Ash ....do....	-------	-------	16.00	-------	-------	-------
			100.00			
Calorific value determined, calories	6,303	-------	6,126	‡ 5,805	-------	-------
Calorific value determined, B. T. U.	11,345	-------	11,027	‡10,449	-------	-------

*Refuse from boiler test, laboratory No. 1358: Combustible, 13.12 per cent; ash, 86.88 per cent.

†Specific gravity of the coke substance, 1.87; apparent specific gravity of the coke, 0.93; percentage of porosity, 51 per cent.

‡Derived from the determinations on the carload sample.

CHEMICAL ANALYSES OF IOWA NO. 2 COAL.

(Run-of-mine coal from mine No. 5. Received from Mammoth Vein Coal Company, Hamilton, Iowa.)

	Mine sample No. 1	Mine sample No. 2	Car sample*	Car sample (second portion)†	Sample from boiler test‡	Sample from gas-producer test	S'mple of coal from coke test w'sh'd coal
Laboratory sample number......	1289	1291	1570	1608	1490	1611	1483
Loss of moisture on air drying, per cent	9.30	9.50	10.40	15.50	10.40	14.90	10.10
Analysis of air-dried sample:							
Proximate—							
Moisture ....per cent..	7.00	6.63	4.25	1.76	5.00	2.10	9.73
Volatile matter........do....	40.65	40.82	37.02	39.09	39.45	36.92	39.42
Fixed carbon ....do....	39.52	42.40	41.74	42.04	37.65	36.66	39.41
Ash ....do....	12.83	10.15	16.99	17.11	17.90	24.32	11.44
	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Ultimate—							
Hydrogen ....do....	------	------	4.84	------	------	------	------
Carbon ....do....	------	------	60.36	------	------	------	------
Nitrogen ....do....	------	------	1.46	------	------	------	------
Oxygen ....do....	------	------	11.15	------	------	------	------
Sulphur ....do....	5.49	5.74	5.20	6.09	5.28	6.40	4.37
Ash ....do....	------	------	16.99	------	------	------	------
Calorific value determined, calories	6,302	------	6,212	------	------	------	------
Calorific value determined, B. T. U.	11,344	------	11,182	------	------	------	------
Calorific value calculated from ultimate analysis—calories......	------	------	6,183	------	------	------	------
Calorific value calculated from ultimate analysis—B. T. U......	------	------	11,129	------	------	------	------
Analysis corrected to sample as received:							
Proximate—							
Moisture ....per cent..	15.65	15.50	14.21	16.99	14.88	16.69	18.85
Volatile matter........do....	36.87	36.94	33.17	33.03	35.35	31.42	35.44
Fixed carbon..........do....	35.84	38.37	37.40	35.52	33.73	31.19	35.43
Ash ....do....	11.64	9.19	15.22	14.46	16.04	20.70	10.28
	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Ultimate—							
Hydrogen ....do....	------	------	5.50	------	------	------	------
Carbon ....do....	------	------	54.08	------	------	------	------
Nitrogen ....do....	------	------	1.31	------	------	------	------
Oxygen ....do....	------	------	19.23	------	------	------	------
Sulphur ....do....	5.10	5.19	4.66	5.15	4.73	5.50	3.93
Ash ....do....	------	------	15.22	------	------	------	------
			100.00				
Calorific value determined, calories	5,716	------	5,566	------	§5,436	------	------
Calorific value determined, B. T. U.	10,289	------	10,019	------	§9,785	------	------

*Represents 10 tons of coal.
†Represents 6 tons of coal.
‡Refuse from boiler test. laboratory No. 1491: Combustible, 18.07 per cent; ash, 81.93 per cent.
§Derived from the determinations on the carload sample.

CHEMICAL ANALYSES OF IOWA NO. 3 COAL.

(Lump coal from mine No. 4. Received from Gibson Coal Mining Co., Altoona, Ia.)

	Mine sample No. 1	Mine sample No. 2	Car sample*	Sample from boiler test†	Sample of coal from coke test, washed coal	Coke sample washed coal ‡
Laboratory sample number......	1312	1313	1434	1392	1389	1399
Loss of moisture on air drying—per cent	9.60	11.00	9.80	1.50	6.90	4.00
Analysis of air-dried sample:						
Proximate—						
Moisture ....Per cent..	5.33	5.51	4.52	11.11	10.67	1.80
Volatile matter.........do....	41.82	42.04	40.96	36.69	42.18	1.95
Fixed carbon.........do....	40.69	38.55	38.99	36.31	38.53	78.64
Ash ....do....	12.16	13.90	15.53	15.89	8.62	17.61
	100.00	100.00	100.00	100.00	100.00	100.00
Ultimate—						
Hydrogen ....do....	------	------	4.93	------	------	------
Carbon ....do....	------	------	60.62	------	------	------
Nitrogen ....do....	------	------	.93	------	------	------
Oxygen ....do....	------	------	11.16	------	------	------
Sulphur ....do....	6.52	7.59	6.83	6.16	4.88	4.76
Ash ....do....	------	------	15.53	------	------	------
			100.00			
Calorific value determined, calories	6,539	------	6,309	------	------	------
Calorific value determined, B. T. U.	11,770	------	11,356	------	------	------
Calorific value calculated from ultimate analysis—calories......	------	------	6,271	------	------	------
Calorific value calculated from ultimate analysis—B. T. U......	------	------	11,288	------	------	------
Phosphorus in coke..............	------	------	------	------	------	.018
Analysis corrected to sample as received:						
Proximate—						
Moisture ....per cent..	14.42	15.90	13.88	12.44	16.83	5.73
Volatile matter........do....	37.81	37.42	36.94	36.14	39.27	1.87
Fixed carbon..........do....	36.78	34.31	35.17	35.77	35.87	75.49
Ash ....do....	10.99	12.37	14.01	15.65	8.03	16.91
	100.00	100.00	100.00	100.00	100.00	100.00
Ultimate—						
Hydrogen ....do....	------	------	5.52	------	------	------
Carbon ....do....	------	------	54.68	------	------	------
Nitrogen ....do....	------	------	.84	------	------	------
Oxygen ....do....	------	------	18.80	------	------	------
Sulphur ....do....	5.89	6.76	6.15	6.07	4.55	4.57
Ash ....do....	------	------	14.01	------	------	------
			100.00			
Calorific value determined, calories	5,911	------	5,691	§ 5,679	------	------
Calorific value determined, B. T. U.	10,640	------	10,244	§10,222	------	------

*Represents 12 tons of coal.

†Refuse from boiler test, laboratory No. 1393: Combustible, 27.11 per cent; ash, 72.89 per cent.

‡Specific gravity of the coke substance, 1.88; apparent specific gravity of the coke, 0.81; percentage of porosity, 57.

§Derived from the determinations on the carload sample.

CHEMICAL ANALYSES OF IOWA NO. 4 COAL.

(Lump coal from mine No. 3. Received from Centerville Block Coal Company, Centerville, Iowa.)

	Mine sample No. 1	Mine sample No. 2	Car sample*	Sample from boiler test†	S'mple of coal from coke test w'sh'd coal	Coke sample w'sh'd coal‡	Sample of briquett's from boiler test§
Laboratory sample number	1323	1324	1437	1380	1378	1400	1488
Loss of moisture on air-drying—per cent	9.40	8.60	4.50	2.00	3.60	11.00	3.90
Analysis of air-dried sample:							
Proximate—							
Moisture ....per cent..	8.53	8.25	10.03	11.71	14.81	2.30	9.72
Volatile matter.......do....	39.12	38.23	37.27	34.79	38.99	2.60	37.98
Fixed carbon........do....	44.55	41.40	41.22	38.04	38.79	82.14	39.38
Ash ....do....	7.80	12.12	11.48	15.46	7.41	12.96	12.92
	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Ultimate—							
Hydrogen ....do....	------	------	5.31	------	------	------	5.42
Carbon ....do....	------	------	61.25	------	------	------	62.52
Nitrogen ....do....	------	------	.94	------	------	------	.78
Oxygen ....do....	------	------	16.56	------	------	------	14.31
Sulphur ....do....	4.42	5.21	4.46	5.14	3.70	3.33	4.05
Ash ....do....	------	------	11.48	------	------	------	12.92
			100.00				100.00
Calorific value determined—calories	6,703	------	6,237	------	------	------	6,292
Calorific value determined—B. T. U	12,065	------	11,227	------	------	------	11,326
Calorific value calculated from ultimate analysis—calories	------	------	6,165	------	------	------	6,394
Calorific value calculated from ultimate analysis—B. T. U.	------	------	11,097	------	------	------	11,509
Phosphorus in coke	------	------	------	------	------	.013	------
Analysis corrected to sample as received:							
Proximate—							
Moisture ....per cent..	17.13	16.14	14.08	13.48	17.88	13.05	13.24
Volatile matter.......do....	35.44	34.94	35.59	34.09	37.59	2.32	36.50
Fixed carbon........do....	40.36	37.84	39.37	37.28	37.39	73.10	37.85
Ash ....do....	7.07	11.08	10.96	15.15	7.14	11.53	12.41
	100.00	100.00	100.00	100.00	100.06	100.00	100.00
Ultimate—							
Hydrogen ....do....	------	------	5.57	------	------	------	5.64
Carbon ....do....	------	------	58.49	------	------	------	60.08
Nitrogen ....do....	------	------	.90	------	------	------	.75
Oxygen ....do....	------	------	19.82	------	------	------	17.22
Sulphur ....do....	4.00	4.76	4.26	5.04	3.57	2.97	3.90
Ash ....do....	------	------	10.96	------	------	------	12.41
			100.00				100.00
Calorific value determined—calories	6,073	------	5,957	** 5,613	------	------	6,047
Calorific value determined—B. T. U.	10,931	------	10,723	**10,103	------	------	10,885

*Represents 31 tons of coal.

†Refuse from the boiler test, laboratory No. 1381: Combustible, 19.25 per cent; ash, 80.75 per cent.

‡Specific gravity of the coke substance, 1.82; apparent specific gravity of the coke, 0.81; percentage of porosity, 55.

§Refuse from the boiler test of the briquettes, laboratory No. 1486: Combustible, 23.82 per cent; ash, 76.18 per cent.

**Derived from the determinations on the carload sample.

CHEMICAL ANALYSES OF IOWA NO. 5 COAL.
(Run-of-mine coal from mine No. 1. Received from Inland Fuel Company, Chariton, Iowa.)

	Mine sample No. 1	Mine sample No. 2	Car Sample*	Sample from boiler test†	Sample of coal from coke test washed coal
Laboratory sample number	1332	1333	1433	1423	1419
Loss of moisture on air drying—per cent	9.40	7.10	6.80	3.80	6.70
Analysis of air-dried sample:					
Proximate—					
Moisture.............per cent..	10.25	12.37	9.22	12.69	13.45
Volatile matter..........do....	35.10	36.98	32.71	33.01	33.30
Fixed carbon............do....	46.12	42.95	44.52	40.37	44.75
Ash ....do....	8.53	7.70	13.55	13.93	8.50
	100.00	100.00	100.00	100.00	100.00
Ultimate—					
Hydrogen ....do....	--------	--------	5.35	--------	--------
Carbon ....do....	--------	--------	59.89	--------	--------
Nitrogen ....do....	--------	--------	1.22	--------	--------
Oxygen ....do....	--------	--------	16.57	--------	--------
Sulphur ....do....	2.64	3.34	3.42	3.21	2.44
Ash ....do....	--------	--------	13.55	--------	--------
			100.00		
Calorific value determined—calories.	6,442	--------	6,105	--------	--------
Calorific value determined—B. T. U..	11,596	--------	10,989	--------	--------
Calorific value calculated from ultimate analysis—calories..........	--------	--------	6,045	--------	--------
Calorific value calculated from ultimate analysis—B. T. U............	--------	--------	10,881	--------	--------
Analysis corrected to sample as received:					
Proximate—					
Moisture ....per cent..	18.69	18.59	15.39	16.01	19.25
Volatile matter ....do....	31.80	34.36	30.49	31.76	31.07
Fixed carbon ....do....	41.78	39.90	41.49	38.83	41.75
Ash ....do....	7.73	7.15	12.63	13.40	7.93
	100.00	100.00	100.00	100.00	100.00
Ultimate—					
Hydrogen ....do....	--------	--------	5.74	--------	--------
Carbon ....do....	--------	--------	55.81	--------	--------
Nitrogen ....do....	--------	--------	1.14	--------	--------
Oxygen ....do....	--------	--------	21.49	--------	--------
Sulphur ....do....	2.39	3.10	3.19	3.09	2.28
Ash ....do....	--------	--------	12.63	--------	--------
			100.00		
Calorific value determined—calories.	5,836	--------	5,690	‡ 5,583	--------
Calorific value determined—B. T. U..	10,505	--------	10,242	‡ 10,049	--------

*Represents 7 tons of coal.
†Refuse from the boiler test, laboratory No. 1422: Combustible, 15.28 per cent; ash, 84.72 per cent.
‡Derived from the determinations on the carload sample.

BOILER TESTS ON IOWA COALS

Regular and special observations on test of Iowa No. 1 coal, November 3, 1904.

REGULAR.

(Duration of trial, 10.017 hours.)

Time	Steam pressure gage	Temperatures			Calorimeter		Draft pres'res		Flue gases		
		Outside	Boiler room	Flue gases, base of stack	Steam discharge	Water separated in 10 minutes	In hood, in inches of water	In furnace, in inches of water	CO_2.	O_2.	CO.
	Lbs.	°F.	°F.	°F.	Lbs.	Lbs.			Per ct	Per ct.	Per ct.
7.43	81			525			0.45	0.09			
8	90	45	52	475	4.48	0.029	.22	.07			
8.20	100	49	54	517			.33	.09			
8.40	90	50	56	517			.34	.09	9.4	9.5	0.0
9	100	52	58	483	4.78	.027	.29	.11			
9.20	92	55	60	500			.31	.11			
9.40	96	58	63	514			.29	.09	9.8	8.2	.3
10	97	59	66	506	4.60	.027	.36	.15			
10.20	89	60	66	514			.36	.13			
10.40	83	60	67	507			.39	.15	9.8	9.2	.4
11	81	60	67	507	3.69	.02	.52	.27			
11.20	62	62	68	480							
11.40	82	62	69	532			.53	.18	7.4	12.5	.0
12	78	62	71	556	4.12	.035	.53	.17			
12.20	84	63	70	524			.36	.10			
12.40	83	64	70	557			.51	.17	8.9	9.8	.2
1	79	64	71	553	4.00	.029	.52	.20			
1.20	85	64	70	562			.54	.22			
1.40	71	65	71	562			.52	.14	8.7	10.8	.0
2	86	65	72	580	3.86	.026	.61	.20			
2.20	64	65	73	552			.68	.12			
2.40	77	65	73	600			.70	.18	8.0	11.6	.0
3	90	66	74	528	4.16	.02	.18	.06			
3.20	83	65	73	537			.44	.17			
3.40	82	65	72	539			.44	.19	9.1	10.1	.3
4	80	65	72	573	3.95	.022	.54	.19			
4.20	80	63	71	557			.56	.25			
4.40	90	62	70	577			.61	.22	8.8	10.8	.0
5	79	61	69	575	4.16	.039	.66	.23			
5.20	79	60	68	502							
5.44	83			537			.66	.10	6.8	13.8	.0
Total	2,596	1,756	1,956	16,548	41.80	.274	13.45	4.44	86.7	106.3	1.2
Av.	83.7	60.5	67.4	534	4.18	.0274	.464	.153	8.67	10.63	.12

Regular and special observations on test of Iowa No. 1 coal, November 3, 1904. (Continued.)

SPECIAL.

Time	Height of water		Weight of coal burned		Weight of water fed to boiler	
	In tank	In gage glass	During period	Total	During period	Total
	Inches	*Inches*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
Start, 7.43	40.00	2.50				
8.08	31.50	4.75	700	700	1,632	1,632
8.42	26.00	5.00	700	1,400	3,409	5,041
9.14	27.25	4.75	700	2,100	3,182	8,223
9.56	36.50	4.50	700	2,800	3,978	12,201
10.43	24.75	5.50	700	3,500	4,154	16,355
11.38	31.50	3.00	700	4,200	4,898	21,253
12.07	26.50	5.00	700	4,900	2,779	24,032
12.50	35.25	2.50	700	5,600	4,779	28,811
1.29	29.75	2.75	700	6,300	4,042	32,853
2.20	30.50	3.25	700	7,000	4,857	37,710
2.46	33.75	3.75	700	7,700	2,172	39,882
3.16	32.00	3.50	700	8,400	3,359	43,241
4	24.50	4.00	700	9,100	4,710	47,951
4.42	27.50	4.50	700	9,800	4,089	52,040
Close, 5.44	40.00	3.00	531	10,331	5,333	57,373

RECORD OF FURNACE CONDITIONS.

Time	Observation	Time	Observation
	Boiler under a load during night.	1.06	Fire raked, 8 inches thick.
7	Cleaned fire.	1.40	Fire sliced, 10 inches thick.
7.43	Test started, fire 2 inches thick.	2	Fire raked, 10 inches thick.
9.01	Fire raked, 7 inches thick.	2.03	Cleaning fire.
9.33	Fire sliced, 9 inches thick.	2.18	Fire cleaned, 4 inches thick.
9.49	Fire raked, 10 inches thick.	2.44	Fire raked, 6 inches thick.
10.14	Do.	3.10	Fire raked, 8 inches thick.
10.53	Do.	3.35	Do.
11.10	Cleaning fire.	3.57	Do.
11.23	Fire cleaned, 3 inches thick.	4.30	Fire sliced, 9 inches thick.
11.49	Fire raked, 6 inches thick.	5.05	Fire raked.
12.27	Fire raked, 8 inches thick.	5.08	Cleaning fire.
12.47	Fire raked, 7 inches thick.	5.20	Fire cleaned, 3 inches thick.
		5.44	Test closed, fire 2 inches thick.

Refuse dark and heavy. Coal burned freely with long flame. 99 firings during test.

Steam Test of Iowa No. 1 Coal

CONDITIONS OF BOILER TRIAL.

Made by boiler division, United States Geological Survey.
At fuel-testing plant, Louisiana Purchase Exposition, St. Louis, Mo.
Kind of boiler, Heine safety.
To determine the economy of coal as a fuel.
Steam jets not operated. Hughes apparatus operated.
Kind of fuel, Iowa No. 1.
Kind of furnace, hand fired.
State of the weather, cloudy.
Method of starting and stopping the test, alternate.
Number of boiler (plant number), 2.
Type of boiler, water tube.

1.	Date of trial, November 3, 1904.		
2.	Duration of trial	hours..	10.017

DIMENSIONS AND PROPORTIONS.

3.	Grate surface	square feet..	40.55
3.1	Width of grate	feet..	6.16
3.2	Length of grate	do ..	6.58
4.	Height of furnace	inches..	26.
5.	Approximate width of air spaces in grate	do...	.5
6.	Proportion of air space to whole grate surface	per cent..	44
6.1	Area of chimney	square feet..	7.67
6.2	Height of chimney above grate	feet..	113.25
6.3	Length of flue connecting to chimney	do ..	None
6.4	Kind of draft		Natural
7.	Water-heating surface	square feet..	2,031
7.1	Outside diameter of shell	inches..	42.94
7.2	Length of shell (outside to outside of heads)	feet..	21.58
7.3	Number of tubes		116
7.4	Diameter of tubes (outside—inside)	inches.. / ..do....	3.5 / 3.26
7.5	Length of tubes exposed	feet..	17.87
8.	Superheating surface	Square feet..	None
9.	Ratio of water-heating surface to grate surface		50.1:1
10.	Ratio of minimum draft area to grate surface		1:9.1

AVERAGE PRESSURES.

11.	Barometer	inches of mercury.. / pounds..	29.61 / 14.53
11.1	Steam pressure by gage per square inch	..do.... / ..do....	83.70 / *98.23
12.	Force of draft between damper and boiler	inches of water..	.46
13.	Force of draft in furnace	do....	.15
14.	Force of draft or blast in ash pit	do....	0

*Absolute.

AVERAGE TEMPERATURES.

15.	Of external air	degrees..	60.5
16.	Of fireroom	do....	67.4
17.	Of steam	do....	326.3
18.	Of feed water in tank	do....	57.4
19.	Of feed water entering economizer	do....	....
20.	Of feed water entering boiler	do....	195
21.	Of escaping gases from boiler	do....	534
22.	Of escaping gases from economizer	do....	....
22.1	Of furnace	do....	....

FUEL.

23. Size and condition: Nut—small, 80 per cent; slack, 20 per cent; dull.

24.	Weight of wood used in lighting fire	pounds..	None
25.	Weight of coal as fired	do....	10,331
26.	Percentage of moisture in coal		8.69
27.	Total weight of dry coal consumed	pounds..	9,433
28.	Total ash and refuse	do....	1,875
29.	Quality of ash and refuse: Clinker	per cent..	63
30.	Total combustible consumed	pounds..	7,558
		do....	*7,292
31.	Percentage of ash and refuse in dry coal		19.88

PROXIMATE ANALYSIS OF COAL.

		Per cent of coal	Per cent of combustible
32.	Fixed carbon	39.89	54.66
33.	Volatile matter	33.08	45.34
34.	Moisture	8.69	....
35.	Ash	18.34	....
		100.00	100.00
36.	Sulphur, separately determined	6.39	....

ULTIMATE ANALYSIS OF DRY COAL.

37.	Carbon (C)	61.67	77.17
38.	Hydrogen (H)	4.01	5.02
39.	Oxygen (O)	6.26	7.83
40.	Nitrogen (N)	.97	1.21
41.	Sulphur (S)	7.00	8.77
42.	Ash	20.09	....
		100.00	100.00
43.	Moisture in sample of coal as received	8.69	....

ANALYSIS OF ASH AND REFUSE.

44.	Carbon	per cent..	13.12
45.	Earthy matter	do....	86.88

*Calculated from chemistry of ash.

FUEL PER HOUR.

46.	Dry coal consumed per hour	pounds..	942
47.	Combustible consumed per hour	..do.... / ..do....	755 / *728
48.	Dry coal per square foot of grate surface per hour	do....	23.23
49.	Combustible per square foot of water-heating surface per hour	..do.... / ..do....	.372 / *.358

CALORIFIC VALUE OF FUEL.

50.	Calorific value by oxygen calorimeter per pound of dry coal, B. T. U	11,443
51.	Calorific value by oxygen calorimeter per pound of combustible, B. T. U	14,320
52.	Calorific value by analysis, per pound of dry coal, B. T. U	11,257
53.	Calorific value by analysis, per pound of combustible, B. T. U	14,087

QUALITY OF STEAM.

54.	Percentage of moisture in steam		.651
55.	Number of degrees of superheating		....
56.	Quality of steam (dry steam=unity)	per cent..	99.5

WATER.

57.	Total weight of water fed to boiler	pounds..	57,373
58.	Equivalent water fed to boiler from and at 212°	do....	68,675
59.	Water actually evaporated, corrected for quality of steam	do....	57,086
60.	Factor of evaporation		1.197
61.	Equivalent water evaporated into dry steam from and at 212°	pounds..	68,332

WATER PER HOUR.

62.	Water evaporated per hour, corrected for quality of steam	pounds..	5,690
63.	Equivalent evaporation per hour from and at 212°	do....	6,822
64.	Equivalent evaporation per hour from and at 212° per square foot of water-heating surface	pounds..	3.36

HORSEPOWER.

65.	Horsepower developed (34½ pounds of water evaporated per hour into dry steam from and at 212°=1 horsepower)	197.7
66.	Builders' rated horsepower	210
67.	Percentage of builders' rated horsepower developed	94.16

ECONOMIC RESULTS.

68.	Water apparently evaporated under actual conditions per pound of coal as fired. (Item 57÷item 25)	pounds..	5.55
69.	Equivalent evaporation from and at 212° per pound of coal as fired. (Item 61÷item 25)	pounds..	6.61
70.	Equivalent evaporation from and at 212° per pound of dry coal. (Item 61÷item 27)	pounds..	7.24

*Calculated from chemistry of ash.

71.	Equivalent evaporation from and at 212° per pound of combustible (Item 61÷item 30)	..do....	9.04
		do....	*9.37

EFFICIENCY.

72.	Efficiency of the boiler (heat absorbed by the boiler per pound of combustible divided by the heat value of 1 pound of combustible	per cent..	60.96
		....do....	*63.19
73.	Efficiency of boiler, including the grate (heat absorbed by the boiler per pound of dry coal divided by the heat value of 1 pound of dry coal)	per cent..	61.10

COST OF EVAPORATION.

74.	Cost of coal per ton of 2,000 pounds delivered in boiler room (assumed)	$1.00
75.	Cost of fuel for evaporating 1,000 pounds of water under observed conditions	$0.09
76.	Cost of fuel used for evaporating 1,000 pounds of water from and at 212°	$0.0756

SMOKE OBSERVATIONS.

77.	Percentage of smoke as observed		50.4
78.	Weight of soot per hour obtained from smoke meter	ounces..	....
79.	Volume of soot per hour obtained from smoke meter	cubic inches..	....

METHOD OF FIRING.

80.	Kind of firing (spreading, alternate or coking)		Alternate
81.	Average thickness of fire	inches..	8
82.	Average intervals between firing for each furnace during time when fires are in normal condition	minutes..	6
83.	Average intervals between times of leveling or breaking up	minutes..	30

ANALYSIS OF THE DRY GASES.

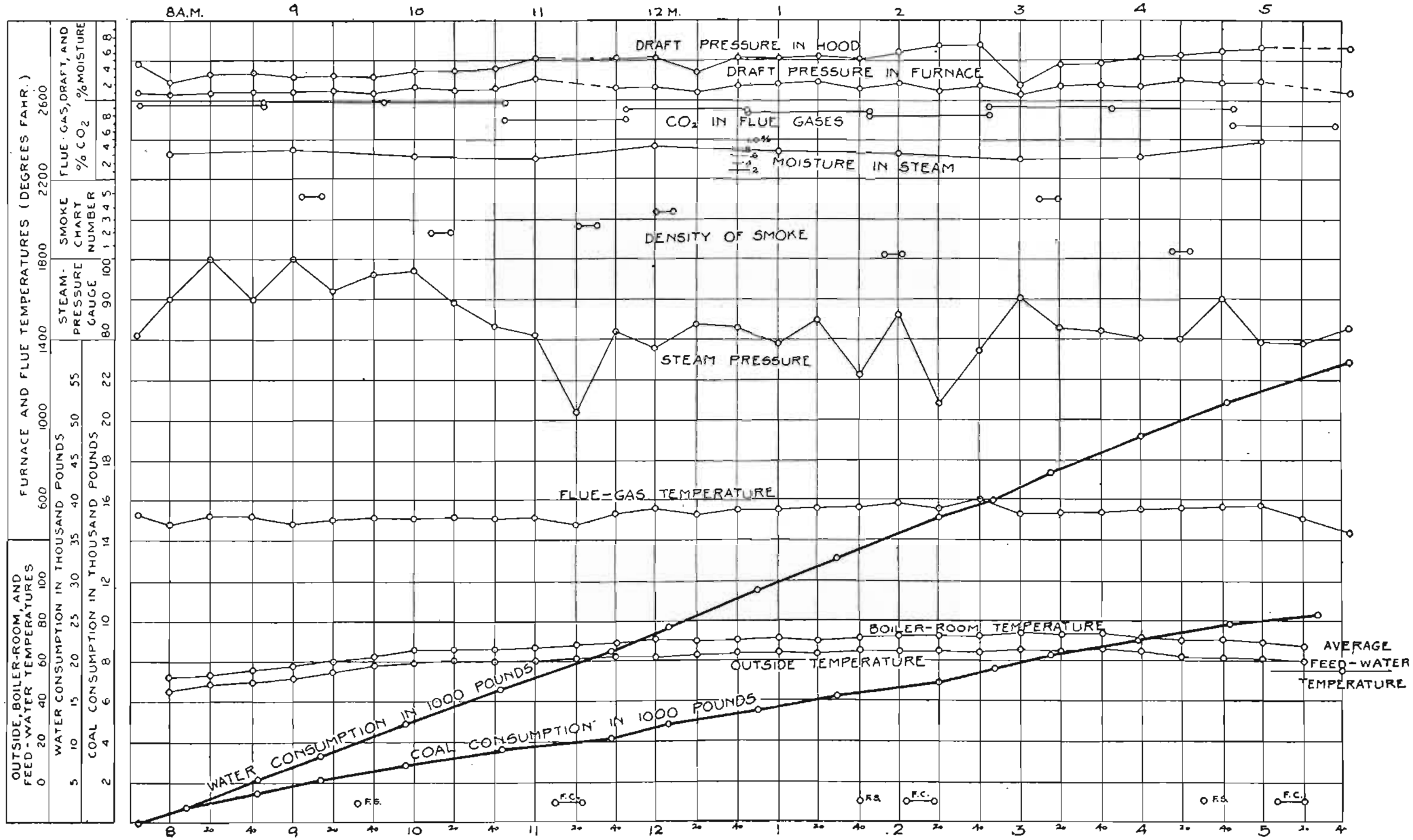
84.	Carbon dioxide (CO_2)	per cent..	8.67
85.	Oxygen (O)	do....	10.63
86.	Carbon monoxide (CO)	do....	.12
87.	Hydrogen and hydrocarbons	do....	....
88.	Nitrogen (by difference) (N)	do....	80.58

HEAT BALANCE, OR DISTRIBUTION OF THE HEATING VALUE OF THE COMBUSTIBLE.

Total heat value of 1 pound of combustible, B. T. U. 14,320

		B. T. U.	Per cent.
1.	Heat absorbed by the boiler=evaporation from and at 212° per pound of combustible×965.7	9,049	*63.19
2.	Loss due to moisture in coal=per cent of moisture referred to combustible÷100×[(212−t)+966+0.48 (T−212)] (t=temperature of air in the boiler room; T=that of the flue gases)	151	1.05

*Calculated from chemistry of ash.



Graphic log sheet, Iowa No. 1 coal (nut, dull).

3. Loss due to moisture formed by the burning of hydrogen= per cent of hydrogen to combustible÷100×9×[(212−t)+966+0.48 (T−212)]	572	3.99
4. Loss due to heat carried away in the dry chimney gases= weight of gas per pound of combustible×0.24×(T−t)	2,442	17.05
5. Loss due to incomplete combustion of carbon= $\frac{CO}{CO_2+CO}\times\frac{\text{per cent C in combustible}}{100}\times 10{,}150$	107	.75
6. Loss due to unconsumed hydrogen and hydrocarbons, to heating the moisture in the air, to radiation, and unaccounted for. (Some of these losses may be separately itemized if data are obtained from which they may be calculated)	1,999	13.97
		100.00

REMARKS.

Dry coal per indicated horsepower hour = 3.91 pounds.
Dry coal per electrical horsepower hour = 4.82 pounds.

*Calculated from chemistry of ash.

Regular and special observation on test of Iowa No. 2 coal, November 28, 1904.

REGULAR.

(Duration of trial, 9.917 hours.)

Time	Steam pressure gage	Temperatures			Calorimeter		Draft pres'res		Flue gases		
		Outside	Boiler room	Flue gases, base of stack	Steam discharge	Water separated in 10 minutes	In hood, in inches of water	In furnace, in inches of water	CO_2.	O_2.	CO.
	Lbs.	°F.	°F.	°F.	Lbs.	Lbs.			Per ct.	Per ct.	Per ct.
7.29	85			615			0.58	0.14			
7.40	97	30	50	625			.59	.13			
8	92	32	50	650	4.51	0.033	.62	.16			
8.20	91	34	51	640			.61	.18	7.2	12.2	0.0
8.40	89	35	51	610			.57	.18			
9	81	36	52	615	4.07	.04	.61	.26			
9.20	84	38	53	635			.53	.16	8.9	10.6	.0
9.40	81	39	54	605			.59	.19			
10	80	40	56	605	3.98	.037	.61	.20			
10.20	78	41	57	615			.59	.22	8.0	11.7	.0
10.40	79	43	58	615			.57	.24			
11	80	45	59	615	3.86	.04					
11.20	81	48	63	630			.56	.17	7.6	11.8	.0
11.40	77	50	63	625			.57	.15			
12	79	51	64	635	3.93	.045	.62	.24			
12.20	85	52	64	655			.68	.20	8.8	10.2	.3
12.40	78	52	64	620			.59	.20			
1	83	54	65	630	4.05	.034	.60	.22			
1.20	83	54	66	600			.69	.22	8.2	11.8	.0
1.40	82	55	66	645			.68	.24			
2	80	56	67	570	3.81	.04					
2.20	81	56	70	630			.61	.12	7.5	12.3	.0
2.40	82	57	69	650			.66	.26			
3	83	57	70	655	4.05	.02	.63	.15			
3.20	82	57	70	655			.70	.25	8.6	10.7	.2
3.40	75	57	70	650			.68	.30			
4	81	57	70	650	4.10	.04	.68	.30			
4.20	82	57	70	645			.66	.27	8.3	11.5	.4
4.40	81	57	68	635			.68	.22			
5	81	56	68	560	4.21	.045					
5.24	84			645			.59		7.9	12.0	.0
Total	2,557	1,396	1,798	19,430	40.57	.374	17.35	5.57	81.0	114.8	.9
Av.	82.5	48	62	627	4.057	.0374	.62	.21	8.1	11.48	.09

Regular and special observations on test of Iowa No. 2 coal, November 28, 1904—Continued.

SPECIAL.

Time	Height of water		Weight of coal burned		Weight of water fed to boiler	
	In tank	In gage glass	During period	Total	During period	Total
	Inches	*Inches*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
Start, 7.29	40.00	3.75				
7.57	31.00	4.50	700	700	2,177	2.177
8.27	24.50	3.00	700	1,400	3,435	5,612
8.56	30.00	3.25	700	2,100	2,760	8,372
9.46	26.50	3.50	700	2,800	4,562	12,934
10.22	29.50	5.25	700	3,500	3,046	15,980
11.16	25.00	2.00	700	4,200	4,533	20,513
11.47	30.00	2.00	700	4,900	3,510	24,023
12.16	28.00	4.25	700	5,600	2,518	26,541
1.04	27.50	4.75	700	6,300	4,298	30,839
1.38	28.50	2.75	700	7,000	3,798	34,637
2.23	24.00	2.75	700	7,700	3,438	38,075
2.54	24.00	2.00	700	8,400	2,794	40,869
3.25	20.00	2.75	700	9,100	3,149	44,018
3.57	30.00	4.75	700	9,800	3,164	47,182
4.33	30.50	4.50	700	10,500	3,228	50,410
Close, 5.24	40.00	3.25	486	10,986	4,620	55,030

RECORD OF FURNACE CONDITIONS.

Time	Observation	Time	Observation
		1.16	Fire sliced, 8 inches thick.
	Boiler under light load during night.	1.29	Fire raked, 8 inches thick.
7	Fire cleaned.	1.55	Cleaning fire.
7.29	Test started, fire 2 inches thick.	2.05	Fire cleaned, 3 inches thick.
		2.37	Fire raked, 7 inches thick.
		3.03	Fire raked, 8 inches thick.
8.50	Fire raked, 7 inches thick.	3.32	Do.
9.10	Fire sliced, 8 inches thick.	3.50	Do.
9.43	Fire raked, 8 inches thick.	4.12	Do.
10.05	Do.	4.16	Fire sliced, 8 inches thick.
10.16	Fire sliced, 9 inches thick.	4.46	Fire raked, 9 inches thick.
10.36	Fire raked, 10 inches thick.	4.56	Cleaning fire.
10.55	Fire raked, 8 inches thick.	5.05	Fire cleaned, 3 inches thick.
11.02	Cleaning fire.	5.20	Fire raked, 2 inches thick.
11.12	Fire cleaned, 3 inches thick.	5.24	Test closed, fire 2 inches thick.
11.50	Fire raked, 6 inches thick.		
12.14	Fire raked, 8 inches thick.		
12.44	Do.		
1.09	Do.		

Clinker dark and heavy. Firing deadened the fire. Coal did not burn freely. 106 firings during test.

Steam Test of Iowa No. 2 Coal

CONDITIONS OF BOILER TRIAL.

Made by boiler division, United States Geological Survey.
At fuel-testing plant, Louisiana Purchase Exposition, St. Louis, Mo.
Kind of boiler (commercial name), Heine Safety.
To determine the economy of coal as a fuel.
Steam jets not operated. Hughes apparatus operated.
Kind of fuel, Iowa No. 2.
Kind of furnace, hand fired.
State of the weather, cloudy.
Method of starting and stopping the test, alternate.
Number of boiler (plant number), 2.
Type of boiler, water tube.

1.	Date of trial, November 28, 1904.		
2.	Duration of trial	hours	9.917
3-10	Dimensions and proportions of boiler same as given in test of coal No. 1.		

AVERAGE PRESSURES.

11.	Barometer	inches of mercury	29.23
		pounds	14.35
11.1	Steam pressure by gage per square inch	do	82.5
		do	*96.85
12.	Force of draft between damper and boiler	inches of water	.62
13.	Force of draft in furnace	do	.21
14.	Force of draft or blast in ash pit	do	0

AVERAGE TEMPERATURES.

15.	Of external air	degrees	48
16.	Of fireroom	do	62
17.	Of steam	do	325.3
18.	Of feed water in tank	do	48
19.	Of feed water entering economizer	do	....
20.	Of feed water entering boiler	do	169
21.	Of escaping gases from boiler	do	627
22.	Of escaping gases from economizer	do	....
22.1	Of furnace	do	....

FUEL.

23.	Size and condition: Nut—small, 50 per cent; slack, 50 per cent; very dirty.		
24.	Weight of wood used in lighting fire	pounds	None
25.	Weight of coal as fired	do	10,986
26.	Percentage of moisture in coal		14.88
27.	Total weight of dry coal consumed	pounds	9,351
28.	Total ash and refuse	do	1,629
29.	Quality of ash and refuse, clinker	per cent	58
30.	Total combustible consumed	pounds	7,722
		do	†7,294
31.	Percentage of ash and refuse in dry coal		17.44

*Absolute.
†Calculated from chemistry of ash.

PROXIMATE ANALYSIS OF COAL.

		Per cent of coal	Per cent of combustible
32.	Fixed carbon	33.73	48.83
33.	Volatile matter	35.35	51.17
34.	Moisture	14.88	....
35.	Ash	16.04	....
		100.00	100.00
36.	Sulphur, separately determined	4.73	....

ULTIMATE ANALYSIS OF DRY COAL.

37.	Carbon (C)	62.04	76.42
38.	Hydrogen (H)	4.49	5.53
39.	Oxygen (O)	7.59	9.35
40.	Nitrogen (N)	1.50	1.85
41.	Sulphur (S)	5.56	6.85
42.	Ash	18.82	....
		100.00	100.00
43.	Moisture in sample of coal as received	14.88	....

ANALYSIS OF ASH AND REFUSE.

44.	Carbon	per cent..	18.07
45.	Earthy matter	do....	81.93

FUEL PER HOUR.

46.	Dry coal consumed per hour	pounds..	944
47.	Combustible consumed per hour	..do.... ..do....	779 *736
48.	Dry coal per square foot of grate surface per hour	do....	23.28
49.	Combustible per square foot of water-heating surface per hour	..do.... ..do....	.383 *.363

CALORIFIC VALUE OF FUEL.

50.	Calorific value by oxygen calorimeter per pound of dry coal, B. T. U.	11,497
51.	Calorific value by oxygen calorimeter per pound of combustible, B. T. U.	14,162
52.	Calorific value by analysis per pound of dry coal, B. T. U.	11,444
53.	Calorific value by analysis per pound of combustible, B. T. U.	14,097

QUALITY OF STEAM.

54.	Percentage of moisture in steam		.913
55.	Number of degrees of superheating		None
56.	Quality of steam (dry steam=unity)	per cent..	99.3

*Calculated from chemistry of ash.

WATER.

57. Total weight of water fed to boiler....................pounds.. 55,030
58. Equivalent water fed to boiler from and at 212°...........do.... 66,394
59. Water actually evaporated, corrected for quality of steam..do.... 54,645
60. Factor of evaporation.. 1.2065
61. Equivalent water evaporated into dry steam from and at 212° ....pounds.. 65,929

WATER PER HOUR.

62. Water evaporated per hour, corrected for quality of steam ....pounds.. 5,510
63. Equivalent evaporation per hour from and at 212°......do.... 6,648
64. Equivalent evaporation per hour from and at 212° per square foot of water-heating surface................pounds.. 3.27

HORSEPOWER.

65. Horsepower developed (34½ pounds of water evaporated per hour into dry steam from and at 212°=1 horsepower).......... 192.7
66. Builders' rated horsepower................................ 210
67. Percentage of builder's rated horsepower developed........... 91.76

ECONOMIC RESULTS.

68. Water apparently evaporated under actual conditions per pound of coal as fired. (Item 57÷item 25).................pounds.. 5.01
69. Equivalent evaporation from and at 212° per pound of coal as fired. (Item 61÷item 25).......................pounds.. 6
70. Equivalent evaporation from and at 212° per pound of dry coal. (Item 61÷item 27)..............................pounds.. 7.05
71. Equivalent evaporation from and at 212° per pound of combustible. (Item 61÷item 30).............. { ..do.... 8.54 / ..do.... *9.04 }

EFFICIENCY.

72. Efficiency of the boiler (heat absorbed by the boiler per pound of combustible divided by the heat value of 1 pound of combustible)................. { per cent.. 58.23 / ....do.... *61.64 }
73. Efficiency of boiler, including the grate (heat absorbed by the boiler per pound of dry coal divided by the heat value of 1 pound of dry coal)...........................per cent.. 59.22

COST OF EVAPORATION.

74. Cost of coal per ton of 2,000 pounds delivered in boiler room (assumed) $1.00
75. Cost of fuel for evaporating 1,000 pounds of water under observed conditions $0.0998
76. Cost of fuel used for evaporating 1,000 pounds of water from and at 212° $0.0833

*Calculated from chemistry of ash.

SMOKE OBSERVATIONS.

77.	Percentage of smoke as observed	46.8
78.	Weight of soot per hour obtained from smoke meter....ounces..	....
79.	Volume of soot per hour obtained from smoke meter ....cubic inches..	....

METHOD OF FIRING.

80.	Kind of firing (spreading, alternate or coking)	Alternate
81.	Average thickness of fire....inches..	8
82.	Average intervals between firing for each furnace during time when fires are in normal condition....minutes..	5.6
83.	Average intervals between times of leveling or breaking up ....minutes	25

ANALYSIS OF THE DRY GASES.

84.	Carbon dioxide (CO_2)....per cent..	8.1
85.	Oxygen (O) ....do....	11.48
86.	Carbon monoxide (CO)....do....	.09
87.	Hydrogen and hydrocarbons....do....	....
88.	Nitrogen (by difference) (N)....do....	80.33

HEAT BALANCE, OR DISTRIBUTION OF THE HEATING VALUE OF THE COMBUSTIBLE.

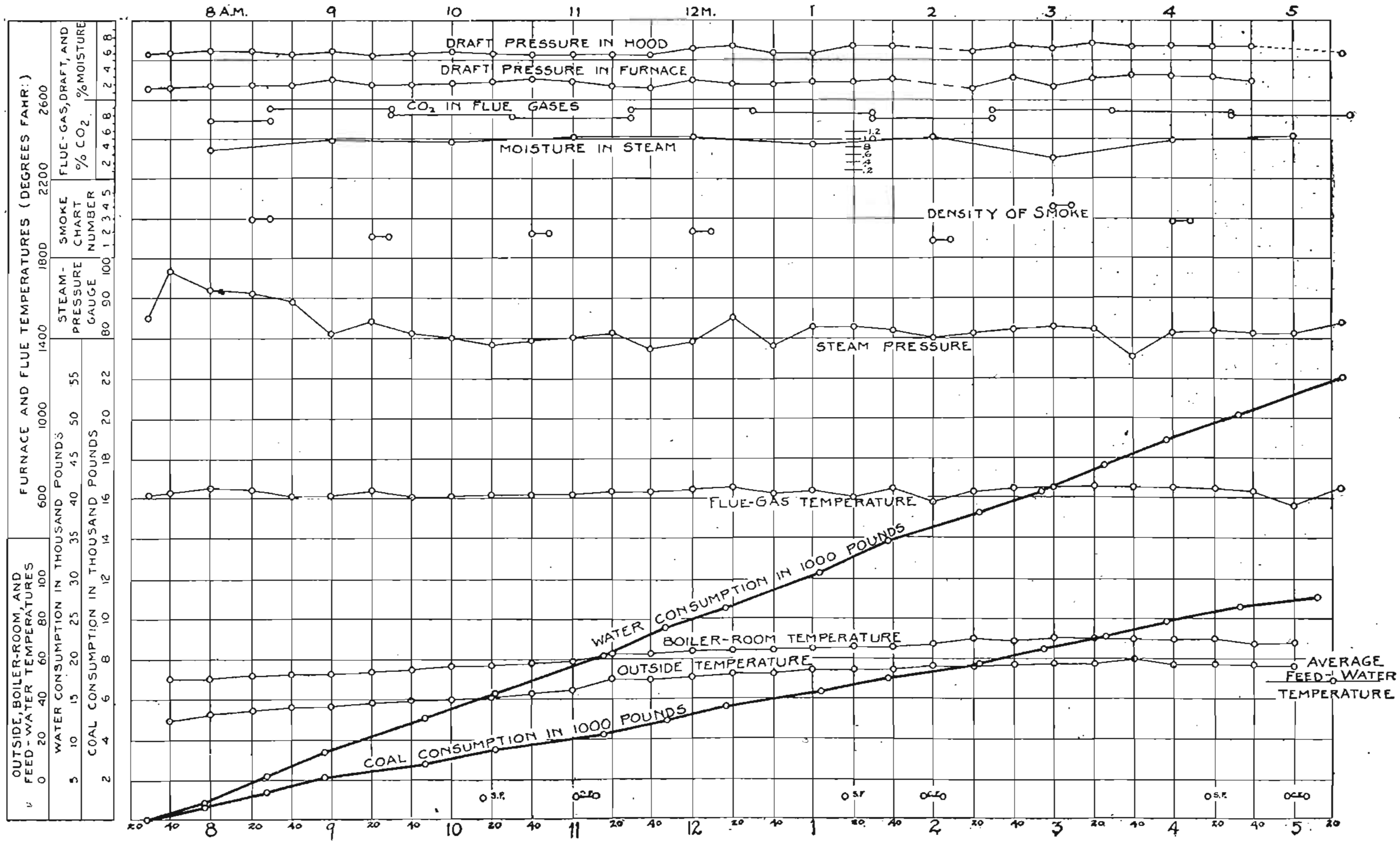
Total heat value of 1 pound of combustible, B. T. U. 14,162

		B. T. U.	Per cent.
1.	Heat absorbed by the boiler=evaporation from and at 212° per pound of combustible×965.7	8,730	*61.64
2.	Loss due to moisture in coal=per cent of moisture referred to combustible÷100×[$(212-t)+966+0.48$ $(T-212)$] (t= temperature of air in the boiler room; T=that of the flue gases	279	1.97
3.	Loss due to moisture formed by the burning of hydrogen=per cent of hydrogen to combustible÷100×9×[$(212-t)+966+0.48$ $(T-212)$]	650	4.59
4.	Loss due to heat carried away in the dry chimney gases= weight of gas per pound of combustible×0.24×$(T-t)$	3,137	22.15
5.	Loss due to incomplete combustion of carbon= $\frac{CO}{CO^2+CO}\times\frac{\text{per cent C in combustible}}{100}\times 10{,}150$	85	.62
6.	Loss due to unconsumed hydrogen and hydrocarbons, to heating the moisture in the air, to radiation, and unaccounted for. (Some of these losses may be separately itemized if data are obtained from which they may be calculated)	1,281	9.03
			100.00

REMARKS.

Dry coal per indicated horsepower hour=4.01 pounds.
Dry coal per electrical horsepower hour=4.95 pounds.

*Calculated from chemistry of ash.



Graphic log sheet, Iowa No. 2 coal (nut, dirty).

Regular and special observations on test of Iowa No. 3 coal, November 8, 1904.

REGULAR.

(Duration of trial, 10.033 hours.)

Time	Steam-pressure gage	Temperatures			Calorimeter		Draft pres'res		Flue gases		
		Outside	Boiler room	Flue gases, base of stack	Steam discharge	Water separated in 10 minutes	In hood, in inches of water	In furnace, in inches of water	CO_2.	O_2.	CO.
	Lbs.	*°F.*	*°F.*	*°F.*	*Lbs.*	*Lbs.*			*Per ct.*	*Per ct.*	*Per ct.*
7.46	82	47	50				0.12	0.06			
8	78	47	50	580			.69	.18			
8.20	84	47	50	625			.73	.24			
8.40	84	47	48	555	4.10	0.043	.47	.21	7.2	12.0	0.0
9	82	48	49	550			.47	.15			
9.20	83	50	51	556			.47	.19			
9.40	83	51	51	560	4.08	.038	.55	.30	8.7	11.6	.3
10	83	52	56	560			.51	.18			
10.20	86	53	58	555			.54	.26			
10.40	78	54	60	549	4.08	.059	.53	.22	8.6	11.1	.1
11	75	55	64	525			.55	.10			
11.20	82	56	64	590			.58	.19			
11.40	89	57	66	600	4.10	.023	.66	.18	7.8	13.0	.0
12	85	57	65	610			.59	.19			
12.20	82	58	66	595			.61	.23			
12.40	78	57	66	590	3.91	.047	.62	.25	7.6	13.8	.0
1	83	57	66	580			.59	.26			
1.20	84	56	67	575			.67	.29			
1.40	80	56	68	570	4.02	.05	.60	.32	6.7	13.4	.0
2	83	56	67	554			.60	.31			
2.20	94	56	68	565			.57	.16			
2.40	80	56	68	610	3.81	.021	.60	.16	6.0	14.4	.0
3	79	56	68	620			.60	.19			
3.20	90	56	67	616			.67	.20			
3.40	89	55	67	603	4.44	.037	.61	.23	6.6	13.6	.0
4	95	55	66	595			.60	.22			
4.20	75	54	65	574			.59	.31			
4.40	93	53	64	565	4.44	.047	.64	.35	6.8	13.6	.0
5	78	52	63	550			.70	.36			
5.20	90	51	64	560			.60	.18			
5.48	80	49	63	600					5.8	14.7	.0
Total	2,587	1,656	1,905	17,337	36.98	.365	17.33	6.67	71.8	131.2	.4
Av.	83.5	53.4	61.5	578	4.11	.0406	.578	.222	7.18	13.12	.04

Regular and special observations on test of Iowa No. 3 coal, November 8, 1904—Continued.

SPECIAL.

Time	Height of water		Weight of coal burned		Weight of water fed to boiler	
	In tank	In gage glass	During period	Total	During period	Total
	Inches	*Inches*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
Start, 7.46	40.00	3.00				
8.08	42.25	4.25	700	700	1,340	1,340
8.38	38.50	3.00	700	1,400	3,187	4,527
9.13	43.50	5.00	700	2,100	2,823	7,350
9.40	42.75	4.00	700	2,800	2,922	10,272
10.17	39.00	2.75	700	3,500	3,821	14,093
11.11	35.00	3.25	700	4,200	4,502	18,595
11.42	33.00	3.50	700	4,900	3,203	21,798
12.25	35.00	3.75	700	5,600	4,234	26,032
1.08	38.50	4.50	700	6,300	3,975	30,007
1.55	37.50	3.00	700	7,000	4,377	34,384
2.43	42.00	3.75	700	7,700	3,281	37,665
3.24	42.50	3.00	700	8,400	4,046	41,711
4.01	44.50	5.00	700	9,100	2,985	44,696
4.29	41.00	2.50	700	9,800	3,600	48,296
5.28	35.00	4.00	700	10,500	4,278	52,574
Close, 5.48	40.00	3.00	168	10,668	2,533	55,107

RECORD OF FURNACE CONDITIONS.

Time	Observation	Time	Observation
	Boiler under a load during night.	12.55	Fire raked, 9 inches thick.
	Fire cleaned.	1.30	Fire raked.
		1.41	Fire raked, 10 inches thick.
7.46	Test started, fire 1½ inches thick.	2.01	Fire raked.
		2.05	Cleaning fire.
8.32	Fire raked, 5 inches thick.	2.14	Fire cleaned, 4 inches thick.
9.05	Fire raked, 7 inches thick.	2.40	Fire raked, 6 inches thick.
9.27	Fire raked, 8 inches thick.	3.12	Fire raked, 8 inches thick.
9.58	Fire sliced, 9 inches thick.	3.35	Fire raked, 7 inches thick.
10.05	Fire raked, 10 inches thick.	3.58	Fire raked, 8 inches thick.
10.44	Do.	4.20	Do.
10.50	Cleaning fire.	5.07	Cleaning fire.
11.01	Fire cleaned, 4 inches thick.	5.17	Fire cleaned, 4 inches thick.
12.16	Fire raked, 6 inches thick.	5.48	Test closed, fire 1½ inches thick.
12.40	Fire raked, 8 inches thick.		

Ash dark and heavy. Coal burned rapidly, with long flame. 88 firings during test.

Steam Test of Iowa No. 3 Coal

CONDITIONS OF BOILER TRIAL.

Made by boiler division, United States Geological Survey.
At fuel-testing plant, Louisiana Purchase Exposition, St. Louis, Mo.
Kind of boiler, Heine safety.
To determine the economy of coal as a fuel.
Steam jets not operated. Hughes apparatus operated.
Kind of fuel, Iowa No. 3.
Kind of furnace, hand fired.
State of weather, clear.
Method of starting and stopping the test, alternate.
Number of boiler (plant number), 2.
Type of boiler, water tube.

1.	Date of trial, November 8, 1904.		
2.	Duration of trial	hours..	10.033
3-10	Dimensions and proportions of boiler same as given in test of coal No. 1.		

AVERAGE PRESSURES.

11.	Barometer	inches of mercury..	29.45
		pounds..	14.46
11.1	Steam pressure by gage per square inch	..do....	83.5
		..do....	*97.96
12.	Force of draft between damper and boiler	inches of water..	.58
13.	Force of draft in furnace	do....	.22
14.	Force of draft or blast in ash pit	do....	0

AVERAGE TEMPERATURES.

15.	Of external air	degrees..	53.4
16.	of fireroom	do....	61.5
17.	Of steam	do....	326.1
18.	Of feed water in tank	do....	56.1
19.	Of feed water entering economizer	do....	....
20.	Of feed water entering boiler	do....	190
21.	Of escaping gases from boiler	do....	578
22.	Of escaping gases from economizer	do....	....
22.1	Of furnace	do....	....

FUEL.

23.	Size and condition: Nut—small, 70 per cent; slack, 30 per cent; dull.		
24.	Weight of wood used in lighting fire	pounds..	None
25.	Weight of coal as fired	do....	10,668
26.	Percentage of moisture in coal		12.44
27.	Total weight of dry coal consumed	pounds..	9,341
28.	Total ash and refuse	do....	1,431
29.	Quality of ash and refuse: Clinker	per cent..	57
30.	Total combustible consumed	pounds..	7,910
		.. do....	†7,283
31.	Percentage of ash and refuse in dry coal		15.32

*Absolute.
†Calculated from chemistry of ash.

PROXIMATE ANALYSIS OF COAL.

		Per cent of coal.	Per cent of combustible
32.	Fixed carbon	35.77	49.74
33.	Volatile matter	36.14	50.26
34.	Moisture	12.44	....
35.	Ash	15.65	....
		100.00	100.00
36.	Sulphur, separately determined	6.07	....

ULTIMATE ANALYSIS OF DRY COAL.

37.	Carbon (C)	62.34	75.9
38.	Hydrogen (H)	4.56	5.55
39.	Oxygen (O)	7.34	8.94
40.	Nitrogen (N)	.96	1.17
41.	Sulphur (S)	6.93	8.44
42.	Ash	17.87	....
		100.00	100.00
43.	Moisture in sample of coal as received	12.44	....

ANALYSIS OF ASH AND REFUSE.

44.	Carbon	per cent..	27.11
45.	Earthy matter	do....	72.89

FUEL PER HOUR.

46.	Dry coal consumed per hour	pounds..	931
47.	Combustible consumed per hour	..do.... ..do....	788 *726
48.	Dry coal per square foot of grate surface per hour	..do....	22.96
49.	Combustible per square foot of water-heating surface per hour	..do.... ..do....	.388 *.357

CALORIFIC VALUE OF FUEL.

50.	Calorific value by oxygen calorimeter per pound of dry coal, B. T. U.	11,671
51.	Calorific value by oxygen calorimeter per pound of combustible, B. T. U.	14,210
52.	Calorific value by analysis per pound of dry coal, B. T. U.	11,605
53.	Calorific value by analysis per pound of combustible, B. T. U.	14,130

QUALITY OF STEAM.

54.	Percentage of moisture in steam		.978
55.	Number of degrees of superheating		None
56.	Quality of steam (dry steam=unity)	per cent..	99.25

*Calculated from chemistry of ash.

WATER.

57. Total weight of water fed to boiler....................pounds.. 55,107
58. Equivalent water fed to boiler from and at 212°..........do.... 66,035
59. Water actually evaporated, corrected for quality of steam..do.... 54,694
60. Factor of evaporation.. 1.1983
61. Equivalent water evaporated into dry steam from and at 212° ....pounds.. 65,540

WATER PER HOUR.

62. Water evaporated per hour, corrected for quality of steam ....pounds.. 5,451
63. Equivalent evaporation per hour from and at 212°......do.... 6,532
64. Equivalent evaporation per hour from and at 212° per square foot of water-heating surface.......................pounds.. 3.22

HORSEPOWER.

65. Horsepower developed (34½ pounds of water evaporated per hour into dry steam from and at 212°=1 horsepower)...... 189.3
66. Builders' rated horsepower................................. 210
67. Percentage of builders' rated horsepower developed............ 90.15

ECONOMIC RESULTS.

68. Water apparently evaporated under actual conditions per pound of coal as fired. (Item 57÷item 25)..............pounds.. 5.17
69. Equivalent evaporation from and at 212° per pound of coal as fired. (Item 61÷item 25)........................pounds.. 6.14
70. Equivalent evaporation from and at 212° per pound of dry coal. (Item 61÷item 27).........................pounds.. 7.02
71. Equivalent evaporation from and at 212° per pound of combustible. (Item 61÷item 30) .... { ..do.... 8.29 / ..do.... *9.00

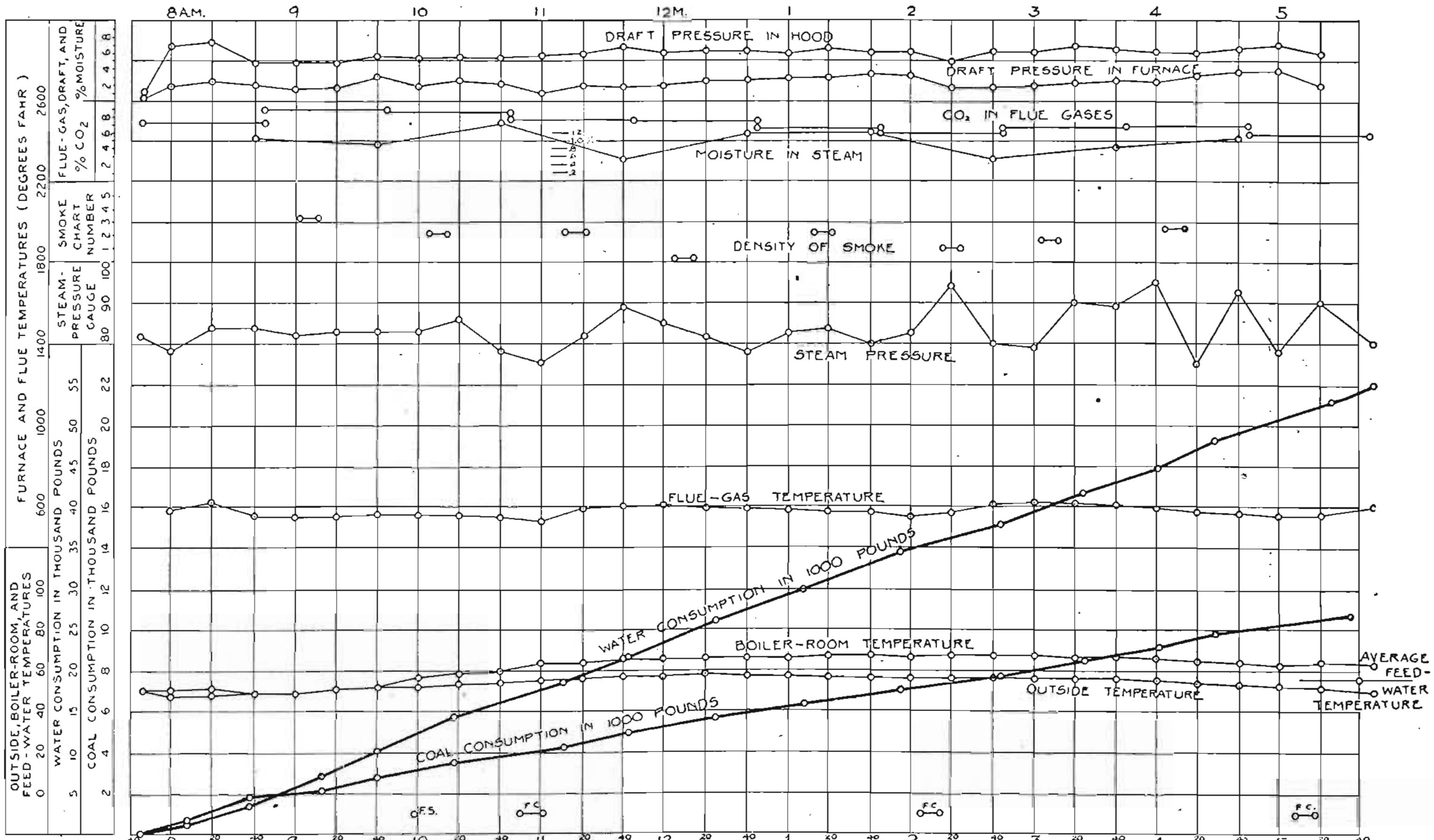
EFFICIENCY.

72. Efficiency of the boiler (heat absorbed by the boiler per pound of combustible divided by the heat value of 1 pound of combustible).................. { per cent.. 56.34 / ....do.... *61.16
73. Efficiency of boiler, including the grate (heat absorbed by the boiler per pound of dry coal divided by the heat value of 1 pound of dry coal)............................per cent.. 58.09

COST OF EVAPORATION.

74. Cost of coal per ton of 2,000 pounds delivered in boiler room (assumed) $1.00
75. Cost of fuel for evaporating 1,000 pounds of water under observed conditions $0.0967
76. Cost of fuel used for evaporating 1,000 pounds of water from and at 212°.. $0.0814

*Calculated from chemistry of ash.



Graphic log sheet, Iowa No. 3 coal (nut, dull).

SMOKE OBSERVATIONS.

77.	Percentage of smoke as observed	34.8
78.	Weight of soot per hour obtained from smoke meter..ounces..	....
79.	Volume of soot per hour obtained from smoke meter ....cubic inches..	....

METHOD OF FIRING.

80.	Kind of firing (spreading, alternate or coking)	Spreading
81.	Average thickness of fire....inches..	8
82.	Average intervals between firing for each furnace during time when fires are in normal condition....minutes..	6.8
83.	Average intervals between times of leveling or breaking up ....minutes..	30

ANALYSIS OF THE DRY GASES.

84.	Carbon dioxide (CO_2)....per cent..	7.18
85.	Oxygen (O) ....do....	13.12
86.	Carbon monoxide (CO) ....do....	.04
87.	Hydrogen and hydrocarbons....do....	....
88.	Nitrogen (by difference) (N)....do....	79.66

HEAT BALANCE, OR DISTRIBUTION OF THE HEATING VALUE OF THE COMBUSTIBLE.

Total heat value of 1 pound of combustible, B. T. U. 14,210

		B. T. U.	Per cent.
1.	Heat absorbed by the boiler=evaporation from and at 212° per pound of combustible×965.7	8,691	*61.16
2.	Loss due to moisture in coal=per cent of moisture referred to combustible÷100×[(212−t)+966+0.48 (T−212)] (t= temperature of air in the boiler room; T=that of the flue gases)	223	1.57
3.	Loss due to moisture formed by the burning of hydrogen=per cent of hydrogen to combustible÷100×9×[(212−t)+966+0.48 (T−212)]	645	4.54
4.	Loss due to heat carried away in the dry chimney gases= weight of gas per pound of combustible×0.24×(T−t)....	3,222	22.67
5.	Loss due to incomplete combustion of carbon= $\frac{CO}{CO_2+CO}\times\frac{\text{per cent C in combustible}}{100}\times 10{,}150$	43	.30
6.	Loss due to unconsumed hydrogen and hydrocarbons, to heating the moisture in the air, to radiation, and unaccounted for. (Some of these losses may be separately itemized if data are obtained from which they may be calculated)	1,386	9.76
			100.00

REMARKS.

Dry coal per indicated horsepower hour=4.03 pounds.
Dry coal per electrical horsepower hour=4.97 pounds.

*Calculated from chemistry of ash.

Regular and special observations on test of Iowa No. 4 coal, November 7, 1904.

REGULAR.

(Duration of trial, 10 hours.)

Time	Steam-pressure gage	Temperatures			Calorimeter		Draft pres'res		Flue gases		
		Out-side	Boiler room	Flue gases, base of stack	Steam dis-charge	Water separ-ated in 10 min-utes	In hood in inches of water	In fur-nace, in inches of water	CO_2.	O_2.	CO.
	Lbs.	°*F.*	°*F.*	°*F.*	*Lbs.*	*Lbs.*			*Per ct.*	*Per ct.*	*Per ct.*
8	80	------	50	------	------	------	------	------	------	------	------
8.10	95	------	50	570	------	------	0.50	0.09	------	------	------
8.20	90	------	50	560	4.55	0.065	.45	.19	------	------	------
8.40	95	49	50	575	------	------	.47	.14	------	------	------
9	92	52	52	565	------	------	.48	.16	7.8	11.2	0.2
9.20	89	48	54	535	------	------	.49	.27	------	------	------
9.40	97	49	56	547	4.69	.07	.45	.19	------	------	------
10	87	50	58	553	------	------	.49	.26	8.4	11.0	.0
10.20	83	52	60	537	4.29	.06	.51	.28	------	------	------
10.40	87	55	62	532	------	------	.49	.20	------	------	------
11	86	60	64	510	------	------	------	------	------	------	------
11.20	94	62	66	545	4.40	.05	.46	.12	7.8	11.9	.0
11.40	88	63	67	573	------	------	.47	.15	------	------	------
12	88	65	68	560	------	------	.47	.19	------	------	------
12.20	91	66	70	560	4.03	.039	.50	.21	8.4	11.0	.2
12.40	83	66	70	540	------	------	.51	.22	------	------	------
1	105	67	71	527	------	------	.50	.27	------	------	------
1.20	83	66	71	530	4.42	.06	.49	.26	------	------	------
1.40	81	66	71	523	------	------	.49	.30	------	------	------
2	92	66	71	515	------	------	.50	.31	------	------	------
2.20	86	65	71	510	4.21	.05	.40	.09	------	------	------
2.40	90	66	72	525	------	------	.40	.06	------	------	------
3	88	65	72	567	------	------	.45	.10	6.4	14.0	.0
3.20	86	65	71	597	4.36	.06	.57	.16	------	------	------
3.40	93	66	71	600	------	------	.56	.18	------	------	------
4	80	63	70	610	------	------	.60	.19	------	------	------
4.20	92	61	70	603	4.44	.04	.59	.22	------	------	------
4.40	82	60	68	590	------	------	.59	.24	------	------	------
5	93	59	67	578	------	------	.60	.27	7.8	12.3	.3
5.20	83	58	67	557	4.40	.07	.50	.07	------	------	------
5.40	78	56	66	590	------	------	.52	.21	------	------	------
6	78	------	------	540	------	------	------	------	6.8	14.8	.0
Total	2,815	1,685	1,996	17,224	43.79	.564	14.5	5.6	53.4	86.2	.7
Av.	88	60	64.4	556	4.379	.0564	.50	.193	7.63	12.31	.1

Regular and special observations on test of Iowa No. 4 Coal, November 7, 1904—Continued.

SPECIAL.

Time	Height of water		Weight of coal burned		Weight of water fed to boiler	
	In tank	In gage glass	During period	Total	During period	Total
	Inches	*Inches*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
Start, 8	40.00	5.25				
8.21	31.25	3.00	700	700	1,923	1,923
9	38.50	4.50	700	1,400	2,861	4,784
9.37	35.50	4.00	700	2,100	3,519	8,303
10.28	44.50	2.50	700	2,800	4,420	12,723
11.24	40.00	2.50	700	3,500	3,436	16,159
12	34.00	4.00	700	4,200	3,012	19,171
12.40	35.50	2.50	700	4,900	4,228	23,399
1.19	40.25	3.00	700	5,600	3,352	26,751
2.46	41.25	3.00	700	6,300	5,013	31,764
3.23	35.00	2.50	700	7,000	3,076	34,840
3.55	38.50	3.00	700	7,700	2,793	37,633
4.33	42.25	4.50	700	8,400	3,701	41,334
5.28	39.00	3.00	700	9,100	5,779	47,113
Close, 6	40.00	5.25	285	9,385	1,652	48,765

RECORD OF FURNACE CONDITIONS.

Time	Observation	Time	Observation
	Boiler under a load during night.	1.08	Fire raked, 8 inches thick.
7	Fire cleaned.	1.37	Fire raked, 9 inches thick.
8	Test started, fire 3 inches thick.	2.02	Do.
8.50	Fire raked, 6 inches thick.	2.08	Cleaning fire, difficult to remove clinker.
9.35	Fire sliced.	2.43	Fire cleaned, 4 inches thick.
9.59	Fire raked, 8 inches thick.	5	Fire raked, 8 inches thick.
10.25	Do.	5.18	Cleaning fire.
10.39	Fire sliced.	5.27	Fire cleaned, 4 inches thick.
10.57	Cleaning fire.	5.53	Fire raked.
11.08	Fire cleaned, 4 inches thick.	6	Test closed, fire 3 inches thick.
11.57	Fire raked, 6 inches thick.		

Ash dark and heavy. Coal burned freely with long flame. 83 firings during test.

Steam Test of Iowa No. 4 Coal

CONDITIONS OF BOILER TRIAL.

Made by boiler division, United State Geological Survey.
At fuel-testing plant, Louisiana Purchase Exposition, St. Louis, Mo.
Kind of boiler, Heine safety.
To determine the economy of coal as a fuel.
Steam jets not operated. Hughes apparatus operated.
Kind of fuel, Iowa No. 4.
Kind of furnace, hand fired.
State of weather, clear.
Method of starting and stopping the test, alternate.
Number of boiler (plant number), 2.
Type of boiler, water tube.

1.	Date of trial November 7, 1904.		
2.	Duration of trial	hours..	10
3-10	Dimensions and proportions of boiler same as given in test of coal No. 1.		

AVERAGE PRESSURES.

11.	Barometer	inches of mercury..	29.45
		pounds..	14.45
11.1	Steam pressure by gage per square inch	..do....	88
		..do....	*102.5
12.	Force of draft between damper and boiler	inches of water..	.5
13.	Force of draft in furnace	do....	.193
14.	Force of draft or blast in ash pit	do....	0

AVERAGE TEMPERATURES.

15.	Of external air	degrees..	60
16.	Of fireroom	do....	64.4
17.	Of steam	do....	329.3
18.	Of feed water in tank	do....	60
19.	Of feed water entering economizer	do....	....
20.	Of feed water entering boiler	do....	181
21.	Of escaping gases from boiler	do....	556
22.	Of escaping gases from economizer	do....	....
22.1	Of furnace	do....	....

FUEL.

23.	Size and condition: Mine run—lump, 30 per cent; small, 50 per cent; slack, 20 per cent; dull.		
24.	Weight of wood used in lighting fire	pounds..	None
25.	Weight of coal as fired	do....	9,385
26.	Percentage of moisture in coal		13.48
27.	Total weight of dry coal consumed	pounds..	8,120
28.	Total ash and refuse	do....	1,302
29.	Quality of ash and refuse: Clinker	per cent..	59
30.	Total combustible consumed	pounds..	6,818
		.. do....	†6,447
31.	Percentage of ash and refuse in dry coal		16.03

*Absolute.
†Calculated from chemistry of ash.

PROXIMATE ANALYSIS OF COAL.

		Per cent of coal	Per cent of combustible
32.	Fixed carbon	37.28	52.23
33.	Volatile matter	34.09	47.77
34.	Moisture	13.48	....
35.	Ash	15.15	....
		100.00	100.00
36.	Sulphur separately determined	5.04	....

ULTIMATE ANALYSIS OF DRY COAL.

37.	Carbon (C)	63.43	76.89
38.	Hydrogen (H)	4.35	5.27
39.	Oxygen (O)	7.92	9.6
40.	Nitrogen (N)	.97	1.18
41.	Sulphur (S)	5.82	7.06
42.	Ash	17.51	....
		100.00	100.00
43.	Moisture in sample of coal as received	13.48	....

ANALYSIS OF ASH AND REFUSE.

44.	Carbon	per cent..	19.25
45.	Earthy matter	do....	80.75

FUEL PER HOUR.

46.	Dry coal consumed per hour	pounds..	812
47.	Combustible consumed per hour	..do.... ..do....	682 *645
48.	Dry coal per square foot of grate surface per hour	do....	20.02
49.	Combustible per square foot of water-heating surface per hour	..do.... ..do....	.336 *.318

CALORIFIC VALUE OF FUEL.

50.	Calorific value by oxygen calorimeter per pound of dry coal, B. T. U	11,678
51.	Calorific value by oxygen calorimeter per pound of combustible, B. T. U	14,157
52.	Calorific value by analysis per pound of dry coal, B. T. U	11,545
53.	Calorific value by analysis per pound of combustible, B. T. U	13,996

QUALITY OF STEAM.

54.	Percentage of moisture in steam		1.27
55.	Number of degrees of superheating		None
56.	Quality of steam (dry steam=unity)	per cent..	99.03

*Calculated from chemistry of ash.

WATER.

57. Total weight of water fed to boiler..................pounds.. 48,765
58. Equivalent water fed to boiler from and at 212°..........do.... 58,289
59. Water actually evaporated, corrected for quality of steam..do.... 48,292
60. Factor of evaporation 1.1953
61. Equivalent water evaporated into dry steam from and at 212° ....pounds.. 57,723

WATER PER HOUR.

62. Water evaporated per hour, corrected for quality of steam ....pounds.. 4,829
63. Equivalent evaporation per hour from and at 212°......do.... 5,772
64. Equivalent evaporation per hour from and at 212° per square foot of water-heating surface........................pounds.. 2.84

HORSEPOWER.

65. Horsepower developed (34½ pounds of water evaporated per hour into dry steam from and at 212°=1 horsepower)........ 167.3
66. Builders' rated horsepower.................................... 210
67. Percentage of builders' rated horsepower developed............. 79.7

ECONOMIC RESULTS.

68. Water apparently evaporated under actual conditions per pound of coal as fired. (Item 57÷item 25)................pounds.. 5.196
69. Equivalent evaporation from and at 212° per pound of coal as fired. (Item 61÷item 25..........................pounds.. 6.15
70. Equivalent evaporation from and at 212° per pound of dry coal. (Item 61÷item 27)..................................pounds.. 7.11
71. Equivalent evaporation from and at 212° per pound of combustible. (Item 61÷item 30)................ { ..do.... 8.47 / ..do.... *8.95 }

EFFICIENCY.

72. Efficiency of the boiler (heat absorbed by the boiler per pound of combustible divided by the heat value of 1 pound of combustible).................... { per cent.. 57.78 / ....do.... *61.05 }
73. Efficiency of boiler, including the grate (heat absorbed by the boiler per pound of dry coal divided by the heat value of 1 pound of dry coal)..................................per cent.. 58.79

COST OF EVAPORATION.

74. Cost of coal per ton of 2,000 pounds delivered in boiler room (assumed) $1.00
75. Cost of fuel for evaporating 1,000 pounds of water nnder observed conditions $0.0962
76. Cost of fuel used for evaporating 1,000 pounds of water from and at 212°.. $0.0813

*Calculated from chemistry of ash.

SMOKE OBSERVATIONS.

77.	Percentage of smoke as observed	41
78.	Weight of soot per hour obtained from smoke meter....ounces..	....
79.	Volume of soot per hour obtained from smoke meter ....cubic inches..	....

METHOD OF FIRING.

80.	Kind of firing (spreading, alternate or coking)	Spreading
81.	Average thickness of fire....inches..	8
82.	Average intervals between firing for each furnace during time when fires are in normal condition....minutes..	7.2
83.	Average intervals between times of leveling or breaking up ....minutes..	46

ANALYSIS OF THE DRY GASES.

84.	Carbon dioxide (CO_2)....per cent..	7.63
85.	Oxygen (O) ....do....	12.31
86.	Carbon monoxide (CO)....do....	.10
87.	Hydrogen and hydrocarbons....do....	....
88.	Nitrogen (by difference) (N)....do....	79.96

HEAT BALANCE, OR DISTRIBUTION OF THE HEATING VALUE OF THE COMBUSTIBLE.

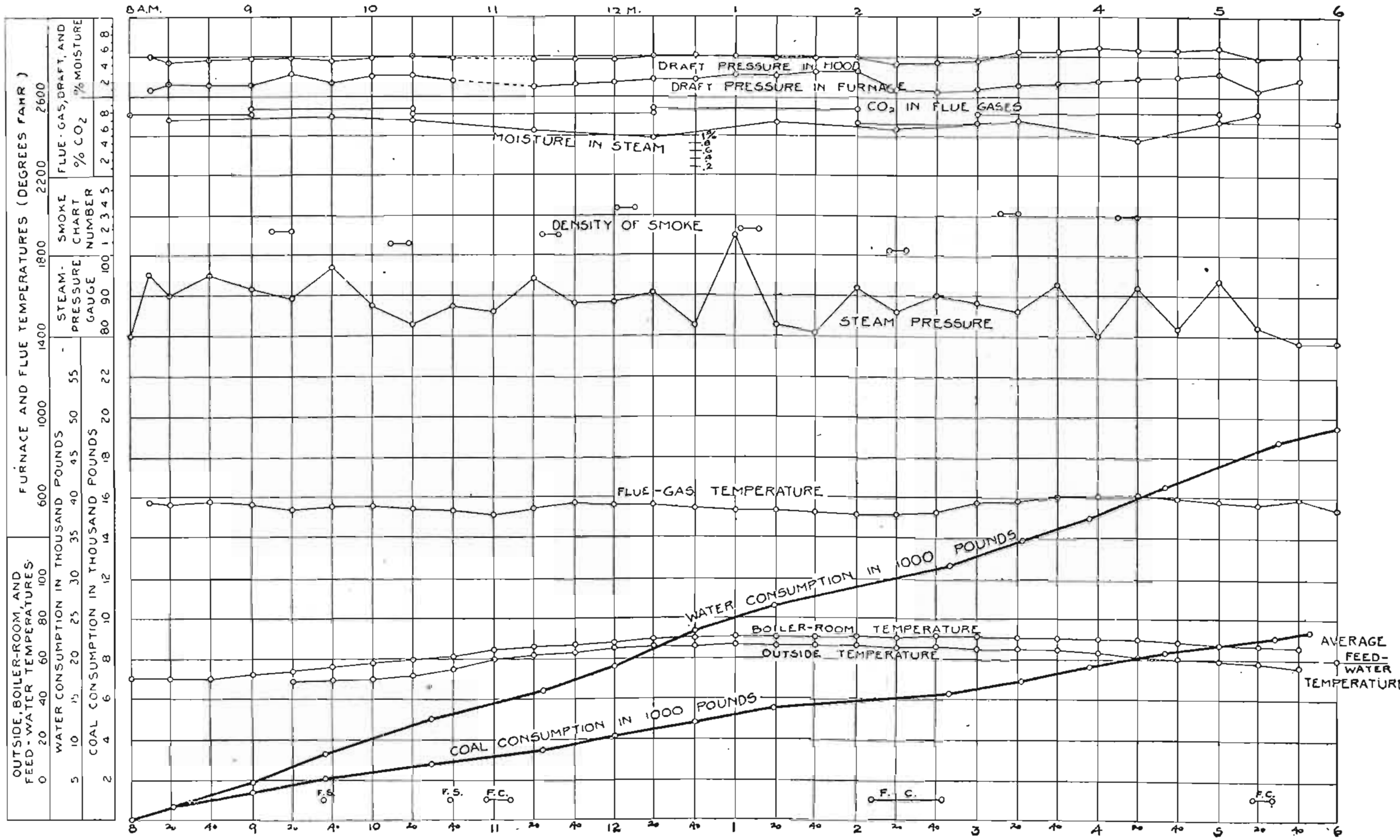
Total heat value of 1 pound of combustible, B. T. U............ 14,157

		B. T. U.	Per cent.
1.	Heat absorbed by the boiler=evaporation from and at 212° per pound of combustible×965.7	8,643	*61.05
2.	Loss due to moisture in coal=per cent of moisture referred to combustible÷100×[(212−t)+966+0.48 (T−212)] (t= temperature of air in the boiler room; T=that of the flue gases)	242	1.71
3.	Loss due to moisture formed by the burning of hydogen= per cent of hydrogen to combustible÷100×9×[(212−t)+ 966+0.48 (T−212)]	606	4.28
4.	Loss due to heat carried away in the dry chimney gases= weight of gas per pound of combustible×0.24×(T−t)....	2,906	20.53
5.	Loss due to incomplete combustion of carbon= $\frac{CO}{CO_2+CO}\times\frac{\text{per cent C in combustible}}{100}\times 10{,}150$	101	.71
6.	Loss due to unconsumed hydrogen and hydrocarbons, to heating the moisture in the air, to radiation, and unaccounted for. (Some of these losses may be separately itemized if data are obtained from which they may be calculated)	1,659	11.72
			100.00

REMARKS.

Dry coal per indicated horsepower hour=3.98 pounds.
Dry coal per electrical horsepower hour=4.91 pounds.

*Calculated from chemistry of ash.



Graphic log sheet, Iowa No. 4 coal (run-of-mine, dull).

Regular and special observations on test of Iowa No. 4 coal (large briquettes), November 26, 1904.

REGULAR.

(Duration of trial, 10.033 hours.)

Time	Steam pressure gage	Temperatures			Calorimeter		Draft pres'res		Flue gases		
		Outside	Boiler room	Flue gases, base of stack	Manometer, pressure per square inch	Temperature of steam	In hood, in inches of water	In furnace in inches of water	CO_2.	O_2.	CO.
	Lbs.	°F.	°F.	°F.	Lbs.	°F.			Per ct.	Per ct.	Per ct.
7.44 -----	84	------	------	515	------	------	------	------	------	------	------
8 --------	100	------	49.0	660	------	------	0.75	0.22	------	------	------
8.20 -----	104	------	49.0	660	------	------	.56	.15	------	------	------
8.40 -----	102	31.0	49.0	665	------	------	.65	.19	6.5	13.1	0.1
9 --------	100	32.0	49.0	645	------	------	.60	.21	------	------	------
9.20 -----	103	32.0	49.5	615	------	------	.55	.23	------	------	------
9.40 -----	102	34.0	50.0	603	------	------	.50	.10	8.7	11.0	.0
10 -------	102	36.0	51.0	590	0.4	282	.55	.28	------	------	------
10.20 ----	98	36.0	52.0	600	.4	268	.60	.32	------	------	------
10.40 ----	100	36.0	53.0	585	.5	277	.70	.40	7.5	12.1	.0
11 -------	102	37.0	54.0	665	------	------	.66	.11	------	------	------
11.20 ----	97	38.5	60.0	670	.6	269	.60	.14	------	------	------
11.40 ----	104	38.0	60.0	655	.5	283	.60	.20	7.0	12.5	------
12 -------	99	39.0	62.0	630	.2	266	.60	.25	------	------	------
12.20 ----	100	40.0	59.0	600	.2	274	.60	.30	------	------	------
12.40 ----	103	40.0	61.0	595	.0	260	.65	.34	6.8	13.2	.0
1 --------	97	41.0	63.0	600	.2	265	.70	.35	------	------	------
1.20 -----	97	42.0	63.0	615	.3	283	.60	.29	------	------	------
1.40 -----	104	42.0	63.0	615	.5	278	.65	.33	6.2	14.1	.0
2 --------	101	42.0	64.0	575	.5	278	------	------	------	------	------
2.20 -----	99.5	42.0	64.0	660	.4	282	.55	.13	------	------	------
2.40 -----	98	42.0	63.0	670	.5	281	.60	.16	7.0	13.5	------
3 --------	97	42.0	62.0	650	.6	278	.50	.16	------	------	------
3.20 -----	100	43.0	61.0	650	.5	278	.50	.16	------	------	------
3.40 -----	103	42.0	62.0	650	.5	280	.55	.19	8.6	10.8	.5
4 --------	98	42.0	62.0	650	.5	283	.60	.23	------	------	------
4.20 -----	95	41.0	60.0	645	.5	279	.55	.22	------	------	------
4.40 -----	100	40.0	60.0	650	.5	278	.55	.18	8.4	11.4	.0
5 --------	89	39.0	61.0	635	.5	278	------	------	------	------	------
5.20 -----	82.5	38.0	60.0	630	.4	267	.45	.07	------	------	------
5.46 -----	83.5	------	------	------	------	------	------	------	8.2	11.0	.0
Total --	3044.5	1047.5	1675.5	18,848	9.2	6,067	15.97	5.91	74.9	122.7	.6
Av. ---	98.2	38.8	57.7	628	.42	276	.59	.22	7.49	12.27	.06

Regular and special observations on test of Iowa No. 4 coal (large briquettes), November 26, 1904—Continued.

SPECIAL.

Time	Height of water		Weight of coal burned		Weight of water fed to boiler	
	In tank	In gage glass	During period	Total	During period	Total
	Inches	*Inches*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
Start, 7.44	40.00	3.50				
7.58	39.00	2.50	600	600		
8.21	33.50	4.75	600	1,200	1,847	1,847
8.49	31.50	4.50	600	1,800	3,377	5,224
9.25	34.50	4.50	600	2,400	3,629	8,853
10.02	43.75	4.25	600	3,000	3,346	12,199
11	34.75	12.00	600	3,600	2,244	14,443
11.26	24.50	6.00	600	4,200	3,985	18,428
12.02	27.00	5.00	600	4,800	4,010	22,438
12.42	29.50	2.50	600	5,400	3,270	25,708
1.24	27.25	2.00	600	6,000	3,480	29,188
2.15	33.50	4.50	600	6,600	3,191	32,379
2.44	28.00	3.50	600	7,200	3,213	35,592
3.16	38.00	4.00	600	7,800	3,039	38,631
3.54	44.00	4.00	600	8,400	4,086	42,717
4.30	23.00	5.50	600	9,000	3,882	46,599
5.15	35.00	4.00	600	9,600	4,260	50,859
Close, 5.46	40.00	2.25	300	9,900	2,699	53,558

RECORD OF FURNACE CONDITIONS.

Time	Observation	Time	Observation
	Fire banked under boiler during night.	12.30	Fire raked, 11 incehs thick.
		12.48	Fire sliced.
7.15	Fire cleaned.	1.15	Do.
7.44	Test started, fire 3 inches thick.	1.45	Fire raked, 11 inches thick.
		1.55	Cleaning fire.
8.04	Fire raked, 6 inches thick.	2.07	Fire cleaned.
8.15	Fire raked, 9 inches thick.	2.08	Fire raked, 3 inches thick.
8.26	Fire raked.	2.27	Fire raked, 8 inches thick.
8.55	Fire raked, 10 inches thick.	2.35	Fire raked, 9 inches thick.
9.37	Fire raked, 12 inches thick.	3.15	Fire raked, 12 inches thick.
9.43	Fire sliced.	4.07	Do.
10.06	Fire raked, 10 inches thick.	4.26	Fire sliced and raked, 10 inches thick.
10.20	Do.		
10.21	Fire sliced.	4.47	Fire raked, 10 inches thick.
10.40	Fire raked, 8 inches thick.	4.50	Fire raked, 7 inches thick.
10.44	Cleaning fire.	5.02	Cleaning fire.
10.53	Fire cleaned.	5.10	Fire cleaned, 2½ inches thick.
11.22	Fire raked, 8 inches thick.	5.35	Fire raked, 4 inches thick.
11.30	Fire raked, 10 inches thick.	5.46	Test closed, fire 3 inches thick.
11.49	Do.		
12.21	Fire raked, 12 inches thick.		

Refuse dark and heavy. Briquettes fell apart in fire; burned with long flame.

Steam Test of Iowa No. 4 Coal (Briquettes)

CONDITIONS OF BOILER TRIAL.

Made by boiler division, United States Geological Survey.
At fuel-testing plant, Louisiana Purchase Exposition, St. Louis, Mo.
Kind of boiler, Heine safety.
To determine the economy of coal as a fuel.
Steam jets not operated. Hughes apparatus operated.
Kind of fuel, Iowa No. 4 (briquettes).
Kind of furnace, hand fired.
State of the weather, clear.
Method of starting and stopping the test, alternate.
Number of boiler (plant number), 1.
Type of boiler, water tube.

1. Date of trial, November 26, 1904.
2. Duration of trial....hours.. 10.033

3-10 Dimensions and proportions of boiler same as given in test of coal No. 1.

AVERAGE PRESSURES.

11.	Barometer	inches of mercury..	29.97
		....pounds..	14.71
11.1	Steam pressure by gage per square inch	..do....	98.2
		..do....	*112.91
12.	Force of draft between damper and boiler	inches of water..	.59
13.	Force of draft in furnace	do....	.22
14.	Force of draft or blast in ash pit	do....	0

AVERAGE TEMPERATURES.

15.	Of external air	degrees..	38.8
16.	Of fireroom	do....	57.7
17.	Of steam	do....	336.5
18.	Of feed water in tank	do....	57.6
19.	Of feed water entering economizer	do....	....
20.	Of feed water entering boiler	do....	....
21.	Of escaping gases from boiler	do....	628
22.	Of escaping gases from economizer	do....	....
22.1	Of furnace	do....	....

FUEL.

23.	Size and condition: Large briquettes.		
24.	Weight of wood used in lighting fire	pounds..	None
25.	Weight of coal as fired	do....	9,900
26.	Percentage of moisture in coal		13.24
27.	Total weight of dry coal consumed	pounds..	8,589
28.	Total ash and refuse	do....	1,186
29.	Quality of ash and refuse: Clinker	per cent..	58
30.	Total combustible consumed	pounds..	7,403
		.. do....	*7,078
31.	Percentage of ash and refuse in dry coal		13.82

*Absolute.
*Calculated from chemistry of ash.

PROXIMATE ANALYSIS OF COAL.

		Per cent of coal	Per cent of combustible
32.	Fixed carbon	37.85	50.9
33.	Volatile matter	36.50	49.1
34.	Moisture	13.24	....
35.	Ash	12.41	....
		100.00	100.00
36.	Sulphur, separately determined	3.9	....

ULTIMATE ANALYSIS OF DRY COAL.

37.	Carbon (C)	69.25	80.82
38.	Hydrogen (H)	4.81	5.61
39.	Oxygen (O)	6.28	7.33
40.	Nitrogen (N)	.86	1.00
41.	Sulphur (S)	4.49	5.24
42.	Ash	14.31	....
		100.00	100.00
43.	Moisture in sample of coal as received	13.24	....

ANALYSIS OF ASH AND REFUSE.

44.	Carbon	per cent..	23.82
45.	Earthy matter	do....	76.18

FUEL PER HOUR.

46.	Dry coal consumed per hour	pounds..	856
47.	Combustible consumed per hour	..do.... ..do....	738 *705
48.	Dry coal per square foot of grate surface per hour	do....	21.11
49.	Combustible per square foot of water-heating surface per hour	..do.... ..do....	.364 *.348

CALORIFIC VALUE OF FUEL.

50.	Calorific value by oxygen calorimeter per pound of dry coal, B. T. U	12,546
51.	Calorific value by oxygen calorimeter per pound of combustible, B. T. U	14,641
52.	Calorific value by analysis per pound of dry coal, B. T. U	12,749
53.	Calorific value by analysis per pound of combustible, B. T. U	14,878

QUALITY OF STEAM.

54.	Percentage of moisture in steam		.84
55.	Number of degrees of superheating		None
56.	Quality of steam (dry steam=unity)	per cent..	99.36

*Calculated from chemistry of ash.

WATER.

57. Total weight of water fed to boiler.................pounds.. 53,558
58. Equivalent water fed to boiler from and at 212°........do.... 64,270
59. Water actually evaporated, corrected for quality of steam..do.... 53,215
60. Factor of evaporation.. 1.2
61. Equivalent water evaporated into dry steam from and at 212° ....pounds.. 63,858

WATER PER HOUR.

62. Water evaporated per hour, corrected for quality of steam ....pounds.. 5,304
63. Equivalent evaporation per hour from and at 212°......do.... 6,385
64. Equivalent evaporation per hour from and at 212° per square foot of water-heating surface......................pounds.. 3.13

HORSEPOWER.

65. Horsepower developed (34½ pounds of water evaporated per hour into dry steam from and at 212°=1 horsepower)............ 184.5
66. Builders' rated horsepower.................................. 210
67. Percentage of builders' rated horsepower developed............ 87.86

ECONOMIC RESULTS.

68. Water apparently evaporated under actual conditions per pound of coal as fired. (Item 57÷item 25)................pounds.. 5.41
69. Equivalent evaporation from and at 212° per pound of coal as fired. (Item 61÷item 25)........................pounds.. 6.43
70. Equivalent evaporation from and at 212° per pound of dry coal. (Item 61÷item 27)..............................pounds.. 7.43
71. Equivalent evaporation from and at 212° per pound of combustible. Item 61÷item 30).................. { ..do.... 8.62 / ..do.... *9.02

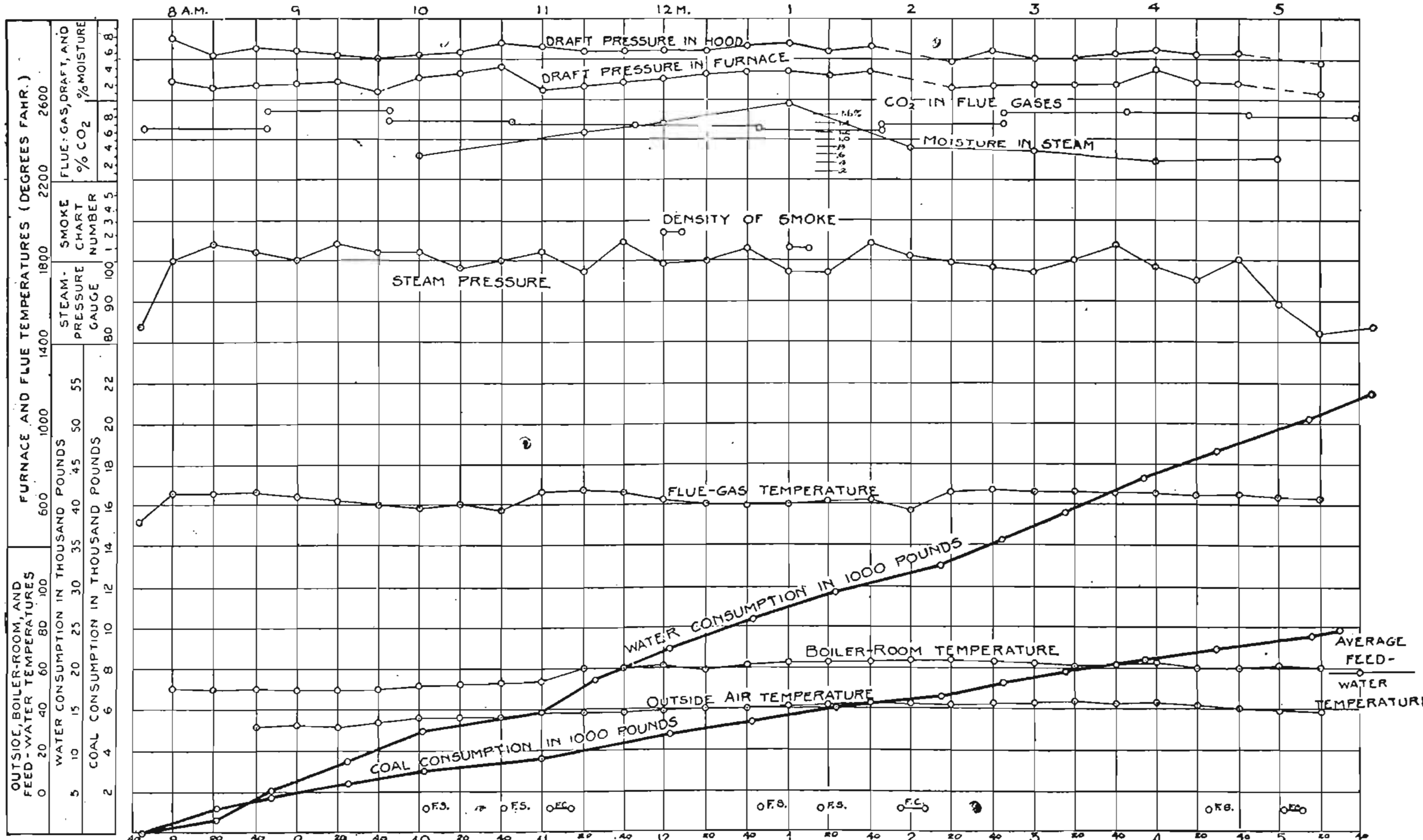
EFFICIENCY.

72. Efficiency of the boiler (heat absorbed by the boiler per pound of combustible divided by the heat value of 1 pound of combustible).................... { per cent.. 56.85 / ....do.... *59.49
73. Efficiency of boiler, including the grate (heat absorbed by the boiler per pound of dry coal divided by the heat value of 1 pound of dry coal) ....per cent.. 57.18

COST OF EVAPORATION.

74. Cost of coal per ton of 2,000 pounds delivered in boiler room (assumed) $1.00
75. Cost of fuel for evaporating 1,000 pounds of water under observed conditions $0.0924
76. Cost of fuel used for evaporating 1,000 pounds of water from and at 212° $0.0778

*Calculated from chemistry of ash.



Graphic log sheet, Iowa No. 4 coal (large briquettes).

SMOKE OBSERVATIONS.

77.	Percentage of smoke as observed	27.3
78.	Weight of soot per hour obtained from smoke meter..ounces..	....
79.	Volume of soot per hour obtained from smoke meter ....cubic inches..	....

METHOD OF FIRING.

80.	Kind of firing (spreading, alternate or coking)	Alternate
81.	Average thickness of fire.....inches..	10
82.	Average intervals between firing for each furnace during the time when fires are in normal condition.....minutes..	....
83.	Average intervals between times of leveling or breaking up .....minutes..	20

ANALYSIS OF THE DRY GASES.

84.	Carbon dioxide (CO_2).....per cent..	7.49
85.	Oxygen (O) .....do....	12.27
86.	Carbon monoxide (CO).....do....	.06
87.	Hydrogen and hydrocarbons.....do....	....
88.	Nitrogen (by difference) (N).....do....	80.18

HEAT BALANCE. OR DISTRIBUTION OF THE HEATING VALUE OF THE COMBUSTIBLE.

Total heat value of 1 pound of combustible, B. T. U. 14,641

		B. T. U.	Per cent.
1.	Heat absorbed by the boiler=evaporation from and at 212° per pound of combustible×965.7	8,710	*59.49
2.	Loss due to moisture in coal=per cent of moisture referred to combustible÷100×[(212−t)+966+0.48 (T−212)] (t= temperature of air in the boiler room, T=that of the flue gases)	235	1.61
3.	Loss due to moisture formed by the burning of hydrogen= per cent of hydrogen to combustible÷100×9×[(212−t)+ 966+0.48 (T−212)]	666	4.55
4.	Loss due to heat carried away in the dry chimney gases= weight of gas per pound of combustible×0.24×(T−t)	3,621	24.73
5.	Loss due to incomplete combustion of carbon= $\frac{CO}{CO_2+CO}\times\frac{\text{per cent C in combustible}}{100}\times 10{,}150$	65	.45
6.	Loss due to unconsumed hydrogen and hydrocarbons, to heating the moisture in the air, to radiation, and unaccounted for. (Some of these losses may be separately itemized if data are obtained from which they may be calculated)	1,344	9.17
			100.00

REMARKS.

Dry coal per indicated horsepower hour=3.80 pounds.
Dry coal per electrical horsepower hour=4.70 pounds.

*Calculated from chemistry of ash.

Regular and special observations on test of Iowa No. 5 coal, November 14, 1904.

REGULAR.

(Duration of trial 9.983 hours.)

Time	Steam-pressure gage	Temperatures			Calorimeter		Draft pres'res		Flue gases		
		Out-side	Boiler room	Flue gases, base of stack	Steam dis-charge	Water separ-ated in 10 min-utes	In hood, in inches of water	In fur-nace, in inches of water	CO_2.	O_2.	CO
	Lbs.	*°F.*	*°F.*	*°F.*	*Lbs.*	*Lbs.*			*Per ct.*	*Per ct.*	*Per ct.*
7.32	83		43	475			0.40	0.14			
7.40	88	28	43	512			.44	.15			
8	86	30	43	525	4.21	0.033	.48	.18			
8.20	84	33	43	510			.47	.19	7.4	12.0	0.0
8.40	73	35	43	495			.36	.16			
9	81	38	45	530	4.02	.047	.52	.34			
9.20	77	40	47	530			.64	.35	7.8	11.8	.0
9.40	86	41	48	505			.50	.32			
10	80	40	48	535	4.13	.05	.58	.24			
10.20	85	41	50	540			.60	.31	8.7	11.3	.0
10.40	83	42	52	520			.66	.39			
11	78	43	54	520	4.21	.056					
11.20	86	44	56	525			.51	.13	7.6	12.4	.0
11.40	81	45	56	520			.49	.19			
12	84	45	57	515	4.21	.029	.50	.18			
12.20	82	46	57	530			.49	.17	8.3	10.1	.8
12.40	84	46	57	542			.58	.29			
1	79	46	57	515	4.04	.034	.57	.24			
1.20	83	46	57	520			.55	.28	8.2	10.8	.4
1.40	79	47	58	540			.67	.34			
2	78	47	58	555	4.16	.05	.56	.23			
2.20	80	47	59	535					7.9	11.8	.2
2.40	75	47	60	500			.36	.13			
3	79	47	59	525	3.96	.038	.42	.15			
3.20	84	47	59	510			.55	.22	7.3	12.3	.5
3.40	83	46	59	575			.53	.21			
4	86	46	59	570	4.00	.026	.56	.26			
4.20	80	45	59	530			.59	.34	7.9	11.6	.3
4.40	80	45	58	565			.57	.22			
5	81	42	57	560	4.00	.052					
5.20	83	40	55	575			.37	.09	7.2	12.5	.6
5.31	82	39	54	565			.16	.04			
Total	2,613	1,314	1,710	16,969	40.94	.415	14.68	6.48	78.3	116.6	2.8
Av.	81.7	42.4	53.5	530	4.094	.0415	.51	.224	7.83	11.66	.28

Regular and special observations on test of Iowa No. 5 coal, November 14, 1904—Continued.

SPECIAL.

Time	Height of water		Weight of coal burned		Weight of water fed to boiler	
	In tank	In gage glass	During period	Total	During period	Total
	Inches	*Inches*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
Start, 7.32	40.00	3.00				
8.03	39.00	3.00	700	700	2,597	2,597
8.29	26.50	3.00	700	1,400	3,276	5,873
9	30.00	3.00	700	2,100	2,965	8,838
9.45	33.00	3.50	700	2,800	3,460	12,298
10.31	33.00	3.25	700	3,500	4,519	16,817
11.16	30.00	4.00	700	4,200	3,726	20,543
11.41	34.00	3.75	700	4,900	3,023	23,566
12.09	27.25	4.00	700	5,600	2,848	26,414
12.45	25.50	3.75	700	6,300	4,629	31,043
1.18	35.00	3.25	700	7,000	2,781	33,824
1.53	29.75	4.25	700	7,700	3,773	37,597
2.47	27.00	3.25	700	8,400	4,944	42,541
3.22	32.00	4.50	700	9,100	3,083	45,624
4.02	37.50	3.00	700	9,800	4,630	50,254
4.28	31.00	3.25	700	10,500	2,834	53,088
5.24	31.50	4.50	700	11,200	5,260	58,348
Close, 5.31	40.00	3.25			735	59,083

RECORD OF FURNACE CONDITIONS.

Time	Observation	Time	Observation
	Boiler under a light load during night.	12.51	Fire sliced, 8 inches thick.
7	Fire cleaned.	1.06	Fire raked, 8 inches thick.
7.32	Test started, fire 3 inches thick.	1.42	Do.
8.18	Fire raked, 5 inches thick.	1.51	Fire sliced, 9 inches thick.
8.41	Fire raked, 7 inches thick.	2.08	Fire raked, 8 inches thick.
8.58	Fire raked, 8 inches thick.	2.10	Cleaning fire.
9.10	Fire raked, 9 inches thick.	2.27	Fire cleaned, 4 inches thick.
9.19	Fire sliced, 10 inches thick.	2.41	Fire raked, 6 inches thick.
9.36	Fire raked, 10 inches thick.	3.11	Fire raked, 7 inches thick.
9.53	Do.	3.38	Fire raked, 8 inches thick.
9.58	Fire sliced, 10 inches thick.	4.13	Fire raked, 7 inches thick.
10.25	Fire raked, 9 inches thick.	4.40	Fire sliced, 8 inches thick.
10.35	Do.	4.50	Fire raked, 9 inches thick.
11	Cleaning fire.	5	Cleaning fire.
11.05	Fire cleaned, 3 inches thick.	5.08	Fire cleaned, 4 inches thick.
12.30	Fire raked, 7 inches thick.	5.31	Test closed, fire 3 inches thick.
12.43	Do.		

Clinker dark and heavy. 94 firings during test.

Steam Test of Iowa No. 5 Coal

CONDITIONS OF BOILER TRIAL.

Made by boiler division, United States Geological Survey.
At fuel-testing plant, Louisiana Purchase Exposition, St. Louis, Mo.
Kind of boiler, Heine safety.
To determine the economy of coal as a fuel.
Steam jets not operated. Hughes apparatus operated.
Kind of fuel, Iowa No. 5.
Kind of furnace, hand fired.
State of weather, clear.
Method of starting and stopping the test, alternate.
Number of boiler (plant number), 2.
Type of boiler, water tube.

1.	Date of trial November 14, 1904.		
2.	Duration of trial	hours..	9.983
3-10	Dimensions and proportions of boiler same as given in test of coal No. 1.		

AVERAGE PRESSURES.

11.	Barometer	inches of mercury..	29.75
		pounds..	14.6
11.1	Steam pressure by gage per square inch	do....	81.7
		do....	*96.3
12.	Force of draft between damper and boiler	inches of water..	.51
13.	Force of draft in furnace	do....	.22
14.	Force of draft or blast in ash pit	do....	0

AVERAGE TEMPERATURES.

15.	Of external air	degrees..	42.4
16.	Of fireroom	do....	53.5
17.	Of steam	do....	324.9
18.	Of feed water in tank	do....	51.4
19.	Of feed water entering economizer	do....	....
20.	Of feed water entering boiler	do....	177
21.	Of escaping gases from boiler	do....	530
22.	Of escaping gases from economizer	do....	....
22.1	Of furnace	do....	....

FUEL.

23.	Size and condition: Nut, medium bright—small, 65 per cent; slack 35 per cent.		
24.	Weight of wood used in lighting fire	pounds..	None
25.	Weight of coal as fired	do....	11,200
26.	Percentage of moisture in coal		16.01
27.	Total weight of dry coal consumed	pounds..	9,407
28.	Total ash and refuse	do....	1,328
29.	Quality of ash and refuse, clinker	per cent..	57
30.	Total combustible consumed	pounds..	8,079
		do....	*7,700
31.	Percentage of ash and refuse in dry coal		14.12

*Absolute.
*Calculated from chemistry of ash.

PROXIMATE ANALYSIS OF COAL.

		Per cent of coal	Per cent of combustible
32.	Fixed carbon	38.83	55.01
33.	Volatile matter	31.76	44.99
34.	Moisture	16.01	....
35.	Ash	13.04	....
		100.00	100.00
36.	Sulphur, separately determined	3.09	

ULTIMATE ANALYSIS OF DRY COAL.

37.	Carbon (C)	65.21	77.59
38.	Hydrogen (H)	4.71	5.6
39.	Oxygen (O)	9.12	10.85
40.	Nitrogen (N)	1.33	1.58
41.	Sulphur (S)	3.68	4.38
42.	Ash	15.95	....
		100.00	100.00
43.	Moisture in sample of coal as received	16.01	

ANALYSIS OF ASH AND REFUSE.

44.	Carbon	per cent..	15.49
45.	Earthy matter	do....	84.51

FUEL PER HOUR.

46.	Dry coal consumed per hour	pounds..	942
47.	Combustible consumed per hour	do.... do....	809 *771
48.	Dry coal per square foot of grate surface per hour	do....	23.23
49.	Combustible per square foot of water-heating surface per hour	do.... do....	.398 *.38

CALORIFIC VALUE OF FUEL.

50.	Calorific value by oxygen calorimeter per pound of dry coal, B. T. U.	11,963
51.	Calorific value by oxygen calorimeter per pound of combustible, B. T. U.	14,233
52.	Calorific value by analysis per pound of dry coal, B. T. U.	11,848
53.	Calorific value by analysis per pound of combustible, B. T. U.	14,096

QUALITY OF STEAM.

54.	Percentage of moisture in steam		1
55.	Number of degrees of superheating		None
56.	Quality of steam (dry steam=unity)	per cent..	99.24

*Calculated from chemistry of ash.

WATER.

57. Total weight of water fed to boiler....................pounds.. 59,083
58. Equivalent water fed to boiler from and at 212°........do.... 71,065
59. Water actually evaporated, corrected for quality of steam..do.... 58,632
60. Factor of evaporation.. 1.2028
61. Equivalent water evaporated into dry steam from and at 212° ....pounds.. 70,523

WATER PER HOUR.

62. Water evaporated per hour, corrected for quality of steam ....pounds.. 5,873
63. Equivalent evaporation per hour from and at 212°......do.... 7,064
64. Equivalent evaporation per hour from and at 212° per square foot of water-heating surface.......................pounds.. 3.48

HORSEPOWER.

65. Horsepower developed (34½ pounds of water evaporated per hour into dry steam from and at 212°=1 horsepower)........ 204.75
66. Builders' rated horsepower.................................... 210
67. Percentage of builders' rated horsepower developed............ 97.5

ECONOMIC RESULTS.

68. Water apparently evaporated under actual conditions per pound of coal as fired. (Item 57÷item 25).................pounds.. 5.28
69. Equivalent evaporation from and at 212° per pound of coal as fired. (Item 61÷item 25)..........................pounds.. 6.3
70. Equivalent evaporation from and at 212° per pound of dry coal. (Item 61÷item 27)...............................pounds.. 7.5
71. Equivalent evaporation from and at 212° per pound of combustible. (Item 61÷item 30)................ { ..do.... 8.73 / ..do.... *9.16 }

EFFICIENCY.

72. Efficiency of the boiler (heat absorbed by the boiler per pound of combustible divided by the heat value of 1 pound of combustible).................... { per cent.. 59.23 / ....do.... *62.10 }
73. Efficiency of boiler, including the grate (heat absorbed by the boiler per pound of dry coal divided by the heat value of 1 pound of dry coal)............................per cent.. 60.54

COST OF EVAPORATION.

74. Cost of coal per ton of 2,000 pounds delivered in boiler room (assumed) $1.00
75. Cost of fuel for evaporating 1,000 pounds of water under observed conditions $0.0947
76. Cost of fuel for evaporating 1,000 pounds of water from and at 212° $0.0793

SMOKE OBSERVATIONS.

77. Percentage of smoke as observed............................ 49.5
78. Weight of soot per hour obtained from smoke meter....ounces.. ....
79. Volume of soot per hour obtained from smoke meter ....cubic inches.. ....

*Calculated from chemistry of ash.

METHOD OF FIRING.

80.	Kind of firing (spreading, alternate or coking)	Alternate
81.	Average thickness of fire .... inches..	9
82.	Average intervals between firing for each furnace during time when fires are in normal condition .... minutes..	6.3
83.	Average intervals between times of leveling or breaking up .... do....	22

ANALYSIS OF THE DRY GASES.

84.	Carbon dioxide (CO_2) .... per cent..	7.83
85.	Oxygen (O) .... do....	11.66
86.	Carbon monoxide (CO) .... do....	.28
87.	Hydrogen and hydrocarbons .... do....	....
88.	Nitrogen (by difference) (N) .... do....	80.23

HEAT BALANCE, OR DISTRIBUTION OF THE HEATING VALUE OF THE COMBUSTIBLE.

Total heat value of 1 pound of combustible, B. T. U. 14,233

		B. T. U.	Per cent
1.	Heat absorbed by the boiler=evaporation from and at 212° per pound of combustible×965.7	8,846	*62.1
2.	Loss due to moisture in coal=per cent of moisture referred to combustible÷100×[(212−t)+966+0.48 (T—212)] (t= temperature of air in the boiler room; T=that of the flue gases)	290	*2.03
3.	Loss due to moisture formed by the burning of hydrogen= per cent of hydrogen to combustible÷100×9×[(212−t)+ 966+0.48 (T—212)]	644	4.52
4.	Loss due to heat carried away in the dry chimney gases= weight of gas per pound of combustible×0.24×(T−t)	2,709	19.03
5.	Loss due to incomplete combustion of carbon= $\frac{CO}{CO_2+CO}\times\frac{\text{per cent C in combustible}}{100}\times 10{,}150$	272	1.91
6.	Loss due to unconsumed hydrogen and hydrocarbons, to heating the moisture in the air, to radiation, and unaccounted for. (Some of these losses may be separately itemized if data are obtained from which they may be calculated)	1,472	10.41
			100.00

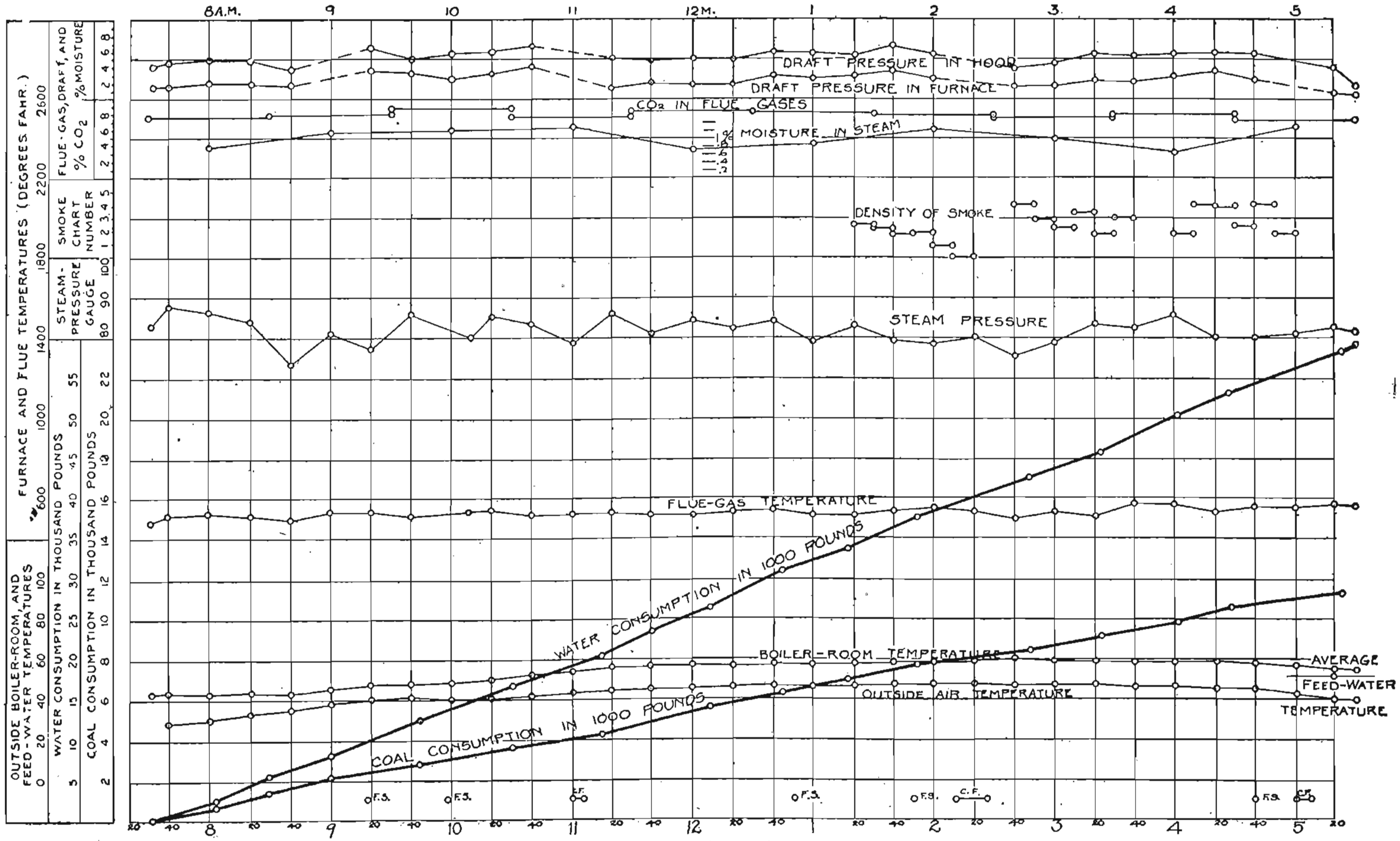
REMARKS.

Dry coal per indicated horsepower hour=3.77 pounds.
Dry coal per electrical horsepower hour=4.66 pounds.

*Calculated from chemistry of ash.

PRODUCER-GAS TESTS

The general results of tests of gas producer and gas engine using Iowa No. 2 coal are shown in the following tables:



Graphic log sheet, Iowa No. 5 coal (nut, medium bright).

LOG OF PRODUCER-GAS TEST ON IOWA NO. 2 COAL, JANUARY 30, 31, 1905.

(Coal from mine No. 5 of the Mammoth Vein Coal Company, Hamilton, Iowa.)

Time	Coal consumed by producer (pounds)	Gas meter (cubic feet)	Temperature of gas (°F.)	Water meter (cubic feet)	Manometers at gas meter (inches water)		Auxiliary motors		Speed counters on gas engine		Load		Temperature of gas leaving producer (°C.)	Manometers at producer		Gas calorimeter						
																Temperatures			Cubic centimeters of water collected	Cubic feet of gas	B. T. U.	
																	Water (°C.)					
					1	2	Watt meter	Ammeter	1	2	Volts	Amperes		Air entering (inches mercury)	Gas leaving (inches water)	Gas (°F.)	Inlet	Outlet			As read	Standardized
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
9.30 a. m. *a*	300																					
10.05 a. m.		1,001,250	51	47,015	2.0	− 0.7	85,100		0,000		242	624	290									
10.25 a. m.		1,007,800	55		2.3	+ 0.6			2,035		220	624	440	0.4	5.0	52	4.2	10.9	1,020	0.2	135.3	133.8
10.45 a. m.	300	1,013,700	58		2.4	+ 1.0			4,061		230	624	500			52	4.2	11.0	1,120	.2	150.7	148.0
11.05 a. m.		1,020,950	63	47,190	2.2	.6	87,000		6,061		231	624	490			56	4.2	10.9	1,120	.2	148.8	147.2
11.25 a. m.	300	1,026,700	63		2.2	.0			8,076		228	619	490			63	4.6	17.6	450	.2	115.9	116.3
11.45 a. m.		1,032,900	65		2.3	.7			10,119		227	624	440	.45	5.5	64	4.3	12.3	970	.2	154.0	154.8
11.55 a. m.	300																					
12.05 p. m.		1,038,750	67	47,365	2.4	1.0	89,150		12,161		238	624	390			64	4.2	13.4	910	.2	165.9	166.7
12.25 p. m.		1,044,240	68		2.4	1.0			14,202		232	649				69	4.4	13.2	1,020	.2	177.0	179.5
12.30 p. m.	300																					
12.45 p. m.		1,049,800	69		2.4	1.0					239	624				62	4.3	15.4	720	.2	158.3	158.5
1.05 p. m.		1,055,500	69	47,519	2.4	1.0	91,490		18,107		238	624	450			62	4.4	13.9	740	.2	139.3	139.5
1.15 p. m.	300																					
1.25 p. m.		1,061,240	69		2.4	1.0			20,198		240	624	420	.4	5.0	64	4.4	14.5	740	.2	148.0	148.8
1.45 p. m.		1,066,750	70		2.5	1.2			22,248		240	619	460			68	4.6	15.2	830	.2	174.2	176.4
2.05 p. m.		1,072,210	70		2.5	1.2	93,480		24,283		238	584	500									*b*
2.20 p. m.	300																					
2.25 p. m.		1,077,950	71		2.5	1.0			26,277		242	624	510									*b*
2.45 p. m.		1,083,820	72		2.5	1.0			28,280		228	624	490	.5	5.0							*b*
3.05 p. m.	300	1,090,150	71	47,859	2.5	.8	95,500		30,282		239	624	490			68	4.5	14.3	760	.2	147.6	149.4
3.25 p. m.		1,096,000	72		2.5	1.2			32,313		240	604	420			67	4.6	17.5	610	.2	163.5	165.2
3.45 p. m.		1,101,730	72		2.5	1.0			34,106		241	614	470			67	4.6	17.5	610	.2	163.5	165.2
4.05 p. m.		1,107,360	73		2.5	1.0	97,520		36,157		240	604	490			66	4.4	17.4	630	.2	162.3	163.8
4.10 p. m.	300																					
4.25 p. m.		1,113,000	73		2.5	1.0			38,190		240	619	460			67	4.5	17.3	630	0.2	159.9	161.6
4.45 p. m.		1,118,720	72		2.5	1.0			40,227		241	614	460			68	4.5	17.3	630	.2	159.9	161.8
5.05 p. m.	300	1,124,350	73	48,203	2.5	1.0	99,670		42,270		240	614	410	0.3	5.0	68	4.5	17.6	640	.2	166.3	168.4

a January 30. Average barometer for entire test, 29.92 inches.

b Meter connected with calorimeter clogged.

5.25 p. m.		1,130,050	73		2.5	1.0			44,309		238	624	460			69	4.5	17.6	650	.2	168.6	171.1
5.45 p. m.		1,135,730	73		2.4	1.0			46,343		238	624	480			69	4.6	17.6	630	.2	162.3	164.8
6 p. m.	300																					
6.05 p. m.		1,141,280	73		2.5	1.0	101,750		48,383		241	614	410			71	4.5	17.7	640	.2	167.4	170.5
6.25 p. m.		1,146,550	73		2.5	1.2			50,448		236	601	420	.3	4.5	71	4.6	18.0	620	.2	164.7	167.7
6.45 p. m.		1,151,920	73		2.4	1.1			52,461		240	619	415			72	4.6	17.9	620	.2	163.5	166.8
6.50 p. m.	300																					
7.05 p. m.		1,157,350	74		2.4	1.1	103,800		54,475		239	619	490	.45	6.0	72	4.6	17.7	640	.2	166.3	169.8
7.25 p. m.		1,163,100	74		2.4	1.1			56,480		238	624	480			70	4.6	16.2	670	.2	154.3	156.9
7.45 p. m.		1,169,350	73		2.4	1.0			58,519		240	619	510			70	4.5	16.2	660	.2	153.2	155.7
7.50 p. m.	300																					
8.05 p. m.		1,175,750	73		2.4	.8	105,950		60,545		240	619	470			70	4.5	16.6	660	.2	158.3	160.9
8.25 p. m.		1,181,800	73		2.4	1.0			62,577		244	619	490			69	4.5	16.7	700	.2	169.4	171.8
8.30 p. m.	300																					
8.45 p. m.		1,187,550	73		2.4	1.0			64,601		238	624	450			70	4.5	16.6	690	.2	165.5	169.9
9.05 p. m.		1,193,250	74		2.4	1.0			66,631		241	624	420	.4	5.0	70	4.5	16.8	700	.2	169.4	172.2
9.25 p. m.		1,199,100	74		2.4	1.0			68,631		239	624	500			73	4.6	16.2	710	.2	165.5	169.3
9.30 p. m.	300																					
9.45 p. m.		1,204,950	74		2.4	1.0			70,640		242	624	520			68	4.6	15.0	760	.2	156.7	158.7
10.05 p. m.		1,210,900	73		2.4	1.0			72,677		236	624	540			67	4.6	15.0	820	.2	169.0	170.8
10.25 p. m.		1,217,000	73		2.4	1.0			74,715		242	624	550			64	4.4	14.6	760	.2	153.8	154.6
10.30 p. m.	300																					
10.45 p. m.		1,223,400	73		2.3	.5			76,745		240	614	600			66	4.5	13.3	850	.2	148.4	149.8
11.05 p. m.		1,230,300	73	49,005	2.1	— 0.4	111,500		78,754		236	624	620			68	4.6	12.3	1,040	0.2	158.7	160.6
11.15 p. m.	300																					
11.25 p. m.		1,237,350	73		2.1	.0			80,775		244	624	580			70	4.6	12.7	980	0.2	157.5	160.2
11.45 p. m.		1,244,300	74		2.1	.0			82,797		240	614	580	0.5	6.5	70	4.6	12.7	1,000	.2	160.7	163.4
12 p. m.	300																					
12.05 a. m. *a*		1,251,090	73		2.2	+ .3	113,460		84,860		238	614	520			70	4.6	13.8	850	.2	155.1	157.8
12.25 a. m.		1,257,590	74		2.2	.3			86,894		240	624	550			69	4.5	13.4	960	.2	169.4	171.8
12.45 a. m.	300	1,264,300	74		2.2	.3			88,930		236	494	620			70	4.5	12.9	950	.2	158.3	160.9
1.05 a. m.		1,271,410	74		2.2	— .1	115,290		90,943		239	624	550			70	4.6	12.4	1,090	.2	168.6	171.4
1.15 a. m.	300																					
1.25 a. m.		1,278,760	74		2.2	— .3			92,938		235	508	520	.3	6.0	70	4.6	11.3	1,090	.2	144.8	147.2
1.45 a. m.	300	1,285,920	74		2.0	— .1			94,964		237	518	580			70	4.6	12.1	1,000	.2	148.8	151.3
2.05 a. m.	300	1,292,750	74		2.2	+ .2	117,200		97,006		239	518	560	.4	6.0	70	4.4	13.3	880	.2	155.1	157.7
2.25 a. m.		1,299,390	74		2.2	.2			99,047		237	614	490			70	4.6	13.2	950	.2	161.9	164.5
2.45 a. m.	300	1,306,030	74		2.3	.3			101,065		241	604	450	.4	6.0	70	4.4	13.2	950	.2	165.8	168.5
3.05 a. m.		1,312,790	74	49,640	2.2	..	118,980		103,082		241	560	450			70	4.5	12.6	990	.2	159.1	161.7
3.25 a. m.		1,320,800	73		2.2	— .1			105,040		232	493	520			69	4.5	11.0	1,070	.2	138.0	140.0
3.30 a. m.	300																					
3.45 a. m.		1,326,590	73		2.3	+ .3			107,081		233	466	490			69	4.4	13.2	850	.2	148.4	150.5
4.05 a. m.		1,333,200	73		2.2	.1			109,085		233	404	640			68	4.6	12.0	970	.2	142.4	144.1
4.15 a. m.	300																					
4.25 a. m.		1,340,480	73		2.2	— .4			111,030		239	466	600									*b*
4.45 a. m.		1,347,600	73		2.4	+ .3			113,072		234	404	700			68	4.4	12.4	860	.2	136.5	137.2
5 a. m.	300																					
5.05 a. m.		1,354,600	73		2.4	.8			115,116		248	374	530			68	4.4	13.3	720	.2	127.0	128.6
5.25 a. m.		1,361,506	72		2.3	.8			117,161		244	374	510			68	4.4	15.4	710	.2	154.7	156.6

a January 31.

b Calorimeter reading lost.

LOG OF PRODUCER-GAS TEST ON IOWA NO. 2 COAL, JANUARY 30, 31, 1905—Continued.

Time	Coal consumed by producer (pounds)	Gas meter (cubic feet)	Temperature of gas (°F.)	Water meter (cubic feet)	Manometers at gas meter (inches water)		Auxiliary motors		Speed counters on gas engine		Load		Temperature of gas leaving producer (°C.)	Manometers at producer		Gas calorimeter						
					1	2	Watt meter	Ammeter	1	2	Volts	Amperes		Air entering (inches mercury)	Gas leaving (inches water)	Temperatures: Gas (°F.)	Temperatures: Water (°C.) Inlet	Temperatures: Water (°C.) Outlet	Cubic centimeters of water collected	Cubic feet of gas	B. T. U. As read	B. T. U. Standardized
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
5.45 a. m.	300	1,367,490	72	50,064	2.3	0.8			119,193		232	454	610			68	4.4	14.5	730	0.2	146.0	147.8
6.05 a. m.		1,373,100	71		2.3	.7	124,100		121,212		236	463	530			67	4.5	15.4	700	.2	151.1	152.7
6.25 a. m.		1,380,400	72		2.3	.8			123,222		230	466	570			68	4.4	14.7	740	.2	151.1	152.8
6.30 a. m.	300																					
6.45 a. m.		1,387,700	72		2.3	.8			125,227		236	476	470			67	4.4	15.3	730	.2	156.3	157.9
7.05 a. m.		1,394,525	72		2.3	.0			127,227		230	476	580			68	4.5	14.5	740	.2	146.8	148.6
7.25 a. m.		1,401,350	72		2.3	.0			129,197		224	466	660			66	4.5	12.7	890	.2	144.8	146.3
7.30 a. m.	300																					
7.45 a. m.		1,408,900	72		2.1	— .5			131,200		226	414	620			65	4.7	10.7	950	.2	113.1	113.8
8.05 a. m.	300	1,416,600	72	50,347	2.2	— 1.0	127,490		133,198		242	324	660									*a*
8.25 a. m.		1,424,300	72		2.2	— 1.0			135,204		238	294	700			65	4.5	10.3	950	.2	109.1	109.8
8.45 a. m.		1,431,850	73		2.2	— 1.0			137,198		236	518	540			66	4.5	11.7	1,020	.2	145.6	147.0
9.05 a. m.		1,439,250	75		2.1	— 1.0	129,100		139,171		234	476	660	.5	6.0	67	4.5	11.4	1,040	.2	142.4	143.8
9.15 a. m.	300																					
9.25 a. m.		1,446,500	76		2.1	— .8			141,177		235	301	610			67	4.6	13.0	860	.2	143.2	144.7
9.45 a. m.		1,453,650	76		2.0	— .7			143,165		248	314	690	.65	7.5	66	4.6	9.7	1,000	.2	99.2	100.1
9.55 a. m.	300																					
10.05 a. m.		1,460,850	77	50,620	2.0	— .6	130,900		145,204		242	424	630			66	4.6	12.8	840	.2	136.5	137.7
10.25 a. m.	300	1,467,650	78		2.1	— .2			145,144		256	314	660			68	4.5	13.0	830	.2	139.7	141.5
10.45 a. m.		1,473,800	78		2.3	+ .8			147,192		246	354	640	.65	7.5	68	4.6	13.2	800	.2	136.5	138.2
11.05 a. m.		1,479,950	77	50,770	2.3	+ .6	132,600		149,229		251	314	680			69	4.7	13.1	790	.2	131.3	133.2

a Flame of calorimeter burner went out.

GAS ANALYSES.

Time	CO_2.	O_2.	CO.	H_2	CH_4	N.	Total	B.T.U.
10.30 a. m.*	9.4	0.0	12.6	7.8	5.6	64.6	100.0	127.8
12.30 p. m.	10.6	.2	11.2	22.1	8.2	47.7	100.0	199.3
2.30 p. m.	10.4	.2	12.0	6.8	6.8	63.8	100.0	138.0
4.30 p. m.	9.8	.2	12.6	12.0	7.4	58.0	100.0	164.5
6.30 p. m.	10.2	.2	13.0	6.7	9.2	60.7	100.0	166.7
8.30 p. m.	9.6	.2	13.6	5.8	9.2	61.6	100.0	165.6
10.30 p. m.	10.4	.2	13.0	5.5	7.3	63.6	100.0	142.3
12.30 a. m.†	11.0	.0	11.2	6.5	6.8	64.5	100.0	134.1
2.30 a. m.	11.8	.0	8.4	4.9	8.9	66.0	100.0	141.2
4.30 a. m.	13.0	.0	6.2	3.9	7.8	69.1	100.0	118.3
6.30 a. m.	12.0	.0	9.8	5.6	8.8	63.8	100.0	147.2
8.30 a. m.	13.4	.4	9.8	3.8	.0	72.6	100.0	117.6

*January 30.
†January 31.

PRODUCER-GAS TEST ON IOWA NO. 2. COAL.

1.	Duration of test, in hours	13.33
	AVERAGE TEMPERATURE, °F.	
2.	Gas leaving producer	893
	OUTSIDE POWER CHARGED AGAINST PRODUCER PLANT.	
3.	Total steam used by producer.....pounds..	3,065
4.	Steam used by producer per hour.....do....	230
5.	Equivalent in pounds of coal per hour	45.9
6.	Equivalent in pounds of dry coal per hour	38.2
7.	Equivalent in pounds of combustible per hour	28.7
8.	Average horsepower required to drive auxiliary machinery	10.9
9.	Total water used in scrubber and tar extracter..cubic feet..	2,133
10.	Cubic feet of water per hour per horsepower of producer plant	.64
11.	Cubic feet of water per 1,000 cubic feet of gas produced	9.12
	COAL CONSUMED IN PRODUCER.	
12.	Total coal consumed.....pounds..	4,833
13.	Moisture in coal.....per cent..	16.69
14.	Total dry coal consumed.....pounds..	4,030
15.	Refuse from dry coal.....per cent..	24.85
16.	Total refuse from coal.....pounds..	1,000
17.	Total combustible consumed.....do....	3,030

COAL PER HOUR.

18.	Coal consumed in producer.....................pounds..	362.5
19.	Dry coal consumed in producer...................do....	302.5
20.	Combustible consumed in producer.................do....	227.5
21.	Equivalent coal used by producer plant.............do....	408.4
22.	Equivalent dry coal used by producer plant........do....	340.7
23.	Equivalent combustible used by producer plant......do....	256.2

COAL CONSUMED PER SQUARE FOOT OF FUEL BED PER HOUR.

24.	Coal as fired ....pounds..	9.43
25.	Dry coal ....do....	7.87
26.	Combustible ....do....	5.92

BRITISH THERMAL UNITS FROM COAL.

27.	Per pound of coal as fired..............................	8,735
28.	Per pound of dry coal...................................	10,489
29.	Per pound of combustible................................	13,950
30.	From coal as fired, per hour............................	3,175,000
31.	From dry coal, per hour.................................	3,175,000
32.	From combustible, per hour..............................	3,175,000

GAS PRODUCED, CUBIC FEET.

(Gas at 62° F. and 14.7 pounds pressure.)

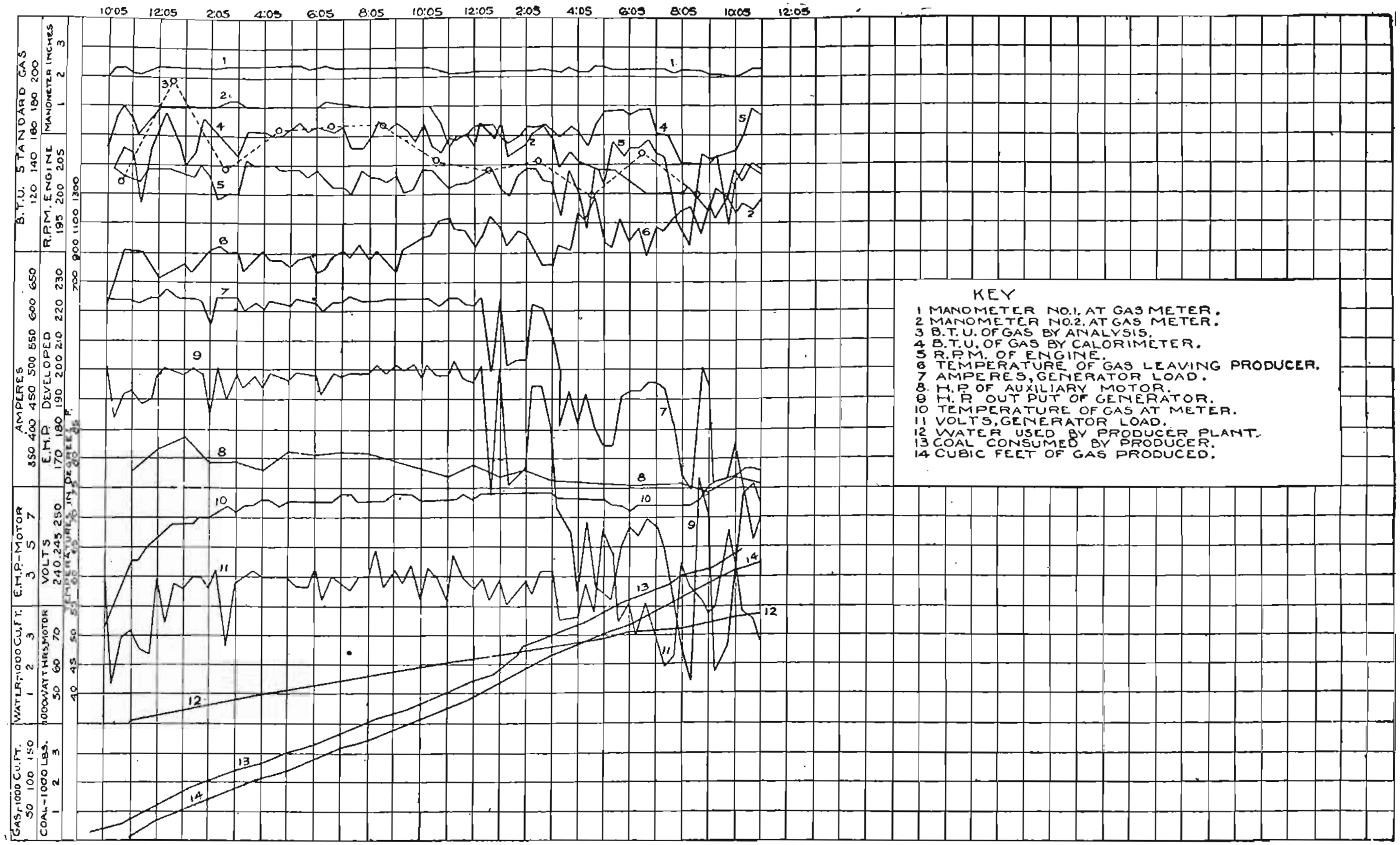
33.	Total	234,110
34.	Per hour	17,570
35.	Per pound coal consumed in producer....................	48.5
36.	Per pound dry coal consumed in producer................	58.1
37.	Per pound combustible consumed in producer............	77.2
38.	Per pound equivalent coal used by producer plant........	43
39.	Per pound equivalent dry coal used by producer plant....	51.6
40.	Per pound equivalent combustible used by producer plant..	68.5

BRITISH THERMAL UNITS FROM STANDARD GAS.

41.	Per cubic foot..	160.2
42.	Per pound dry coal burned in producer...................	9,300
43.	Per hour per brake horsepower...........................	12,130

AVERAGE HORSEPOWER DEVELOPED.

44.	Electrical horsepower available for outside purposes........	186.6
45.	Electrical horsepower developed at switch board..........	197.5
46.	Brake horsepower available for outside purposes...........	219.5
47.	Brake horsepower developed at engine....................	232.3



Graphic log sheet, producer-gas test, Iowa No. 2 coal.

COAL PER HORSEPOWER PER HOUR

	Coal as fired	Dry coal	Combustible
48. Pounds consumed in producer per electrical horsepower available for outside purposes.	1.94	1.62	1.22
49. Pounds consumed in producer per electrical horsepower developed at switch board....	1.84	1.53	1.15
50. Pounds consumed in producer per brake horsepower* available for outside purposes	1.65	1.38	1.04
51. Pounds consumed in producer per brake horsepower* developed at engine	1.56	1.30	.98
52. Equivalent pounds used by producer plant per electrical horsepower available for outside purposes	2.19	1.83	1.37
53. Equivalent pounds used by producer plant per electrical horsepower developed at switch board	2.07	1.73	1.30
54. Equivalent pounds used by producer plant per brake horsepower* available for outside purposes	1.86	1.55	1.17
55. Equivalent pounds used by producer plant per brake horsepower* developed at engine	1.76	1.47	1.10

AVERAGE COMPOSITION OF COAL AND GAS.

56. Coal:	Per cent
Moisture	16.69
Volatile matter	31.42
Fixed carbon	31.19
Ash	20.70
	100.00
Sulphur	5.50

57. Gas by volume:	Per cent.
Carbon dioxide (CO_2)..	10.06
Oxygen (O_2)	.17
Carbon monoxide (CO)..	12.57
Hydrogen (H_2)	9.53
Methane (CH_4)	7.67
Nitrogen (N_2)	60.00
	100.00

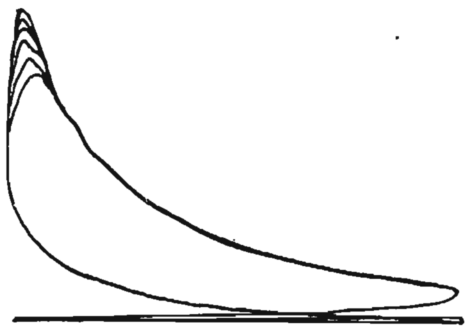
This coal was very high in sulphur (5.50 per cent), but did not clinker in the producer. The results were, however, not so satisfactory as might be expected. There is no doubt that better records can be made from this coal in a second test. The lack of uniformity in the gas made it difficult to adjust the engine to meet the changes.

Fifty gallons of black tar were extracted.

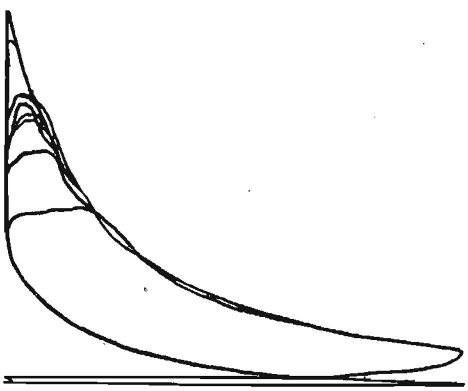
*Based on an assumed efficiency of 85 per cent for generator and belt.

GAS ENGINE.

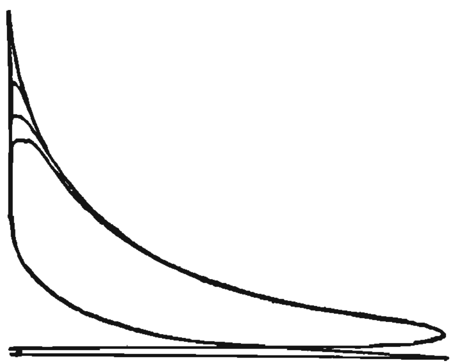
The report covers the records taken from 10:45 a. m. January 30 to 12:05 a. m. January 31, a period of 13:33 hours. After 12:05 a. m. January 31 it was impossible to carry full load on the engine.



Right cylinder. M. E. P., 58; Max., 280; Rel., 24; I. H. P., 93.2



Center cylinder. M. E. P., 59; Max., 260; Rel., 26; I. H. P., 94.8



Left cylinder. M. E. P., 50; Max., 290; Rel., 24; I. H. P., 80.3

Figure 103. Indicator diagrams taken January 30, 1905, during gas-engine test on Iowa No. 2 coal. Revolutions per minute, 204.1.

The results of tests made on the gas engine are given below:

REPORT OF GAS-ENGINE TEST ON IOWA NO. 2. COAL.

Coal: General number, Iowa No. 2; special number, G. P. 22. Car initials and number, 43574, Wabash.

Duration of test, in hours	13.33
Revolutions per minute (mean)	202.7
Explosions per minute (mean)	101.35
Cubic feet gas per hour, by meter	17,820
Cubic feet standard gas per hour (i. e., 62° F., 14.7 pounds pressure)	17,560

Maximum pressure:	
First cylinder	272
Second cylinder	282
Third cylinder	272
Pressure at release:	
First cylinder	24
Second cylinder	26
Third cylinder	24
Mean effective pressure:	
First cylinder	58
Second cylinder	59
Third cylinder	54
Indicated horsepower:	
First cylinder	93
Second cylinder	95
Third cylinder	87.05
Total indicated horsepower	275.05
Horsepower delivered (electrical horsepower)	197.5
Mechanical efficiency (engine and generator combined)....per cent..	71.8
Cubic feet standard gas per hour per indicated horsepower	63.9
Cubic feet standard gas per hour per electrical horsepower	88.9

COKING TESTS ON IOWA COALS

IOWA NO. 1.

Lump and fine coal from mine No. 2, Anchor Coal Company, Laddsdale, Iowa.

In this test, as in all those on Iowa coals, the charge was of washed coal (page 474). The charge weighed 9,500 pounds, and after burning 46 hours yielded 4,828 pounds of coke and 572 pounds of breeze and ash. The coke was brittle, with cracks lengthwise and crosswise through it. It was also high in sulphur and ash.

Analysis of Iowa No. 1 coal.

Character of coal	Chemical lab-orat'ry number	Moisture *Per ct.*	Volatile matter *Per ct.*	Fixed carbon *Per ct.*	Ash *Per ct.*	Sulphur *Per ct.*	Remarks
Washed	1356	12.84	35.91	41.00	10.25	4.61	Used for coking test.

Coking test and coke production.

Test number	When charged	When drawn	Time in oven *Hours*	Coal charged (wet) *Lbs.*	Large coke *Lbs.*	Medium coke *Lbs.*	Total coke made *Lbs.*	Breeze and ash *Lbs.*	Per ct. of yield			
									Large	Medium	Total	Breeze and ash
31 (washed)--	Nov. 3, 3 p. m--	Nov. 5, 1 p. m--	46	9,500	916	3,912	4,828	572	9.5	41.2	50.8	6.0

Physical and chemical properties of coke produced.

Test number	Grams in 1 cubic inch		Pounds in 1 cubic foot		Percentage by volume		Compressive strength per cubic inch (one-fourth ultimate strength) *Lbs.*	Height of furnace charge supported without crushing *Feet.*	Hardness	Specific gravity	Chemical laboratory number	Chemical analysis					
	Dry	Wet	Dry	Wet	Coke	Cells						Moisture *Per cent*	Volatile matter *Per cent*	Fixed carbon *Per cent*	Ash *Per cent*	Sulphur *Per cent*	Phosphorus *Per cent*
31-------	11.4	19.75	43.32	75.05	49	51	180	72	2.2	1.87	1371	10.53	1.63	70.39	17.45	3.89	0.051

The coke produced with this washed coal showed cracks lengthways and crossways. It was very brittle and broke up into small pieces in handling. These pieces seemed to be fairly hard and of good cell structure. The ash, sulphur, and phosphorus are high, making the coke unfit for blast furnace and foundry purposes, and the smallness of the pieces would make it undesirable for use in lead or zinc works.

IOWA NO. 2.

Run-of-mine coal from mine No. 5, Mammoth Vein Coal Company, Hamilton, Iowa.

The charge in this test consisted of 10,000 pounds of washed coal (page 474), which was burned for 64 hours. The coke (3,866 pounds, with 1,153 pounds of breeze and ash) was all in small pieces sintered together and with no bond.

Analysis of Iowa No. 2 coal.

Character of coal	Chemical laboratory number	Moisture Per ct.	Volatile matter Per ct.	Fixed carbon Per ct.	Ash Per ct.	Sulph'r Per ct.	Remarks
Washed	1483	18.85	35.44	35.43	10.28	3.93	Used for coking test.

Coking test and coke production.

Test number	When charged	When drawn	Time in oven Hours	Coal ch'ged (wet) Lbs.	Total coke made Lbs.	Breeze and ash Lbs.
49 (washed)	Nov. 26, 5 p. m.	Nov. 29, 9 a. m.	64	10,000	3,866	1,153

This charge made some coke, all in small pieces, sintered together, which broke up in drawing so that ash and breeze formed one-fourth of the total product. This coke could be used only for domestic purposes and would not be very desirable, even for such use, on account of its high ash and sulphur. The small-sized pieces of this coke would make a poor fuel at lead or zinc furnaces.

IOWA NO. 3.

Lump coal from mine No. 4, Gibson Coal Mining Company, Altoona, Iowa.

The charge in this test consisted of 8,000 pounds of washed coal (page 475), which was burned for 43 hours. It yielded 3,336 pounds of fine-fingered, brittle coke that was high in sulphur and ash, and 585 pounds of breeze and ash.

Analysis of Iowa No. 3 coal.

Character of coal	Chemical laboratory number	Moisture Per ct.	Volatile matter Per ct.	Fixed carbon Per ct.	Ash Per ct.	Sulphur Per ct.	Remarks
Washed	1389	16.83	39.27	35.87	8.03	4.55	Used for coking test.

Coking test and coke production.

Test number	When charged	When drawn	Time in oven *Hours*	Coal charged *Lbs.*	Large coke *Lbs.*	Medium coke *Lbs.*	Total coke made *Lbs.*	Breeze and ash *Lbs.*	Per ct. of yield			
									Large	Medium	Total	Breeze and ash
35 (washed)---	Nov. 8, 2 p. m.---	Nov. 10, 9. a. m.-	43	8,000	865	2,471	3,336	535	10.8	30.9		7.3

Physical and chemical properties of coke produced.

Test number	Grams in 1 cubic inch		Pounds in 1 cubic foot		Percentage by volume		Compressive strength per cubic inch (one-fourth ultimate strength) *Lbs.*	Height of furnace charge supported without crushing *Feet*	Hardness	Specific gravity	Chemical laboratory number	Chemical analysis					
	Dry	Wet	Dry	Wet	Coke	Cells						Moisture *Per cent*	Volatile matter *Per cent*	Fixed carbon *Per cent*	Ash *Per cent*	Sulphur *Per cent*	Phosphorus *Per cent*
35-------	13.1	22.42	49.78	85.19	43	57	165	66	2.8	1.88	1399	5.73	1.87	75.49	16.91	4.57	0.018

This coal made a brittle, fine-fingered coke, in small pieces, which broke up easily, although they were hard. The cell structure was high and the ash and sulphur very high, which would exclude any of this coke from metallurgical use.

IOWA NO. 4.

Lump coal from mine No. 3, Centerville Block Coal Company, Centerville, Iowa.

The coke produced in this test was of the same general character as that obtained from Iowa No. 3, except that it was not quite so high in either sulphur or ash. The charge consisted of 8,000 pounds of washed coal (page 475), which was burned for 40 hours, producing 3,722 pounds of coke and 426 pounds of breeze and ash.

Analysis of Iowa No. 4 coal.

Character of coal	Chemical laboratory number	Moisture *Per ct.*	Volatile matter *Per ct.*	Fixed carbon *Per ct.*	Ash *Per ct.*	Sulphur *Per ct.*	Remarks
Washed ------------	1378	17.80	37.59	37.39	7.14	3.59	Used for coking test.

Coking test and coke production.

Test number	When charged	When drawn	Time in oven *Hours*	Coal charged (wet) *Lbs.*	Large coke *Lbs.*	Medium coke *Lbs.*	Total coke made *Lbs.*	Breeze and ash *Lbs.*	Per ct. of yield			
									Large	Medium	Total	Breeze and ash
34 (washed)	Nov. 7, 5 p. m.	Nov. 9, 9 a. m.	40	8,000	1,114	2,608	3,722	426	13.9	32.6	46.5	5.3

Physical and chemical properties of coke produced.

Test number	Grams in 1 cubic inch		Pounds in 1 cubic foot		Percentage by volume		Compressive strength per cubic inch (one-fourth ultimate strength) *Lbs.*	Height of furnace charge supported without crushing *Feet*	Hardness	Specific gravity	Chemical laboratory number	Chemical analysis					
	Dry	Wet	Dry	Wet	Coke	Cells						Moisture *Per cent*	Volatile matter *Per cent*	Fixed carbon *Per cent*	Ash *Per cent*	Sulphur *Per cent*	Phosphorus *Per cent*
34	12.6	21.6	47.88	82.08	45	55	160	64	2.6	1.82	1400	13.05	2.32	73.10	11.53	2.97	0.013

The coke from this coal showed the same structure as the other Iowa cokes. It was fine fingered, very brittle, and broke up into small pieces. The cell structure was high, ash and phosphorus normal, but sulphur very high. Lead and zinc works could use it, but it is not very desirable even for them on account of the small size of the coke.

IOWA NO. 5.

Run-of-mine coal from Inland mine No. 1, Inland Fuel Company, Chariton, Iowa.

The result of this test, made on 9,000 pounds of washed coal (page 475), and burned for 66 hours, was a mixture of unburned coal, charred coke, and ash.

Analysis of Iowa No. 5 coal.

Character of coal	Chemical laboratory number	Moisture *Per ct.*	Volatile matter *Per ct.*	Fixed carbon *Per ct.*	Ash *Per ct.*	Sulphur *Per ct.*	Remarks
Washed	1419	19.25	31.07	41.75	7.93	2.28	Used for coking test.

Coking test.

Test number	When charged	When drawn	Time in oven *Hours*	Coal ch'ged (wet) *Lbs.*	Remarks
40 (washed)........	Nov. 14, 3 p. m..	Nov. 17, 9 a. m........	66	9,000	No coke.

Though this washed coal started off very well in a hot oven, all that was gotten out of it was unburned coal mixed with pieces of charred coal and ashes. There was no sign of fusing and the coal was manifestly noncoking.

All of the Iowa coals tested are too high in sulphur to produce blast-furnace coke, and as the sulphur occurs largely as gypsum it can not be removed by washing. The ash is also high in relation to the fixed carbon.

BRIQUETTING TEST WITH IOWA COAL

Iowa No. 4.—One ton of this coal was briquetted with 7 per cent of pitch E.* The briquettes were well pressed, of a grayish color, but on cooling crumbled decidedly. They weighed 6.73 pounds each. As they did not contain an excess of pitch, 7 tons more of this coal were briquetted with 8 per cent of pitch E, in order to have a sufficient quantity for a steam test. The resultant briquettes were bluish black in color, but were not quite hard enough, although fairly strong, and would stand considerable rough treatment in transportation. In burning they held together until consumed. They weighed, on an average, 6.77 pounds each. The eggettes made from this same mixture were stronger than the briquettes, had a polished surface, but were very brown in color. In the cook stove they burned satisfactorily, crumbling little until consumed.

The steaming test made of these briquettes gave considerably better results than the original coal, indicating that the coal has been much improved by briquetting. The results of the boiler tests of both the coal and briquettes are given in the table below:

*Pitch E shows the following composition.

Proximate analysis; moisture, 1.02; volatile matter, 54.11; fixed carbon, 44.04; ash, 0.83; sulphur, 0.66.

Ultimate analysis; Hydrogen, 4:22; carbon, 91.30; nitrogen, 1.00; oxygen, 1.99; sulphur, 0.66.

Analyst, Mr. E. E. Somermeier, St. Louis Testing Station. See Prof. Paper No. 48, p. 1397, U. S. Geological Survey. See also Bull. 343, p. 52, U. S. Geological Survey.

Results of steam test of Iowa No. 4 coal and briquettes.

Fuel	Chemical composition					Duration of trial *Hours*	Total coal consumed *Lbs.*	Horsepower developed by boiler	Dry coal burned per square foot of grate surface per hour *Lbs.*	Equivalent evaporation from and at 212° F. per lb. of dry coal *Lbs.*	Dry coal per indicated horsepower hour *Lbs.*	Dry coal per electrical horsepower hour *Lbs.*
	Fixed carbon *Per cent*	Volatile matter *Per cent*	Moisture *Per cent*	Ash *Per cent*	Sulphur (separately determined) *Per ct.*							
Briquettes	37.85	36.50	13.24	12.41	3.90	10.03	9,900	184.5	21.11	7.43	3.80	4.70
Coal, mine run	37.28	34.09	13.48	15.15	5.04	10.00	9,385	167.3	20.02	7.11	3.98	4.91

WASHING TESTS WITH IOWA COALS.

IOWA NO. 1.

Lump and fine coal from mine No. 2, Anchor Coal Company, Laddsdale, Iowa.

About 5 tons of this coal were washed for a coking test, but the coal was not tried in a raw condition, and consequently the coking test affords no clue to the improvement made by washing. The change is shown by the chemical analyses:

Analyses showing effect of washing Iowa No. 1 coal.

	Car sample	Washed coal for coking
Ash	16.0	10.25
Sulphur	5.03	4.61

IOWA NO. 2.

Run-of-mine coal from mine No. 5, Mammoth Vein Coal Company, Hamilton, Iowa.

About 5½ tons of coal were washed for a coking test. The reduction of impurities effected by washing was not great, as shown by the following analyses:

Analyses showing effect of washing Iowa No. 2 coal.

	Car Sample	Washed coal for coking
Ash	15.22	10.28
Sulphur	4.66	3.93

IOWA NO. 3.

Lump coal from mine No. 4, Gibson Coal Mining Company, Altoona, Iowa.

About 4½ tons of this coal were washed for a coking test. The improvement in the quality of the coal effected by washing is shown in the following analyses:

Analyses showing effect of washing Iowa No. 3 coal.

	Car sample	Washed coal for coking
Ash	14.01	8.03
Sulphur	6.15	4.55

IOWA NO. 4.

Lump coal from mine No. 3, Centerville Block Coal Company, Centerville, Iowa.

A charge consisting of about 4½ tons of this coal was washed for coking purposes. The results were not so satisfactory as those obtained on other samples from this state. The analyses are given below:

Analyses showing effect of washing Iowa No. 4 coal.

	Car sample	Washed coal for coking
Ash	10.96	7.14
Sulphur	4.26	3.59

IOWA NO. 5.

Run-of-mine coal from mine No. 1, Inland Fuel Company, Chariton, Iowa.

A charge consisting of nearly 5 tons of this coal was washed for a coking test, but the coal did not coke, although the washing was fairly successful in reducing the impurities, as shown by the following analyses:

Analyses showing effect of washing Iowa No. 5 coal.

	Car sample	Washed coal for coking
Ash	12.63	7.93
Sulphur	3.19	2.28

ANALYSES OF IOWA COALS

BY JAMES H. LEES AND A. W. HIXSON.

COLLECTION OF SAMPLES

While the present volume was in preparation it was thought well to compile as complete a list of analyses of Iowa coals as possible. It soon became apparent, however, that these analyses were not comparable with one another since they were made by different persons and under widely varying conditions. Hence it seemed desirable that a series of samples should be collected and analyzed under conditions as nearly uniform as could be secured. The Assistant State Geologist collected such a series and the analyses have been made by Professor A. W. Hixson, of the department of Mining at the State University of Iowa.

Sixteen mines were sampled, selected as representative of the important mining districts of the state. Practically the same method of mine sampling was used as was employed by the United States Geological Survey in collecting the samples which were analyzed at its coal-testing station at the Louisiana Purchase Exposition at St. Louis in 1904. The method was about as follows: The room or entry selected for sampling was one from which coal was being mined at the time the sample was taken and thus a fresh face was assured. A portion of the face was cleaned to remove powder smoke or coal which had been exposed to the air for any considerable period of time. A strip was then cut across the seam from floor to roof and about three inches wide and one inch deep. All bony streaks or sulphur bands over one-fourth inch thick were thrown out. The coal cut down in this way was collected, as it fell, upon a rubber cloth to avoid any danger of mixture with dirt or moisture on the floor. Immediately upon arrival above ground the sample was broken up, on a clean hard surface, into fragments one-half inch or less in diameter. It was then thoroughly mixed and quartered, alternate quarters rejected and the remaining quarters mixed and further pulverized and again quartered, until about a quart remained. This was put into a clean can with a tight fitting lid which was driven down solid and the joint sealed by wrapping with tire-tape, so that it would be air-tight. In short every effort was made to the end that the sample should represent as closely as might be the commercial output of the mine and that the original characteristics of the coal should be preserved until it was analyzed.

A slip of paper giving the number of the sample together with the name and location of the mine was enclosed in the can to render identification certain. The sample number was also marked on the outside of the can. The sample was later shipped by express to the laboratory at Iowa City.

The following papers by Marius R. Campbell give an outline of methods of mine sampling. Commercial Value of Coal-Mine Sampling: Trans. Am. Inst. Min. Eng., Vol. 36, pp. 1053-1065. The Value of Coal-Mine Sampling: Economic Geology, Vol. II, No. 1, pp. 48-57, 1907.

LABORATORY METHODS

The methods followed in the analytical work were essentially those adopted in the report of the committee on coal analysis of the American Chemical Society and those employed in the chemical laboratory of the coal testing plant of the United States Geological Survey at the Louisiana Purchase Exposition at St. Louis in 1904.

The analytical work consisted of the proximate analysis of the coal samples with the determination of sulphur and calorific value in addition.

PREPARATION OF THE SAMPLE

When the sample arrived at the laboratory it was immediately given a serial number for identification purposes in the laboratory. The number and description on the tag were compared with the number and description on the slip of paper within the can to make sure they agreed. They were then entered in a book for permanent record together with any notes concerning the condition of sample when it arrived. The coal was then poured out upon a well cleaned bucking board, crushed, mixed and quartered down to one pint. One-half of this was spread out upon a shallow tinned iron tray ten inches in diameter, weighed, and then set aside for air drying. The other half was run through a coffee mill and a portion of this was placed in a tightly stoppered bottle for the moisture determination. The crushing and quartering down of the sample were done as quickly as possible to prevent loss of moisture. The coal was air dried for ninety-six hours and then weighed. The time at which the weighing was done together with the temperature and humidity of the air was recorded. The air dried sample was then crushed and quartered down to 150 grams. The final crushing was to 100 mesh. This sample was then placed in a tightly stoppered bottle and used for determinations other than moisture. All samples were mixed on a rolling cloth before weighing out for each determination to insure a perfectly homogeneous sample. All determinations were made in duplicate.

Moisture

One gram of the coarsely ground fresh coal was dried in a weighed porcelain crucible at 105° C. for one hour, in a double walled bath heated by electricity. The crucible and contents were then cooled in a dessicator and weighed covered. Moisture in the air dried sample was determined in like manner. It was found that the moisture determination in the finely ground fresh sample was not reliable since a considerable amount of moisture was lost in grinding and for this reason the sample used for the moisture determination was ground in a coffee mill.

Ash

The portion of powdered coal used for the determination of moisture in the air dried sample was burned at first over a Bunsen burner with a very low flame until all of the volatile matter was expelled. The final burning was done in a case gasoline muffle furnace, the temperature being kept at that of low redness. Burning was continued until the ash was burned to constant weight.

Note—For convenience the following equivalents are given: 1 gram=15.43 grains, 1 cm. (centimeter)=0.394 inch, 1 cc. (cubic centimeter)=.061 cubic inch. 100°C. is the equivalent of 212°F., the boiling point of water.

Volatile Combustible Matter

One gram of the air dried sample was weighed into a previously ignited and weighed platinum crucible with a tightly fitting cover. This was heated for seven minutes over the full flame of a Bunsen burner, then cooled and weighed. The crucible was supported on a pipe clay triangle resting upon a tripod, the bottom of the crucible being 7 cm. from the top of the burner. The burner when burning freely gave a flame from 17 to 20 cm. high. The flame was protected from air currents by an asbestos chimney surrounding the burner. The volatile combustible matter was found by subtracting the per cent of moisture from the loss found here.

Fixed Carbon

It is the difference between the sum of the other constituents determined and 100. Sulphur which goes partly into the volatile combustible matter and partly into the coke was not considered here. Fixed carbon may also be found by subtracting the per cent of ash from the per cent of residue left after expelling the volatile matter.

Sulphur

This was determined by the Escka method. One gram of the finely powdered air dried coal was weighed in a platinum dish of 100 cc. capacity. To this was added 1.5 grams of an intimate mixture of 1 part dry sodium carbonate and 2 parts magnesium oxide. The coal and the mixture were well mixed together with a glass rod. The contents of the dish were then heated over a Bunsen burner very gently until all of the volatile matter was expelled. This required about thirty minutes. Then the heat was increased until all traces of carbon disappeared. To prevent any sulphur from the gas contaminating the determination the platinum dish was fitted into a hole in a piece of asbestos board.

After all traces of carbon were removed the contents of dish were transferred to a numbered beaker and digested with 75 cc. of water for thirty minutes. The solution was then filtered, and the residue was washed twice by decantation with 50 cc. of boiling water. The residue was then transferred to the filter paper and again washed with hot water until the filtrate gave only a slight opalescence with nitric acid and silver nitrate. The filtrate at this point amounted to about 200 cc.

10 cc. of saturated bromine water and 3 cc. of concentrated hydrochloric acid were then added to the solution. The solution was boiled slowly until all of the bromine was expelled. Then the sulphur was precipitated by adding to the boiling solution 10 cc. of a ten per cent solution of barium chloride. This was added drop by drop and the solution stirred vigorously. The precipitate was allowed to stand two hours at a temperature slightly below boiling. The barium sulphate was then filtered off and was washed with hot water until free from chlorides.

The filter with the moist precipitate was transferred to a weighed porcelain crucible which was heated over a low flame until the paper was burned off. The heat was then raised until the precipitate became a dull red and the heating continued until the carbon was burned out. The crucible and precipitate were then cooled in a dessicator and weighed.

Blank determinations were made, using all of the reagents in the same quantities and the determination was carried out exactly as with the coal. Any barium sulphate found was subtracted from that obtained in the coal determination. The true weight of barium sulphate multiplied by 0.1373 gave the weight of sulphur.

Calorific Value

This was determined with a Parr Standard Calorimeter, which was installed in a room as free as possible from fluctuations in temperature. The apparatus was carefully standardized, the water equivalent being determined by different methods. The correction components used for the chemical, iron wire fuse, and for the varying compositions of the different coals were those determined by Prof. S. W. Parr of the State University of Illinois.

The thermometers used were standardized by the Bureau of Standards in Washington, D. C.

One gram of the powdered air dried coal was weighed into the bomb of the calorimeter. To this was added one gram of accelerator (Potassium Chlorate) and 15 grams of perfectly dry and pure sodium peroxide. The false cap was then put in position and screwed firmly in place and the ingredients mixed by shaking the bomb thoroughly. The material was then shaken to the bottom of the bomb, the false top removed, the ignition device inserted and firmly screwed in place. The bomb now complete was put in place into the can which contained exactly two liters of distilled water. The lid was then placed on the calorimeter tub, pulley attached and the thermometer inserted so that the bulb was half way to the bottom. The water was stirred by metal wings attached to the bomb which was revolved by a belt from a small motor.

The motor was started and apparatus allowed to run for five minutes before ignition in order that the rate of change of temperature might be noted by taking reading each minute. At the end of the fifth minute the charge in the bomb was ignited by closing a switch which allowed an electric current of four and one-half amperes to quickly fuse a 34 gauge iron wire, four inches long, which extended into the charge in the bomb. The temperature was read at the end of each minute until the maximum was reached, then for five minutes to obtain the rate of change of temperature due to radiation.

The apparatus was then taken apart, each piece dried thoroughly, and prepared for a new charge. The room temperature was taken during each determination.

The calorific value was then calculated by multiplying the number of British Thermal Units corresponding to one degree increase in temperature by the total rise of temperature obtained after the correction factors had been subtracted.

The calorific value was also calculated in calories.

METHOD OF STATEMENT

All of the analyses were made upon the air dried samples. The results on the sample as received were calculated by correcting the analyses for loss of moisture in air drying. The results of the actual analyses on the air dried sample and those corrected to sample as received follow in the tables.

DESCRIPTION OF MINES SAMPLED

Sample No. 1

Operator.—High Bridge Coal Company, Madrid.

Mine.—High Bridge mine, High Bridge, Dallas county, on Boone division Chicago, Milwaukee and St. Paul Railroad.

Sample collected.—May 12, 1909.

Description.—The sample was collected from the face of the west entry, about 1,300 feet from the shaft. The coal is here 3 feet 11 inches thick. It has a clay roof and about three inches of black shale on the floor. This is underlain by gray fire clay. The present capacity of the mine is 300 tons daily. See page 89.

Sample No. 2

Operator.—Ogden Coal Company, Ogden*.

Mine.—Ogden No. 1, two miles north of Ogden, Boone county, on switch from main line Minneapolis and St. Louis Railroad.

Sample collected.—May 14, 1909.

Description.—The sample was taken from the fourth northeast entry. The coal is here 4 feet 4 inches thick and is free from sulphur bands or balls as well as from rock. It is the "lower vein" of the Boone county mines and averages 4½ to 5½ feet. The "upper vein" is about fifty feet above and is about 3½ feet thick.

The shaft is 275 feet deep. It was completed in August of 1907. The mine now has an output of 400 tons, of three grades, lump, range and steam. The railroad company uses 125 tons daily. About 200 men are employed in the mine. Electric haulage is being installed. The same company is sinking a second shaft two miles south of Ogden. See page 74.

Sample No. 3

Operator.—Willow Grove Coal Company (Henry McElheny), Angus.

Mine.—Willow Grove mine, on northwest border of Angus in Greene county. No railroad connections.

Sample collected.—May 14, 1909.

Description.—This sample was taken from the fourth east-south entry. The seam is here 4 feet 2 inches thick. The coal

*The Fort Dodge, Des Moines and Southern Railroad Company (electric) has since purchased a controlling interest in the property. (July,1909.)

breaks with angular fracture and shows bright clean faces. Thin films of lime or gypsum occur along joints and stratification planes. The vein worked is called the lower vein. Its thickness ranges from 4 to 5½ feet. The "middle vein" is separated from the lower by a sandstone roof 3½ to 20 feet thick, with an average of 14 feet. Owing to the character of the roof the mine is very wet. See page 361.

Sample No. 4

Operator.—Atwood Coal Company, What Cheer.

Mine.—Blyth mine, three miles northwest of Rose Hill, Mahaska county, on long switch from Knoxville branch Chicago, Rock Island and Pacific Railroad.

Sample collected.—May 18, 1909.

Description.—The mine was sampled in the fifth north entry on the west side of the mine, 840 feet from the shaft. The vein dips steeply in this entry. It shows a thickness of 5 feet 1 inch where sampled. The coal is very clean looking, without sulphur bands or rock. Only one vein is present. The mine has been running four years, the first two as a country mine, and at present employs 100 men. See page 202.

Sample No. 5

Operator.—Armstrong Brothers Coal Company, What Cheer.

Mine.—Armstrong, one mile east of What Cheer, Keokuk county. No railroad connections.

Sample collected.—May 19, 1909.

Description.—The sample was taken from the first north entry off the west main entry. The coal here showed a thickness of 4 feet 2 inches and was clean and free from impurities. See page 288.

Sample No. 6

Operator.—Crescent Coal Company, Oskaloosa.

Mine.—Crescent No. 5, White City, Mahaska county, on Buxton branch Chicago and North-Western Railroad.

Sample collected.—May 19, 1909.

Description.—This sample was cut from the first room on the eighth north entry on the east side of the mine, about one mile from the shaft. The coal was 7 feet 8 inches thick, with about

8 inches of slaty coal near the roof. It was dipping steeply away from the entry.

The shaft is seventy-two feet deep. The mine is equipped with tail-rope haulage on the main entry about one-half mile in, to the main parting. See page 216.

Sample No. 7

Operator.—Phillips Fuel Company, Ottumwa.

Mine.—Bear Creek mine, at Bear Creek, Wapello county, four miles southwest of Ottumwa, on Chicago, Milwaukee and St. Paul Railroad.

Sample collected.—May 20, 1909.

Description.—The sample is from the first south entry. Here the coal is 4 feet 6 inches thick and is in the main clean and free from rock except near the roof, where some bowlders occur. One of these near the place of sampling measured ten inches in thickness.

The mine was opened in the fall of 1908. At the time it was sampled forty miners were employed and tail-rope haulage was already installed in the main entry. Hoisting is done by a double engine, geared to the drum. The shaft is forty-six feet deep. See page 302.

Sample No. 8

Operator.—Phillips Fuel Company, Ottumwa.

Mine.—Rutledge No. 5, at Rutledge, Wapello county, on Chicago, Milwaukee and St. Paul Railroad.

Sample collected.—May 20, 1909.

Description.—The mine was sampled in the seventeenth west entry on the north side of the shaft, about one mile from the bottom. The seam is here 3 feet 10 inches thick and is free from rock, although there are some sulphur concretions. The average thickness of the bed is 42 inches. See page 298.

Sample No. 9

Operator.—Wapello Coal Company, Hiteman.

Mine.—Wapello No. 4, three miles northwest of Hiteman, Monroe county, on branch from main line Chicago, Burlington and Quincy Railroad.

Sample collected.—May 21, 1909.

Description.—The sample is from the seventeenth room off the tenth west entry off the sixteenth north entry. The vein measured where sampled 5 feet 4 inches and is free from sulphur and rock. The average thickness is about 5½ feet.

The mine uses tail-rope haulage for about a mile underground and the entries run in one-half mile farther. The output is about 900 tons daily. See page 242.

Sample No. 10

Operator.—Campbell Coal Company, New Market.

Mine.—Campbell No. 1, nearly one mile east of New Market, Taylor county, on Keokuk, Shenandoah and Red Oak division Chicago, Burlington and Quincy Railroad.

Sample collected.—May 22, 1909.

Description.—The sample was collected from the second west entry off the second north entry. The bed was 16 inches thick where sampled. It varies from 16 to 20 inches in different parts of its extent. In some places it shows thin streaks of sulphur or clay one-eighth to one-half inch thick. The coal is brittle and breaks easily with angular fracture. The mine is on the right-of-way and is served by a short siding. See page 383.

Sample No. 11

Operator.—Bolton-Hoover Coal Company, Oskaloosa.

Mine.—Bolton No. 2, Bolton, Mahaska county, on long switch from Oskaloosa and Tracy line Chicago, Burlington and Quincy Railroad.

Sample collected.—June 15, 1909.

Description.—The sample is from the first room on the fifth north entry, about 1,200 feet in from the mouth of the slope and seventy feet below the surface. The face was here 5 feet 3 inches in height. It showed a few thin sulphur streaks, some up to 1½ inches in thickness, and a few bowlders. The mine has a daily capacity of 400 tons. The coal is hauled out of the mine and overland to the top works, about 1,200 feet distant, by rope. The top works are located on the railroad, at the old slope. The haulage engine is located here also and serves both slopes. The tail-rope runs on the surface nearly one-fourth mile beyond the mouth of the slope and enters the mine through an old drill hole. See page 205.

Sample No. 12

Operator.—English Creek Coal Company, Oskaloosa.

Mine.—Hawkeye mine at Hawkeye, about two miles east of Knoxville, Marion county, on Washington and Knoxville line Chicago, Rock Island and Pacific Railroad.

Sample collected.—June 16, 1909.

Description.—The sample is from room five, thirteenth entry east. The coal here showed a face of 6 feet, with some thin streaks of sulphur and occasional bowlders. The mine employs 125 men. See page 192.

Sample No. 13

Operator.—Colfax Consolidated Coal Company, Colfax.

Mine.—Mine No. 8, four miles southeast of Colfax, on Colfax Northern Railroad.

Sample collected.—June 17, 1909.

Description.—The sample was cut from the end of the main west entry, 1,700 feet west from the shaft. The seam was here 5 feet 7 inches thick and presented a clean face except for a half inch sulphur band one foot from the bottom.

The shaft is 164 feet deep and penetrates the "first vein," one to two feet thick, eighty feet from the surface. The mine employs 400 men and has an output of 800-900 tons per day. See page 159.

Sample No. 14

Operator.—Keystone Coal Mining Company, Des Moines.

Mine.—Keystone mine, Des Moines, Polk county, at west city limits, on Chicago, Milwaukee and St. Paul Railroad.

Sample collected.—June 21, 1909.

Description.—The sample was taken from the face of the second north entry, where the vein has just risen from a swamp on to the top of a hill. Where sampled the vein measured 4 feet 2 inches. In the swamp it was 7 feet thick. It will vary from 3 feet 8 inches to 7 feet in different parts of the mine. Some thin sulphur streaks were present in the face, but no rock or thick sulphur bands.

The shaft is 165 feet deep. It was sunk in July of 1908. The mine is not yet well opened up, but already has an output of seventy-five to eighty tons daily and employs twenty-three men. See page 114.

Sample No. 15

Operator.—Bennett Bros. Coal Company, Des Moines.

Mine.—Bennett mine, Des Moines, Polk county, south side Raccoon river. No railroad connections.

Sample collected.—June 21, 1909.

Description.—The mine was sampled at the end of the fourth west entry off the first south entry. The vein here measured 4 feet 6 inches. Its average thickness is 4 feet 4 inches, with occasional portions up to 5 or 6 feet. The coal is clean, without rock or sulphur bands, and breaks into angular fragments.

The mine is 125 feet deep and employs 100 men who put out 100-300 tons daily. The mine has been running six years and supplies a large local trade. See page 120.

Sample No. 16

Operator.—Enterprise Coal Company, Des Moines.

Mine.—Mine No. 2, Enterprise, Polk county, on St. Paul and Des Moines Railroad.

Sample collected.—June 22, 1909.

Description.—The sample was cut from the break-through near the face of the second west entry off the first south entry. The coal was 5 feet thick here, and carried a two-inch sulphur band one foot from the top. Clay slips are present in places. This mine is considered to be in the second vein and is the only one now working this horizon with the possible exception of the Bennett mine. A daily output of 400 tons is maintained. See page 143.

CHEMICAL ANALYSES OF COALS

Chemical Analysis of Mine Sample No. 1, from High Bridge Mine of the Hign Bridge Coal Company, High Bridge, Dallas Co., Iowa.

Laboratory sample number	18	....	18
Loss of moisture on air drying, per cent......	10.47	....	----------
Analysis of air-dried sample:		Analysis corrected to sample as received:	
Proximate—			
Moisture, per cent......	8.65	per cent..................	19.12
Volatile matter, per cent	33.14	per cent..................	29.34
Fixed carbon, per cent..	45.00	per cent..................	39.84
Ash, per cent...........	13.21	per cent..................	11.70
	100.00		100.00
Sulphur, per cent.........	2.75	per cent..................	2.44
Calorific value, B. T. U....	11,675	B. T. U..................	10,338
Calorific value, Calories...	6,486	Calories	5,743

Chemical Analysis of Mine Sample No. 2, from the Ogden Mine of the Ogden Coal Co., Two Miles North of Ogden, Boone Co., Iowa.

Laboratory sample number	13	....	13
Loss of moisture on air drying, per cent......	10.65	....	----------
Analysis of air-dried sample:		Analysis corrected to sample as received:	
Proximate—			
Moisture, per cent......	8.91	per cent..................	19.56
Volatile matter, per cent	37.81	per cent..................	33.43
Fixed carbon, per cent..	43.31	per cent..................	38.29
Ash, per cent...........	9.97	per cent..................	8.82
	100.00		100.00
Sulphur, per cent.........	6.10	per cent..................	5.40
Calorific value, B. T. U....	11,894	B. T. U..................	10,515
Calorific value, Calories...	6,608	Calories	5,841

Chemical Analysis of Mine Sample No. 3, from Willow Grove Coal Company, Angus, Greene Co., Iowa.

Laboratory sample number	17	....	17
Loss of moisture on air drying, per cent......	8.08	....	----------
Analysis of air-dried sample:		Analysis corrected to sample as received:	
Proximate—			
Moisture, per cent......	5.57	per cent..................	13.65
Volatile matter, per cent	38.73	per cent..................	35.41
Fixed carbon, per cent..	40.40	per cent..................	30.94
Ash, per cent...........	15.30	per cent..................	14.00
	100.00		100.00
Sulphur, per cent.........	5.37	per cent..................	4.91
Calorific value, B. T. U....	11,234	B. T. U..................	10,274
Calorific value, Calories...	6,241	Calories	5,708

Chemical Analysis of Mine Sample No. 4, from the Blyth Mine of the Atwood Coal Company, Rose Hill, Mahaska Co., Iowa.

Laboratory sample number	10	....	10
Loss of moisture on air drying, per cent......	9.53	....	----------
Analysis of air-dried sample:		Analysis corrected to sample as received:	
Proximate—			
Moisture, per cent......	5.58	per cent..................	15.11
Volatile matter, per cent	36.34	per cent..................	32.68
Fixed carbon, per cent..	44.30	per cent..................	39.83
Ash, per cent...........	13.78	per cent..................	12.38
	100.00		100.00
Sulphur, per cent.........	6.51	per cent..................	5.85
Calorific value, B. T. U....	11,814	B. T. U..................	10,623
Calorific value, Calories...	6,563	Calories	5,901

Chemical Analysis of Mine Sample No. 5, from Mine of Armstrong Brothers, What Cheer, Keokuk Co., Iowa.

Laboratory sample number	12	....	12
Loss of moisture on air drying, per cent......	7.83	....	----------
Analysis of air-dried sample:		Analysis corrected to sample as received:	
Proximate—			
Moisture, per cent......	7.43	per cent..................	15.26
Volatile matter, per cent	38.21	per cent..................	34.99
Fixed carbon, per cent..	41.10	per cent..................	37.62
Ash, per cent...........	13.26	per cent..................	12.13
	100.00		100.00
Sulphur, per cent.........	5.15	per cent..................	4.72
Calorific value, B. T. U....	11,410	B. T. U..................	10,445
Calorific value, Calories...	6,339	Calories	5,803

Chemical Analysis of Mine Sample No. 6, from Crescent Mine No. 5, of the Crescent Coal Co., White City, Mahaska Co., Iowa.

Laboratory sample number	11	....	11
Loss of moisture on air drying, per cent......	6.82	....	----------
Analysis of air-dried sample:		Analysis corrected to sample as received:	
Proximate—			
Moisture, per cent......	6.17	per cent..................	12.98
Volatile matter, per cent	36.71	per cent..................	34.04
Fixed carbon, per cent..	41.72	per cent..................	38.68
Ash, per cent...........	15.40	per cent..................	14.30
	100.00		100.00
Sulphur, per cent.........	5.87	per cent..................	5.47
Calorific value, B. T. U....	11,497	B. T. U..................	10,663
Calorific value, Calories...	6,387	Calories	5,924

Chemical Analysis of Mine Sample No. 7, from Bear Creek Mine of the Phillips Fuel Company, Ottumwa, Iowa.

Laboratory sample number	16	....	16
Loss of moisture on air drying, per cent......	7.49	....	----------
Analysis of air-dried sample:		Analysis corrected to sample as received:	
Proximate—			
Moisture, per cent......	4.79	per cent..................	12.28
Volatile matter, per cent	37.59	per cent..................	34.64
Fixed carbon, per cent..	43.22	per cent..................	39.82
Ash, per cent...........	14.40	per cent..................	13.26
	100.00		100.00
Sulphur, per cent.........	6.63	per cent..................	6.11
Calorific value, B. T. U....	11,695	B. T. U..................	10,776
Calorific value, Calories...	6,497	Calories	5,987

Chemical analysis of Mine Sample No. 8, From Rutledge No. 5 Mine of the Phillips Fuel Company, Ottumwa, Iowa.

Laboratory sample number	19	....	19
Loss of moisture on air drying, per cent......	7.53	....	----------
Analysis of air-dried sample:		Analysis corrected to sample as received:	
Proximate—			
Moisture, per cent......	5.84	per cent..................	13.37
Volatile matter, per cent	38.78	per cent..................	35.68
Fixed carbon, per cent..	44.14	per cent..................	40.61
Ash, per cent...........	11.24	per cent..................	10.34
	100.00		100.00
Sulphur, per cent.........	6.26	per cent..................	5.76
Calorific value, B. T. U....	12,010	B. T. U..................	11,051
Calorific value, Calories...	6,672	Calories	6,139

Chemical Analysis of Mine Sample No. 9, from Mine No. 4 of the Wapello Coal Company, Hiteman, Monroe Co., Iowa.

Laboratory sample number	15	....	15
Loss of moisture on air drying, per cent......	8.21	....	----------
Analysis of air-dried sample:		Analysis corrected to sample as received:	
Proximate—			
Moisture, per cent......	8.40	per cent..................	16.51
Volatile matter, per cent	36.26	per cent..................	33.01
Fixed carbon, per cent..	42.80	per cent..................	38.97
Ash, per cent...........	12.54	per cent..................	11.41
	100.00		100.00
Sulphur, per cent.........	2.10	per cent..................	1.92
Calorific value, B. T. U....	11,564	B. T. U..................	10,528
Calorific value, Calories...	6,424	Calories	5,849

Chemical Analysis of Mine Sample No. 10, from Mine No. 1 of Campbell Coal Co., New Market, Taylor Co., Iowa.

Laboratory sample number	14	....	14
Loss of moisture on air drying, per cent......	10.97	....	----------
Analysis of air-dried sample:		Analysis corrected to sample as received:	
Proximate—			
Moisture, per cent......	9.24	per cent..................	20.21
Volatile matter, per cent	34.17	per cent..................	30.05
Fixed carbon, per cent..	43.60	per cent..................	38.33
Ash, per cent...........	12.99	per cent..................	11.41
	100.00		100.00
Sulphur, per cent.........	4.78	per cent..................	4.18
Calorific value, B. T. U....	11,494	B. T. U..................	10,115
Calorific value, Calories...	6,385	Calories	5,619

Chemical Analysis of Mine Sample No. 11, from Mine No. 2 of the Bolton-Hoover Coal Company, Bolton, Mahaska Co., Iowa.

Laboratory sample number	23	....	23
Loss of moisture on air drying, per cent......	9.16	....	----------
Analysis of air-dried sample:		Analysis corrected to sample as received:	
Proximate—			
Moisture, per cent......	5.48	per cent..................	14.64
Volatile matter, per cent	40.15	per cent..................	36.26
Fixed carbon, per cent..	44.88	per cent..................	40.53
Ash, per cent...........	9.49	per cent..................	8.57
	100.00		100.00
Sulphur, per cent.........	3.26	per cent..................	2.94
Calorific value, B. T. U....	12,183	B. T. U..................	11,003
Calorific value, Calories...	6,768	Calories	6,113

Chemical Analysis of Mine Sample No. 12, from Hawkeye Mine of the English Creek Coal Mining Company, Hawkeye, near Knoxville, Marion Co., Iowa.

Laboratory sample number	21	....	21
Loss of moisture on air drying, per cent......	13.80	....	----------
Analysis of air-dried sample:		Analysis corrected to sample as received:	
Proximate—			
Moisture, per cent......	4.50	per cent..................	18.30
Volatile matter, per cent	36.37	per cent..................	31.12
Fixed carbon, per cent..	44.36	per cent..................	37.95
Ash, per cent...........	14.77	per cent..................	12.63
	100.00		100.00
Sulphur, per cent.........	6.03	per cent..................	5.16
Calorific value, B. T. U....	11,939	B. T. U..................	10,215
Calorific value, Calories...	6,633	Calories	5,675

Chemical Analysis of Mine Sample No. 13, from Mine No. 8 of the Colfax Consolidated Coal Company, near Colfax, Jasper Co., Iowa.

Laboratory sample number	24	....	24
Loss of moisture on air drying, per cent......	12.68	....	----------
Analysis of air-dried sample:		Analysis corrected to sample as received:	
Proximate—			
Moisture, per cent......	5.47	per cent..................	18.15
Volatile matter, per cent	39.17	per cent..................	33.91
Fixed carbon, per cent..	42.94	per cent..................	37.18
Ash, per cent...........	12.42	per cent..................	10.76
	100.00		100.00
Sulphur, per cent.........	3.49	per cent..................	3.02
Calorific value, B. T. U....	11,588	B. T. U..................	10,034
Calorific value, Calories...	6,438	Calories	5,574

Chemical Analysis of Mine Sample No. 14, from Mine of the Keystone Coal Mining Company, Third Vein, Des Moines, Polk Co., Iowa.

Laboratory sample number	20	....	20
Loss of moisture on air drying, per cent......	8.64	....	----------
Analysis of air-dried sample:		Analysis corrected to sample as received:	
Proximate—			
Moisture, per cent......	4.78	per cent..................	13.42
Volatile matter, per cent	38.06	per cent..................	34.60
Fixed carbon, per cent..	41.83	per cent..................	38.03
Ash, per cent...........	15.33	per cent..................	13.95
	100.00		100.00
Sulphur, per cent.........	6.26	per cent..................	5.70
Calorific value, B. T. U....	11,481	B. T. U..................	10,440
Calorific value, Calories...	6,378	Calories	5,800

Chemical analysis of Mine Sample No. 15, from Mine of the Bennett Bros. Coal Company, Des Moines, Polk Co., Iowa.

Laboratory sample number	22	....	22
Loss of moisture on air drying, per cent......	8.77	....	----------
Analysis of air-dried sample:		Analysis corrected to sample as received:	
Proximate—			
Moisture, per cent......	4.62	per cent..................	13.39
Volatile matter, per cent	38.88	per cent..................	35.30
Fixed carbon, per cent..	44.20	per cent..................	40.14
Ash, per cent...........	12.30	per cent..................	11.17
	100.00		100.00
Sulphur, per cent.........	5.15	per cent..................	4.68
Calorific value, B. T. U....	12,139	B. T. U..................	11,023
Calorific value, Calories...	6,744	Calories	6,124

Chemical Analysis of Mine Sample No. 16, from Mine No. 2 of the Enterprise Coal Company, Second Vein, Enterprise, Polk Co., Iowa.

Laboratory sample number	25	....	25
Loss of moisture on air drying, per cent......	8.61	....	----------
Analysis of air-dried sample:		Analysis corrected to sample as received:	
Proximate—			
Moisture, per cent......	6.08	per cent..................	14.69
Volatile matter, per cent	41.01	per cent..................	37.25
Fixed carbon, per cent..	44.17	per cent..................	40.12
Ash, per cent...........	8.74	per cent..................	7.94
	100.00		100.00
Sulphur, per cent.........	3.79	per cent..................	3.44
Calorific value, B. T. U....	12,454	B. T. U..................	11,313
Calorific value, Calories...	6,919	Calories	6,285

The analyses on the following pages for which G. E. Patrick is given as authority are taken from Iowa Geological Survey, volume II, pp. 504-509, 1894. Samuel Calvin, Geologist.

Those given on authority of Rush Emery are taken from Geology of Iowa, Vol. II, pp. 361-395. 1870. C. A. White, State Geologist.

Those given on authority of G. Hinrichs are quoted from First and Second Annual Report of the State Geologist, pp. 222-224, 1868. C. A. White, State Geologist.

Those for whom J. D. Whitney is given as authority are taken from Geology of Iowa, Vol. I, pp. 403-414. 1858. James Hall, State Geologist.

Where the Iowa State College is quoted as authority the analyses are given in Volume XVII of Iowa Geological Survey, pp. 170 ff, 529, 530, or, in the various county reports published by the present Survey.

Those analyses given on authority of N. W. Lord are found in U. S. G. S., Bull. No. 261, pp. 41-43, and Professional Paper No. 48, pp. 221-225, 270. The analyses were made at the fuel testing plant at St. Louis in 1904.

The analysis given by D. D. Owen is found in Geol. Iowa, Wisconsin and Illinois, p. 53, 1839.

Those credited to the State University are here published for the first time.

Analyses credited to George W. Prentiss are from the laboratory of the Chicago, Milwaukee and Saint Paul Railway, West Milwaukee, Wis. With the exception of the analyses from Foster, Moravia and F. W. Cox, Excelsior, sulphur was not determined separately, but one-half is assigned to volatile combustible and one-half to fixed carbon.

It should be noted that the high moisture content of the mine samples analyzed at the St. Louis Testing Station is due in part at least to the fact that these samples were put immediately upon being gathered into air-tight tin flasks and thus retained all their moisture when received at the chemical laboratory. The same is true of the mine samples analyzed at the State University. In the case of the car samples the coal would naturally lose several per cent of moisture by evaporation before it was delivered to the boiler. It is probable, therefore, that the analyses of these car samples correspond in general to most of the analyses from other sources.

CHEMICAL ANALYSES OF IOWA COALS

LOCALITIES	Moisture	Total combustibles	Ash	Volatile combustible matter	Fixed carbon	Coke—Fixed carbon plus ash	SULPHUR In sulphides	SULPHUR In sulphates	SULPHUR Total	Calorimetry B. T. U.	AUTHORITY
ADAMS COUNTY—											
Plowman shaft, Briscoe, top	8.97	80.48	10.55	36.44	44.04	54.59	3.15	.11	3.26	------	G. E. Patrick
Same, middle of seam	9.09	74.95	15.96	32.04	42.91	58.87	2.46	.13	2.59	------	G. E. Patrick
Same, bottom of seam	8.72	77.39	13.89	32.01	45.38	59.27	3.67	.27	3.94	------	G. E. Patrick
Wyles mine, Carbon, average	8.01	80.12	11.87	35.26	44.86	56.73	4.25	.11	4.36	------	G. E. Patrick
Reese mine, Carbon, average	9.12	81.51	9.36	35.71	45.79	55.12	3.89	.18	4.07	------	G. E. Patrick
Hinton mine, Eureka, average	8.68	81.91	9.70	33.85	47.72	57.43	4.38	.19	4.58	------	G. E. Patrick
Rawson mine, Quincy, "fresh coal"	10.41	83.66	5.93	35.13	48.53	54.46	------	------	------	------	Rush Emery
Same, calculated on dried coal	------	93.38	6.62	39.20	54.18	60.80	------	------	------	------	Rush Emery
Same "opened fourteen months"	10.29	85.54	4.17	38.32	47.22	51.39	------	------	------	------	Rush Emery
Same, calculated on dried coal	------	95.35	4.65	42.71	52.64	57.29	------	------	------	------	Rush Emery
Average of county, two samples	10.35	84.60	5.05	36.72	47.88	52.93	------	------	------	------	Rush Emery
Same, calculated on dried coal	------	94.37	5.63	40.96	53.41	59.04	------	------	------	------	Rush Emery
Average of 6	8.76	79.34	11.89	34.22	45.12	------	------	------	3.60	------	Iowa State Col'ge
APPANOOSE COUNTY—											
Diamond mine, Centerville, top	9.66	82.06	8.28	34.72	47.34	55.62	2.57	.14	2.71	------	G. E. Patrick
Same, middle of seam	10.12	83.67	6.21	35.63	48.04	54.25	2.13	.07	2.20	------	G. E. Patrick
Same, middle of seam, calculated on dried coal	------	93.09	6.91	39.64	53.45	------	2.45	.08	2.53	------	G. E. Patrick
Same, bottom of seam	10.28	84.64	5.08	36.89	47.75	52.83	2.67	.13	2.80	------	G. E. Patrick
Scandinavian mine, Centerville, average	9.23	40.46	6.97	36.21	47.58	54.55	2.79	.12	2.91	------	G. E. Patrick

CHEMICAL ANALYSES OF IOWA COALS—CONTINUED

LOCALITIES	Moisture	Total combustibles	Ash	Volatile combustible matter	Fixed carbon	Coke—Fixed carbon plus ash	SULPHUR In sulphides	SULPHUR In sulphates	SULPHUR Total	Calorimetry B. T. U.	AUTHORITY
Appanoose mine, Cincinnati, sample of room	6.54	80.37	13.09	36.20	44.17	57.26	4.40	.13	4.53	------	G. E. Patrick
Same, vein above clay seam	6.20	78.11	15.69	34.00	44.11	59.80	3.67	.16	3.83	------	G. E. Patrick
Same, vein below lower clay seam	7.53	75.14	17.33	29.31	45.83	63.16	6.73	.82	7.55	------	G. E. Patrick
Thistle mine, Cincinnati, top	3.18	85.22	11.60	36.55	48.67	60.27	3.57	.11	3.68	------	G. E. Patrick
Same, middle of seam	5.80	90.71	3.49	37.71	53.00	56.49	2.97	.05	3.02	------	G. E. Patrick
Same, middle of seam, calculated to dry basis	------	96.29	3.71	40.03	56.26	------	3.15	.05	3.20	------	G. E. Patrick
Same, bottom of seam	6.02	87.80	6.18	36.90	50.90	57.08	3.13	.17	3.30	------	G. E. Patrick
Same, below sulphur band	2.88	72.69	24.43	29.03	43.66	68.09	3.61	.43	4.04	------	G. E. Patrick
Whitebreast No. 19, Forbush, average	9.70	82.98	7.31	35.84	47.14	54.45	4.14	.27	4.41	------	G. E. Patrick
Average 12	7.26	83.54	9.20	35.87	47.67	------	------	------	3.75	------	Iowa State Col'ge
Centerville Block Coal Co.	11.49	82.03	6.52	33.47	48.56	------	------	------	2.92	12,681	Iowa State Col'ge
Same	------	92.64	7.36	37.79	54.85	------	------	------	3.29	12,681	Iowa State Col'ge
Centerville Block Coal Co., lump coal	14.00	74.80	10.90	35.50	39.30	------	------	------	4.26	10,723	Iowa State Col'ge
Same, Mystic seam, mine sample No. 1	17.13	75.80	7.07	35.44	40.36	------	------	------	4.00	10,931	N. W. Lord
Same, air-dried sample	8.53	83.67	7.80	39.12	44.55	------	------	------	4.42	12,065	N. W. Lord
Same, Mystic seam, mine sample No. 2	16.14	72.78	11.08	34.94	37.84	------	------	------	4.76	------	N. W. Lord
Same, air-dried sample	8.25	79.63	12.12	38.23	41.40	------	------	------	5.21	------	N. W. Lord
Same, Mystic seam, car sample	14.08	74.96	10.96	35.59	39.37	------	------	------	4.26	10,723	N. W. Lord
Same, air-dried sample	10.03	78.49	11.48	37.27	41.22	------	------	------	4.46	11,227	N. W. Lord
Same, washed coal	17.88	74.98	7.14	37.59	37.39	------	------	------	3.57	------	N. W. Lord
Same, air-dried sample	14.81	77.78	7.41	38.99	38.79	------	------	------	3.70	------	N. W. Lord
Same, coke sample	13.05	75.42	11.53	2.32	73.10	------	------	------	2.97	------	N. W. Lord
Same, air-dried sample	2.30	84.74	12.96	2.60	82.14	------	------	------	3.33	------	N. W. Lord

Lodwick Bros. Coal Co., Mystic..........	16.21	78.74	5.05	32.74	46.00	------	------	------	2.64	12,780	Iowa State Col'ge
Same	------	93.98	6.02	39.07	54.91	------	------	------	3.15	12,780	Iowa State Col'ge
*Same, Walnut Valley................	12.58	79.41	4.69	34.65	44.76	------	------	------	3.32	------	Geo. N. Prentiss
Moravia	6.18	79.52	14.30	40.73	38.79	------	------	------	4.06	------	Geo. N. Prentiss
Anchor Coal Co., steam coal............	10.00	74.70	15.30	33.00	41.70	------	------	------	------	9,963	Iowa State Col'ge
Same, lump coal....................	8.20	75.70	16.00	30.70	45.00	------	------	------	5.03	11,027	Iowa State Col'ge
BOONE COUNTY—											
Angus mine, Angus, average............	8.62	82.75	8.64	38.33	44.41	53.05	2.59	.08	2.67	------	G. E. Patrick
Dalby mine, Angus, top of seam.........	2.71	87.26	10.03	39.90	47.36	57.39	5.17	.15	5.32	------	G. E. Patrick
Same, middle of seam...............	2.13	92.14	5.73	44.21	47.93	53.66	3.72	.10	3.82	------	G. E. Patrick
Same, bottom of seam...............	3.69	85.70	10.61	45.12	40.58	51.19	4.10	.16	4.25	------	G. E. Patrick
Northwestern mine, Boonesboro, top....	13.23	81.21	5.56	37.52	43.69	49.25	------	------	------	------	Rush Emery
Same, bottom of seam...............	11.51	82.60	5.89	38.86	43.74	49.63	------	------	------	------	Rush Emery
Same, top of seam, calculated on dried coal	------	93.61	6.39	43.25	50.36	56.75	------	------	------	------	Rush Emery
Same, bottom of seam, calculated on dried coal	------	93.34	6.66	43.91	49.43	56.09	------	------	------	------	Rush Emery
Average of county, 2 samples...........	12.37	81.91	5.72	38.19	43.72	49.44	------	------	------	------	Rush Emery
Same, calculated on dried coal........	------	93.48	6.52	43.58	49.90	56.42	------	------	------	------	Rush Emery
Crowe Coal Co., Boone..................	4.03	88.09	7.88	39.79	48.30	------	------	------	3.99	12,729	Iowa State Col'ge
Same	------	91.79	8.21	41.46	50.33	------	------	------	4.16	12,729	Iowa State Col'ge
Street Railway Power Plant............	11.49	64.16	24.36	26.33	37.83	------	------	------	9.53	------	Iowa State Col'ge
Boone Coal & Mining Co., Frazer mine...	14.77	73.71	11.48	37.67	36.05	47.53	2.76	0.19	2.95	------	Iowa State Col'ge
Average of 6..........................	6.82	85.44	7.74	40.99	44.45	------	------	------	4.01	------	Iowa State Col'ge
Johnson Coal Co., Boone, slack, 9 samples	11.70	48.20	40.10	22.10	26.10	------	------	------	------	7,363	Iowa State Col'ge
Same, lump, 5 samples..............	15.30	69.30	15.20	27.70	41.60	------	------	------	------	11,412	Iowa State Col'ge
Rogers Coal Co., Boone, slack, 3 samples.	12.00	46.50	41.20	20.40	26.10	------	------	------	------	7,463	Iowa State Col'ge
Heaps & Crowe, Boone, lump coal.......	13.30	60.70	26.00	27.80	32.90	------	------	------	------	9,905	Iowa State Col'ge
Same, slack, 4 samples..............	12.00	46.00	42.00	14.80	31.20	------	------	------	------	7,588	Iowa State Col'ge
Ogden Coal Co., Ogden..................	19.56	71.72	8.82	33.43	38.29	------	------	------	5.40	10,515	State Univ. Iowa
Same, air-dried sample..............	8.91	81.12	9.97	37.81	43.31	------	------	------	6.10	11,894	State Univ. Iowa

*Sulphur not separately determined.

LOCALITIES	Moisture	Total combustibles	Ash	Volatile combustible matter	Fixed carbon	Coke—Fixed carbon plus ash	SULPHUR In sulphides	In sulphates	Total	Calorimetry B. T. U.	AUTHORITY
DALLAS COUNTY—											
Tudor mine, Dawson, top	4.64	81.73	13.63	39.84	41.89	55.52	2.08	.13	2.21	------	G. E. Patrick
Same, middle of seam	5.62	79.86	14.52	36.79	43.07	57.59	4.69	.24	4.93	------	G. E. Patrick
Same, bottom of seam	6.55	84.00	9.45	37.45	46.55	56.00	3.27	.08	3.35	------	G. E. Patrick
Keeler mine, Linden, average	7.41	67.97	24.61	27.86	40.10	64.72	6.53	.65	7.18	------	G. E. Patrick
Redfield mine, Redfield, top	11.36	78.15	10.49	38.46	39.69	50.18	2.76	.04	2.80	------	G. E. Patrick
Same, middle of seam	10.55	75.60	13.85	30.18	45.42	59.27	3.83	.24	4.07	------	G. E. Patrick
Same, bottom of seam	12.76	72.94	14.30	34.72	38.22	52.52	3.01	.10	3.11	------	G. E. Patrick
Tabor mine, Woodward, average	7.15	77.94	14.90	35.54	42.40	57.30	5.74	.69	6.44	------	G. E. Patrick
Redfield mine, Des Moines Coal Co	12.83	83.74	3.43	37.30	46.44	49.87	------	------	------	------	Rush Emery
Same, calculated on dried coal	------	96.07	3.93	42.79	53.28	57.21	------	------	------	------	Rush Emery
Average of 8	8.25	77.28	14.47	35.11	42.17	------	------	------	4.24	------	Iowa State Col'ge
Platt Pressed and Fire Brick Co., Van Meter	------	91.58	8.42	40.54	51.04	------	------	------	3.68	11,941	Iowa State Col'ge
High Bridge Coal Co., High Bridge	19.12	69.18	11.70	29.34	39.84	------	------	------	2.44	10,338	State Univ. Iowa
Same, air-dried sample	8.65	78.14	13.21	33.14	45.00	------	------	------	2.75	11,675	State Univ. Iowa
DAVIS COUNTY—											
Dye mine, Laddsdale, bottom	4.48	87.40	8.12	44.26	43.14	51.26	4.26	.12	4.38	------	G. E. Patrick
Sickles mine, Laddsdale, top of seam	3.06	92.34	4.60	42.82	49.52	54.12	5.19	.23	5.42	------	G. E. Patrick
Same, middle of seam	2.06	90.66	7.28	43.84	46.82	54.10	6.51	.29	6.80	------	G. E Patrick
Same, bottom of seam	2.59	75.41	22.00	36.97	38.44	60.44	7.05	.22	7.27	------	G. E. Patrick
Same, average	2.57	86.13	11.29	41.21	44.43	56.22	6.25	.24	6.49	------	G. E. Patrick

Bloomfield	5.24	87.66	7.10	37.00	50.66	------	------	------	2.25	13,204	Iowa State Col'ge
Average of 5	2.95	86.29	10.66	41.82	44.47	------	------	------	6.07	------	Iowa State Col'ge
Lumsden Coal Co.	------	92.52	7.48	39.06	53.46	------	------	------	2.38	12,097	Iowa State Col'ge
DECATUR COUNTY—											
Coals from veins penetrated in Sharp's prospect, Leon. See p. 247 of this vol.											
Vein No. 1	4.98	80.31	14.71	34.79	45.52	------	------	------	2.51	------	U. S. Geol. Surv.
Veins Nos. 1 and 2	5.59	79.52	15.89	40.33	38.19	------	------	------	3.55	------	Iowa State Col'ge
Vein No. 3	4.22	88.07	7.71	40.23	47.84	------	------	------	4.05	------	U. S. Geol. Surv.
Vein No. 3	4.76	85.14	10.10	39.68	45.46	------	------	------	3.62	------	Iowa State Col'ge
Vein No. 4	5.09	80.94	13.97	42.62	38.32	------	------	------	2.68	------	Iowa State Col'ge
Vein No. 5	5.02	84.60	10.32	44.30	40.30	------	------	------	3.78	------	U. S. Geol. Surv.
Vein No. 5	5.45	79.95	14.60	41.01	38.94	------	------	------	8.75	------	Iowa State Col'ge
Veins Nos. 7 and 8	3.85	88.70	9.45	47.80	40.90	------	------	------	3.70	------	Iowa State Col'ge
GREENE COUNTY—											
Bussey mine, Rippey	9.92	87.92	2.16	44.39	43.53	45.69	------	------	------	------	Rush Emery
Same, calculated on dried coal	------	97.60	2.40	49.28	48.32	50.72	------	------	------	------	Rush Emery
Kennedy mine, Rippey, top of seam	7.01	84.08	8.91	43.94	40.14	49.05	3.62	.06	3.68	------	G. E. Patrick
Same, middle of seam	9.40	81.64	8.96	39.76	41.88	50.84	3.39	.05	3.44	------	G. E. Patrick
Same, bottom of seam	9.70	82.90	7.40	40.36	42.54	49.94	2.94	.06	3.00	------	G. E. Patrick
Average of 4	9.01	84.14	6.86	42.11	43.03	------	------	------	3.37	------	Iowa State Col'ge
Willow Grove Coal Co., Angus	13.65	66.35	14.00	35.41	30.94	------	------	------	4.91	10,274	State Univ. Iowa
Same, air-dried sample	5.57	79.13	15.30	38.73	40.40	------	------	------	5.37	11,234	State Univ. Iowa
GUTHRIE COUNTY—											
Eclipse mine, Fanslers, top of seam	7.73	86.44	5.83	39.85	46.59	52.42	3.62	.05	3.67	------	G. E. Patrick
Same, middle of seam	7.04	83.61	9.35	37.94	45.67	55.02	4.32	.07	4.39	------	G. E. Patrick
Same, bottom of seam	6.89	76.23	16.88	32.67	43.56	60.44	9.50	.68	10.18	------	G. E. Patrick
Reese mine, Panora, cannel	4.88	59.09	36.03	30.80	28.29	64.32	10.57	.50	11.07	------	G. E. Patrick
Same, average, bituminous	6.41	80.39	13.19	38.07	42.32	55.51	5.59	.13	5.72	------	G. E. Patrick
Suggett mine, Stuart, top of seam	9.61	79.19	11.20	34.63	44.56	55.76	4.01	.11	4.12	------	G. E. Patrick
Same, bottom of seam	9.30	81.07	9.63	36.80	44.27	53.90	3.48	.05	3.53	------	G. E. Patrick
Marshall mine, Long Branch	13.39	82.50	4.11	34.96	47.54	51.65	------	------	------	------	Rush Emery

CHEMICAL ANALYSES OF IOWA COALS—CONTINUED

LOCALITIES	Moisture	Total combustibles	Ash	Volatile combustible matter	Fixed carbon	Coke—Fixed carbon plus ash	SULPHUR In sulphides	SULPHUR In sulphates	SULPHUR Total	Calorimetry B. T. U.	AUTHORITY
Same, calculated on dried coal........	------	95.26	4.74	40.38	54.88	59.62	------	------	------	------	Rush Emery
Wasson mine, Panora..................	11.90	78.84	9.26	35.86	42.98	52.24	------	------	------	------	Rush Emery
Same, calculated on dried coal........	------	89.49	10.51	40.70	48.79	59.30	------	------	------	------	Rush Emery
Lonsdale mine, Deer Creek............	13.22	84.08	2.70	37.25	46.83	49.53	------	------	------	------	Rush Emery
Same, calculated on dried coal........	------	96.89	3.11	42.92	53.97	57.08	------	------	------	------	Rush Emery
Average of county, three samples........	12.84	81.80	5.36	36.02	45.78	51.14	------	------	------	------	Rush Emery
Same, calculated on dried coal.......	------	93.88	6.12	41.33	52.55	58.67	------	------	------	------	Rush Emery
Average of 7..........................	7.41	78.00	14.59	35.82	42.18	------	------	------	6.08	------	Iowa State Col'ge
HAMILTON COUNTY—											
Silver mine, Webster City...............	9.00	84.80	6.20	34.19	50.61	56.81	3.09	1.12	4.21	------	G. E. Patrick
Stockdale mine, bottom of seam.........	7.22	82.61	10.17	35.16	47.45	57.62	5.80	.21	6.01	------	G. E. Patrick
Same, top of seam...................	8.01	84.96	7.03	37.99	46.97	54.00	5.28	.11	5.39	------	G. E. Patrick
HARDIN COUNTY—											
Fuller mine, Eldora....................	12.45	79.37	8.18	35.73	43.64	51.82	------	------	------	------	J. D. Whitney
Same, calculated on dried coal........	------	90.66	9.34	40.81	49.85	59.19	------	------	------	------	J. D. Whitney
Chaffin mine, Eldora, top of seam.......	11.32	83.52	5.16	32.69	50.83	55.99	2.02	1.47	3.49	------	G. E. Patrick
Same, middle of seam...............	10.90	80.17	8.63	38.98	41.49	50.12	1.76	1.89	3.65	------	G. E. Patrick
Same, bottom of seam...............	9.63	84.29	6.08	34.44	49.85	55.93	2.25	.30	2.55	------	G. E. Patrick
Buckner mine, Eldora..................	7.92	87.26	4.82	42.54	44.72	49.54	------	------	------	------	Rush Emery
Same, calculated on dried coal.......	------	94.77	5.23	46.20	48.57	53.80	------	------	------	------	Rush Emery

Sample found at Eldora	7.92	83.62	8.46	40.80	42.82	51.28	------	------	------	------	Rush Emery
Same, calculated on dried coal	------	90.81	9.19	44.31	46.50	55.69	------	------	------	------	Rush Emery
Average of county, 2 samples	7.92	85.44	6.44	41.67	43.77	50.41	------	------	------	------	Rush Emery
Same, calculated on dried coal	------	92.79	7.21	45.25	47.54	54.75	------	------	------	------	Rush Emery
JASPER COUNTY—											
Jasper mine, Colfax, top of seam	7.72	79.97	12.31	38.14	41.83	54.14	3.73	.48	4.21	------	G. E. Patrick
Same, middle of seam	8.38	77.86	13.76	35.78	42.08	55.84	1.11	.13	1.24	------	G. E. Patrick
Same, bottom of seam	8.88	77.66	13.46	32.21	45.45	58.91	4.87	.05	4.92	------	G. E. Patrick
Snook mine, Newton	4.61	87.71	7.68	44.41	43.30	50.98	------	------	------	------	Rush Emery
Same, calculated on dried coal	------	91.95	8.05	46.56	45.39	53.44	------	------	------	------	Rush Emery
Slaughter bank, Newton	8.33	86.23	5.44	41.72	44.51	49.95	------	------	------	------	J. D. Whitney
Same, calculated on dried coal	------	94.07	5.93	45.51	48.56	54.49	------	------	------	------	J. D. Whitney
Jasper County Coal & Mining Co., Colfax	5.45	87.46	7.09	40.49	46.97	------	------	------	2.91	12,134	Iowa State Col'ge
Same	------	92.51	7.49	42.24	50.27	------	------	------	3.08	12,134	Iowa State Col'ge
Average of 4	7.40	80.81	11.08	37.64	43.17	------	------	------	3.46	------	Iowa State Col'ge
Colfax Consolidated Coal Co., Colfax, mine No. 6	9.34	79.27	12.39	39.19	39.08	------	------	------	2.84	11,206	Iowa State Col'ge
Same, steam coal	11.50	72.30	16.20	30.80	41.50	------	------	------	------	10,742	Iowa State Col'ge
Same, mine No. 8	18.15	71.19	10.76	33.91	37.18	------	------	------	3.02	10,034	State Univ. Iowa
Same, air-dried sample	5.47	82.11	12.42	39.17	42.94	------	------	------	3.49	11,588	State Univ. Iowa
*JEFFERSON COUNTY—											
Shaw bank, Perlee	2.00	93.50	4.50	50.20	43.40	47.80	------	------	------	------	G. Hinrichs
Coalport mine, Fairfield	1.20	94.40	4.40	48.40	46.00	50.40	------	------	------	------	G. Hinrichs
Richardson min^ Fairfield, top of seam	2.10	92.20	5.70	46.00	46.20	51.90	------	------	------	------	G. Hinrichs
Same, bottom of seam	0.70	97.70	1.60	48.80	48.90	50.50	------	------	------	------	G. Hinrichs
Young & Stubbs mine, Fairfield, top of seam	0.90	95.00	4.10	44.60	50.40	54.50	------	------	------	------	G. Hinrichs
Same, bottom of seam	0.30	88.70	11.10	46.50	42.20	53.30	------	------	------	------	G. Hinrichs
Read mine, Fairfield	2.50	85.90	11.60	42.00	44.00	55.50	------	------	------	------	G. Hinrichs
Average for county, 7 samples	1.40	92.50	6.10	46.60	45.90	51.00	------	------	------	------	G. Hinrichs

*The samples from this county had been in a warmed room about a week previous to being analyzed, hence the small amounts of moisture.

CHEMICAL ANALYSES OF IOWA COALS—CONTINUED

LOCALITIES	Moisture	Total combustibles	Ash	Volatile combustible matter	Fixed carbon	Coke—Fixed carbon plus ash	SULPHUR In sulphides	SULPHUR In sulphates	SULPHUR Total	Calorimetry B. T. U.	AUTHORITY
KEOKUK COUNTY—											
Pioneer mine, Thornburg, top of seam	4.78	92.65	2.57	49.17	43.48	46.05	4.38	.20	4.58	------	G. E. Patrick
Same, middle of seam	7.79	89.83	2.38	44.05	45.78	48.16	2.06	.39	2.45	------	G. E. Patrick
Same, bottom of seam	5.56	86.18	8.28	38.37	47.79	56.07	2.45	.07	2.52	------	G. E. Patrick
What Cheer, No. 5, What Cheer, top of seam	5.40	75.90	18.70	35.16	40.74	59.44	13.79	.92	14.71	------	G. E. Patrick
Same, middle of seam	5.96	82.16	11.88	35.89	46.27	58.15	6.56	.29	6.85	------	G. E. Patrick
Same, bottom of seam	7.14	76.26	16.60	33.96	42.30	58.90	6.67	.40	7.07	------	G. E. Patrick
Average of 6	6.11	83.82	10.07	39.43	44.39	------	------	------	6.36	------	Iowa State Col'ge
Armstrong mine, What Cheer	15.26	72.61	12.13	34.99	37.62	------	------	------	4.72	10,445	State Univ. Iowa
Same, air-dried sample	7.43	79.31	13.26	38.21	41.10	------	------	------	5.15	11,410	State Univ. Iowa
*Crescent Coal Co., What Cheer	4.75	61.19	22.10	29.77	31.42	59.50	------	------	11.96	------	Geo. N. Prentiss
*Same	1.08	82.00	9.96	34.84	47.16	60.60	------	------	6.96	------	Geo. N. Prentiss
LUCAS COUNTY—											
Cleveland mine, Cleveland, top of seam	9.95	80.27	9.78	37.70	42.57	52.35	3.69	.07	3.76	------	G. E. Patrick
Same, middle of seam	9.39	84.21	6.43	38.62	45.59	52.02	2.69	.06	2.75	------	G. E. Patrick
Same, bottom of seam	7.46	82.11	10.43	36.99	45.12	55.55	2.97	.07	3.04	------	G. E. Patrick
Same, average of seam	8.92	82.19	8.88	37.77	44.43	33.30	3.11	.07	3.18	------	G. E. Patrick
Lucas mine, Lucas, average	11.29	79.88	8.83	37.13	42.69	51.52	2.89	.08	3.98	------	G. E. Patrick
Inland Fuel Co., Chariton, lump coal	15.30	71.80	12.60	30.40	41.40	------	------	------	3.19	10,242	Iowa State Col'ge
Same, mine sample No. 1	18.69	73.58	7.73	31.80	41.78	------	------	------	2.39	10,505	N. W. Lord
Same, air-dried sample	10.25	81.22	8.53	35.10	46.12	------	------	------	2.64	11,596	N. W. Lord

Same, mine sample No. 2	18.59	74.26	7.15	34.36	39.90	------	------	------	3.10	------	N. W. Lord
Same, air-dried sample	12.37	79.93	7.70	36.98	42.95	------	------	------	3.34	------	N. W. Lord
Same, car sample, run-of-mine	15.39	71.98	12.63	30.49	41.49	------	------	------	3.19	10,242	N. W. Lord
Same, air-dried sample	9.22	77.23	13.55	32.71	44.52	------	------	------	3.42	10,989	N. W. Lord
Same, washed coal	19.25	72.82	7.93	31.07	41.75	------	------	------	2.28	------	N. W. Lord
Same, air-dried sample	13.45	78.05	8.50	30.30	44.75	------	------	------	2.44	------	N. W. Lord
Average of 5	9.40	81.73	8.87	37.65	44.08	------	------	------	3.34	------	Iowa State Col'ge
MADISON COUNTY—											
Clark mine, Northbranch	6.75	77.28	15.97	31.85	45.43	61.40	------	------	------	------	Rush Emery
Same, calculated on dried coal	------	82.94	17.06	34.17	48.77	65.83	------	------	------	------	Rush Emery
MAHASKA COUNTY—											
American mine, Evans, top of seam	3.55	91.84	4.61	46.43	45.41	50.02	3.48	.09	3.57	------	G. E. Patrick
Same, middle of seam	5.16	90.71	4.13	45.42	45.29	49.42	3.65	.06	3.71	------	G. E. Patrick
Same, bottom of seam	4.45	83.33	12.22	36.46	46.87	59.09	4.17	.06	4.23	------	G. E. Patrick
Same, cannel-like part	5.13	84.91	9.96	42.46	42.45	52.41	4.79	.41	5.20	------	G. E. Patrick
Griffith mine, Given, average	2.84	83.85	13.31	41.01	42.84	56.15	4.41	.08	4.49	------	G. E. Patrick
Burns mine, Oskaloosa	4.01	93.83	2.16	47.76	46.07	48.23	------	------	------	------	Rush Emery
Same, calculated on dried coal	------	97.74	2.26	49.75	47.99	50.25	------	------	------	------	Rush Emery
Carey mine, Rose Hill, average	4.91	84.70	10.39	41.69	43.01	53.40	5.00	.09	5.09	------	G. E. Patrick
Burtis mine, Oskaloosa, top of seam	5.23	90.27	4.50	42.27	48.00	52.50	------	------	------	------	Rush Emery
Same, calculated on dried coal	------	95.26	4.74	44.61	50.65	55.39	------	------	------	------	Rush Emery
Same, bottom of seam	5.38	82.63	11.99	34.03	48.60	60.59	------	------	------	------	Rush Emery
Same, calculated on dried coal	------	87.33	12.67	35.96	51.37	64.04	------	------	------	------	Rush Emery
Garretson & Seever mine, Oskaloosa, top of seam	6.14	92.64	1.22	44.35	48.29	49.51	------	------	------	------	Rush Emery
Same, calculated on dried coal	------	98.71	1.29	47.25	51.46	52.75	------	------	------	------	Rush Emery
Upper part of seam	4.66	80.62	14.72	35.62	45.00	59.72	------	------	------	------	Rush Emery
Same, calculated on dried coal	------	84.56	15.44	37.36	47.20	62.64	------	------	------	------	Rush Emery
Nichol mine, Oskaloosa, top of seam	3.28	95.43	1.29	40.28	55.15	56.44	------	------	------	------	Rush Emery
Same calculated on dried coal	------	98.66	1.34	41.65	57.01	58.35	------	------	------	------	Rush Emery
Same, bottom of seam	4.30	86.50	9.20	34.06	52.44	61.64	------	------	------	------	Rush Emery
Same, calculated on dried coal	------	90.39	9.61	35.60	54.79	64.40	------	------	------	------	Rush Emery
Haddon bank, Oskaloosa	4.83	90.62	4.55	37.76	52.86	57.41	------	------	------	------	Rush Emery
Same, calculated on dried coal	------	95.21	4.79	39.68	55.53	60.32	------	------	------	------	Rush Emery

CHEMICAL ANALYSES OF IOWA COALS—CONTINUED

LOCALITIES	Moisture	Total combustibles	Ash	Volatile combustible matter	Fixed carbon	Coke—Fixed carbon plus ash	SULPHUR In sulphides	SULPHUR In sulphates	SULPHUR Total	Calorimetry B. T. U.	AUTHORITY
Average of county, 8 samples	4.73	88.07	6.20	39.52	49.55	55.75	------	------	------	------	Rush Emery
Same, calculated on dried coal	------	93.48	6.52	41.48	52.00	58.52	------	------	------	------	Rush Emery
Given mine, Oskaloosa, top of seam	1.70	85.80	12.60	39.90	45.90	58.50	------	------	------	------	G. Hinrichs
Same, bottom of seam	2.90	84.70	13.40	44.50	40.20	53.60	------	------	------	------	G. Hinrichs
Iowa Coal Co. mine, Oskaloosa, top of seam	4.90	92.40	2.70	46.50	45.90	48.60	------	------	------	------	G. Hinrichs
Same, bottom of seam	5.10	88.40	6.50	39.90	48.50	55.00	------	------	------	------	G. Hinrichs
Roberts & Co. mine, Oskaloosa, top of seam	3.90	90.90	5.20	42.10	48.80	54.00	------	------	------	------	G. Hinrichs
Same, bottom of seam	6.40	87.50	6.20	41.00	46.50	52.60	------	------	------	------	G. Hinrichs
Average of 6 samples	4.10	88.20	7.70	42.30	46.00	53.70	------	------	------	------	G. Hinrichs
Whitebreast Fuel Co., Pekay	9.98	83.67	6.35	41.46	42.21	------	------	------	2.53	13,050	Iowa State Col'ge
Same	------	92.95	7.05	46.06	46.89	------	------	------	2.81	13,050	Iowa State Col'ge
Atwood Coal Co., Blyth	15.11	72.51	12.38	32.68	39.83	------	------	------	5.85	10,623	State Univ. Iowa
Same, air-dried sample	5.58	80.64	13.78	36.34	44.30	------	------	------	6.51	11,814	State Univ. Iowa
Crescent Coal Co., White City, No. 5	12.98	72.72	14.30	34.04	38.68	------	------	------	5.47	10,663	State Univ. Iowa
Same, air-dried sample	6.17	78.43	15.40	36.71	41.72	------	------	------	5.87	11,497	State Univ. Iowa
Bolton-Hoover Coal Co., Bolton No. 2	14.64	76.79	8.57	36.26	40.53	------	------	------	2.94	11,003	State Univ. Iowa
Same, air-dried sample	5.48	85.03	9.49	40.15	44.88	------	------	------	3.26	12,183	State Univ. Iowa
Excelsior Coal, Co., Excelsior	5.45	81.30	9.85	40.65	40.65	52.20	------	------	3.40	------	Geo. N. Prentiss
*Same	3.73	87.84	3.83	49.97	37.87	44.00	------	------	4.60	------	Geo. N. Prentiss
F. W. Cox, Excelsior	5.46	85.35	9.19	36.77	48.58	------	------	------	2.59	------	Geo. N. Prentiss
*American Coal Co., Oskaloosa	2.30	85.41	6.44	48.87	36.54	45.90	------	------	5.85	------	Geo. N. Prentiss
*Same	5.82	72.74	18.40	30.56	42.18	62.10	------	------	3.04	------	Geo. N. Prentiss

MARION COUNTY—											
Bousquet mine, Coalport, bottom of seam	5.89	90.79	3.32	43.25	47.54	50.86	------	------	------	------	Rush Emery
Same, calculated on dried coal........	------	96.47	3.53	45.94	50.53	54.06	------	------	------	------	Rush Emery
Same, top of seam....................	5.95	78.60	15.45	34.97	43.63	58.08	------	------	------	------	Rush Emery
Same, calculated on dried coal..	------	83.57	16.43	37.18	46.39	62.82	------	------	------	------	Rush Emery
Sherwood mine, Marysville, top of seam..	5.62	92.58	1.80	36.61	55.97	57.77	------	------	------	------	Rush Emery
Same, calculated on dried coal.........	------	98.09	1.91	38.80	59.29	61.20	------	------	------	------	Rush Emery
Same, bottom of seam..............	6.12	83.19	10.69	31.49	51.70	62.39	------	------	------	------	Rush Emery
Same, calculated on dried coal..	------	88.62	11.38	33.54	55.08	66.46	------	------	------	------	Rush Emery
Yanser mine, Marysville, top of seam....	5.56	90.54	3.90	40.38	50.16	54.06	------	------	------	------	Rush Emery
Same, calculated on dried coal........	------	95.86	4.14	42.75	53.11	57.25	------	------	------	------	Rush Emery
Same, bottom of seam..............	5.82	87.14	7.04	38.56	48.58	55.62	------	------	------	------	Rush Emery
Same, calculated on dried coal..	------	92.53	7.47	40.94	51.59	59.06	------	------	------	------	Rush Emery
Sherwood, Newman & Ferren mine, Oskaloosa, top of seam................	5.73	92.14	2.13	46.54	45.60	47.73	------	------	------	------	Rush Emery
Same, calculated on dried coal........	------	98.73	2.27	49.36	48.37	50.64	------	------	------	------	Rush Emery
Same, bottom of seam..............	5.38	87.83	6.79	39.76	48.07	54.86	------	------	------	------	Rush Emery
Same, calculated on dried coal..	------	92.82	7.18	42.02	50.80	57.98	------	------	------	------	Rush Emery
Clemen mine, Marysville................	6.81	85.29	7.90	36.01	49.28	57.18	------	------	------	------	Rush Emery
Same, calculated on dried coal........	------	91.53	8.47	38.64	52.89	61.36	------	------	------	------	Rush Emery
Bussing mine, Knoxville, top of seam....	6.56	89.54	3.90	45.29	44.25	48.15	------	------	------	------	Rush Emery
Same, calculated on dried coal........	------	95.81	4.19	48.44	47.37	51.56	------	------	------	------	Rush Emery
Same, middle of seam................	6.40	79.72	13.88	39.35	40.37	54.25	------	------	------	------	Rush Emery
Same, calculated on dried coal..	------	85.17	14.83	42.04	43.13	57.96	------	------	------	------	Rush Emery
Same, bottom of seam................	5.72	91.76	2.52	46.30	45.46	47.98	------	------	------	------	Rush Emery
Same, calculated on dried coal..	------	97.33	2.67	49.11	48.22	50.89	------	------	------	------	Rush Emery
Average of county, 12 samples..........	5.97	87.43	6.60	39.88	47.55	54.15	------	------	------	------	Rush Emery
Same, calculated on dried coal........	------	92.96	7.04	42.40	50.56	57.60	------	------	------	------	Rush Emery
Roberts & Fisher bank, Otley, top of seam	9.30	84.70	6.00	41.80	42.90	48.90	------	------	------	------	G. Hinrichs
Same, bottom of seam...............	10.70	81.50	7.80	38.30	43.20	51.00	------	------	------	------	G. Hinrichs
O'Neal bank, Knoxville, upper bed......	7.80	82.40	9.80	35.40	47.00	56.80	------	------	------	------	G. Hinrichs
Same, lower bed....................	7.70	81.60	10.70	35.70	45.90	56.60	------	------	------	------	G. Hinrichs
Nossaman bank, Flagler, top of seam....	3.90	90.00	6.20	42.40	47.50	53.70	------	------	------	------	G. Hinrichs
Same, bottom of seam...............	4.80	77.70	17.50	40.20	37.40	54.90	------	------	------	------	G. Hinrichs
Average of 6 samples..................	7.40	82.90	9.70	38.90	44.00	53.70	------	------	------	------	G. Hinrichs

*Sulpbur not separately determined.

CHEMICAL ANALYSES OF IOWA COALS—CONTINUED

LOCALITIES	Moisture	Total combustibles	Ash	Volatile combustible matter	Fixed carbon	Coke—Fixed carbon plus ash	SULPHUR In sulphides	SULPHUR In sulphates	SULPHUR Total	Calorimetry B. T. U.	AUTHORITY
Average of 4	6.17	87.06	6.78	37.79	49.27						Iowa State Col'ge
Mammoth Vein Coal Co., Everist, lump coal	14.20	70.50	15.20	33.10	37.40				4.66	10,019	Iowa State Col'ge
Mine No. 5, Mammoth Vein Coal Co., Hamilton, mine sample No. 1	15.65	72.71	11.64	36.87	35.84				5.10	10,289	N. W. Lord
Same, air-dried sample	7.00	80.17	12.83	40.65	39.52				5.49	11,344	N. W. Lord
Same, mine sample No. 2	15.50	75.31	9.19	36.94	38.37				5.19		N. W. Lord
Same, air-dried sample	6.63	83.22	10.15	40.82	42.40				5.74		N. W. Lord
Same, car sample, run-of-mine	14.21	70.57	15.22	33.17	37.40				4.66	10,019	N. W. Lord
Same, air-dried sample	4.25	78.76	16.99	37.02	41.74				5.20	11,182	N. W. Lord
Same, car sample, second portion	16.99	68.55	14.46	33.03	35.52				5.15		N. W. Lord
Same, air-dried sample	1.76	81.13	17.11	39.09	42.04				6.09		N. W. Lord
Same, washed coal	18.85	70.87	10.28	35.44	35.43				3.93		N. W. Lord
Same, air-dried sample	9.73	78.83	11.44	39.42	39.41				4.37		N. W. Lord
English Creek Coal Co., Hawkeye	18.30	69.07	12.63	31.12	37.95				5.16	10,215	State Univ. Iowa
Same, air-dried sample	4.50	80.73	14.77	36.37	44.36				6.03	11,939	State Univ. Iowa
MONROE COUNTY—											
Chicago and Iowa mine, Albia, average	6.09	81.20	12.67	43.19	38.04	50.71	5.54	.19	5.73		G. E. Patrick
Enterprise mine, average	5.09	89.51	5.39	44.62	44.89	50.28	4.91	.29	5.20		G. E. Patrick
Iowa and Wisconsin mine, Albia, top of seam	4.02	63.70	32.28	31.15	32.55	64.83	7.17	.87	8.04		G. E. Patrick
Same, middle of seam	4.94	83.26	11.80	38.23	45.03	56.83	4.96	.34	5.30		G. E. Patrick
Same, bottom of seam	4.00	86.45	9.55	34.95	51.50	61.05	4.09	.29	4.38		G. E. Patrick

Smoky Hollow mine, Avery, average	5.05	87.57	7.38	42.64	44.93	52.30	4.20	.59	4.79	------	G. E. Patrick
Deep Vein mine, Foster, top of seam	5.75	81.04	13.21	40.36	40.68	53.89	4.24	.36	4.60	------	G. E. Patrick
Same, middle of seam	6.67	91.03	2.30	44.75	46.28	48.58	3.34	.10	3.44	------	G. E. Patrick
Same, bottom of seam	5.77	79.29	14.94	35.25	44.04	58.98	5.21	.20	5.41	------	G. E. Patrick
Miller mine, Albia, bottom of seam	4.71	89.14	6.15	37.84	51.30	57.45	------	------	------	------	Rush Emery
Same, calculated on dried coal	------	93.54	6.46	39.70	53.84	60.30	------	------	------	------	Rush Emery
Same, top of seam	4.57	89.02	6.41	43.80	45.22	51.63	------	------	------	------	Rush Emery
Same, calculated on dried coal	------	93.28	6.72	45.89	47.39	54.11	------	------	------	------	Rush Emery
Buchanan mine, Albia	5.16	86.09	8.75	40.21	45.88	54.63	------	------	------	------	Rush Emery
Same, calculated on dried coal	------	90.78	9.22	42.40	43.38	57.60	------	------	------	------	Rush Emery
Barber mine, Albia	6.04	92.06	1.90	42.49	49.57	51.47	------	------	------	------	Rush Emery
Same, calculated on dried coal	------	97.97	2.03	45.22	52.75	54.78	------	------	------	------	Rush Emery
Perry mine, Albia	4.43	89.20	6.37	42.69	46.51	52.88	------	------	------	------	Rush Emery
Same, calculated on dried coal	------	93.34	6.66	44.67	48.67	55.33	------	------	------	------	Rush Emery
Miller mine, N. E. of Albia	4.90	91.37	3.73	43.65	47.72	51.45	------	------	------	------	Rush Emery
Same, calculated on dried coal	------	96.08	3.92	45.90	50.18	54.10	------	------	------	------	Rush Emery
Average of county, 6 samples	4.97	89.48	5.55	41.78	47.70	53.25	------	------	------	------	Rush Emery
Same, calculated on dried coal	------	94.16	5.84	43.96	50.20	56.04	------	------	------	------	Rush Emery
Whitebreast Fuel Co., Hilton	6.51	83.04	10.45	37.97	45.07	------	------	------	3.02	12,396	Iowa State Col'ge
Same	------	88.82	11.18	40.61	48.21	------	------	------	3.26	12,396	Iowa State Col'ge
Hocking Coal Co., mine No. 3	6.63	79.25	14.12	38.37	40.88	------	------	------	6.92	------	Iowa State Col'ge
Same, mine No. 1	------	84.88	15.12	40.02	44.86	------	------	------	7.41	12,037	Iowa State Col'ge
Same, mine No. 2	5.80	85,27	9.03	42.56	42.71	------	------	------	3.75	12,560	Iowa State Col'ge
Same	------	90.52	9.48	45.18	45.34	------	------	------	3.98	12,560	Iowa State Col'ge
Consolidation Coal Co., Buxton, mine No. 10	9.48	81.65	10.87	35.58	46.07	------	------	------	2.06	12,030	Iowa State Col'ge
Same	------	93.71	6.29	48.69	45.02	------	------	------	3.58	12,030	Iowa State Col'ge
Same, mine No. 9	6.19	85.90	5.91	43.60	42.30	------	------	------	3.45	------	Iowa State Col'ge
Same, mine No. 11	------	89.92	12.08	37.09	50.83	------	------	------	2.27	10,585	Iowa State Col'ge
Average of 8	5.55	84.80	9.65	40.38	44.42	------	------	------	5.21	------	Iowa State Col'ge
Smoky Hollow Coal Co., Avery, steam coal	10.80	73.20	16.00	35.40	37.80	------	------	------	------	9,719	Iowa State Col'ge
Mine No. 6, Smoky Hollow Coal Co., Avery, "third seam"	12.03	78.59	9.38	40.62	37.97	------	------	------	5.04	------	N. W. Lord
Same, air-dried sample	5.81	84.14	10.05	43.49	40.65	------	------	------	5.41	------	N. W. Lord
Same	15.84	74.78	9.38	36.90	37.88	------	------	------	4.68	10,854	N. W. Lord
Same, air-dried sample	6.07	83.46	10.47	41.18	42.28	------	------	------	5.22	12,114	N. W. Lord
Wapello Coal Co., Hiteman, No. 4	16.51	71.98	11.41	33.01	38.97	------	------	------	1.92	10,528	State Univ. Iowa
Same, air-dried sample	8.40	79.06	12.54	36.26	42.80	------	------	------	2.10	11,564	State Univ. Iowa
*Soap Creek Coal Co., Foster	6.41	81.85	7.87	42.18	39.67	------	------	------	3.87	------	Geo. N. Prentiss
Foster	6.57	81.53	11.90	47.91	33.62	------	------	------	7.60	11,541	Geo. N. Prentiss

*Sulphur not separately determined.

CHEMICAL ANALYSES OF IOWA COALS—CONTINUED

LOCALITIES	Moisture	Total combustibles	Ash	Volatile combustible matter	Fixed carbon	Coke—Fixed carbon plus ash	SULPHUR In sulphides	SULPHUR In sulphates	SULPHUR Total	Calorimetry B. T. U.	AUTHORITY
POLK COUNTY—											
Redhead mine, Des Moines	4.80	89.00	2.30	44.70	44.30	50.50	—	—	—	—	G. Hinrichs
Christy mine, Des Moines, top of seam	5.53	88.05	6.42	44.70	43.35	49.77	4.78	.09	4.87	—	G. E. Patrick
Same, middle of seam	6.18	84.12	9.70	38.65	45.47	55.17	5.14	.15	5.56	—	G. E. Patrick
Same, bottom of seam	6.60	75.62	17.78	33.84	41.78	59.56	4.79	.19	4.98	—	G. E. Patrick
Same, average	6.10	82.59	11.30	39.06	43.53	54.83	4.99	.14	5.13	—	G. E. Patrick
Gibson mine, Des Moines, average	7.04	82.89	9.72	40.06	43.17	52.89	4.09	.16	4.25	—	G. E. Patrick
Manbeck mine, Des Moines, average	6.82	76.58	16.19	36.93	39.65	56.84	4.44	.29	4.73	—	G. E. Patrick
Marquisville	5.09	91.03	3.88	43.30	47.73	—	—	—	2.60	10,574	Iowa State Col'ge
Average of 5	6.43	83.61	11.96	38.84	44.77	—	—	—	4.87	—	Iowa State Col'ge
Flint Brick Co., Des Moines, steam coal	13.00	69.60	16.20	30.10	39.50	—	—	—	—	9,952	Iowa State Col'ge
Norwood Coal Co., Norwoodville, steam coal	14.20	70.70	15.00	32.30	38.40	—	—	—	—	10,479	Iowa State Col'ge
Gibson Coal Mining Co., Des Moines, lump coal	13.80	72.00	14.00	36.90	35.10	—	—	—	6.15	10,244	Iowa State Col'ge
Marquisville, nut coal	5.80	73.50	20.60	30.00	43.50	—	—	—	—	11,136	Iowa State Col'ge
Mine No. 4, Gibson Coal Mining Co., Altoona, "third vein," mine sample No. 1	14.42	74.59	10.99	37.81	36.78	—	—	—	5.89	10,640	N. W. Lord
Same, air-dried sample	5.33	82.51	12.16	41.82	40.69	—	—	—	6.52	11,770	N. W. Lord
Same, mine sample No. 2	15.90	71.73	12.37	37.42	34.31	—	—	—	6.76	—	N. W. Lord
Same, air-dried sample	5.51	80.59	13.90	42.04	38.55	—	—	—	7.59	—	N. W. Lord
Same, car sample, lump coal	13.88	72.11	14.01	36.94	35.17	—	—	—	6.15	10,244	N. W. Lord
Same, air-dried sample	4.52	79.95	15.53	40.96	38.99	—	—	—	6.83	11,356	N. W. Lord

Same, washed coal	16.83	75.14	8.03	39.27	35.87	------	------	------	4.55	------	N. W. Lord
Same, air-dried sample.........	10.67	80.71	8.62	42.18	38.53	------	------	------	4.88	------	N. W. Lord
Same, coke sample	5.73	77.36	16.91	1.87	75.49	------	------	------	4.57	------	N. W. Lord
Same, air-dried sample.........	1.80	80.59	17.61	1.95	78.64	------	------	------	4.76	------	N. W. Lord
Des Moines Coal and Mining Co.........	------	95.91	4.09	45.62	50.29	------	------	------	2.74	12,041	Iowa State Col'ge
Keystone Coal Mining Co., Des Moines...	13.42	72.63	13.95	34.60	38.03	------	------	------	5.70	10,440	State Univ. Iowa
Same, air-dried sample...............	4.78	79.89	15.33	38.06	41.83	------	------	------	6.26	11,481	State Univ. Iowa
Bennett Coal Co., Des Moines............	13.39	75.44	11.17	35.30	40.14	------	------	------	4.68	11,023	State Univ. Iowa
Same, air-dried sample...............	4.62	83.08	12.30	38.88	44.20	------	------	------	5.15	12,139	State Univ. Iowa
Enterprise Coal Co., Enterprise, mine No. 2	14.69	77.37	7.94	37.25	40.12	------	------	------	3.44	11,313	State Univ. Iowa
Same, air-dried sample...............	6.08	85.18	8.74	41.01	44.17	------	------	------	3.79	12,454	State Univ. Iowa
POWESHIEK COUNTY—											
Smith & Barrowman mine, Searsboro, top of seam	5.41	89.30	5.29	41.39	47.91	53.20	------	------	------	------	Rush Emery
Same, calculated on dried coal........	------	94.41	5.59	43.77	50.64	56.23	------	------	------	------	Rush Emery
Same, bottom of seam................	6.28	86.67	7.05	36.51	50.16	57.21	------	------	------	------	Rush Emery
Same, calculated on dried coal..	------	92.47	7.53	38.95	53.52	61.05	------	------	------	------	Rush Emery
Same, average of undried coal........	5.84	87.99	6.17	38.95	49.04	55.21	------	------	------	------	Rush Emery
Same, average of dried coal..........	------	93.44	6.56	41.36	52.08	58.64	------	------	------	------	Rush Emery
Smith & Barrowman mine, Searsboro....	8.20	89.50	2.40	42.00	47.40	49.80	------	------	------	------	G. Hinrichs
SCOTT COUNTY—											
Havill coal bank, Buffalo................	2.87	77.21	19.90	36.39	40.82	60.72	------	------	0.19	------	J. D. Whitney
Same, calculated on dried coal........	------	79.50	20.48	37.47	42.03	62.51	------	------	------	------	J. D. Whitney
"Lower coal," Buffalo..................	3.13	87.85	9.02	38.77	49.08	58.10	------	------	1.57	------	J. D. Whitney
Same, calculated on dried coal........	------	90.69	9.31	40.02	50.67	59.98	------	------	------	------	J. D. Whitney
Friedley & Hoyt mine, Buffalo, top of seam	3.48	89.79	6.73	41.32	48.47	55.20	4.99	.54	5.33	------	G. E. Patrick
Same, middle of seam...............	3.66	87.46	8.88	41.44	46.02	54.90	3.72	.15	3.87	------	G. E. Patrick
Same, bottom of seam................	2.89	82.03	15.08	38.09	43.94	59.02	7.80	.38	8.18	------	G. E. Patrick
Hanlon & Blackwell mine, Buffalo, top of seam	2.66	86.66	10.68	42.10	44.56	55.24	3.11	.05	3.16	------	G. E. Patrick
Same, bottom of seam................	5.07	83.59	11.34	39.33	44.26	55.60	4.38	.22	4.60	------	G. E. Patrick

CHEMICAL ANALYSES OF IOWA COALS—CONTINUED

LOCALITIES	Moisture	Total combustibles	Ash	Volatile combustible matter	Fixed carbon	Coke—Fixed carbon plus ash	SULPHUR In sulphides	SULPHUR In sulphates	SULPHUR Total	Calorimetry B. T. U.	AUTHORITY
Friedley mine, Muscatine	3.94	92.98	3.08	37.46	55.52	58.60	3.03	.07	3.10	------	G. E. Patrick
Average of 6	3.61	87.18	9.29	39.95	47.13	------	------	------	4.71	------	Iowa State Col'ge
Duck creek, Sec. 27, Twp. 70, R. 4 E.	------	92.50	7.50	42.50	50.00	------	------	------	------	------	D. D. Owen
TAYLOR COUNTY—											
Adams shaft, New Market	8.00	79.68	12.31	35.41	44.29	56.58	5.29	.59	5.88	------	G. E. Patrick
Anderson mine, New Market, average	8.06	80.57	11.36	34.99	45.58	56.95	4.72	.45	5.17	------	G. E. Patrick
Campbell mine, New Market, top of seam	7.44	80.64	11.92	37.79	42.85	54.77	3.54	.14	3.68	------	G. E. Patrick
Same, middle of seam	8.21	82.77	9.02	35.28	47.49	56.51	3.85	.43	4.28	------	G. E. Patrick
Same, bottom of seam	7.94	79.93	12.13	37.41	42.52	54.65	4.70	.54	5.24	------	G. E. Patrick
Average of 5	5.93	80.71	11.34	36.17	44.54	------	------	------	4.85	------	Iowa State Col'ge
Campbell Coal Co., New Market, mine No. 1	20.21	68.38	11.41	30.05	38.33	------	------	------	4.18	10,115	State Univ. Iowa
Same, air-dried sample	9.24	77.77	12.99	34.17	43.60	------	------	------	4.78	11,494	State Univ. Iowa
VAN BUREN COUNTY—											
Cox coal bank, Hillsboro	7.92	88.50	3.58	41.74	46.76	50.34	------	------	.29	------	J. D. Whitney
Same, calculated on dried coal	------	96.11	3.89	45.33	50.78	54.67	------	------	------	------	J. D. Whitney
Crail bank, Hillsboro	5.30	92.33	2.37	37.98	54.35	56.72	------	------	0.55	------	J. D. Whitney
Same, calculated on dried coal	------	97.50	2.50	40.11	57.39	59.89	------	------	------	------	J. D. Whitney
Slaughter bank, Farmington	8.62	85.50	5.88	38.08	47.42	53.30	------	------	1.02	------	J. D. Whitney
Same, calculated on dried coal	------	93.57	6.43	41.67	51.90	58.33	------	------	------	------	J. D. Whitney

Specimen one-half mile above Farmington	4.62	88.37	7.01	37.27	51.10	58.11	------	------	------	------	J. D. Whitney
Same, calculated on dried coal........	------	92.65	7.35	39.07	53.58	61.93	------	------	------	------	J. D. Whitney
33 Manhard bank, Selma..................	7.76	88.34	3.90	40.23	48.11	52.01	------	------	1.69	------	J. D. Whitney
Same, calculated on dried coal........	------	95.77	4.23	43.62	52.15	56.38	------	------	------	------	J. D. Whitney
Specimen from Business Corners........	5.42	87.19	7.39	39.39	47.80	55.19	------	------	0.49	------	J. D. Whitney
Same, calculated on dried coal........	------	92.19	7.81	41.65	50.54	58.35	------	------	------	------	J. D. Whitney
Average of 3..........................	8.10	87.44	4.45	40.01	47.43	------	------	------	------	------	Iowa State Col'ge
New York Coal Co. mine, Farmington, top of seam......................	6.40	87.20	7.10	43.20	44.00	50.10	------	------	------	------	G. Hinrichs
Same, bottom of seam................	6.40	88.50	5.10	45.70	42.90	47.90	------	------	------	------	G. Hinrichs
*Business Corner mine, Business Corners, top of seam.................	1.30	97.40	1.30	51.10	46.20	47.50	------	------	------	------	G. Hinrichs
*Same, bottom of seam.............	1.30	93.80	4.90	50.10	43.70	48.60	------	------	------	------	G. Hinrichs
Rodefer bank, Independent, top of seam..	6.10	91.40	2.50	46.80	44.70	47.10	------	------	------	------	G. Hinrichs
Same, bottom of seam................	6.60	86.20	7.20	47.40	38.80	46.00	------	------	------	------	G. Hinrichs
Carmine bank, Sec. 13, Twp. 70, R. 8, top of seam	5.40	86.70	6.90	40.30	46.40	53.30	------	------	------	------	G. Hinrichs
Same, bottom of seam................	4.50	87.30	8.30	45.90	41.40	49.70	------	------	------	------	G. Hinrichs
*Carter mine, Bentonsport..............	1.70	91.30	6.90	41.90	49.40	56.40	------	------	------	------	G. Hinrichs
Average for county, 9 samples..........	4.40	90.00	5.60	47.00	43.00	50.60	------	------	------	------	G. Hinrichs
WAPELLO COUNTY—											
Whitebreast No. 22, Keb, top of seam....	5.54	84.79	9.67	41.24	43.55	53.22	6.35	.11	6.46	------	G. E. Patrick
Same, middle of seam................	6.82	82.03	11.15	35.29	46.74	57.89	9.53	.16	9.69	------	G. E. Patrick
Same, bottom of seam................	7.55	79.09	13.36	33.43	45.66	59.02	6.05	.25	6.30	------	G. E. Patrick
Same, sample of room................	5.08	74.54	20.38	33.66	40.88	61.26	6.49	.28	6.77	------	G. E. Patrick
Eldon mine, Laddsdale, top..............	3.81	93.39	2.80	41.69	51.70	54.50	2.57	.33	2.90	------	G. E. Patrick
Same, middle of seam................	3.72	85.37	10.91	42.88	42.49	53.40	2.93	.66	3.59	------	G. E. Patrick
Same, bottom of seam................	3.24	87.97	8.79	45.82	42.15	50.94	2.80	.56	3.36	------	G. E. Patrick
Brigg mine, Eddyville..................	4.07	94.55	1.38	50.65	43.90	45.28	------	------	------	------	Rush Emery
Same, calculated on dried coal........	------	98.56	1.44	52.80	45.76	47.20	------	------	------	------	Rush Emery
Brown & Godfrey mine, Ottumwa.........	6.50	89.60	3.90	41.35	48.25	52.15	------	------	------	------	Rush Emery
Same, calculated on dried coal........	------	95.83	4.17	44.22	51.61	55.78	------	------	------	------	Rush Emery
Wylie mine, Eddyville..................	3.95	85.69	10.36	36.98	48.71	59.07	------	------	------	------	Rush Emery
Same, calculated on dried coal........	------	89.22	10.78	38.51	50.71	61.49	------	------	------	------	Rush Emery

*These samples had been in a warm room about a week before being analyzed, hence the small amount of moisture.

CHEMICAL ANALYSES OF IOWA COALS—CONTINUED

LOCALITIES	Moisture	Total combustibles	Ash	Volatile combustible matter	Fixed carbon	Coke—Fixed carbon plus ash	SULPHUR In sulphides	SULPHUR In sulphates	SULPHUR Total	Calorimetry B. T. U.	AUTHORITY
Allen mine, Ottumwa, top of seam........	5.06	67.93	27.01	27.61	40.32	67.33	------	------	------	------	Rush Emery
Same, calculated on dried coal.........	------	71.55	28.45	29.08	42.47	70.92	------	------	------	------	Rush Emery
Same, bottom of seam................	3.35	91.79	4.86	46.75	45.04	49.90	------	------	------	------	Rush Emery
Same, calculated on dried coal..	------	94.98	5.02	48.37	46.61	51.63	------	------	------	------	Rush Emery
Dudley mine, Dudley, top of seam.........	5.48	92.51	2.01	45.76	46.75	48.76	------	------	------	------	Rush Emery
Same, calculated on dried coal.........	------	97.88	2.12	48.41	49.47	51.59	------	------	------	------	Rush Emery
Same, bottom of seam................	4.97	87.01	8.02	42.50	44.51	52.53	------	------	------	------	Rush Emery
Same, calculated on dried coal..	------	91.56	8.44	44.72	46.84	55.28	------	------	------	------	Rush Emery
Evans mine, Chilicothe, top of seam......	6.98	89.47	3.55	39.36	50.11	53.66	------	------	------	------	Rush Emery
Same, calculated on dried coal.........	------	96.17	3.83	42.31	53.86	57.69	------	------	------	------	Rush Emery
Same, bottom of seam................	6.16	90.08	3.76	36.96	53.12	56.88	------	------	------	------	Rush Emery
Same, calculated on dried coal..	------	96.00	4.00	39.39	56.61	60.61	------	------	------	------	Rush Emery
Marshall mine, Eddyville, top of seam....	5.21	87.70	7.09	42.19	45.51	52.60	------	------	------	------	Rush Emery
Same, calculated on dried coal.........	------	92.52	7.48	44.51	48.01	55.49	------	------	------	------	Rush Emery
Same, bottom of seam................	5.85	88.46	5.59	39.69	48.77	54.46	------	------	------	------	Rush Emery
Same, calculated on dried coal..	------	93.96	6.04	42.16	51.80	57.84	------	------	------	------	Rush Emery
Inskeep mine, Ottumwa, top of seam......	3.87	92.11	4.02	42.96	49.15	53.17	------	------	------	------	Rush Emery
Same, calculated on dried coal.........	------	95.82	4.18	44.69	51.13	55.31	------	------	------	------	Rush Emery
Same, bottom of seam................	3.68	85.49	10.83	42.05	43.44	54.27	------	------	------	------	Rush Emery
Same, calculated on dried coal..	------	88.77	11.23	43.66	45.11	56.34	------	------	------	------	Rush Emery
Heacock mine, Chilicothe, top of seam...	5.35	87.65	7.00	42.41	45.24	52.24	------	------	------	------	Rush Emery
Same, calculated on dried coal.........	------	92.61	7.39	44.81	47.80	55.19	------	------	------	------	Rush Emery
Same, bottom of seam................	3.89	77.77	18.34	36.94	40.83	59.17	------	------	------	------	Rush Emery
Same, calculated on dried coal..	------	80.91	19.09	38.43	42.48	61.57	------	------	------	------	Rush Emery
Average of county, 15 samples..........	4.96	87.19	7.85	40.94	46.25	54.10	------	------	------	------	Rush Emery

Same, calculated on dried coal	------	91.76	8.24	43.07	48.69	56.93	------	------	------	------	Rush Emery
Roseland Coal Co., Ottumwa, steam coal	11.20	71.90	15.70	30.70	41.20	------	------	------	------	8,594	Iowa State Col'ge
Average of 11	5.42	83.98	10.60	38.73	45.25	------	------	------	5.85	------	Iowa State Col'ge
Henry Shock & Co., Sec 8, Twp. 78, R. 14, top of seam	7.80	85.00	7.20	38.60	46.50	53.60	------	------	------	------	G. Hinrichs
Same, bottom of seam	6.10	90.00	3.90	41.70	48.30	52.30	------	------	------	------	G. Hinrichs
Alpine Coal Co., Alpine, top of seam	4.20	88.70	7.20	44.70	44.00	51.20	------	------	------	------	G. Hinrichs
Same, bottom of seam	4.90	81.80	13.30	39.10	42.70	56.00	------	------	------	------	G. Hinrichs
Brown & Godfrey mine, Ottumwa, top of seam	7.10	84.90	8.00	43.60	41.30	49.30	------	------	------	------	G. Hinrichs
Same, middle of seam	7.40	88.50	4.20	44.30	44.10	48.30	------	------	------	------	G. Hinrichs
Same, bottom of seam	3.50	86.20	10.30	40.00	46.10	56.50	------	------	------	------	G. Hinrichs
Average for county, 7 samples	6.90	85.40	7.70	41.70	43.70	52.40	------	------	------	------	G. Hinrichs
Mine No. 2, Anchor Coal Co., Laddsdale, middle seam	11.35	78.14	10.51	38.65	39.49	------	------	------	4.72	11,345	N. W. Lord
Same, air-dried sample	3.74	84.85	11.41	41.96	42.89	------	------	------	5.12	12,317	N. W. Lord
Same, lower seam	12.07	75.60	12.33	37.28	38.32	------	------	------	4.99	------	N. W. Lord
Same, air-dried sample	4.43	82.17	13.40	40.52	41.65	------	------	------	5.42	------	N. W. Lord
Same, car sample, lump and fine coal	8.24	75.76	16.00	30.74	45.02	------	------	------	5.03	11,027	N. W. Lord
Same, air-dried sample	5.21	78.27	16.52	31.76	46.51	------	------	------	5.20	11,392	N. W. Lord
Same, washed coal	12.84	76.91	10.25	35.91	41.00	------	------	------	4.61	------	N. W. Lord
Same, air-dried sample	8.92	80.37	10.71	37.53	42.84	------	------	------	4.82	------	N. W. Lord
Same, coke sample	10.53	71.99	17.45	1.63	70.39	------	------	------	3.89	------	N. W. Lord
Same, air-dried sample	2.11	78.80	19.09	1.79	77.01	------	------	------	4.25	------	N. W. Lord
Keb	9.81	82.24	7.95	37.49	44.75	------	------	------	------	------	C., B. & Q. R. R.
Eldon Coal & Mining Co., Laddsdale	4.23	86.68	9.09	40.92	45.76	------	------	------	4.75	13,141	Iowa State Col'ge
Same	------	90.50	9.50	42.72	47.78	------	------	------	4.96	13,141	Iowa State Col'ge
Carbon Coal Co., Willard	------	91.14	8.86	36.94	54.20	------	------	------	2.86	12,245	Iowa State Col'ge
Phillips Fuel Co., Bear Creek mine	12.28	74.46	13.26	34.64	39.82	------	------	------	6.11	10,776	State Univ. Iowa
Same, air-dried sample	4.79	80.81	14.40	37.59	43.22	------	------	------	6.63	11,695	State Univ. Iowa
Same	2.12	82.93	14.95	48.19	34.74	49.69	------	------	6.82	12,304	C., M. & St. P. Ry.
Phillips Fuel Co., Rutledge No. 5	13.37	76.29	10.34	35.68	40.61	------	------	------	5.76	11,051	State Univ. Iowa
Same, air-dried sample	5.84	82.92	11.24	38.78	44.14	------	------	------	6.26	12,010	State Univ. Iowa
Phillips Fuel Co., Rutledge	------	------	------	------	------	------	------	------	------	12,550	Geo. N. Prentiss

CHEMICAL ANALYSES OF IOWA COALS—CONTINUED

LOCALITIES	Moisture	Total combustibles	Ash	Volatile combustible matter	Fixed carbon	Cōke—Fixed carbon plus ash	SULPHUR In sulphides	In sulphates	Total	Calorimetry B. T. U.	AUTHORITY
WARREN COUNTY—											
Bennum mine, Summerset, top..........	7.31	82.09	10.60	36.63	45.46	56.06	5.02	.09	5.11	------	G. E. Patrick
Same, bottom of seam................	9.43	82.14	8.43	36.96	45.18	53.61	3.62	.16	3.78	------	G. E. Patrick
Dillard mine, Spring Hill, top of seam....	11.56	83.27	5.17	42.89	40.38	45.55	------	------	------	------	Rush Emery
Same, calculated on dried coal........	------	94.15	5.85	48.49	45.66	51.51	------	------	------	------	Rush Emery
Same, middle of seam................	14.13	80.60	5.27	36.59	44.01	49.28	------	------	------	------	Rush Emery
Same, calculated on dried coal..	------	93.87	6.13	42.61	51.26	57.39	------	------	------	------	Rush Emery
Same, below middle of seam..........	10.76	82.32	6.92	38.76	43.56	50.48	------	------	------	------	Rush Emery
Same, calculated on dried coal..	------	92.25	7.75	43.43	48.82	56.57	------	------	------	------	Rush Emery
Same, bottom of seam................	12.64	83.17	4.19	41.62	41.55	45.74	------	------	------	------	Rush Emery
Same, calculated on dried coal..	------	95.20	4.80	47.64	47.56	52.36	------	------	------	------	Rush Emery
Average of county, four samples.........	12.27	82.34	5.39	39.96	42.38	47.77	------	------	------	------	Rush Emery
Same, calculated on dried coal........	------	93.87	6.13	45.54	48.33	54.46	------	------	------	------	Rush Emery
Average of four.........................	10.60	82.01	7.36	38.26	43.75	------	------	------	4.44	------	Iowa State Col'ge
WAYNE COUNTY—											
Frey mine, Confidence, below parting....	9.26	80.45	10.29	34.21	46.24	36.53	4.71	.26	4.97	------	G. E. Patrick
Same, above parting..................	9.39	78.69	11.92	34.71	43.98	55.90	2.97	.20	3.17	------	G. E. Patrick
Same, middle of seam................	8.01	75.41	16.58	37.22	38.19	54.77	3.24	.09	3.33	------	G. E. Patrick
Same, top of seam....................	9.37	77.12	13.51	31.78	45.34	58.85	3.53	.37	3.90	------	G. E. Patrick
Average of 4..........................	9.01	77.91	13.07	34.48	43.43	------	------	------	3.84	------	Iowa State Col'ge

WEBSTER COUNTY—											
Collins No. 6, Coalville, average	7.48	84.06	8.44	39.52	44.54	52.99	4.98	.26	5.24	------	G. E. Patrick
Collins No. 4, Coalville, average	7.80	82.88	9.32	37.74	45.14	54.46	3.97	.12	4.09	------	G. E. Patrick
Old Reese mine, Fort Dodge	9.92	48.77	41.31	29.69	22.08	63.39	------	------	------	------	G. E. Patrick
Carlson mine, Kalo, average	10.10	76.53	13.36	32.83	43.69	57.06	1.68	.18	1.86	------	G. E. Patrick
Craig Cannel mine, Kalo, "cannel" coal	5.87	78.26	15.87	39.04	39.22	55.09	6.87	.25	7.12	------	G. E. Patrick
Craig slope, Kalo, bituminous	8.46	81.37	10.17	37.97	43.40	53.57	5.19	.10	5.29	------	G. E. Patrick
Crooked Creek mine, Lehigh, top of seam	7.74	78.94	13.32	34.47	44.47	57.79	4.83	.81	5.64	------	G. E. Patrick
Same, middle of seam	8.52	82.65	8.83	38.64	44.01	52.84	3.71	.48	4.19	------	G. E. Patrick
Same, bottom of seam	8.57	81.86	9.57	37.57	44.29	53.86	3.47	.18	3.65	------	G. E. Patrick
Crooked Creek, shaft, Lehigh, average	6.99	76.66	16.34	34.40	42.26	58.60	5.67	.37	6.04	------	G. E. Patrick
Corey mine, Lehigh, average	7.77	81.27	11.00	38.05	43.21	54.21	7.02	.68	7.70	------	G. E. Patrick
Same	------	85.96	14.04	37.98	47.98	------	------	------	5.90	12,431	Iowa State Col'ge
Colburn mine, Fort Dodge	13.02	80.60	6.38	37.54	43.06	49.44	------	------	------	------	J. D. Whitney
Same, calculated on dried coal	------	92.66	7.34	43.16	49.50	56.84	------	------	------	------	J. D. Whitney
Section 18, T. 88, R. 28	14.95	77.87	7.18	34.98	42.89	50.07	------	------	0.81	------	J. D. Whitney
Same, calculated on dried coal	------	91.56	8.44	41.13	50.43	58.87	------	------	------	------	J. D. Whitney
Section 13, T. 88, R. 28	9.46	73.35	17.19	33.69	39.66	56.85	------	------	2.52	------	J. D. Whitney
Same, calculated on dried coal	------	81.01	18.99	37.21	43.80	62.79	------	------	------	------	J. D. Whitney
Rees mine, Fort Dodge	14.05	77.61	8.34	36.42	41.19	49.53	------	------	------	------	Rush Emery
Same, calculated on dried coal	------	90.32	9.68	42.38	47.94	57.62	------	------	------	------	Rush Emery
"Cannel coal," Sec. 17, Twp. 88 N., R. 29 W.	10.46	74.37	15.17	37.44	36.93	52.10	------	------	------	------	Rush Emery
Same, calculated on dried coal	------	83.06	16.94	41.80	41.26	58.20	------	------	------	------	Rush Emery
Section 17, Twp. 88 N., R. 28 W.	10.13	73.33	16.54	37.25	36.08	52.62	------	------	------	------	Rush Emery
Same, calculated on dried coal	------	81.59	18.41	41.44	40.15	58.56	------	------	------	------	Rush Emery
Collins mine, Coalville	13.91	78.83	7.26	37.00	41.83	49.09	------	------	------	------	Rush Emery
Same, calculated on dried coal	------	91.57	8.43	42.98	48.59	57.02	------	------	------	------	Rush Emery
"Cannel coal," Rees mine, Fort Dodge	9.92	48.77	41.31	26.69	22.08	63.39	------	------	------	------	Rush Emery
Same, calculated on dried coal	------	54.14	45.86	29.63	24.51	70.37	------	------	------	------	Rush Emery
Average of county, 4 samples	12.14	76.04	11.82	37.03	39.01	50.83	------	------	------	------	Rush Emery
Same, calculated on dried coal	------	86.64	13.36	42.15	44.49	57.85	------	------	------	------	Rush Emery
Tyson seam, near Lehigh	12.70	77.03	10.27	44.12	32.91	------	------	------	5.33	------	Iowa State Col'ge
Lehigh	17.47	70.94	11.59	31.35	39.59	------	------	------	4.87	------	Iowa State Col'ge
Average of 10	7.83	80.65	11.52	37.23	43.42	------	------	------	5.08	------	Iowa State Col'ge

In 1901-02, at the Iowa State College, Mr. F. M. Weakly made a study of the chemical compositions of Iowa coals, from which the following is quoted:

"The moisture in Iowa coals varies (for the coals tested) from 4.03 to 17.47, the average being 8.08. This moisture is high, as compared with that in coals of other states.

"Eliminating moisture from our comparisons, in volatile matter the Iowa coals are rich, varying from 36.94 to 48.69, with an average of 41.49.

"The fixed carbon ranges from 44.86 to 54.91, with an average of 49.62, slightly lower than that of many coals from other states.

"Total combustibles are high, running from 84.88 to 95.91, with an average of 91.11.

"Ash is low, being from 4.09 to 15.12, with an average of 8.89.

"Sulphur is high, from 2.27 to 7.41, with an average of 3.72.

"The coals high in sulphur are also high in ash."

Concurrently with the work of Mr. Weakly, Messrs Austin and Peshak, under the direction of Professor G. W. Bissell, determined the calorific powers of samples of coal from twenty or more mines from the same district, fourteen of the samples being the same as used by Mr. Weakly.

The following table exhibits the results of the work of Messrs. Austin and Peshak:

CALORIFIC POWER OF IOWA COALS.

PER POUND OF DRY FUEL.

	B. T. U.
Slack coal, Marquisville, Iowa	10574
Lumsden Coal and Mining Company	12097
Saylor Coal Company, Marquisville	8585
Des Moines Coal and Mining Company, Marquisville	12041
Whitebreast Fuel Company, Hilton, Iowa	12396
Whitebreast Fuel Company, Pekay, Iowa	13050
Hocking Valley Coal Company, Mine No. 1	12037
Hocking Valley Coal Company, Mine No. 2	12560
Lumsden Coal Company, Bloomfield, Iowa	13204
Humboldt Electric Company, cannel coal, Kalo, Iowa	10451
Humboldt Electric Company, mine coal, Kalo, Iowa	10922
Centerville Block Coal Company	12681
Eldon Coal and Mining Company, Laddsdale	13141
Consolidation Coal Company, Buxton, No. 10	12030
Consolidation Coal Company, Buxton, No. 11	10585

Lodwick Brothers Coal Company, Mystic	12780
Carbon Coal Company, Willard	12245
Crowe Coal Mining Company, Boone	12729
Boone Electric Light Company	9205
Corey Coal Company, Lehigh	12431
Platt Pressed and Fire Brick Company, Van Meter	11941
Jasper County Coal and Mining Company, Colfax	12134
Empire Coal Company	10881
A. A. Conway Coal Company	10132

An average of 64 analyses by the State Geologist gives the following chemical composition:

*Moisture	8.57
Fixed carbon	45.42
Volatile matter	39.24
Ash	6.77
	100.00

Analyses of coal from 16 mines in Des Moines river district give:

†Moisture	8.08
Fixed carbon	45.60
Volatile matter	38.14
Ash	8.18
	100.00
Sulphur	3.42

or on the basis of oven dried samples,

†Fixed carbon	49.62
Volatile matter	41.49
Ash	8.89
	100.00
Sulphur	3.72

Average of Iowa coals:§

Moisture	13.16
Carbon, volatile	33.36
Carbon, fixed	39.69
Ash	13.76
Sulphur	4.65
Calorific value	10,019 to 11,027

*Steam boiler economy. Kent, p. 74.
†F. M. Weakly, the Iowa Engineer, June, 1902.
§Iowa State College Eng. Exp. Station.

HISTORY OF COAL MINING IN IOWA

BY

JAMES H. LEES

COAL STATISTICS

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CONTENTS

CHAPTER III

HISTORY OF COAL MINING IN IOWA

BY JAMES H. LEES.

Various sources have been utilized in the preparation of the following notes. A large part of the information has been gained by interviews and correspondence with the men who have been instrumental in the development of the industry, or from those who have seen its growth. The reports of the present Survey, as well as those of previous ones, have been used, as have also other publications of various kinds. No claim is made for the completeness of the history; only such salient facts are given as could be gathered together in the time at the writer's disposal. The accompanying data and tables on the production of coal in Iowa, prepared by Dr. S. W. Beyer, will be found useful in illustrating the growth of the state's most important mineral industry.

So far as can be learned the first mining of any consequence in Iowa was done about 1840. The early settlers in many cases knew of the existence of coal beds but wood was so plentiful and offered so many advantages in the way of convenience and cleanliness that there was no inducement for using the less cleanly supply of fuel stored underground. In many cases coal was considered merely as a curiosity to be laid on the mantel. At about the date mentioned, however, the demand for coal had become great enough so that mines were opened in the eastern part of the state and within the next twenty years the industry had gained a foothold, although still a somewhat precarious one, over practically all the productive area of the state.

Van Buren County. Mr. Jacob P. Alfrey of Farmington, Van Buren county, who was the first white child born in Iowa, is authority for the statement that the first mine opened up in the vicinity of Farmington was operated by Lem Brattain in 1840. He ran the mine for a few years and then sold out to Samuel Knight who conducted the business until 1848 or 1850. During most of the period of Mr. Knight's operations there was no railroad into Farmington and hence his market was chiefly local. Some coal, however, was hauled as far as Keokuk by team. The steamboats which came up the Des Moines also used large quantities. The coal was of excellent quality and much desired for steam purposes. Mr. Knight finally sold his mine to the New York Coal Company who operated here for about twenty years. This firm worked the mine on quite an extensive scale for those days. From forty to fifty men were employed and the mine was connected by a switch with the Des Moines Valley railroad, which has since become part of the Chicago, Rock Island and Pacific. In those days miners were paid about five cents per bushel for mining and the coal sold at the mine for from $2.00 to $2.50 per ton. During the fiscal year of 1854-'55 about 100,000 bushels of coal were raised in the Farmington district. This had an average value at the mines of six and one-fourth cents per bushel. At the Mississippi river markets it retailed at eighteen to twenty cents per bushel, or $4.50 to $5.00 per ton.

About the same time, during the later 40's, coal was taken from mines owned by Senator Eliab Doud, near the present town of Douds. The mines were managed by Mr. Van Sicle, who was an intelligent and enterprising mine operator, and coal was supplied to the steamers running up the Des Moines river.

In 1856 Alexander Findlay opened up the first mine in the Douds district to be operated on a large scale. This was a slope mine located northeast of Douds. It was run for several years and later shafts were sunk in the same vicinity. Before this time there had been a number of small openings in the hillsides, the first of which were opened about 1846 or '48. They were operated only during the winter months to supply the local demand. Alex. Findlay's business was carried on by his son Hugh, who after the exhaustion of the old mines at Business

Corners sank a shaft in 1892, about a mile and a half to the northwest. This was operated to supply the railroad chutes at Douds until it caught fire three years ago. Since then another shaft has been sunk. The Findlays have also done some mining near Cedar creek, three miles north of Birmingham. Mines have been run in this vicinity ever since.

When Dr. D. D. Owen made his studies in Iowa in 1849 he found quite a number of banks opened in various parts of the county. He states that the coal esteemed the best by the blacksmiths in the neighborhood of Bentonsport was that from Jackson's bank.

Worthen mentions several mines as being in operation when he visited Van Buren county in 1857. Among these were the Cox and the Martin banks north and northwest of Hillsboro, and several along the Des Moines river near Iowaville, a town which has since gone by the names of Independent and Selma. He states that one of the Hillsboro mines was working a seven-foot vein divided by ten inches of slate. According to this author the best coal came from Business Corners and Iowaville and was mined from the "second seam."

Another mine near Farmington was opened in 1844 by Mr. Slaughter. Ten years later James Alfrey opened up the Alfrey mine which has been operated more or less up to the present time. At present there are five mines working in this district and about thirty men are employed.

In 1892 the Ratcliffe Coal Co. opened a mine one mile north of Douds and operated it about four years. They then abandoned this and worked one over at Business Corners, about a mile southeast. After working this out they returned to their former location and sank a new shaft adjacent to the old one. This is still in operation and is at present supplying coal to the local chutes of the Rock Island at Douds.

The Felmlee Coal Co. opened a shaft mine near the Findlay mine about four years ago and ship some coal from their mine.

When C. A. White inspected this region in 1868 he found that the McHugh mine at Independent had been running a long time and that there were other mines in the same locality which were supplying a local trade. In addition there were local mines in operation near Keosauqua which had been worked for many years previously. There were also several mines near Bentonsport. The Farmington mines had been operated extensively to supply Keokuk and other markets.

It will be seen that coal has been mined in nearly all parts of Van Buren county, but as this shares with the other marginal areas of the Lower Coal Measures the pockety character of the coal basins the county has not been able to keep to the front in the keen competition of recent years. After the Civil war the price of coal and the wages paid were about the same as at present. About ten cents per bushel or $2.50 per ton was the selling price at the mine and if a certain amount was sold a tax was laid on the output. Near Fairfield wages were sometimes as high as $2.00 per ton, owing to a bad vein, but near Douds the price was about $1.00, as at present. After the panic of '93, however, prices dropped until coal was mined for three and one-half to less than three cents per bushel, or ninety to seventy-five cents per ton, and sold as low as $1.25 per ton. In the Farmington district the current wage for mining is eighty-five cents and the selling price $3.00 per ton, delivered.

Miners at Douds are chiefly American and British. All of the Van Buren mines have been very simply equipped. Mule haulage and gin hoist has been the extent to which they have gone with one or two exceptions. In this they resemble most of the mines of the eastern coal counties. The beds are too local in extent and the market too limited to warrant much expenditure of labor or capital. As in other localities also much of the early supply of coal was obtained by stripping as well as by drifts. Shaft mines are shallow, ranging from thirty to seventy feet in depth.

Scott County. About the same time that operations began in Van Buren county the pioneers of Scott county were beginning to use coal. So far as is known to the writer the first notice of coal in Scott county of scientific nature is by Owen in his report on the Geology of Wisconsin, Illinois and Iowa. He visited Scott in 1839 and mentions an outcrop of coal along Duck creek (Tp. 78, R. 4 E., Sec. 27, N. ½), of which he gives an analysis. No mention is made of any mines in the region at that time. The first bank to be opened up was by Mr. Wright in 1840. This mine was located near Jamestown, a few miles north of Buffalo. These two places have been the centers of all the mining done in Scott county. Mr. Wright ran his mine until after the war when it was leased by Hiram Hall, who operated it four or five years. The property was then bought by Robert Williams who worked it for some time. Coal is still being mined on this property.

Mr. Williams started the first mining operations at Jamestown about 1848, by opening a mine on his property. This was run intermittently until 1855, and from that time until the present mining has been carried on steadily. In 1854 John Murray began taking coal from his land and carried on work until 1903. The year after Murray opened his mine John James began mining near Jamestown in a basin which extends about two miles in a northeast-southwest direction. The basin is, however, very narrow, only about fifty yards wide before it begins to rise to the sides, with a total of 200 yards. Coal in the "swamp" is five feet thick, and thins on higher ground to two and one-half or three feet or even less, where worked. About 1860 John Morris came to Jamestown and began operating the James mines, which he managed for twenty years. With his coming systematic mining really had its origin. He opened drifts from the creek valley and later was the first man to sink shafts. The coal was raised from these by horse power. The daily output by 1868 was from 1,200 to 1,500 bushels, upon which Mr. James received a royalty of a cent a bushel. This coal sold for fifteen cents a bushel although the usual price has been from eight to ten cents, of which the miner received from five to six cents, depending on the selling price. In the winter of 1856-'57, however, coal was hauled to Davenport and sold for fifty to sixty cents per bushel, owing to a coal famine. A few years later, after the war, the price had dropped to twenty cents. In ante-bellum days farmers drove to Jamestown distances of fifty or sixty miles to obtain coal. Oftentimes there would be a line of seventy-five or 100 teams waiting at the mines for a load and many of these would wait two or three days for their supply. The mines were kept working at their full capacity all through the season and miners would put out from fifty to 100 bushels per day. From 1870-'73 there were 200 to 300 men at work in these mines.

After Morris left the district Mr. James began operating the mines himself. These are still in operation, although not extensively. Work is confined chiefly to taking out what coal was left during earlier operations. About the time that Morris left some of the mines put in hoisting engines. At present none of the operations are extensive enough to employ anything but horse gins.

While John Morris was opening up the James mines Robert Williams was also beginning more extensive operations on his land and by 1870 he had two shafts at work and was employing fifty or sixty men. Mines have been run on the Williams property ever since.

There were also a number of mines worked on the Durham estate between 1858 and 1898. The bed here was quite extensive, underlying probably 150 acres. It was quite level and ran from two feet eight inches to three feet four inches in thickness. There were also a number of other banks near Buffalo and Jamestown which were operated from the fifties until comparatively recent years. One of the most important of these was the bank of Charles G. Rowan, who began mining southwest of Jamestown in 1869 and operated until 1904, when he retired. Since then his mines have been operated under lease. The coal runs from two and one-half to three and one-half feet, and is of excellent quality for fuel.

Among the more important of the later operators has been Thomas Webster, who came to Scott county from the east twenty years ago and mined near Buffalo from that time until he retired about two years ago. He has opened one drift and four shafts. The later shafts were equipped with steam pumps although hoisting was by horse power. The coal is rather soft but is bright and does not carry much sulphur. Mr. Webster's sons, Robert and Ralph, are now operating a shaft two miles below Buffalo which they opened in the fall of 1908. It is fifty-five feet deep and reaches a vein three to four feet and locally five feet thick. The prospects for mining are better near Buffalo than at

Jamestown as the coal in sight near the latter place is nearly worked out. There are still several mines operating near Jamestown, however, but all on land which has been worked for many years.

Mining in the Scott county field has always been rather haphazard. There has not been much system about prospecting and in a field of such nature as this one only systematic work can yield the best results. In the Buffalo district mining is done by shooting but at Jamestown pick work and wedging is the rule as the coal is so seamy that it will not stand blasting. During the first thirty years of mining operations the openings were all slopes or drifts, but since then most of the coal has been removed from shafts. As the Coal Measures are thin these shafts are never very deep, varying from forty to 125 feet. The miners push their cars to the shaft and cage them, as the roadways are too low for mules. Mining is prosecuted on the room and pillar plan. None of the mines have railroad connections and hence the market is of necessity limited in extent. Some years ago Mr. Webster shipped coal as far as Muscatine, Fulton, Durant, etc., but of late years the territory is more restricted, not extending beyond Davenport.

Muscatine County. Although the Coal Measure outlier which has been mined so long in Scott county occupies a larger area in Muscatine, not much coal has been mined within the last named county. Only one vein is of workable thickness and this is of inferior quality. Operations have been going on for over fifty years, however, in the vicinity of Muscatine. The localities which have been most extensively worked are West Hill in Muscatine and the Hoor property about three miles east of town. The former of these, like most of the other openings along the bluffs, ceased to be productive long ago, and the latter was abandoned on the death of the owner, about 1892. It was a drift mine and was worked for a number of years, so that the entries were driven into the hill about 1,000 feet along a three-foot vein. A number of other small banks were operated in the eastern part of the county, and about 1895 a few drifts were opened about five miles east of Muscatine, near the edge of the outlier. A few thousand bushels of coal were removed from these for purely local trade.

Lee County. Lee county is another of those lying on the border of the Coal Measures within which coal mining has been carried on in a desultory manner for many years. A number of small outliers occur in different parts of the county and coal has been taken from these since the early 50's. When Worthen made his survey of the Des Moines valley in 1856 he noted that coal had already been opened up along the Skunk river in the northern part of the county. The seam worked was ten to fourteen inches thick. In later years considerable coal was taken out by drifting and stripping. One of the oldest and best known localities was the Norris mine in which the coal was said to be twenty-four to thirty inches thick. Another mine which was of considerable local importance was the Hardwick mine, five miles west of West Point. The vein here mined was three to three and one-half feet thick and was reached at first by shaft and later by drift. This mine at one time furnished abundant supplies for the local market but no work has been carried on here for a number of years.

Jefferson County. Jefferson county coal was exploited earlier possibly, than that of any other district in the state and White states that "many years before any railroad had reached Iowa Fairfield coal was carried in wagons to the Mississippi river towns, and was in high repute among blacksmiths." As early as the time of Dr. Owen's reconnaissance up the Des Moines river in 1849 coal of excellent quality was being mined on Walnut and Cedar creeks, near Fairfield in Jefferson county. A few years later, in 1856, when Worthen examined the district, the Huntsinger coal bank, two miles south of Fairfield, and the Richardson bank, two miles west of the same town, were in operation. Worthen further states that the lower coal seam was opened in nearly every township in the county.

By the time that White was making his survey of Iowa the Burlington and Missouri River railroad had been built through Fairfield and two mines, the Heron and the Richardson, were shipping coal over it to Burlington. At the same time Brown and Company were working a four-foot bed of coal at Coalport, ten miles east of Fairfield and were shipping a large part of their output to Burlington and intermediate points. As the mines were nearly a mile north of the railroad the coal was brought to it over a wooden sidetrack. Coal was mined by this company for nearly thirty-five years preceding 1894.

The most important mines in Jefferson county were located at Perlee, about seven miles northeast of Fairfield. The Jefferson County Coal Company operated several mines here between 1870 and 1884. The first of these was a shaft mine sunk to three to three and one-half feet of coal and used mules for underground haulage and steam hoist. During the last year or two it was worked a single rope with steam power was used to bring the coal to the bottom of the shaft. About 100 acres were mined out. Another mine was sunk about 1888 but does not seem to have been operated long, and the district is apparently worked out. The Washington Coal Company also operated a shaft mine which penetrated two seams of coal about three feet six inches thick. The coal was considered to be of very good quality and the middle eighteen inches is said to have been used for gas making with good results.

A two-horse gin was used for hoisting and mules were used below in the main entries. As the seam was too thin to allow the mules to get to the face the cars were handled by men between the miners and the entries. The entries were blasted out to make height for the mules. The mine was worked out and abandoned about 1882. Both these mines furnished large quantities of coal to the Chicago, Rock Island and Pacific Railroad. The Jefferson County mine supplied the locomotives with an average of eighty tons a day for fourteen years.

Quite a number of local mines have been operated in various parts of the county from the earliest days until the present but in recent years the output has been very small.

Davis County. Davis has never been ranked among the large producers of coal, but for at least forty years, more or less work has been carried on in the northeastern corner of the county, chiefly for local trade. White mentions the fact that when his party was studying the coal fields about 1866 there were a number of mines along Soap creek. The first report of the State Mine Inspectors states that in 1881 there were eleven mines in operation giving employment to eighty-five men. About 1890

Ely Dye burned some coal from his drift about three miles southwest of Eldon with the object of testing its coking quality. The coke obtained was quite clean and firm and possessed excellent heating qualities, although it was somewhat soft. It was used by a brewery and iron works at Ottumwa.

Appanoose County. Probably no county in Iowa has supported so many coal mines at one time as has Appanoose. When Bain made his survey of this county in 1894 he found over eighty mines in operation at that time. The wide extent and ready accessibility of the Mystic seam make its exploitation easy and so while extensive operations do not seem to have been begun here quite as early as in some other counties mining soon assumed large proportions and the county has consistently held high rank as a producer. There are several centers of mining operations, of which Mystic, Centerville, Brazil and Cincinnati are the leaders. The Mystic field seems to have been the first to be developed. The earliest mine opened here was that of A. M. Elgin who began operations in 1857 on Little Walnut creek, a mile and a half north of the city. From that time to this there have been operations close by although the mine has never had any railroad connections. Drifts have been driven and entries worked for some time and then abandoned and new ones opened up. The hills have been honeycombed and entries are still being opened. The first large mine at Mystic was opened in 1858 by Isaac Fuller and furnished most of the coal for Centerville for a number of years. In 1881 it was made a shipping mine. It has since been exhausted.

There was not a great deal of activity in the Mystic district until the Chicago, Milwaukee and St. Paul railroad was built through in 1887. Then mining began on a large scale and has been prosecuted vigorously since. The first railroad mine was a slope opened by Wm. and Alex. Orr and Pat Colgan in 1887, and was soon sold to the Railroad company. Sixty miners were employed. Quite a number of mines were opened very shortly, among which were the Lone Star drift and the Seddon slope (both owned by Seddon Brothers), the Lee Brothers' mine, and the Silknetter slopes. All these were operated by mule power. In 1889 the Lodwick Brothers Coal Company opened a slope and a drift, both of which had railroad connections. This firm has been operating here ever since and at present is operating six mines at Mystic, Clarkdale and Diamond. A large number of mines have been opened, both in the immediate vicinity of Mystic and in all directions from it; at Forbush and Clarkdale to the east, at Rathbun and Darbyville to the north and at Diamond and Plano to the west. Local operators have not been the only ones to appreciate the value of this field, as is testified by the Iowa Coal Company of Chicago, who opened a large slope mine in 1893, by the Brown and Bowers Coal Company of Kansas City, who drove a drift mine in 1895, the Kansas City mine, opened in 1889 by "Missouri" Williams and James Seddon and the Big Jo Block Coal Company of Chicago, who operate the Jucket mine opened in 1894 by F. H. Juckett. Along with the Lodwick Brothers the Lee Brothers have been among the important miners. They were among the pioneers and have operated a large number of mines, both those which they have themselves opened as well as several which they have acquired. At present three mines are under their control. One of these was first opened by Mr. Philips in 1865 as a local mine and was reopened as a railroad mine in 1891 by Milburn Brothers. Lee Brothers also manufacture the Lee electric mining machine, one of their own invention. While all the coal is raised from the Mystic seam there is another bed 180 feet below which so far has not been developed. The vein has been worked at Ottumwa and Willard, in Wapello county. At the latter place L. L. Lodwick formerly operated a mine which reached this coal at ninety feet. The Milwaukee Railroad uses 1,000 tons of coal a day from Mystic, and of this Lodwick Brothers furnish 375 tons.

Mining at Mystic is done on the long wall plan and the miners work in the underclay. At present all the coal is taken out by pick work. Machines were in use for eight or ten years and two years ago ten or twelve were being operated but at present (1909) none are in service. They were of the Lee longwall type. The miners have never taken kindly to their use, mainly from extreme conservatism, and when the wage scale was made in 1908 a board of three miners and three operators was chosen to discuss the machine wage scale for loaders. As they could not agree the arbitration board was called in and in May, 1909, raised the scale nine cents at Centerville and ten cents at Mystic. All the operators in the county who were using machines immediately took them out, as the margin of profit was too slight. The decision has really worked an injury to the miners. Men who were making $2.50 to $4.00 per day working after the machines are now obliged to pick coal and in many cases cannot make over $1.00 per day.

In the Centerville district the first shaft was sunk by Wm. Henderson about one-half mile from the Chicago, Burlington and Quincy depot. This was opened about 1868 and was operated by horse power. The next year Ben Kindig opened a shallow shaft in the west part of town and supplied a local trade for several years. There were several other shafts opened in the next two or three years and in 1872 the Watson Coal Company opened the first mine in the district which was equipped with steam hoist. The mine was located on land owned by A. R. Henderson and Dr. Patterson and the royalty paid was twelve and one-half cents per ton. In 1875 Alexander Dargavell, who has been one of the most influential operators in the development of this field, formed a company, with W. J. Phillips and W. W. Oliver, and sank a horse power shaft east of town. This mine is still running in a small way. Four years later the Centerville Coal Company opened a shaft and equipped it with steam hoist. This opening is still being worked but is very much improved and enlarged compared with its original condition. Coal has been mined for many years in this locality at Relay for White mentions the mine at the Talbot mill, on Cooper creek, and this is said to have been operated about fifty years ago. In 1881 Messrs. Dargavell, Oliver and C. W. Lane formed the Diamond Coal Company and sank a shaft on the Chicago, Rock Island and Pacific railroad three-fourths mile east of the depot. In 1894 Mr. Dargavell and others organized the Centerville Block Coal Company which took over the three mines mentioned above as well as others. The company have also sunk shafts of their own and are now the largest operators in the district. Diamond shaft No. 1 is still operated, by the Centerville Block Coal Company, and is one of the best equipped mines on the Mystic seam.

It was the fourth mine in the district to be equipped with steam hoist. Tail rope haulage was later installed underground and until recently machines were employed for cutting the coal.

About a year after the organization of the Diamond Coal Company the Scandinavian Coal Company was formed. A mine was sunk and equipped with steam hoist. The company have since sunk another shaft and are doing an important business. There are a large number of Swedes in the neighborhood of Centerville and they have formed several co-operative companies in recent years. A number of other companies have opened mines in the neighborhood of Centerville so that today it is one of the leading mining districts in the state.

While at Mystic the coal outcrops in many of the ravines and most of the mines are slopes or drifts yet at Centerville the coal is so deep that nearly all of the mines reach it by shafts. The shafts at Mystic are from twenty to eighty feet deep while some of those to the west at Plano and Jerome are 200 feet deep. Quite a number of mining machines have been used in the mines of the Centerville Block Coal Co. for nearly twenty years, but they were taken out after the decision of the arbitration board. The types used were chiefly the Harrison puncher and the Legg chain machine. Machines have not proved very profitable as the air had to be carried so far and the maintenance expense was so great. There is no electric haulage in Appanoose county mines, nor indeed in any mines of the southern counties. There were some mines using it but they have been out of business for some time. There is some tail-rope haulage and this is best adapted to the service. Except in those cases where electric or rope systems have been employed there has not been much change in carrying methods for some time. Cars ordinarily used hold one ton and are of the same size as those used for a number of years. Prior to 1876 the Iowa mines were worked largely on the single entry system. The Whitebreast Fuel Company was the first in the southern part of the state to introduce the double entry plan, about 1876 or '77. This plan is now generally used but has been improved on in some cases by the adoption of the panel system. This keeps the air on the face better and does away with the possibility of squeezes. It may also simplify the haulage and allow more work from the mules.

Mining began at Brazil many years ago before the railroad was built through. One of the mines was opened on the land of Mr. Stickler and another was opened by John Gordon one-half mile east of Brazil. After the railroad came this mine was opened up again by Lane Brothers. The first railroad mine was opened by J. A. Brazil west of the station about thirty-four years ago and is still being operated. About the same time the Philby Coal Company opened a mine and two or three years later Thomas Philips and ten or twelve miners opened a mine a little north of the depot. This is now abandoned. In 1881 the Tipton Coal Company composed of Thomas Philips, Joseph Turner and Wm. Davis, opened a mine which is still in operation, although the firm name has been changed to the Phoenix Coal Company. Mr. Turner, together with James Campbell, is still interested in the mine. At the same time James and Thomas Lee, of Centerville, who later operated some of the Mystic mines, opened a mine near the Tipton mine. It is now run by the Centerville Block Coal Co. Twenty-five years ago Messrs. Campbell and Philips opened another mine under the name of the Tipton Coal Co. This mine was exhausted last year.

A number of other mines have been opened near Brazil and a large industry has been built up. All of the mines are drifts with the exception of the Lane mine. All of the coal raised is used for domestic purposes except that required by the railroad locomotives. Railroad engineers prefer the coal from the Appanoose mines to that which is supplied from the Missouri mines across the line, as it is softer and cleaner. However, the Missouri coal, while it contains more stone, is mined more cheaply and is used on the engines to a considerable extent.

One of the most important centers on the Mystic vein is located at Cincinnati. As compared with the other districts this is rather young. Mines were opened here a short time prior to 1890. F. H. Ketchum and B. H. Johnson organized the Mendota Coal Company and were the first operators in this district. Mr. Johnson was one of the most able coal men in the district. He is now engaged in mining operations at Centralia, Washington. The Mendota Coal Co. now operate three mines, the last one of which they bought a year and a half ago. David Dinning was the next oldest operator. During early operations in Appanoose county he was a miner and worked for the Diamond Coal Company. Later he with his brother-in-law, David Steele, organized the Thistle Coal Company. Mr. Dinning is now mayor of Cincinnati and vice-president of the State Operators' Association.

The mines at Mendota, just across the line in Missouri, were opened about twenty-five years ago, a short time before the beginning of operations at Cincinnati. There are still three or four mines in operation there. At Exline there have been three mines opened within the past five years. They are worked largely on the co-operative plan. The only work done here before this was in a small drift at Drakes switch, which is still worked occasionally in a small way. At Coal City on the state line is one railroad mine owned by the Manufacturers Coal and Coke Company, who opened it four years ago. In addition there are three or four local mines which have been operated fifteen years or more. The Manufacturers Coal and Coke Co. was originally organized to build the Iowa and St. Louis Railroad, by John W. Gates and other eastern capitalists. They opened a number of mines along the road. Later they sold the road to the Chicago, Burlington and Quincy but they still own under the corporate name given above mines at Coal City and Centerville. The company also owns property in West Virginia.

In addition to the above named places coal has been mined ever since the first settlement of the county at a place known as Hilltown in the southeastern corner of the county on the old Keokuk and Western Railroad. At present there are no extensive operations here.

Operations in the Appanoose field are not so remunerative as are those in some other districts. The thinness of the coal and the consequent necessity of removing the underclay are in part responsible for this state of affairs and the character of the coal also has an influence in the same direction. A shooting coal will yield about thirty per cent of fine coal which costs nothing except the handling and which can be sold for steam purposes. The Mystic coal, however, since it is mined for the most part on the longwall system and with little or no powder, yields only about ten per cent of slack, and most of this has been used for steam for the machines. Hence there is no profit from this source and since the slack contains considerable clay and other impurities its value is still further impaired. The Mystic coal formerly sold for twenty-five to forty cents per ton more than other coals, but it now sells for the same price. It is only the extreme uniformity of the seam and its regularity of occurrence which enables the Mystic coal to compete in the markets with coal from those fields which have thicker deposits.

Wayne County. Although the Mystic seam is known to extend into Wayne county it has never been exploited to anything like the extent in this county that it has been to the east. The chief centers of activity have been Confidence, Promise City, and Seymour, all in the eastern part of the county. Coal was mined in the vicinity of Confidence for local purposes forty or fifty years ago, but no work has ever been done on a large scale. Mr. L. Frye has been the principal operator in this locality for the past thirty years and has opened several mines in the district. Mines were opened at Kniffin as much as thirty years ago and about 1884 operations were begun at Seymour by the Occidental Coal Company and Mr. Thatcher. The latter sold out in 1885 to H. W. McNeill of Oskaloosa. The mine of the former company was transferred to the Chicago Coal Company about 1890. From this time the principal operators were the Chicago Coal Company and the Seymour Coal Company until about 1902 the Numa Block Coal Company superseded them and has since been the largest producer in the county and indeed one of the leaders in the Mystic field. In recent years a few small mines have operated in the vicinity of Seymour, Harvard and Confidence.

Wapello County. Coal has been mined in the vicinity of the Des Moines river almost from the earliest settlement of the county. The high bluffs bordering the valley and the deep ravines opening into it revealed the rich stores of fuel to the hardy pioneers and they soon availed themselves of the opportunities thus presented. The county soon acquired a position among the leaders in the mining industry and has always held a high rank although superseded in late years by others whose production has shown larger growth. The earliest operations on a commercial scale seem to have been conducted in the northwestern part of the county in the neighborhood of Eddyville and Kirkville. Near the former place mines were opened in Mahaska and Monroe counties as well as in Wapello. Worthen describes several coal banks as being in operation in 1857, among which were the Cooper mine near Dahlonega, the Roberts mine opposite Eddyville and the McCready bank on Bear creek, four miles west of Ottumwa. It is worthy of note that while a number of mines have been operated on Bear creek still more extensive work is being prosecuted here today than ever before.

Ten years later when White visited Wapello county he found that the centers of activity had moved somewhat. One of the principal operators then was C. Dudley and Company who worked a four-foot vein south of the present station of Dudley and shipped over the Burlington and Missouri River railroad, now the main line of the Chicago, Burlington and Quincy. Another mine which played quite an important part in the development of the county was that of Henry Shock and Company, at Happy Hollow, three miles below Chillicothe. This mine also furnished a large amount of coal for shipment over the Burlington. In 1868, C. O. Godfrey of Hannibal, Missouri, and James Brown, an enterprising operator, formed the firm of Brown and Godfrey. They opened a drift mine four miles northwest of Ottumwa in a four-foot vein of coal about 100 feet above the St. Louis limestone. Coal was shipped from this mine over the Des Moines Valley railroad. Several other mines were in operation near Kirkville and Eddyville. At this time a large mine was being operated by the Alpine Coal Company at Alpine, two miles below Cliffland, on the Des Moines Valley railroad, under the direction of C. J. Love. The bed was from four to five feet thick and furnished large quantities of excellent coal for the Keokuk market. White states that up to the time of his studies about 1,000,000 bushels of coal had been mined here, a larger output, probably, than that of any other mine in the state at that time.

In 1871 the Union Coal and Mining Company was organized by Messrs. Brown and Godfrey together with a number of Boston men of capital, who were interested in the Burlington and

Missouri River Railroad. Mr. Godfrey was chosen president and Mr. Brown manager. About a year afterwards these two men organized the Watson Coal Company of Centerville. W. J. Ladd of Boston was the first superintendent of the Union company and was soon succeeded by William Haven who held the position until 1874. At this time Samuel A. Flagler took charge and held the position until the company was dissolved. This company took over the Shock and the Brown and Godfrey mines and operated them on a large scale. In 1872 they employed 300 men, who took out 77,000 tons. These mines were single openings ventilated by furnace whose draft was up an air shaft 400 or 500 feet from the entrance and which furnished air in a continuous current from entrance to exit. The fact that the furnace required attention would be manifested by two or three men coming out sick.

The product of the mines was taken on pit cars down tram tracks to the railroad and the empties were drawn back by mules. No screens were used; the coal went to the market and to the railroads in the same condition in which it was mined—run of mine. The coal was largely undermined, and was frequently rib- or center-cut, so that a very small quantity of powder was used in proportion to that now required (?). Payment for mining and sales were made by the bushel and Mr. Haven claims the credit of being the first to introduce the plan of making settlements on the tonnage basis. Payments ranged from four to four and one-half cents per bushel and the unscreened coal sold for $2.25 to $2.50 per ton at the mine. The freight rates to Council Bluffs were made on the basis of $45 for a ten-ton car, but were reduced a few years later when W. B. Strong was General Freight Agent of the B. & M. R. to $35 per car. In 1870 the coal carrying equipment of the Burlington was 138 ten-ton cars, which was added to by the Union Coal and Mining Company furnishing 150 additional twelve-ton cars. The shipment from the mines of this company, in connection with the team trade, was seventy-five to 150 tons daily.

An interesting development occurred at the Happy Hollow mine. After the vein had been worked into the hill 200 or 300 feet it began to pinch out. While sinking a well for company use Mr. Brown encountered a six-inch vein of coal and the idea occurred to him to see what had become of it. So he sank a pit inside the mine and struck a six-foot bed of coal only twelve or fifteen feet below the one worked. The development of this necessitated a very steep grade to the pit mouth and so Mr. Ladd purchased a small mine locomotive, the first one used in the state. A competent engineer from the railroad was employed to make the trial trip, but on going down the grade the boiler flues were uncovered and on reaching the bottom the engineer had to draw his fires and the engine was pulled out by ropes. After this it was used for outside work. The opening of this lower vein stimulated prospecting in other mines and it was not long until unknown riches of mineral wealth were discovered and utilized. About 1876 the company sank another mine near the first. For a number of years this company was the largest operator in the county, but finally abandoned the field.

In 1879 O. M. Ladd opened the mines at Laddsdale in the southeastern part of the county. The camp is located in Davis county but the workings are chiefly in Wapello. The property is now owned by the Anchor Coal Company of Ottumwa.

In 1880 the Phillips Coal and Mining Company was organized and opened a mine two miles northwest of Ottumwa. This mine has been abandoned for a number of years, but the company, under the present name of the Phillips Fuel Company, have worked a total of six shafts in the neighborhood, near Phillips, or Rutledge. The same company are opening up a new mine on Bear creek. The year after the opening of the Rutledge mine the Wapello Coal Company began work at Kirkville and operated several extensive mines here. At one time they employed 435 men in their mines numbers 1 and 3. The vein was five to five one-half feet thick. Four or five slopes and shafts have been operated here but the last were abandoned in 1890 and the company moved to Monroe county and opened mines at Hiteman.

One of the large operators in Iowa has been the Whitebreast Fuel Company of Illinois. This company opened mines near Kirkville in 1887 and named the station Carver. These mines were worked on a large scale and a big tonnage was taken out for three years. The property was then bought by the Wapello

Coal Co., which worked it for two years and then abandoned it in 1892. Although the Union Coal Co. had supposedly exhausted its field the Whitebreast company in 1891 opened up a mine almost adjoining the Union property and operated it extensively for ten years. It was then sold to the Illinois and Iowa Fuel Co. and was worked out three years ago. This mine was located at Keb and was known as Whitebreast No. 22. It was one of the largest in the district, employing as many as 225 men and producing 1,000 tons or more per day. It was connected with the Chicago, Burlington and Quincy by a long spur and the entire output was sold to the Chicago, Milwaukee and St. Paul Railroad. Other mines have at different times been worked in the neighborhood of Ottumwa, some near Willard, and three or four local mines have been in operation at Eldon in the southeast corner of the county, since 1887. They are all comparatively shallow, ranging from sixteen to sixty feet in depth.

As the early mines were all drifts, along the Des Moines river drainage, they gave rise to the theory that the coal would run out under the hills and that none need be expected under the uplands. It was many years before this theory was exploded although when the early geologists were studying the coal prospects of the Des Moines valley they predicted that in time to come the uplands would be found to be as plentifully underlain with coal beds as was the area in immediate proximity to the river. Later developments have abundantly demonstrated the truth of this prediction as the mines at Rutledge, for example, bear testimony. These deeper shafts away from the river have shown that here the coal beds are as extensive and as thick as those bordering the valley, and that they are present in their original entirety while those exposed by the streams have by this very exposure been partly eroded and carried away.

In the early days of mining activity coal was much cheaper than at present and wages paid were correspondingly small. In the early 70's, when commercial mining really had its initiation, lump coal was delivered in Ottumwa for seven to eight cents per bushel, and brought five cents at the mine. Now coal sells for thirteen cents. Along with the increase in the price received for coal has come a corresponding rise in the wages paid. Instead of seventy cents per ton paid the miners of the early day ninety-five cents is now paid for lump coal. The inside day men who then were paid $1.75 per day now receive $2.56. The increases have followed the general advance in wages and in all lines of industry although the strong union organization has doubtless been effective in this direction as well as in others.

In the matter of equipment the Wapello county mines have ranked well with those of other districts. Tail-rope haulage has been installed in the larger mines, such as those at Whitebreast No. 22, the Phillips mines, Consolidation No. 9, near Eddyville, and others. Fan ventilation, steam hoist and safety appliances have added to the efficiency and economy of operation as well as to the safety of the employes.

Monroe County. Although Monroe has had fewer mines in operation than a number of leading counties, yet she has for many years held the supremacy as a producer and her average output per mine is probably larger than that of any other county in the state. The coal industry in Monroe county dates from the early sixties. White in his brief sketch of the geology of the county published in 1868 states that small mines had already been opened along Bluff, Miller and Avery creeks and that the Cedar mines west of Albia were producing coal. None of the mines at that time were scarcely more than country banks and operated chiefly during the winter season to supply the local demand. The first biennial report of the State Mine Inspector covering the years 1880 and 1881 contains some interesting statistics. Herein it is asserted that some thirty mines are in operation in Monroe county employing 638 men. The deepest shaft is reported to be 150 feet and was located near Albia. The total production for 1881 is stated in the report for 1883-'85 to be 98,143 tons. The U. S. Census reports, however, give the output for 1880 as nearly double this amount, namely 181,288 tons. At that time there were few shipping mines in the county and Monroe ranked below several counties which since have been far surpassed.

One of the first operators along the Burlington and Missouri River Railroad was L. L. McBride, who began operations on

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Avery creek west of Fredericks about 1870. He opened a drift and later sank a shaft and finally sold out to the Union Coal and Mining Company in 1872. After working out the mine the company made no further attempts to develop the field although extensive operations by J. G. Evans in later years showed that it would have been wise to do so.

In 1872 or '73 a shaft was sunk on South Cedar creek just west of Albia on the north side of the Burlington by Mr. Rodifer. He introduced the idea of screening his coal, a source of much trouble in subsequent time. His screen was four feet long with one and one-half inch spaces between the bars. This mine was followed by extensive development in the South Cedar creek basin, which attracted the attention of the Wapello Coal Company. After prospecting this company opened up an important territory at Hiteman.

When the State Mine Inspector made his first report, in 1880, the principal mine in Monroe county was that of the Albia Coal Company. It was located three miles west of Albia, on the Chicago, Burlington and Quincy railroad and was a shaft mine using steam hoist. One hundred and sixty miners were employed and the mine had a capacity of 400 tons of screened coal daily. This mine was opened by Henry Miller and others in 1870. Another mine which was opened about the same time as the Albia was the Great Western, but it was abandoned after being worked a few years. One of the important mines of this district was the Iowa and Wisconsin, opened as early as 1885 and well equipped. A large business was done for ten years or more. Near by was the mine of the Chicago and Iowa Coal Company, which was one of the pioneer mines of the county and was equipped with good machinery and safety appliances.

While the Albia field was the first to be developed on a large scale it has not been exploited extensively for some years past. Most of the large operations have been north and south and west, a number of miles away. One of the more important of the early camps was near Avery, where the Avery Coal and Mining Company, the Smoky Hollow Coal Company and the Eureka Coal Company conducted extensive operations as early as 1880. The first two of these concerns used small engines for hauling their output to the main line of the Burlington at Avery. Even in the early 80's a large part of the coal mined in Monroe was shipped over the various railroads—the Burlington, the Iowa Central and others. The Eureka mine was bought in 1885 by the Union Coal Company of Ottumwa. This firm had already been operating mines in this vicinity for years. The Smoky Hollow Coal Company is still operating mines, Nos. 6 and 7 being the only ones worked now. As many as 450 men have been employed by this company at one time.

In the same general district as these mines the Chisholm mine, near the village of the same name, was opened some time prior to 1887. It was operated under various managements until finally in 1892 it was bought by the Whitebreast Fuel Company and was put upon an excellent basis with modern equipment. The mine was operated until about 1898.

One of the earliest portions of northeastern Monroe, or indeed of any part of the county to be opened up, was Coalfield on the Iowa Central. Some years previous to 1873 Thomas Haight had been operating the Black Diamond drift. At the time this was one of the banner mines of the state and had a daily capacity of twenty cars. At this time ten tons was a maximum load for a railroad car. In 1873 or '74 the McNeill Brothers, W. A. and H. W., began mining at Millers creek, near Coalfield, but as the coal there was too thin for profitable mining, they removed to the Muchakinock valley in 1875. This was the first of the operations of these men who have since been among the foremost in the mining industry. The coal veins at Coalfield run not over four feet in thickness, but the quality, for domestic purposes, is scarcely excelled by any coals in the state.

Another important district is that about Hocking, Selection and Hilton. The chief company operating near Hocking is the Hocking Coal Company. This company has operated three mines. Shaft number 1 was put down and operations begun in 1899 while shaft number 2 was sunk during 1900. Both shafts are located on a low terrace along Coal creek, and are 180 and 208 feet in depth respectively. The company did a large amount of preliminary drilling so that the character and limits of the coal basin were pretty well understood. Mine number 1 was abandoned about 1905 and number 3 was opened at the same time. These mines have been thoroughly equipped and have always ranked well in every respect.

At Hilton, a short distance south of Hocking, was mine number 10 of the Whitebreast Fuel Company. This mine was opened late in 1900 and speedily became one of the most important producers in the state. The surface equipment was excellent. Steel framework and corrugated iron sheathing were used exclusively in the buildings. The steel tipple was forty by sixty feet and was able to handle the output of 1,200 tons daily. Hoisting was accomplished by a pair of first-motion engines and the mine was ventilated by a force fan fourteen feet in diameter. The entire equipment and management were on the same excellent and substantial basis that characterized all the operations of this company. The mine was operated about five years and then on account of unfavorable market conditions and for other reasons it was abandoned.

A little farther south a shaft mine was opened in 1888 at Foster, on the Milwaukee railroad, by the Soap Creek Coal Company, in which the Phillips Brothers of Ottumwa were interested. The mine was thoroughly equipped with steam hoisting machinery and ventilating fan and it was operated for a long time, in fact it is still being worked, though from other shafts. It is now owned by the Phillips Fuel Company. A slope which was opened by the same firm a year or two after the shaft was mined longwall.

The Deep Vein Coal Company opened a shaft 208 feet deep at Foster in 1893 and operated on a large scale for a number of years. Mine No. 2 was opened about 1900. At one time over 200 men were employed by this company.

During the last few years the largest operators in Wapello and indeed in the state, have been the Consolidation Coal Company at Buxton and the Wapello Coal Company at Hiteman. The latter concern came to Hiteman in 1890 after abandoning their mines at Kirkville and have operated six mines to the west and northwest of the camp. The company own their own railroad running from the mines five or six miles to the main line of the Burlington at Tower 307, and operate their own locomotive. Mine number 1 was operated thirteen years. After it had been in operation only two or three years it had a capacity of 800 tons of lump coal per day and gave employment to 360 men and boys. Number 2 was opened in January, 1897, and was brought to a capacity of 400 tons per day within six months. The mine was abandoned in 1901, as it was never very profitable. The equipment at these mines was of the very best and it has always been the policy of this company to place and keep their mines on the highest plane of efficiency and then to work them to their limit. Mines numbers 3, 4, 5 and 6 are now in operation. Number 6 was opened up late in 1908. Former Senator L. H. Waterman is the manager for the company, a position which he has held for nearly twenty years. Next to the Consolidation Coal Company this company are the largest operators in the state.

The first biennial report of the State Mine Inspector, printed in 1881, states that unimportant openings had been made along Bluff creek and that a local supply was obtained during the winter months from these country banks. It was not until 1901 that the district became a real factor in the coal production of the county and in 1902 the basin became a most important mining community in the state. In 1900 and 1901 the Consolidation Coal Company founded the town of Buxton on the extension of the Muchakinock branch of the Chicago and North-Western Railway and opened mine number 10 about two miles south of the town. Number 10 is 119 feet through the coal. The early history of the Consolidation company belongs with that of Mahaska county and will be given below. In May of 1901 number 11 was begun and it was opened in 1902. It is about a mile south of number 10. This is the deepest shaft the company have sunk here. It reaches the coal at 207 feet. Number 12, 182 feet deep, was begun in March of 1903, number 13, 100 feet deep, in July of 1903, number 14, 133 feet deep, in May of 1905, and number 15, 189 feet deep, was begun in October of 1908. All these mines reach the same vein, which is four and one-half feet thick. Mine number 14 is in Mahaska county. The mines of this company have all been equipped and managed in the best possible manner and they quickly brought Monroe into the lead among Iowa coal producing counties. Mine number 10 is equipped with a steel tower which is said to be the highest in the state. It meassures sixty-nine feet to the top. The hoisting arrangement is able to raise each minute four cars with 2,000 to 3,000 pounds of coal when running full capacity. All the mines of this company have electric haulage. That on the main entries is by the rack rail system and much of the gathering from rooms is by the third rail and trolley systems. Mines numbers 11 and 13 have been abandoned during the past two years. Mr. B. C. Buxton has been the manager of these mines for many years and has kept them at the highest possible stage of efficiency and economical operation.

Wages in the Monroe fields have advanced considerably during the past twenty years. At that time day men were receiving $2.10 for eleven hours work, whereas at the present time they are paid $2.56 for an eight-hour day. Prices of coal have increased accordingly. The increases are due chiefly to the general advance in wages in all lines of industry. The Buxton mines are worked almost entirely by colored miners, due to labor trouble a number of years ago before the present management took possession. The mines have been union since 1900. The miners are paid only for screened coal and so they will naturally use their powder to the best advantage in shooting the coal. In the early days coal was sold on the railroads by the car. The first track scales were put in at Albia and coal was then sold by weight.

Lucas County. Lucas county formerly contained the largest and deepest mines in the state. It was in this county where the first and almost only successful experiments in regard to the nature and capabilities of Iowa coal were carried on extensively. These investigations were made by the Whitebreast Coal Company, which operated largely in this county. The experiments were made with special reference to the determination of the adaptabilities of the various varieties of coal, their coking properties and the utilization of slack and coal dust. In regard to the latter, briquettes were manufactured in various ways, but it was found that with the methods used the coal dust could not be economically compressed and cemented for commercial purposes.

When St. John examined this region in 1867 he found a number of banks working the upper veins of coal in the northeast part of the county along the branches of Cedar creek, farther west along the Little Whitebreast and Whitebreast creeks and on English creek. These were all small affairs, however, and the first development of any consequence was undertaken by William Haven who in June of 1874 made a lease of lands belonging to Col. Byron O. Carr of Galesburg, Ill. These lands were eight miles west of Chariton on Whitebreast creek. After a year of endeavor Mr. Haven associated with himself Wesley Jones, J. C. Osgood, Louis R. Fix of Burlington and T. J. Potter, who were to furnish a limited amount of capital for prospecting purposes. These men organized the Whitebreast Fuel Company of which Mr. Osgood was president, and prospecting was carried on for some time. But after sinking a drill hole 138 feet it was decided to sink a five-foot shaft instead. It was the intention to use this for an air shaft if coal was found. This was the largest air shaft then known in Iowa. After many trials, troubles and tribulations, on January 16, 1878, five feet four inches of coal was passed through and thus began the career of the Whitebreast field, a field from which a greater tonnage has been raised in shorter time than from any other field in the state. The shaft was 250 feet deep and an eighty-horsepower engine was used for hoisting the coal. Tail-rope haulage was installed in 1882. Electricity was used for lighting the mine, the first installation in the state. When the Mine Inspector made his first report in 1880, 405 men and fifty-two mules were employed and were raising 640 tons per day. The quality of the coal was considered superior to that of any other then produced and it acquired a great reputation and an extensive market. Whitebreast number 1 was the first mine to adopt the plan of shot firing once a day. This avoided the danger of explosions when the men were in the mine and also kept the air pure for the men and mules.

In 1884 and '85 about 125 diamond drill holes were put down north and east of the Whitebreast mines. Conditions were unfavorable, however, and development in mine number three, the one farthest east, was so difficult that the Whitebreast company abandoned Lucas county in 1891, after working out as much coal as possible from mines numbers 1 and 2, near Lucas.

In 1877 or '78, when the success of the original Whitebreast field became apparent, a shaft was sunk one-half mile east of Whitebreast number 1, by Daniel Eikenberry, a prominent lumber merchant of Chariton. The shaft was five feet in diameter and sixty or seventy feet deeper than the Whitebreast shaft, but it failed to show any favorable development and so was abandoned. In 1879 a number of miners employed by the Whitebreast company, together with some capitalists of Chariton, S. H. Mallory, D. Q. Story, D. M. Thompson and others, formed the Chariton Co-operative Coal Company and sank a shaft three-fourths mile north of the Eikenberry hole and northwest of the Whitebreast shaft. This shaft struck the lower vein at 330 feet, the greatest depth af any shaft in the state at the time. The co-operative feature was not very successful and a reorganization was soon effected by which the miners were eliminated from participation. The results were disastrous, however, for the reason that the otherwise capable business men, having no knowledge of mining methods could not properly oversee the work. As a consequence robbing of pillars and mining of coal too near the bottom of the shaft led to its partial caving in and put a stop to all operations in the immediate locality. This mine was well equipped; hoisting was effected by first-motion engines attached to a seven-foot drum and ventilation was afforded by a fourteen-foot exhaust fan. A great amount of water gave much trouble, although after a time pumps were installed which handled it effectively.

The opening of the Whitebreast field seriously interfered with the business of the Union Coal and Mining Company of Ottumwa and hence this company under the direction of its president, J. C. Peasley of Burlington, began an investigation into conditions in the neighborhood of the Whitebreast field. In 1877 they opened up negotiations with Mr. Knotts and finally acquired the Ladow shaft, which was seventy or seventy-five feet deep and reached an upper vein two feet thick. This they enlarged and deepened to 300 feet where the lower bed, over five feet in thickness, was penetrated. Under the direction of

S. A. Flagler the main entries were driven a few hundred feet north and south, chiefly south. Owing, however, to the great quantities of water which came through the sandstone roof it became necessary to abandon the enterprise after expending several thousand dollars in development.

The mine continued in this condition until in 1899 Hon. H. L. Byers, associated with several practical mining men, among whom were George Ramsay of Oskaloosa and Messrs. Shuler and Bates of Illinois, obtained possession of it. They cleaned and re-timbered the old shaft, pumped out the water and used it as an air shaft in connection with the main shaft which they. sank about 300 feet west of it. They ran about a year and then transferred the property to S. W. White of What Cheer, afterwards of White City, and others. About a year later the mine again changed hands and Mr. Reed of Illinois and Mr. Byers managed it for two months, after which Mr. Moody of Kansas City secured part ownership. These men are the present owners but work has been discontinued since late in 1907 and the workings are filled with water.

There was one other important mine in the county; that of the Farmers Co-operative Coal Company at Zero on the eastern edge of the county. About 1878 a number of land owners organized this company and sank a shaft to the lower coal. After several changes in ownership the mine was finally operated under lease by the Whitebreast Fuel Company. Owing to the presence of numerous bowlders in the coal and to the great amount of water which entered the mine through the sandstone roof the mine was abandoned over twenty years ago. It has always been the experience in Lucas county that where the coal had a shale roof operations were successful, but where the roof was sandstone water has driven out the operators.

After 1891 Lucas county dropped from high rank to a low position as there was no further development of the lower veins until Mr. Haven resumed operations in the coal industry. He had sold his interest in the Whitebreast mines to Mr. Osgood in 1883 with the pledge not to engage in mining along the Burlington line for ten years. Upon being released from this pledge he associated with himself certain Ottumwa men in 1896 and began diamond drilling and taking options on extensive tracts of possible coal lands on Little Whitebreast creek. This work resulted in the discovery of a field of 1,200 to 1,600 acres about three and one-half miles northeast of Chariton and again brought Lucas county to the notice of coal operators in the Iowa field. Among the first results was the return of the Whitebreast company who after considerable prospecting west of Lucas opened up a field known as Cleveland number 4, in the spring of 1899. The drilling was done with a one-inch core drill which was too small to show the presence of bony coal in the bed. The handling of this added to the expense of operation and cut it out of the domestic market, so that the mine was closed April 1, 1908. The mine had a steel tipple, motor haulage and excellent safety devices and had a daily capacity of 1,000 tons.

In the summer of 1901 Mr. Haven and others began sinking the shaft of the Inland Fuel Company and soon after sank an air shaft, both of standard size. Work has been confined principally to entry driving, so that at present nearly two and one-fourth miles of entries are open. No rock has been encountered and the mine is practically dry, as the only water which enters is what comes down the shaft from a thin vein of sandstone immediately above the seventy feet of roof shale. A Number 7 Cameron pump working one hour a day empties the sumps.

The persons who were interested in the Inland mine concluded that before bringing the coal into the market they would prospect extensively in north Lucas county. With this end in view they have had diamond drills in operation over five years and as a result five separate basins of coal five to eight feet thick and aggregating over 10,000 acres have been located. So far, however, nothing has been done towards the development of these pending the time of more complete ownership. In the meantime mine number 1 has been developed so that it can on short notice be brought to a production of 1,000 tons daily. The quality of the coal is excellent, as is shown elsewhere in this report, and in spite of the fact that it must be hauled five miles by team and thus must be sold at a considerably higher price than is charged for coal shipped into Chariton it is the coal almost exclusively used whenever it is obtainable.

Keokuk County. Although in recent years Keokuk county has dropped out of the list of important producers yet during the 80's and early 90's it ranked as one of the most important coal districts in the state. At the time of White's survey Keokuk was of no prominence as a producer, but when the Burlington, Cedar Rapids and Northern, now a part of the Chicago, Rock Island and Pacific Railroad, built in to What Cheer, a number of large mines were opened and a large output began. One of the earliest and largest operators was the Starr Coal Company. Their mine was equipped with steam hoist and railroad track scales and employed over 200 men. The capacity of the first mine was about 1,000 tons per day. This company operated three mines and in 1883 consolidated with a number of smaller operators in the district. In 1884 the Chicago and North-Western Railroad Company built a branch line from Belle Plaine through What Cheer to Muchakinock and thus gave the district an outlet to the north. At this time there were twenty mines in the county, eleven of them at What Cheer. In 1886 and '87 the mines of the Starr Coal Company and the Granger Coal Company were acquired by the What Cheer Coal Company. At the time of the consolidation over 1,100 miners and laborers were employed in the mines concerned. Mines were operated by this company in the vicinity of What Cheer and to the north of it until 1899. They were equipped with the best machinery; Harrison mining machines were in use, and fans were used for ventilation. The company operated a total of twelve shafts of which number seven were acquired at the consolidation and five were sunk subsequently.

Another of the large operators was the Crescent Coal Company. This company took over two mines in 1885 and worked them for a number of years. In 1894, after these had been exhausted, two mines were sunk northwest of What Cheer. Number 4 was for several years the best producer in the county, but was abandoned in 1901.

Among the local mines have been a number of quite important producers. Thomas Thompson has been operating near What Cheer since 1893 and the Pioneer Coal Co. operated in the vicinity of Thornburg and What Cheer from 1889 to 1897. A number of mines have also been worked in the neighborhood of Delta, Sigourney and Richland. At present there are only a few local mines in the county and these are all located near What Cheer.

Mahaska County. This was one of the first counties in which coal was known although for some years not much use was made of it. As early as 1843 the farmers knew of the presence of coal but none was used for some time except by the blacksmiths, who found it convenient for their forges. When Owen made his trip up the Des Moines in 1847 Mr. Morgan was working a four-foot bed in the bluffs of Muchakinock creek three miles above Eddyville. It was not long after this that Robert Seevers opened a bank east of Oskaloosa, for he came here in 1853 and began mining soon after. John and James Burdess also opened a mine near Beacon in 1862. The Seever mine was opened in a valley three or four feet below the bed of the creek and struck a four-foot bed of coal. This, like all the early mines, was a drift where the coal had been exposed by erosion. These mines were begun before there was any railroad in the vicinity and hence their trade was local. Later other mines were opened around Eddyville, Pekay, etc., and showed that the coal lay in basins. There was a thin vein of cannel coal found near Oskaloosa and a heavy vein near Given, which runs out into the Des Moines river. A wide "fault" has been located running northeast-southwest under Oskaloosa, and several mines have run into it from both sides.

By 1867, at the time of White's investigations, a number of mines had been opened up. In the north part of the county a four-foot bed of coal was being mined, along Spring creek near Oskaloosa were a number of banks and at Oskaloosa Station, now Beacon, on the Des Moines Valley railroad, two and a half miles from the city, the thickest coal bed then known in the state was being worked. This seam measured from five to nearly eight feet of good and solid coal. The principal operators were Messrs. Roberts and Co. and the Iowa Coal Co. of Keokuk. Their mines had car tracks laid from the station platform of the railroad directly into the rooms so that the mules pulled the loaded cars from the face to the station, where the coal was dumped into cars for shipment. White further states that these mines shipped daily 2,500 bushels of coal "besides a considerable quantity of coke, of good quality, which they have lately commenced preparing for shipment."

Several other openings had been made at this time, near Given, where the Iowa Coal Co. had mines, and all along Muchakinock creek down to Eddyville were small drifts. In conclusion White makes the prediction that "There is no reasonable doubt that the whole ridge between the creek before named (Muchakinock) and the Des Moines river is underlaid by at least one good bed of coal, and indeed it is quite as conclusive that the higher lands of the greater part of the county are so underlaid." While this has proven to be true Muchakinock valley has been from the earliest times the seat of the greatest activity in the county.

The next move in the development of the coal fields was made by Messrs. W. A. and H. W. McNeill, of Oskaloosa. These men, after abandoning their mines in Monroe county, moved to the Muchakinock valley in the spring of 1875. They incorporated under the name of the Iowa Central Coal Co., opened up a six-foot vein five miles south of Oskaloosa and ran in a siding from the Iowa Central railroad, which had built up the valley in 1873. A year or two later the firm reorganized under the name of the Consolidation Coal Co. and absorbed another mine which was being operated in the valley by Messrs. Huggings and Bonifield of Ottumwa, also the Black Diamond mines of Coalfield, Monroe county, and a mine just west of Beacon known as the Eureka mine which had been opened by Mr. Evans of Beacon. The consolidation made this company the largest in the county. In 1878 they had 400 men in their employ.

This company continued the operation of the above mines until 1880, at which time the Chicago and North-Western Railroad Co. bought it. The mines were operated by this company under the management of J. E. Buxton until their exhaustion in 1890 when the camp was moved to Monroe county. The headquarters were at the camp of Muchakinock where the stores and offices were located and around which were the early mines. Nine mines were worked here, of which number 9 was the first to have electric haulage. The rack rail system was used. About a year before the North-Western assumed control the previous management had trouble with the union and shipped in colored miners. These have been employed by the company ever since. The white miners were chiefly Hungarians and Swedes.

That the question of car supply is not one of recent origin is shown by an experience of the original Consolidation Coal Co. In 1875 the output of the Black Diamond mines, 100 tons per day, was considered somewhat phenomenal and was about the largest in the state. But a few years later the question of supplying empties to the different mines arose and the railway, in order to determine the needs of the different mines, advised the owners that each mine, in its turn, would be furnished all the empties it could load in ten hours. When the turn of the Consolidation company came they tried to convince the train dispatcher that he was not giving them a large enough supply. In spite of his assurance to the contrary they were compelled to stop loading at three o'clock after having loaded their quota of 100 cars with lump coal. Cars of that day had a capacity of ten tons.

While the McNeills were operating so extensively a number of other mines were being opened in different parts of the county. Chief among these were the Acme and the Standard, both within the corporate limits of Oskaloosa. After the sale of the Consolidation the Messrs. McNeill, together with Ezekiel Clark of Iowa City and J. K. Graves of Dubuque, organized the Western Union Fuel Co. and bought both of the above mines, which they worked for a few years, until their exhaustion.

In the meantime the McNeill Brothers had, in 1884, organized the American Coal Co. and had taken over two mines at Evans, on the Chicago, Rock Island and Pacific railroad, the old Des Moines Valley. These mines had been opened by Evan Evans of Beacon and Wesley Redhead of Des Moines and had a combined daily output of 100 tons. On account of its not being properly cleaned the dealers had refused to handle the coal with the result that the mines were practically idle. By properly cleaning the coal the new management were able to convince the Railroad Co. and the trade that the quality was really high, and after closing one of the mines they pushed the other up to a capacity of 1,000 tons per day. This mine and others in the vicinity were operated by the McNeills until with the sale of the American Coal Co. in 1901 to Messrs. W. T. Phillips of Oskaloosa and Harry Burkes of Montreal, Canada, they dropped out of the mining industry in Iowa.

During these years John Burdess, who had been one of the pioneer operators, was still carrying on the work near Oskaloosa. He operated until 1888 when his mine was purchased by the Oskaloosa Coal Co. The Iowa Coal Co. also continued operating in the Muchakinock valley until into the 80's when the Beacon Coal Co. acquired their property. During the early years of mining activity in the Muchakinock valley Beacon was the largest mining town in Iowa but by 1885 its importance had so decreased that there were only a few mines at work in a very small way.

About 1875 or '76 the Chicago, Milwaukee and St. Paul Railroad Co. opened up a mine at Excelsior, about three miles south of Oskaloosa. Three mines were operated, under the name of the Excelsior Coal Co., and reached a capacity of 1,500 to 1,600 tons a day. Finally the supply was exhausted and the plant was moved to Carbonado, three miles east of Oskaloosa, in 1890. At these new mines self-dumping cages and quick methods of loading box cars were installed. They were operated until 1898 when the coal became exhausted and the company abandoned mining operations in the county.

The Oskaloosa Coal and Mining Company was organized in 1888 and operated four mines near Oskaloosa. These are all worked out and the company ceased operations in 1905. It ranked among the largest producers of the county.

Several mines were opened in 1890, among them that of W. A. Hoover, at Carbonado, on a switch from the Iowa Central. A double hoisting engine raised coal from a six-foot vein, but as the field was limited the mine closed after two years of work. Another mine which was opened in the same year was the Garfield mine of Geo. Ramsay and Sons. This had connections with the Rock Island and Iowa Central railroads at Beacon, and soon reached a capacity of 600 to 1,000 tons. Tail-rope haulage was used underground. The same firm also opened two mines near

Knoxville Junction, or Evans, one of which is still in operation.

In 1892 the Whitebreast Fuel Co. opened its mine No. 28, at Pekay and rapidly brought it to the front rank. Five feet of coal was found at a depth of ninety-six feet and 275 men were employed to furnish an output of 700 tons and more daily. The mine was worked until 1906 when it was abandoned. At present this company operates no mines in Iowa.

In 1895, the Lost Creek Coal Co. established a camp at Lost Creek and sank a mine, with a private road from the camp to the Iowa Central and Burlington and Western, now the Chicago, Burlington and Quincy, railroads. The company operated three mines which were very important producers. Within a year from the beginning of operations 215 men were employed. The mines were abandoned about 1906.

The extension of the Chicago and North-Western railroad across the Des Moines river and into the Buxton district in 1900 gave a great impetus to mining in the southwestern part of the county. W. S. White and other What Cheer operators transferred the Crescent Coal Co. from What Cheer to Oskaloosa and opened extensive mines at White City. The Rex Fuel Co., also composed of What Cheer men, located near Bussey. Mines were opened at Lakonta near Buxton and at Eveland. Other mines have been opened west of Oskaloosa by the Garfield Coal Co., the Bolton-Hoover Coal Co., and others, and numerous mines, of greater or less importance, have been opened in nearly all parts of the county.

Mahaska early took a prominent place among the coal counties and for many years held first rank. From 1883 to 1900 she consistently yielded over 1,000,000 tons annually and was the only county to reach this mark. In 1901 Polk and Monroe surpassed her and she has since declined to fourth place although in 1908 she was one of the few leaders to show an increased output over the preceding year.

During the period of Mahaska's greatest activity the price paid for mining coal did not vary greatly from seventy-five cents per ton, for lump coal. The size of screens was, in early years, determined by the miners and operators at each mine. Later screens with a space of one and one-fourth inches between bars have been the standard. The men were paid once a month, generally on the Saturdays nearest the twentieth of the month. At present the practice of semi-monthly payments is in common use.

Marion County. It has long been realized that the coal beds of Marion county were among the most extensive in the state. But in spite of this the county has never ranked very high as a producer. Only once previous to 1902 did the output exceed 200,000 tons and never has it approached very close to 400,000 tons. This is due not to the lack or poor quality of the coal nor to the difficulty of securing it, but to the comparative lack of transportation facilities. The largest producers today, the Mammoth Vein Coal Co., are served by a switch over seven miles long, and with this exception the two southern tiers of townships do not have a railroad save along the northern and eastern borders. However, coal has been mined in a small way for over sixty years and in recent years some quite important mines have been opened within the county. When Owen was in Iowa he noted that in section 16, Liberty township, was a five-foot bed of good coal, which could be used for working cast steel. This is in the same locality as the beds since exploited so extensively by the company mentioned above. Nine years after, in 1856, Worthen found a small bank working in a bed of coal up to seven feet thick, on the south bank of the Des Moines river in Polk township. This was at a village called Coalport and here the first mines of any consequence were opened, for in these days when steamers passed up the river this village was one of the most important coaling stations between Eddyville and Des Moines. With the cessation of navigation, however, these mines, which had before been operated at a profit, were closed down, and now only a few old buildings mark the site of the once prosperous village. It is not even given a place on the modern maps.

After this very little was done until the late 60's. Then when White came into Marion county in 1867 he found quite a number of banks opened up near Otley, Pella, Knoxville, Marysville and elsewhere. He noted that a mile above Marysville Jacob Kline had opened a mine in which the coal had a thickness of ten feet, although it was seen to be divided by a thin clay parting three feet from the top. This is evidently the Mammoth Vein. Almost every tributary of the Des Moines had exposed beds of coal in its banks and many of these were being utilized for a local trade. The beds exposed along English creek were being vigorously exploited and the successors of these pioneers today are finding the deposits no less valuable.

When the State Mine Inspector made his first report, in 1881, he found that the chief mines then in operation were Flagler No. 5, owned by the Union Coal and Mining Co., the Oak Hill mine, also near Flagler, and the mine of J. T. James and Co. of Knoxville. The Union Coal and Mining Co. opened up mines near Flagler about 1870. The mines were connected with the Chicago, Burlington and Quincy railroad and were among the most important in the county. Number 5 was a drift, opened in coal so high that mules of ordinary size were employed for haulage. Railroad scales were used for weighing the screened coal. Forty miners were employed and 130 tons per day were raised. In 1887 the company installed new mine cars with a capacity of one ton. The mine was worked until about 1888. The Oak Hill mine was also a drift in coal eight and nine feet thick and had a capacity of 125 tons daily. Mine cars holding 1,000 pounds were used.

About 1883 the Red Rock Coal and Mining Co. bought 4,000 acres of land near Dunreath and prepared to install one of the largest mining plants in the state. But the land was bought without thorough prospecting, on the old theory that the coal lay in extensive beds and that an exposure in the bluffs indicated a widespread deposit. Hence the enterprise never materialized.

The Whitebreast Fuel Co. also operated two mines in this vicinity. One of these was located at Flagler. It was a slope known as No. 11, and employed the tail-rope system of haulage. The other mine, No. 7, was a shallow shaft, located at Swan, in the northwest corner of the county. The equipment was of the highest order in accordance with the practice of the company. It was operated only two or three years and was closed in 1888.

During this time, however, it was an important producer and as many as 285 men were employed. Number 11 was abandoned about 1892, as the coal, which was in a lenticular basin and was fourteen feet thick centrally, thinned in all directions until it became too much attenuated for profitable mining. Both mines shipped all their output over the Chicago, Burlington and Quincy railroad.

Other important mines in the county were the Black Swan, at Swan, operated by Thomas Beck of Des Moines; the Black Diamond at Dunreath; the Otley mines of the Marion County Coal and Mining Co., and the Morgan Valley mine of the Midland Coal and Mining Co. These were all shipping mines and in addition local mines were operated in every township of the county.

By 1898 the scene of greatest activity had moved to the vicinity of Hamilton and Bussey. For a long time there had been mines in the vicinity and by 1891 J. A. Powers was operating the Bussey mine. He carried on extensive prospecting in Liberty township and finally the Mammoth Vein Coal Co. was organized about 1903 and succeeded the O. K. Coal Co., which had been operating in the region. Mr. Powers is president of the new company. Eleven mines have been worked near Marysville and are connected by a long switch with the Wabash railroad at Tracy, seven miles distant. Mr. Powers also owns a mine at Hamilton which was opened in 1902 but was discontinued for some years. It is now being prepared for reopening with a new shaft by which coal will be removed from the old workings. The Mammoth Vein Coal Co. are at present the largest operators in the county and one of the largest in the state. The English Creek Coal Co. which sank their mine near Flagler in 1906 are also among the important producers of the county.

Jasper County. The presence of coal became known to the pioneers of Jasper county in 1847 when it was discovered cropping out in the valley of Coal creek on the farm of Hugh Patterson. It was found also near Vandalia soon afterwards. About eight miles west of Newton on Skunk river, coal was mined in a fairly extensive way at Slaughter's coal bank in 1857 when Whitney studied the geology of Central Iowa. The bed was about four feet thick and the coal was not thought to be of very high quality, although in later years it acquired a high reputation. The slope was operated until 1895. Earlier than this Owen had mentioned the use of coal for blacksmithing purposes from a three-foot seam near the Skunk river.

While mining was carried on from early years in a desultory sort of way it was not until the 70's that work really began on a commercial scale. The first shipping mine in the county was the Watson No. 1, opened four miles east of Colfax and three miles south of the Chicago, Rock Island and Pacific railroad, with which it was connected by a long switch. John Aberheardt was president of the company and James Miller superintendent. The mine had a large output and was sold after a number of years to C. F. Godfrey and Co. Two years after the opening of Watson No. 1, the Couch mine of the Jasper County Coal and Railway Co., three miles south of Newton, was put in operation and shipped over the Monroe branch of the Rock Island. When the State Mine Inspector made his first report this mine was the largest in the county. Its main entries had been driven in 2,000 feet and seventy tons per day were being brought out. Steam power was used for hauling coal out of the slope. D. S. Couch, part owner and superintendent, was interested in Jasper county mines for a number of years. In 1881 he bought an extensive tract of land three miles above Colfax on the South Skunk river, ran a switch known as the Northern Railroad out from the town, and opened up an extensive slope. Soon after this several other mines were opened here by the Standard Fuel Co., the Vulcan Coal Co., the Black Heath Mining Co., and others, and the Chicago Great Western Railroad Co. built a switch from their line at Valeria to provide a northern outlet for these mines. From 1887 to 1893 the Jasper County Coal and Railway Co. operated several quite important mines at a camp named Draper, a few miles east of Monroe. These were among the few mines in the county which were worked longwall. After 1893 they were worked in a small way by Robert Marshall, until 1897. From 1881 to 1900 the Jasper County Coal and Railway Co., later the Jasper County Coal Co., operated a number of mines on the property north of Colfax which Mr. Couch, its former superintendent, had bought. Then, after extensive prospecting it located shaft No. 5 three miles south of Colfax and built in a line of railroad to connect with the Iowa Northern at Colfax. As the company had acquired the branch of the Chicago Great Western from Valeria it now had connections with both the Rock Island and the Great Western, which opened up a splendid market to the north and east. In 1900 the company sank shaft No. 6, which was equipped with the latest and most approved machinery, including a Christy box car loader. Two hundred and seventy men were employed at this mine. Mine number 5 was abandoned the same year after mining out fifty to sixty acres of coal.

At the same time the Colfax Coal and Mining Co., organized in 1899, had sunk a shaft sixty feet deep two miles east of the Jasper county mines and the railroad, now the Colfax Northern, was continued to their mine. This field, southeast of Colfax, soon proved to be the most productive area of Jasper county and has been developed more vigorously than any other part of the county. With its exploitation Jasper county emerged from the comparative quiescence of the few years preceding and again became an important producer.

In 1902 the Colfax Consolidated Coal Co. was organized by a consolidation of the two companies above mentioned. This concern has since operated three mines in this field; mine No. 6 of the Jasper County Coal Co., No. 1 of the Colfax Coal Co., which is now No. 7 of the present company; and No. 8, which was opened in 1905. This is one of the largest and best mines in the state, is equipped with electric lighting and haulage in the main entry and has an installation of the most modern machinery. The camp of Seevers, which was built originally by the Colfax Coal and Mining Co., is located between Numbers 7 and 8 and furnishes accommodations for a number of the miners.

One of the earliest operators in the county was William Snooks, who opened a shaft near Newton in 1886 and has operated here continuously ever since to supply the local trade. Newton is the oldest district in the county and has produced a great deal of coal during its history.

The Warrick Brothers operate a slope near Colfax and have been supplying a local trade since 1903. The Diamond Coal Co. has been supplying the Industrial School at Mitchellville since 1905. There have been a large number of other operators who supply a local trade.

During the last twenty years wages have advanced somewhat, in line with the general trend of business. In the 80's the price of mining was seventy-five cents per ton in summer and eighty-seven and one-half cents in winter. At present ninety-five cents is paid in the Oskaloosa district and $1.00 in the Des Moines district. Formerly the operators could sell to the railroad at fifty cents above the mining price but they cannot do so now. Although selling prices have advanced in recent years coal is sold at closer margins than formerly due to the increased costs of mining.

Polk County. The discovery of coal in this county is credited to the soldiers stationed at Fort Des Moines. The exact date of the discovery does not seem to have been recorded, but it was about 1840. The soldiers dug coal from the vein still exposed in the river bank near the Center street dam, and also near Barlow Granger's, south of the Coon. The coal was used first by the blacksmiths at the Fort. In 1843 Captain Allen and A. N. Hays opened a coal shaft and stone quarry on the banks of the Des Moines, but the coal was in very slight demand as wood was plentiful. One of the earliest transactions in the coal industry occurred in April, 1847, when A. D. Jones presented a bill for eighty-eight bushels of coal furnished the county clerk. The bill was refused, however. What recourse Mr. Jones had is not stated.

There was very little coal used in the county until 1865. It was gathered here and there along the bluffs in wheelbarrows and dumped into wagons. Thirty bushels were called a load, without weighing. Mr. Wesley Redhead, realizing the need of intelligent prospecting and development, organized a coal company in November of 1864 and began the first systematic mining. In August of the next year Mr. Redhead, in company with a number of other men whose names are well known in local history, organized the Des Moines Coal Company and opened up a slope north of town on the west side of the river. This was operated a number of years until the pocket became exhausted. Then in January of 1873 Mr. Redhead, who had bought out the interests of the other members of the firm, began prospecting on his land west of South Park near the south end of the West Seventh street bridge. Mr. Redhead was convinced that coal occurred below the upper vein which was being worked, and having employed John Gibson as foreman, he began drilling. After penetrating three thin beds of coal and a dense limestone layer a five-foot bed of coal was reached on June 2d at a depth of 150 feet. The Black Diamond mine was at once sunk and equipped with the best machinery available, including a boiler and two horizontal engines. Forty men were employed in a short time, and a branch was run from the Indianola railroad. In 1867, when the Chicago, Rock Island and Pacific railroad was built to Des Moines, the Des Moines Coal Company was producing one or two cars per day, but by 1876 twenty car loads per day were being furnished and 150 men were employed. The name of the company was changed in 1874 to the Pioneer Coal Company and the mine was given the same name. It was one of the most important in the district and worked out a large area.

Two years after the Des Moines Coal Company began work the Watson Coal Company was organized and sank a shaft on East Fifteenth street by the Rock Island tracks. A number of the officers and directors of this company were from the east. The same company operated mines at Centerville. It was one of the largest operators in Polk county, and from June 1, 1875, to June 1, 1876, mined 1,113,967 bushels which were sold for $100,257.

In the autumn of 1867 Messrs. A. Y. Rawson and Vincent sank a shaft near the old Des Moines Coal Company's workings and the next spring Thomas and Joseph Beck opened a shaft near Mercy Hospital. After operating for a year they sold it to T. D. Yeoman and Dr. Howe, who ran it for a year. During this time Thomas Beck opened the Eclipse mine on the south side. The Eclipse Coal Company was organized October 1, 1873, with T. D. Yeoman as general manager and Thomas Beck as mine superintendent.

The Eureka shaft, also on the south side, was opened by Messrs. Story and Davis in 1871 and a few years later the Eureka Coal Co., of which Norman Haskins was president, took possession and installed new machinery. This mine was worked for over twenty years. In 1874 Messrs Clark and Sypher sank a mine, later known as the Polk County, on the Indianola railroad a mile and a half from the Courthouse, and in 1875 it was bought by John Gibson. He operated it for several years and later sold it to Wesley Redhead, then he commenced working east of the Capitol. A number of other mines were worked in the 70's, most of them on the south side, with two or three on the east side and as many north of town. Only a few small drifts were worked east of the Capitol previous to 1870. By 1876 about 500 men were employed in the mines and 150,000 tons were produced annually, about one-half of which was shipped. Nine to ten cents per bushel was received for export coal and thirteen to fourteen cents for that sold locally. Some of the larger mines employed steam hoist and mule haulage was in general use underground. About 1870 the office of County Inspector of Mines was established in Polk county and Mr. Beadle was appointed the first inspector. He occupied the position for two years and was succeeded by Daniel Rees. The office was continued for about three years and then seems to have been abolished.

In 1879 George Garver and John Walters began mining in east Des Moines and sank two shafts within a short time. These were Giant numbers 1 and 2, located at Sixteenth and Walker and Twentieth and Grand respectively. They were among the largest of the early mines on the east side, a locality which was to play a very important part in the mining industry of the county. In a few years Mr. Garver with other men had opened several other mines in different parts of town, among them the Garver mine, the Des Moines Coal Company mine and others. In later years Mr. Garver's sons, Henry F. and C. M., have been associated with him and at present are the active members of the Enterprise Coal Company. During the early 80's most of the mines were working the "first" or "second" veins. Only a few had sunk to the "third," among them the Eureka and

Giant number 1. Prospecting was done with churn drills. Few of the mines had advanced beyond the furnace method of ventilation. The Pioneer, the Eclipse and the Giant mines were among the first to install fans. Miners were paid $1.25 per ton for their coal, drivers received $1.75 per day and common laborers $1.50 to $1.60.

It was not until about 1885 that the industry began to extend much beyond the corporation limits. About this time the Walnut Creek Coal and Mining Company opened a mine four miles west of Des Moines on a narrow gauge railroad running north from town, the Altoona Coal and Mining Company sank a shaft at Altoona on the Rock Island, and the Wabash Coal Company and Runnells Coal Company began work at Hastie and Runnells respectively on the line of the Wabash railroad. At that time the Altoona mine was the deepest in the county, reaching a four-foot vein of fairly hard coal at 211 feet. A year or two later the Polk City Coal Co. opened a small shaft 238 feet deep at Polk City to supply the local trade. This was one of the few mines in the county that was worked on the longwall plan. On the south side the Coon Valley, opened in 1879, and later the Manbeck mine, both superintended by Thomas Beck, were doing an extensive shipping and local business. Mr. Beck has been an active operator in this field for over forty years. From this time on mines were opened in all directions. About 1890 the Bloomfield Coal Company began work just north of Des Moines and the Maple Grove Coal and Mining Company was organized and opened a mine northeast of town.

By 1893 there were twenty-three mines in operation. Of these twenty were shipping mines and eighteen were using steam hoist while all but two were using mule haulage underground. The two exceptions were the J. M. Christy and the Eureka Coal Companies, which used tail-ropes below. The financial stringency of that year affected the industry to a considerable extent, as the local demand, both industrial and domestic, was materially reduced and consequently outside markets had to be sought and coal sold at a lower price. Instead of the operators receiving $1.75 to $2.00 per ton at the mines they were forced to sell to the railroads at $1.25 to $1.50. Of necessity the prices paid for mining were diminished accordingly. Nevertheless there were several important producers opened about this time, among them the West Riverside Nos. 1 and 2, Keystone Nos. 1 and 2 and Gibson number 2, the latter located four miles east of the Capitol. Other operators who began about this time and who are still prominent are the Flint Brick, Eagle, Saylor and Evans. At the same time the Merchant mine was opened up at Commerce and was worked longwall.

During the closing years of the last century the larger mines of the county were located some distance from the center of population along the different lines of railway. To the east, on the Rock Island, were the Christy, employing 235 men; the Carbondale, five miles east of Des Moines, employing 225 men; the Gibson No. 2, east of the Carbondale and giving employment to 100 men. To the north, on the Chicago and North-Western, were the Des Moines Coal and Mining Company mine at Marquisville, at which 275 men were working, and the Saylor No. 1, at Saylor, one of the best equipped mines in the state. Northeast of town on the Chicago Great Western railroad was the Maple Grove number 2, where 90 men were employed. The numerous local mines of the county have always ranked high in their equipment and their output, as they supply a large domestic and steam trade and compare in size with many of the shipping mines. Some of the mines were equipped to handle a daily output of 1,000 tons. In the biennial period ending June 30, 1901, there were employed in and about the mines 1,770 men, who were paid wages amounting to $2,007,360. During this same period there were produced 1,800,000 tons of coal. It can be readily seen from these statements what a large growth the mining industry enjoyed in the quarter of a century subsequent to 1876. During more recent years a number of very important mines have been opened. The Des Moines Coal and Mining Company opened up two large mines at Enterprise in the northern part of the county, the first in 1903 and the second in 1907. The mine at Marquisville was abandoned after a serious fire had stopped operations, and the company assumed the name of the Enterprise Coal Company. The Evans mine has been worked by the Norwood Coal and Mining Company for the past eight years, and the Smith-Lowe Coal Company have operated the old Carbondale mines during the same period. The Gibson Coal Company abandoned its mines east of Des Moines and opened Number 4, two miles west of Altoona, in 1902. This was worked out and abandoned a year or so ago and a new mine has been developed near Clive, just west of Des Moines. The Maple Grove Coal Company has changed its name to the Maple Block Coal Company and has opened mine number 2 northeast of Des Moines. There are also a number of new mines which are described elsewhere in this volume.

In the matter of equipment the mines of the county take rank second to none. This will apply to the local as well as to the shipping mines. Of late years all have had steam hoist and fan ventilation, with one or two exceptions, and the top works are modern and adequate for the heavy demands made on them. With the exception of the Commerce and Polk City mines all have been worked room and pillar. Machine mining has never been in general use. Machines were installed at Runnells and at Morgan Valley, just over the line in Marion county, sixteen or seventeen years ago, but were not very successful. Another attempt was made to put them to service at Carbondale about twelve years ago with the same results. They are being used at present in a few mines within the county. Electric haulage has had a similar experience. Few plants have been extensive enough to make its installation advisable or its operation profitable.

Dallas County. Although Dallas has not until very recent years yielded a large output of coal, she has during most of her history been a consistent producer and has contributed a not inconsiderable quota to the state's total. For over forty years coal has been mined from the banks and bluffs of her streams and in a number of cases deep prospecting has revealed the presence of greater and better stores of fuel. By 1867, at the time of St. John's work in western Iowa, coal was being removed from a bank just below Redfield on the lands of J. W. Redfield. The coal was nearly three feet thick and was of fair quality. Some coal was also furnished for blacksmith use from the Marshall coal near Van Meter, but the bed did not exceed six inches in thickness. Two miles above Redfield the Panora coal was being utilized to some extent at the Parker and Piatt mines, although this vein also did not exceed six inches in thickness. A few miles north of these mines, along the middle Raccoon, the Lonsdale coal, here eighteen inches thick, was being mined in a small way by stripping. North of Adel a few miles a thin bed of coal had been worked for a number of years, and on Walnut creek, in the eastern part of the county, the Marshall coal had been opened to some extent. These examples show that the value and extent of the coal beds were already appreciated although nothing seems to have been known of deeper veins.

By 1878 the Chicago and Van Meter Coal Company had sunk a shaft to a three-foot vein at a depth of 256 feet. In 1879 the engine house burned down and entirely new machinery was installed. Steam hoist was used and machines driven by compressed air were employed for cutting the coal. This was the first deep mine in the county and for some time was the only one of consequence. It was opened by Messrs. Boag and Van Meter, but Messrs. J. L. Platt and J. M. Thompson acquired it soon after. At first both room and pillar and longwall methods of mining were used, but by 1883 the longwall method obtained all through the mine as it proved to be more profitable in the thinner veins of western Iowa. In 1879 fifty men were employed and 1,000 bushels were raised per day. Lump coal sold at nine cents per bushel and nut for eight cents. The Chicago, Rock Island and Pacific Railroad used twenty-four tons daily and the remainder of the output was shipped westward or sold locally.

About 1893 the Platt Pressed and Fire Brick Company was established and the plant built close by the Van Meter mine. The two were worked in co-operation and the clay for the plant was taken from between the first and second veins of coal. In later years the entire output of the mine was used at the brick plant. The mine was abandoned in 1902.

During these early years Calwell's slope at Redfield was employing sixteen men and 350 bushels were being mined per day from a three and one-half foot bed of coal. Quite a number of shafts were in operation around Redfield in the 80's and some coal was being mined near Bayard and Linden. In 1870 Frank

West of New York had begun prospecting in Des Moines township and finally sank a forty-foot shaft in section 14, not far from the location of the leading mines of Dallas county today. In 1886 a new field was opened up at Dawson, in the extreme northwest part of the county. Here the Dawson Coal Co. sank a seventy-six foot shaft a few hundred yards from the Chicago, Milwaukee and St. Paul railroad. This reached an upper vein and the company at once sank a larger shaft to a lower four-foot vein at 160 feet. Steam hoist, fan ventilation and self-dumping cages were used, ninety miners were employed and most of the coal was sold to the railroads. The mine was an important producer until 1901.

About 1901 the Carpenter Coal Co. sank a mine between Madrid and Woodward, one and one-half miles south of the Milwaukee railway. This plant was equipped with electric mining apparatus, modern machinery and had good shipping facilities for reaching a northwestern market. It immediately assumed a position in the front rank of producers in central Iowa.

At this same time the Reese Brothers Coal Co. sank two shafts in the neighborhood of Madrid and equipped them with steam power. From this time on Madrid assumed an increasing importance as a mining center, although Hutchinson Brothers, the Dawson Coal Co., operated an important mine two miles west of Dawson. In the fall of 1906 the Carpenter Brothers, under the name of the Scandia Coal Co., opened a large mine at Scandia, and the High Bridge Coal Co. recently sank a shaft at High Bridge, both in the north part of the county. With the entrance of these operators into the field Dallas again assumed an important position. In 1907 her production rose from 5,500 tons of the previous year to 70,000 tons and in 1908 this was raised to 174,600 tons. New territory is being constantly prospected and new deposits revealed and it seems safe to prophesy a splendid future for Dallas county's coal industry.

Guthrie County. Coal was early mined over the entire eastern part of this county to supply the local demand. As early as 1867 there were banks opened in the bluffs of the Middle Raccoon from its entrance into the county to Fanslers and Panora in the eastern part. The Marshall coal was opened up in the southeast part of the county along South Raccoon, on Deer creek, on Beaver creek and on Long branch. The Marshall mines on Long branch and the Lonsdale mine on Deer creek were among the most important then in operation and gave their names to the horizons mined. The Marshall coal was of excellent quality, free from impurities and bright and brittle. The Lonsdale was also a good domestic coal and proved a boon to the dwellers of the prairies.

In 1885 there were twenty-three mines operating along the Middle and South Raccoon rivers and their tributaries in the eastern part of the county. All were purely local. Among the most important was the Clipper mine owned by Marchant and Winters and located near Fanslers. It was 126 feet deep and pierced a two-foot vein which was worked longwall. A feature unusual among the small mines was the use of storage sheds, which equalized the demand on the miners and insured a supply adequate to the demand. Several of the mines near Fanslers were from sixty to eighty feet deep. Those farther to the east were generally shallow shafts or drifts. A mine which supplied an important trade at Panora was that of D. D. Rees, 100 feet deep, working an eighteen-inch vein. About 1891 W. D. Simon opened the Greenbriar mine near Jamaica. It was sixty-eight feet deep to a coal bed two feet four inches thick, and was the only mine in the county worked room and pillar. Steam hoist was utilized for some time and was the only installation of the kind in the county. At this time coal was selling for $2.50 to $3.00 per ton at the mine and the miners received six cents per bushel. The mines have always had a brisk trade in the winter and owing to the lack of storage facilities have often not been able to keep up with the demand as the coal was especially adapted for domestic use.

All the mines above mentioned are still in operation and of late years a number of others have been located near Yale in the same field as the Jamaica mines and near Bayard and Bagley. In consequence of these developments the industry has assumed quite an importance, although the output is not large as compared with some of the other counties and the county has never had a shipping mine.

Story County. Story has never been an important producer of coal and at only a few points, chiefly in the northern part of the county, have serious attempts been made to obtain it. One of the earliest of these was three miles southeast of Collins, near the southwestern part of the county. Here the Collins Fuel Co. in the summer of 1885 sank a shaft 150 feet to a three and one-half foot vein of coal. This was of excellent quality and the demand always exceeded the supply. The mine was last operated in 1896 by Marshall and Crowe of Boone county. Prospecting proved that the bed had a considerable extent to the south and east. Desultory attempts were made to develop the coal resources of the county near McCallsburg in the northern part of the county and near Gilbert, on the western edge of the county on Squaw creek. About 1899 two local mines were worked at the latter locality by the Zenorsville Coal Co. and Hutchinson Brothers. At the former place a three-foot vein was found and operations were carried on in a crude way for several winters.

The most important operations in the county were carried on at Summit, midway between Gilbert and Story City. In 1892 and '93 the North Star Coal and Mining Co. put down a shaft 135 feet deep to a four and one-half foot bed of excellent coal. The mine was equipped with modern top-works, a steam fan was used and the room and pillar plan was pursued in mining the coal. The creep of the underlying fire clay caused considerable trouble and it was not possible to win more than sixty per cent of the coal. A large local trade was supplied and in addition a considerable amount of the output was shipped over the Chicago and North-Western railroad, a spur from which was extended to the mine. Work was carried on here until about 1898. Another mine which was opened at Summit was that of Benson Brothers, the Story County Coal Co. This was opened about 1898 and also had an excellent equipment and shipping facilities over the North-Western. It was abandoned and the plant moved to Boone county in 1901.

Boone County. As in the case of all the counties in which erosion has laid bare the indurated rocks and revealed the beds of coal, the fuel supplies of Boone county were early discovered and soon utilized. As early as 1849, Owen noted that the blacksmiths of the county were obtaining coal from a bed on Honey creek south of Boone. However, it was some years before mining for export was initiated. After the advent of the Chicago and North-Western Railroad in 1866 mining operations were pursued with vigor and Boone now ranks among the leaders in its coal output.

The first shipping mine was a slope opened in 1867 by T. N. Canfield and C. S. Taylor just west of Boonesboro. A few years later they sank a shaft 242 feet deep. Coal was hauled to the railroad, three miles, for several years. In 1874 the company was reorganized and built a spur to the main line of the North-Western at Boone. Eventually the property was purchased and operated by the Railroad Co. The mine was in active operation for nearly thirty years. In the same year that this mine was opened the Moingona Coal Co. opened a mine at Moingona with Wm. Blythe as superintendent. Six mines were operated by this company and for some years their output amounted to 800 or 900 tons per day. After the North-Western Railroad was completed to Council Bluffs the company shipped most of its product there and sold it to the Union Pacific, but when the mines at Carbon, Wyoming, were opened the Moingona company was obliged to seek new markets. For a number of years Moingona was one of the largest camps in the state and was the scene of great mining activity, but for ten years very little work has been done there.

In 1874 the Northwestern Coal and Mining Co. was organized, with Hon. J. F. Duncombe of Fort Dodge as president and Gen. G. M. Dodge as one of the shareholders. This company did an important shipping business from its mine west of Moingona for a number of years. The field has been recently exhausted.

One of the earliest mines in the county was opened about forty years ago at Hahntown by the W. D. Johnson Coal Co. This was a slope near the river bed but some time after a shaft was sunk from the top of the hill to the same vein, the "lower" vein. The company has been operating continuously to the present time. In the early days of mining the upper vein was considered too poor in quality to be worth mining and operators all looked for the lower one. It is about 230 or 240 feet below the upland

and averages four feet in thickness. At about the same time Arnold and Shepard sank a shaft to the same vein at Shepardtown and worked here for ten years. D. C. Wilbur was also one of the pioneer operators and worked several shallow shafts on the river bottoms two and one-half miles east of Boonesboro thirty years or more ago. He teamed his coal to the top of the hill and sold it locally or to the Boone trade. Another of the early operators was the firm of Birmingham and Keating, who worked the lower vein at Incline across the river from the Wilbur mines. The firm is still operating near Boone under the name of the Birmingham Coal Co.

A few years before these mines opened, about 1875 or earlier, Messrs. George Rogers and William Crowe began operations in a small way. Several shallow shafts were sunk along the river and the firm has since become one of the leading operators of the county. Mr. Crowe has retired within recent years but Mr. Rogers has continued at work. Recently the mine being operated was flooded with water and closed. Twenty-five years ago Samuel McBirnie began operating in the upper vein in Mormon Hollow near Boonesboro. Later he sank mines in the lower vein at Incline. He is out of the coal business at present and is a justice of the peace. One of the largest operators in the county was the Clyde Coal Co., which sank its first shaft at Incline, west of Moingona, in 1885. At first water caused a great deal of trouble but this was overcome and operations were conducted on a large scale. Both veins were worked. Mining machines of the Ingersoll punching type were installed and an incline was built across the river from the flats. Up this incline railroad cars were pulled from the mine to the railway by a large engine and cable. The Clyde Coal Co. was the only operator in the district to install mining machines. They have not proved very successful as the mines tend to squeeze and there is not enough room to operate them. Then, too, the roof is not strong enough for their use. Operations were carried on for about fifteen years, by which time the field was exhausted. The manager of the company was Hamilton Brown, who has since gone into railroad promotion enterprises, including the Newton and Northwestern and several roads near Chicago. The superintendent was O. M. Carpenter, who was later interested in the Carpenter Coal Co. and the Scandia Coal Co., of Dallas county, now owned by the Saylor Coal Co. of Des Moines.

Seventeen years ago the Zimbelman Coal Co., composed of George, Lafayette and Alfred Zimbelman, was organized and sank a shaft 220 feet deep to the upper vein. This mine is still in operation and has modern equipment. As many as 100 men have been employed here. The year before this mine was opened Heaps Brothers, James and Andrew, began work and at that time their mine was the farthest on the prairie of any of the mines in the region. The firm has been operating ever since, although both the brothers are dead. James Crowe went into the firm five years ago but was killed at the mine.

Two years ago John and Samuel Smiley and George Heaps opened a mine near Boone. Mr. Heaps has since left the firm and together with Robert Kennedy, former superintendent of the Frazer mines, and P. and W. Benson, has organized the Boone Block Coal Co., which is engaged in sinking a shaft on north Marion street, just inside the corporation limits of Boone. The shaft is to be 243 feet deep to the upper vein, which is here about three feet thick. It is the farthest on the prairie of any of the mines of this district. It has always been supposed that the upper vein thinned out under the prairie and that the sand and drift went down nearly to the lower vein. But nine holes drilled in the vicinity of the shaft showed a good vein of coal. The hole nearest which the shaft is being sunk showed:

	FEET.	TOTAL.
Drift	140	140
Soapstone	30	170
Shale	10	180
Sandstone	9	189
Hard rock with flinty streaks	1	190
Shale, white, solid, hard, sandy	40	230
Slate, black	10	240
Coal	3	243

In the Boone district the upper vein is always worked longwall while the lower bed is mined on the room and pillar plan.

Another district which was one of importance was that of Squaw creek valley, which has already been discussed in connection with Story county. In the vicinity of Zenorsville several mines were sunk and a good deal of coal furnished for the local trade as far back as 1870. This coal was considered to be the best in the state. It was very pure, and rather soft. The principal mine was that of Hutchinson Brothers. James and John Hutchinson operated a slope mine on the room and pillar plan and in the winter employed over forty men, although the mine was almost idle in summer. John Clemmons operated a slope and a shaft near the Hutchinson.

Thirty years ago Angus was one of the most important coal camps in the state. A number of large mines were located near here, in Boone, Greene and Dallas counties, although the leading ones were in Boone. The Rock Island Railroad built in from the south and J. J. Hill bought land and put in a railroad, the Fort Dodge-Angus line of the Minneapolis and St. Louis, to take out coal. At that time 2,000 miners were employed and Angus had a population of 3,000. But after a few years the miners struck for more wages, others were brought in, violence ensued and after nine months of this difficulty Hill sold his land, took up his switches, several miles in length, and the town became dead. At present there are only about 300 inhabitants and little remains to indicate the former prosperity except the numerous dumps and switch grades, which are still in evidence over the prairie.

About the earliest miners here were the Climax Coal Company who came in 1878 and operated three shafts. These were well equipped, were ventilated by exhaust fan and used steam power for hoisting the coal. Mine No. 1 had a capacity of 300 tons daily. Another mine which operated on the Boone county side was that of the Eagle Coal Co., owned by the Chicago, Milwaukee and Saint Paul Railroad, which began in 1883 and had connections with the Milwaukee and the Des Moines and Fort Dodge, now the Minneapolis and Saint Louis, railroads. A blower was used for ventilating the mine. It was worked out and abandoned about 1887. Since then only small mines have operated.

The recent developments in the Madrid district are affecting Boone as well as Dallas county and extensive operations may be looked for there in the near future. The same may be said of the Ogden field, where the finding of an excellent bed of coal three to five feet thick at a depth of 270 feet is already stimulating prospecting. Deeper coals are being located than were known before and western Boone and eastern Greene as well as northern Dallas counties may be expected to reap the benefits within a short time.

Another important district is at Frazer, where the Boone Coal and Mining Co. have operated a total of six mines since 1895. These have been well equipped and have had a large output.

Greene County. The principal mines of Greene county centered around Angus although one of some importance was located at Rippey and a smaller one at Grand Junction. The leading operator at Angus was the Keystone Coal Co., which opened three mines, the first in 1878. This one was worked for ten years. Mine No. 2 was worked for some time until an inflow of water stopped operations. Number 3 was opened in 1887 and was 100 feet deep to a vein of coal four to five feet thick. From this level a slope was driven up to a higher bed a few feet above. The mine was splendidly equipped, employed fan ventilation and used three Legg machines, also a drilling machine supplied with power by a 100-horsepower air compressor. It was worked out in 1889. The Standard mine was also a large producer for five years but was closed in 1887. John McKay was superintendent at both mines.

Several smaller mines have been operated in the vicinity for thirty years. The district had a sudden rise to prominence, enjoyed a phenomenal growth and then seemed to decline as rapidly and as completely as it developed.

Hardin County. The early settlers of northern Iowa were not slow to realize the usefulness of such bodies of coal as they discovered in the bluffs and stream valleys and hence it is not surprising to know that in Hardin coal was being used by the turning of the last century to its latter half. Abram Grimsley, the first blacksmith in Hardin county, is credited with obtaining his supply of coal from the bed of the Iowa river near Eldora as early as 1851. Prior to 1854 S. B. Moran had been prospecting and mining on a small scale near Eldora and soon after that date James Buckner and Edwin Fuller began mining here. As soon as knowledge of the mines spread people came by team from Cedar Rapids, Independence, Waverly and elsewhere, distances of 100 or 125 miles, to obtain coal, as there were no railroads in that part of the state at the time. All of these early mines were drifts and were not commonly kept open more than one season to obtain a winter's supply. During the summer they would cave in and other openings would be made elsewhere.

Near Steamboat Rock coal was mined in 1857 from a drift in a vein four feet six inches thick. The entries were carried in 780 feet. One miner would pick and wheel to the drift mouth eighty-five to 125 bushels per day, for which he was paid four cents per bushel. The coal was used for fuel and for blacksmithing. Prospecting at that time was carried on by means of a spring pole and a two and one-half inch drill, operated by two men.

When White visited this region in 1867 he found that considerable mining had been done to supply the local demand and that, for the three years preceding, the Eldora Coal Co. had been shipping coal over the Central railroad of Iowa and the Dubuque and Sioux City railroad. The bed being mined was four feet thick.

Most of the openings in the county have been near the line between Clay and Eldora townships. These have been called collectively the Chaffin mines and were wrought out about 1880, although a little work was carried on desultorily for ten years longer. During the period of most vigorous exploitation the Chaffin mine proper produced annually over 4,000 tons. In the late 80's the principal mine was that of Bennett and Blair near Eldora, where fifteen miners found employment during the winter. Fourteen hundred tons of coal were produced per year. Since 1890 only one or two small mines have been opened for local use.

Webster County. Coal was known in Webster previous to 1860 as it had been discovered prior to that time by Mr. Gleason and other early settlers. Mining was initiated in the late sixties and the first shipping mine was opened in 1870 by a company of which J. L. Platt was president and in which Hon. J. F. Duncombe was interested. This mine was located on Holaday creek, several miles below Fort Dodge, and about three miles from the Illinois Central, then the Dubuque and Sioux City railroad, which had been built through only a short time previously. The company built a tramway to the railroad and the cars were drawn by mules. Later the track was widened and steam power was substituted for the mules. In the latter part of the same year, Duncombe and Richards sank the first shaft at the locality which has since been known as Coalville. Two miles of railroad were built to connect with the Illinois Central and coal was hauled out by the company's private engine. Large shipments of coal were made from these two mines and after operating them for a few years the company sold them to the Fort Dodge Coal Company. This firm prospected most of the lands in and around Coalville and mined there for seventeen years. Seven large mines were worked and a large output was maintained. As early as 1880 machines were being used by this company and were giving good satisfaction. Fans were at the same time used in some of the shaft mines to afford ventilation.

About the same time that the Fort Dodge Coal Co. began operations the Craig Coal Co. opened a number of mines at Kalo, opposite the river from Coalville. All of these early mines were drifts and relied on natural ventilation. In 1880 the Minneapolis and Saint Louis railroad was built down the river and gave the mines an outlet to the north. By 1883 these two companies were operating six mines and were putting out 600 tons daily. The Fort Dodge Coal Co. was employing 350 miners who dug thirty cars of coal each day. Other early producers were Collins Brothers, who operated a large shipping mine for ten years, and the Standard Coal Co., whose mines were for a time the largest producers at Kalo. Steam power was used for hoisting. At first the Collins mine was operated to supply the local trade, but in 1886, when the Mason City and Fort Dodge railroad, now a part of the Chicago Great Western system, was built near their mine, steam power was installed and a large tonnage was marketed. As many as 100 men were employed.

In 1895 the Pleasant Valley Coal Co. sank a shaft 105 feet at Coalville and furnished it with the best equipment possible. One hundred men were employed and large quantities of coal were shipped from a six-foot bed of coal. The vein was mined out several years ago.

The next important producer to locate in this district was the Gleason Coal Co., which sank its first shaft in 1899. Two hundred thousand tons were taken from this mine before it was abandoned in 1907. A well equipped power house was built and steam hoist was used. In 1908 the company began sinking mine No. 2, the only mine now operating in the Coalville district, a district which has been a consistent and heavy producer of coal during a period of nearly forty years. This new mine is located only about 600 feet from the first Duncombe mine and it gives promise of being a much better producer as the coal is better and thicker than in the old mine.

A great deal of coal has been taken from the Lehigh district, about seven miles southeast of Coalville. The first operator of importance in this field was Hon. W. C. Wilson of Webster City, who in 1871 opened a mine here and subsequently formed the Crooked Creek Coal and Railroad Co. This company built and still operates its own line of railroad over which its coal is hauled. Originally this was run from Judd on the Illinois Central to the mines, but now it extends to Webster City. The first mine was a slope, worked longwall and ventilated by furnace. About 1885 two slopes and in 1894 two other mines were opened.

In addition to these mines W. C. Beem opened Black Diamond No. 1 about 1880 and No. 2 about 1886. Both were located on Crooked creek near Lehigh and were good producers for quite a number of years. The Messrs. Corey have operated quite a number of mines since 1885 and were working as late as 1903. The Webster County Coal and Land Co. was organized about 1899 and operated a mine near Lehigh until 1902. A large number of local and shipping mines have supplied the market with abundant fuel although within recent years the number has been considerably reduced.

In early days miners were paid ninety cents per ton for screened coal. During the last ten years about seventy cents has been the ruling figure for run of mine. The price obtained for coal during this period has varied from $1.25 to $2.50 per ton, according to the quality of the coal and industrial conditions.

Taylor County. Although the coal beds of southwestern Iowa are very thin their regularity and wide extent are factors which have aided in their exploitation and their distance from other fields has insured them a ready market. So far as known the first mining in the county was on the land of J. R. Foster, about two miles south of Henshaw in the bluffs of the East Nodaway. Mr. Foster had been working here for some years before White visited the region in 1866. Although the bed was only eighteen inches thick it was mined profitably as it was of good quality and was in large demand, especially by the blacksmiths. From this time on there were a number of openings made from time to time in the vicinity and also a few miles farther south, near Hawleyville. In the early 80's, one of the principal operators was Gomer Beynon, whose shaft was a mile south of the Foster bank. He opened his second shaft in 1887. During this period a number of mines were opened and a considerable amount of coal was taken out. At first this was the principal locality in the county but later New Market became more prominent.

The first shaft to be sunk in the latter field was opened by John Lindsay in 1883. Unfortunately Mr. Lindsay found mining unprofitable and he soon met with financial embarrassment. The next year W. Harvey Drennen sank a shaft, but did not operate it long. In the next few years several local mines were put down. These were first worked room and pillar but later operations have all been on the semi-longwall or longwall system.

The first shipping mine was opened in 1885 by Benjamin Anderson east of New Market, on the Humeston and Shenandoah railroad, now part of the Burlington system. This shaft was 130 feet deep and the mine was worked longwall. Twenty miners were employed and for some years this was the largest mine in the county. In 1886 Roderick Campbell came to New Market and leased the Lindsay mine which he operated one year. After working another local shaft for some time he and his sons opened a mine one mile east of New Market in 1897, beside the railroad right of way. At first this was a local mine but later shipping connections were made and an outside market has been supplied. The mine is still in operation and is one of the largest producers in the county. In 1901 Campbell No. 2 was sunk, but so far has been used only as an air shaft. Within the next three years following the opening of his first mine Mr. Anderson had sunk two others, one of which is still in operation, although No. 1 was abandoned some years ago. About 1898 William Browning opened a shipping mine west of the Campbell. These three are the only shipping mines in the county but several locals have been opened from time to time.

When mining first began in the New Market district seven cents per bushel was paid for mining while twelve and one-half cents was received in the market. A few years later the miner received five cents for his labor and the coal sold for ten cents per bushel. Within the last twelve years four to five and one-half cents has been paid for mining while the operator has received from seven to eleven cents per bushel for his product. The mines of this district range in depth from sixty-five to 150 feet and are all equipped with horse hoist. Although there have been at least twenty shafts sunk in the vicinity of New Market, not over 140 acres have been mined out since operations began. These mines like those of the neighboring counties are and always have been non-union.

Page County. Coal was mined in Page county in the late 50's and early 60's, twenty or twenty-five years before the railroad went through in 1881. The first work was done at Pinhook, southeast of Clarinda, on the Nodaway river, in the neighborhood of the old Shambaugh mill. Coal was hauled from here in wagons to Omaha and Council Bluffs and Nebraska City. Twenty-five cents per bushel was charged at the mine and on the market sixty cents was received. Numerous drifts were opened here and also at other localities south of Clarinda. One of the largest of these was worked by Thomas Proser and was operated by a shaft and two slopes. It was one of the few mines in the Nodaway seam to be worked on the room and pillar plan.

By 1880 there were several mines opened near Shambaugh, five miles south of Clarinda. These were nearly all shafts and were worked on the longwall plan. In an attempt to discover deeper coal Samuel Pinkerton drilled a hole in the bottom of his shaft, which was 110 feet deep, until he reached a depth of 400 feet but without success. None of these mines supplied more than a local trade and most of them were not worked more than two or three seasons. Wages and selling prices did not vary much from those in force today. Five to six cents per bushel were paid the miners and the operator received nine to ten cents for his coal. Practically nothing has been done at Shambaugh since 1901.

In the early years all the mines near Clarinda were located east of the town. Within the last six years, however, several shafts have been sunk west and southwest of the city and are supplying an important local trade. One of the first of these was that of Johnston and Co., which is still in operation and is the only one which uses steam hoist. The Van Arsdal mine is another which is still open. These mines gave a great impetus to the mining industry of the county and raised its production from 1,850 tons during the fiscal year 1901-1902 to 9,674 tons for the next year.

Within the last three years the Coin Coal Co. has sunk a deep shaft at Coin and has equipped it with steam hoist and jet ventilation. A large local trade keeps the mine employed at its full capacity.

Adams County. Adams has been the most important coal producer of southwestern Iowa if not the pioneer in the industry. Forty-five years or more ago coal was being mined in the banks of the Middle Nodaway by stripping or openings. Carbon has been the center of the industry for many years although during the early 60's the village of Quincy, two miles east of Carbon, was the largest and most important town in the county. Here were situated the offices of the county government and a large business was carried on. But with the advent of the railroad Corning assumed the leading position and later became the county seat. Since then Quincy has declined in importance until today it is practically without economic significance.

Two miles west from Quincy on the banks of the Nodaway the first coal was mined. John Houck was one of the first miners and has operated ever since until recent years. He obtained coal by stripping. When White was in southwestern Iowa in 1866 Messrs. Barnett and Smith were mining coal here and were sinking a shaft in search of deeper beds of coal. Whether they succeeded is not stated, but in view of later developments, it is not at all likely. Other pioneers were Messrs. Wirt, W. Rush and H. Rimby. The first of these worked a bank four miles down the river from Carbon at least forty years ago, and Mr. Rush was one of the first operators to sink a shaft to the coal seam. This was near the outcrop, but since then operations have been carried farther away from the river until now they are all on the east side of Carbon. A little later, about thirty years ago, came Mr. Jones, and he and his son Martin have operated shafts continuously until the present day. The younger Mr. Jones is at present developing a new mine 110 feet deep on the south edge of Carbon. In the late 70's Thomas Gabbie, who had operated the first longwall mine in the Centerville district, came to Carbon and opened a shaft. He and his brother John worked mines in the neighborhood until the close of the last century. When the Mine Inspector made his first tour of the state in 1880 and '81 there were thirteen mines in the county, all near Carbon with one exception, and 176 men were employed. Among later operators have been J. F. Wild, who has run mines here since 1889, and J. F. Ruth, who has opened four mines in the past thirteen years, and whose father, William Ruth, preceded him as an operator in this field. These two, with Mr. Jones, are the only men at present working mines in the vicinity.

In the neighborhood of Briscoe, in the northwest corner of the county, mines have been worked for thirty-five years. Some of the pioneers in this field were Joseph Briscoe and George Plowman, whose mines were among the largest in the field. Mines have been opened up from time to time although at present but one operator is located here, H. K. Demirjean.

Between Briscoe and Carbon, at Eureka, several mines have been opened in the last fifteen or twenty years. James and William Hartshorn and Henry Hudspeth opened mines in the early 90's and work has been continued there until the present. Mc-

Kee Brothers are now working the Dixon shaft near Eureka. Southwest of Carbon is another center of mining, at Hoyt, where operations have been carried on during the last eight or nine years. Only small mines are opened.

Within the last three years two mines have been opened up near Nodaway and have become the largest producers of the county. The shaft of Daugherty and Son is the only one in the county which has ever had steam hoisting equipment. That of Frederick Weil is as large a mine but has horse hoist.

Several small mines have been opened in southern Cass county near Briscoe by Royal Hudspeth, Andrew Bennett and others. They were operated during the late 70's and the 80's, but nothing has been done here for a good many years.

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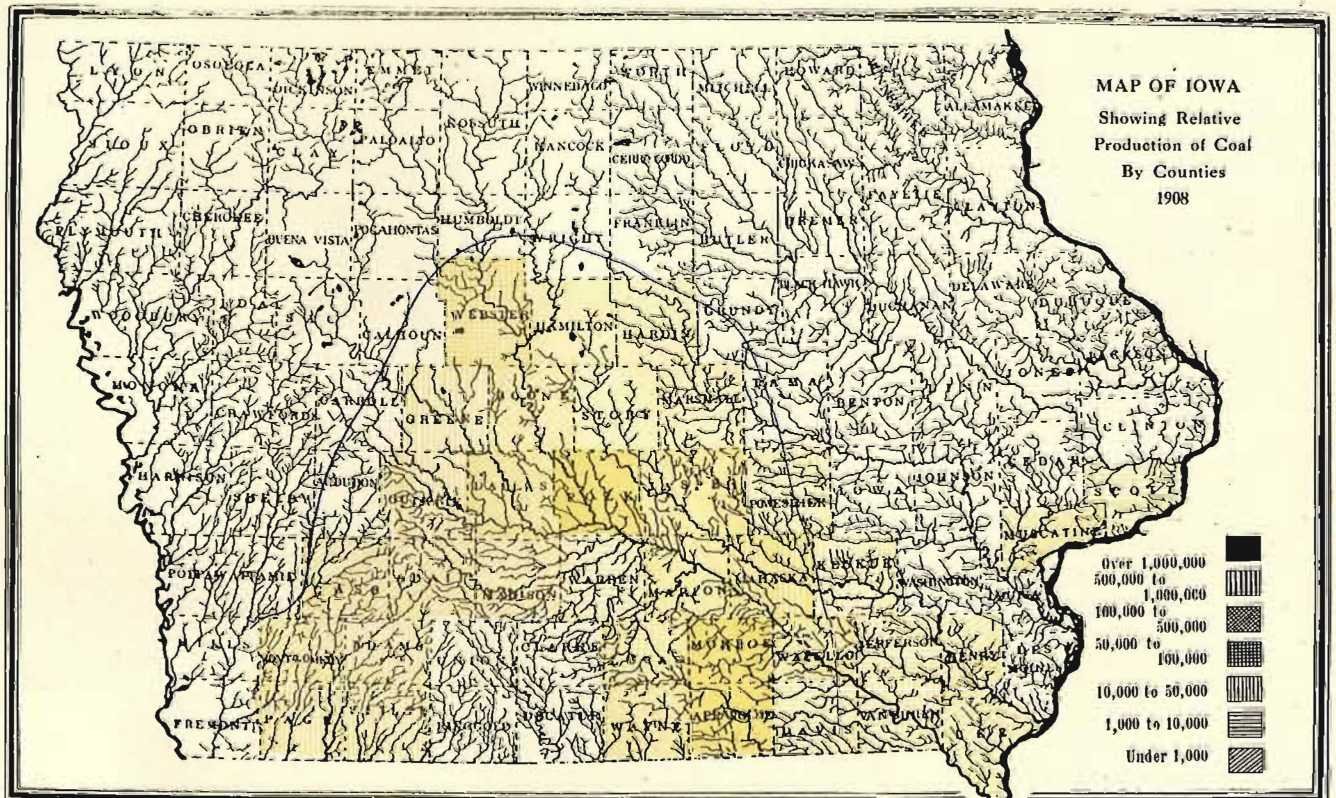
MAP OF IOWA
Showing Relative
Production of Coal
By Counties
1908
Over 1,000,000
500,000 to 1,000,000
100,000 to 500,000
50,000 to 100,000
10,000 to 50,000
1,000 to 10,000
Under 1,000
CHEROKEE
BUENA VISTA
POCAHONTAS
HUMBOLDT
KOSSUTH
HANCOCK
FRANKLIN
BUTLER
WEBSTER
HAMILTON
HARDIN
CALHOUN
GREENE
STORY
BENTON
DELAWARE
CLINTON
JOHNSON
MUSCATINE
AUDUBON
MADISON
WARREN
MARION
MONROE
JEFFERSON
HENRY
WAYNE
DECATUR
RINGGOLD
FREMONT

COAL STATISTICS*

BY S. W. BEYER.

Iowa was probably the second state west of the Mississippi river to open a coal mine, Missouri alone preceding her. The United States Census report for 1840 credits Missouri with a production of about 10,000 tons and gives Iowa's output as 400 tons. According to the Mineral Resources for 1907 the production in Iowa since 1840 has been as follows:

PRODUCTION OF COAL IN IOWA 1840–1908

IN SHORT TONS

Years	Tonnage	Years	Tonnage	Years	Tonnage
1840	400	1863	57,000	1886	4,315,779
1841	500	1864	63,000	1887	4,473,828
1842	750	1865	69,574	1888	4,952,440
1843	1,000	1866	99,320	1889	4,095,358
1844	2,500	1867	150,000	1890	4,021,739
1845	5,000	1868	241,453	1891	3,825,495
1846	6,500	1869	295,105	1892	3,918,491
1847	8,000	1870	263,487	1893	3,972,229
1848	10,000	1871	300,000	1894	3,967,253
1849	12,500	1872	336,000	1895	4,156,074
1850	15,000	1873	392,000	1896	3,954,028
1851	18,000	1874	799,936	1897	4,611,865
1852	20,000	1875	1,231,547	1898	4,618,842
1853	23,000	1876	1,250,000	1899	5,177,479
1854	25,000	1877	1,300,000	1900	5,202,939
1855	28,000	1878	1,350,000	1901	5,617,499
1856	30,000	1879	1,400,000	1902	5,904,766
1857	33,000	1880	1,461,116	1903	6,419,811
1858	37,500	1881	1,960,000	1904	6,519,933
1859	42,000	1882	3,920,000	1905	6,798,609
1860	41,920	1883	4,457,540	1906	7,266,224
1861	50,000	1884	4,370,566	1907	7,574,322
1862	53,000	1885	4,012,575	1908	7,149,517

Data for the years preceding 1883 are very meager. The Federal Census for 1850 reports 359 miners under the head of

*Data obtained largely from the Federal Census reports and the publications of the United States Geological Survey.

trades and professions but gives no other facts relative to the mining industry in Iowa. The Federal Census for 1860 reports sixty-nine mines, capitalized at $34,900, in operation, employing 174 men and producing 41,920 tons of coal valued at $92,180. Incidentally it is stated that the value of the output for 1850 was $4,000 which does not check with the figures given in the table above.

In the census for 1870 the first statistics by counties are to be found. According to this report the leading coal producing counties were:

	TONS.
Polk	45,600
Boone	42,143
Mahaska	32,550
Webster	32,400
Wapello	31,630
Jasper	20,720
Scott	17,325
Monroe	15,410

Lesser amounts were produced by the remainder of the producing counties of today. The total production for the state was 263,487 tons valued at $874,334. It is interesting and instructive to note that Scott ranked seventh in 1870, producing a larger tonnage than for any year, with the single exception of 1906, since county statistics are available. It is probable that the earliest producing counties are faithfully indicated by the above list. The statistical history of the industry by counties and for the state as a whole is shown in the tables appended herewith. The first table gives the total production by counties from 1883 to 1908 and the second table gives the total tonnage, average price per ton, average number of days worked and the average number of men employed for the state as a whole for the years 1875 to 1908 inclusive.

TABLE I—PRODUCTION OF COAL IN IOWA FROM 1883 TO 1908

Counties	1883	1884	1885	1886	1887
Adams	4,358	4,459	4,364	10,731	22,233
Appanoose	144,364	178,064	275,404	168,000	179,593
Boone	523,019	529,842	513,174	330,366	187,116
Dallas	42,793	41,647	36,944	24,624	45,270
Davis	590	1,358	37,694	1,120	2,016
Greene	99,513	107,886	100,337	131,643	118,601
Jasper	51,389	51,896	101,276	320,358	159,083
Jefferson	43,553	9,153	1,250	1,213	11,645
Keokuk	560,045	482,652	417,554	610,741	670,888
Lucas	546,360	460,017	492,750	594,450	529,758
Mahaska	1,038,673	1,044,640	854,319	953,525	1,148,614
Marion	101,903	108,735	112,012	158,697	238,218
Monroe	104,647	110,238	113,699	131,824	205,525
Page	838	1,130	2,037	1,736	1,993
Polk	625,879	694,312	518,442	378,520	341,705
Scott	4,160	4,280	6,650	3,360	9,670
Taylor	105	142	691	9,615	13,642
Van Buren	1,880	1,991	1,336	9,003	29,491
Wapello	266,360	269,607	210,461	265,564	304,722
Warren	14,367	15,374	14,364	26,132	27,772
Wayne	2,119	5,541	28,909	38,080	31,454
Webster	278,387	239,696	162,732	120,710	163,768
Other counties and small mines					
Total output	4,457,540	4,370,566	4,012,575	4,315,779	4,473,828

Counties	1888	1889	1890	1891	1892
Adams	21,075	13,457	†	†	†
Appanoose	235,495	285,194	284,560	409,725	411,984
Boone	156,959	174,392	153,229	151,659	139,820
Dallas	54,457	67,055	33,466	48,710	26,550
Davis	2,016	3,825	†	†	†
Greene	122,127	51,438	45,192	53,215	43,360
Jasper	308,200	199,152	173,044	267,202	163,860
Jefferson	10,514	8,123	*351,600	*800	*1,000
Keokuk	607,002	455,162	349,318	316,303	361,233
Lucas	408,765	339,229	*351,600	*800	*1,000
Mahaska	936,299	1,056,477	1,103,831	1,231,405	1,141,131
Marion	258,330	145,180	153,506	165,867	134,400
Monroe	261,962	258,401	324,031	393,227	507,106
Page	3,842	2,768	†	†	†
Polk	336,749	434,047	367,852	309,467	388,590
Scott	10,170	9,446	†	†	†
Taylor	8,962	9,736	†	10,500	15,204
Van Buren	29,075	39,258	47,464	36,166	28,946
Wapello	426,042	359,199	341,932	165,827	231,472
Warren	19,155	14,515	8,470	2,000	3,600
Wayne	27,208	17,480	25,415	45,000	62,078
Webster	178,881	137,739	118,829	78,022	115,154
Other counties and small mines			140,000	140,000	140,000
Total output	4,952,440	4,095,358	4,021,739	3,825,495	3,918,491

*Combined output.
†Included in small mines.

TABLE I—CONTINUED

Counties	1893	1894	1895	1896	1897
Adams	†	†	---------	---------	---------
Appanoose	489,920	667,271	588,438	544,768	670,143
Boone	172,070	241,522	268,422	316,756	292,218
Dallas	13,461	10,201	6,061	*9,624	6,853
Davis	†	†	---------	---------	---------
Greene	18,000	5,220	7,197	*9,624	9,245
Jasper	162,639	121,804	155,707	164,110	175,316
Jefferson	*482	*1,127	---------	---------	---------
Keokuk	152,097	142,750	266,394	214,474	289,478
Lucas	*482	*1,127	---------	---------	---------
Mahaska	1,419,930	1,152,988	1,016,623	1,047,241	1,420,510
Marion	111,145	108,695	193,768	93,023	129,502
Monroe	393,227	507,106	559,982	433,520	497,831
Page	†	†	---------	---------	---------
Polk	271,731	395,647	485,360	546,051	489,136
Scott	†	†	---------	---------	---------
Taylor	10,990	14,780	14,062	8,400	10,726
Van Buren	22,867	23,619	9,896	8,396	5,760
Wapello	230,460	278,583	261,510	227,077	229,470
Warren	3,000	12,649	6,116	12,824	6,610
Wayne	65,436	42,224	46,315	42,732	56,996
Webster	117,096	103,009	123,882	134,704	168,899
Other counties and small mines	---------	---------	146,391	150,418	153,172
Total	3,972,229	3,967,253	4,156,074	3,954,028	4,611,865

Counties	1898	1899	1900	1901	1902
Adams	---------	---------	---------	---------	19,751
Appanoose	608,165	636,421	680,094	721,997	900,337
Boone	331,543	290,525	266,542	254,054	254,324
Dallas	7,907	10,804	16,777	16,987	18,845
Davis	---------	---------	---------	---------	3,953
Greene	12,920	17,568	17,044	18,810	11,573
Jasper	143,945	191,928	99,948	184,670	233,440
Jefferson	---------	---------	---------	---------	10,610
Keokuk	251,145	314,900	258,933	308,193	106,103
Lucas	6,600	32,419	227,921	221,058	246,400
Mahaska	1,292,787	1,273,473	1,142,017	929,110	723,567
Marion	127,293	231,668	186,446	145,981	315,425
Monroe	584,578	689,004	755,286	1,038,332	1,406,905
Page	---------	---------	---------	---------	10,070
Polk	635,606	749,708	827,482	1,025,014	1,023,860
Scott	---------	---------	---------	---------	10,358
Taylor	6,555	10,965	17,159	23,499	14,207
Van Buren	6,600	9,385	12,108	12,572	14,816
Wapello	249,624	325,029	276,360	312,174	340,762
Warren	7,120	34,815	24,724	14,661	20,127
Wayne	51,550	62,818	65,140	56,578	65,374
Webster	137,548	124,841	123,660	146,020	149,615
Other counties and small mines	157,366	171,208	205,338	187,789	4,344
Total	4,618,842	5,177,479	5,202,939	5,617,499	5,904,766

*Combined output.
†Included in small mines.

TABLE I—CONTINUED

Counties	1903	1904	1905	1906	1907	1908
Adams	22,570	12,970	13,071	11,724	14,343	17,492
Appanoose	893,021	872,920	884,248	1,101,595	1,123,409	1,159,181
Boone	291,321	285,157	292,659	233,110	208,150	237,498
Dallas	15,467	13,086	5,000	5,522	70,042	174,585
Davis	3,160	----------	----------	----------	1,300	3,700
Greene	14,971	27,704	20,058	19,816	16,289	12,931
Jasper	270,804	258,098	306,164	388,582	397,297	393,516
Jefferson	6,844	9,810	3,379	3,744	4,000	†
Keokuk	62,875	41,512	16,460	17,144	27,716	18,301
Lucas	295,554	189,895	147,093	97,147	105,536	†
Mahaska	698,166	675,113	714,945	602,487	757,778	809,233
Marion	324,859	314,908	338,812	372,750	346,999	294,587
Monroe	1,768,054	1,987,450	2,225,677	2,458,473	2,476,021	1,965,619
Page	16,343	18,302	14,013	11,235	14,338	11,364
Polk	1,032,164	1,130,668	1,210,320	1,369,506	1,460,203	1,618,895
Scott	12,653	9,930	6,222	24,778	1,047	----------
Taylor	16,933	16,273	22,345	19,052	19,692	15,833
Van Buren.....	13,561	8,005	6,192	12,137	15,374	12,862
Wapello	382,398	379,560	303,360	243,256	258,651	184,652
Warren	12,760	11,290	9,876	2,850	5,054	6,720
Wayne	105,170	98,879	112,549	136,694	146,901	126,159
Webster	138,296	134,538	113,393	109,522	80,275	63,218
Other counties and small mines	21,867	23,865	32,773	25,100	23,907	23,171
Total	6,419,811	6,519,933	6,798,609	7,266,224	7,574,322	7,149,517

TABLE II

Years	Short Tons	Average price per ton	Average No. of days worked	Average No. men employed
1875	1,231,547	$ 2.03		
1880	1,461,166	1.72		
1882	3,920,000			
1883	4,457,540			
1884	4,370,566			
1885	4,012,575			
1886	4,315,779	1.25		
1887	4,473,828	1.34		
1888	4,952,440	1.30		
1889	4,095,358	1.33		9,247
1890	4,021,739	1.24	213	8,130
1891	3,812,495	1.27	224	8,124
1892	3,918,491	1.32	236	8,170
1893	3,972,229	1.30	204	8,863
1894	3,967,253	1.26	170	9,995
1895	4,156,074	1.20	189	10,066
1896	3,954,028	1.17	178	9,672
1897	4,611,865	1.13	201	10,703
1898	4,618,842	1.14	219	10,262
1899	5,177,479	1.24	229	10,971
1900	5,202,939	1.38	228	11,608
1901	5,617,499	1.39	218	12,653
1902	5,904,766	1.47	227	12,434
1903	6,419,811	1.65	226	14,162
1904	6,519,933	1.61	213	15,629
1905	6,798,609	1.56	209	15,113
1906	7,266,224	1.60	224	15,260
1907	7,574,322	1.62	230	15,585
1908	7,149,517	1.65	205	16,439

In 1908 Iowa ranked ninth in total production and eighth in value of output. She ranked second in both production and value of output of the states west of the Mississippi river. Missouri was apparently the first state west of the Mississippi river to produce coal on a commercial scale and held first place from 1840 to 1873. In 1874 Iowa took the lead and retained it until passed by Colorado in 1900. The ten leading producers of bituminous coal for 1908 are as follows:

TEN LEADING PRODUCING STATES IN 1908

State	Short Tons	Percentage of total	Value	Percentage of total
1. Pennsylvania	117,179,527	28.2	$118,816,303	22.3
2. Illinois	47,659,690	11.5	49,978,247	9.4
3. West Virginia	41,897,843	10.1	40,009,054	7.5
4. Ohio	26,270,639	6.3	27,897,704	5.2
5. Indiana	12,314,890	3.0	13,084,297	2.5
6. Alabama	11,604,593	2.8	14,647,891	2.8
7. Kentucky	10,246,553	2.5	10,317,162	1.9
8. Colorado	9,634,973	2.3	13,586,988	2.6
9. Iowa	7,161,310	1.7	11,706,402	2.2
10. Kansas	6,245,508	1.5	9,292,222	1.7
Whole United States	415,842,698	100.0	$532,314,117	100.0

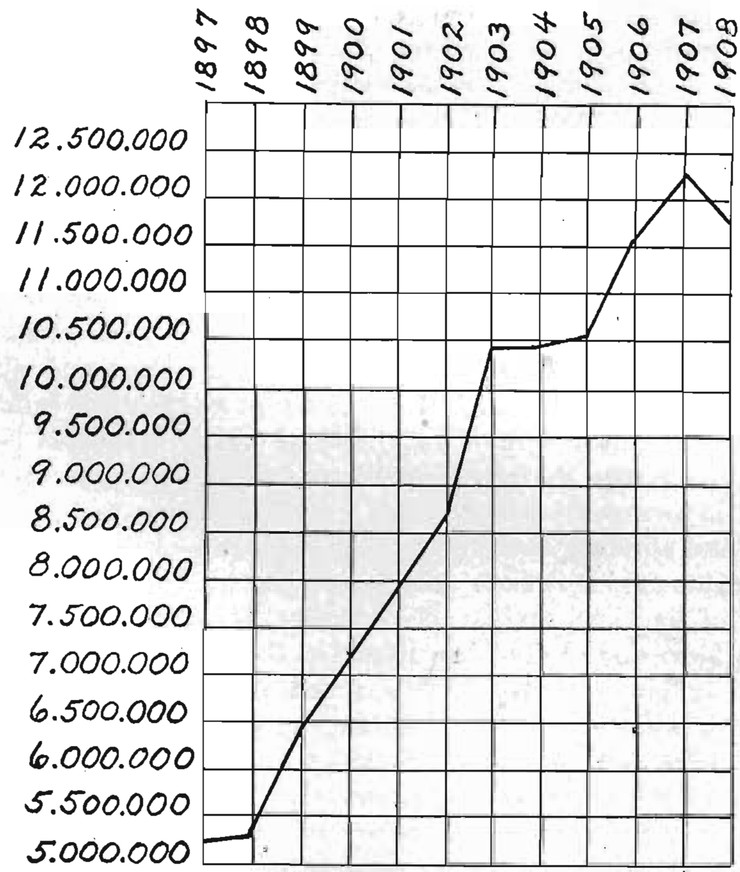

Figure 104. Diagram showing value of coal production from 1897 to 1908.

CHAPTER IV

GENERAL SECTION OF THE DES MOINES STAGE OF IOWA

BY JAMES H. LEES.

It has been already emphasized in preceding pages of this report that the strata of the Des Moines stage present such rapid variations that a close correlation of beds and horizons as developed in different areas of the Des Moines Measures is impossible. Hence it will be understood that the accompanying general section of the Des Moines stage or Lower Coal Measures is intended to represent in very broad outline only the succession of these beds as they are exposed in central Iowa. It is without question true that only in rare cases are beds which are developed in one locality to be identified with those which occur at other places some distance away. Thus the Chariton conglomerate of Appanoose county cannot be considered as belonging to the same beds as the fragmentary limestones and ripple-marked sandstones of similar age in Dallas and Guthrie counties. But the presence of these beds in these widely separated localities shows that the same conditions which were prevalent in what is now southeastern Iowa were also active to the northwest and possibly elsewhere within the area now covered by the sediments of this period. The same situation holds good for the coals of the time. While the individual beds are in most cases quite local and limited in extent yet they usually lie in somewhat definite horizons. This indicates that while the coal swamps were relatively small they were fairly abundant at a given time and the conditions which favored the accumulation of the plant remains were widespread. This is of necessity true since plant growth and the factors which favor the preservation and purity of vegetable remains as coal are dependent upon climatic and crustal conditions. These conditions are more or less uniform over extensive territories and for considerable periods of time. As an instance of this the peat bogs of northern Iowa and other regions may be cited. These speak of conditions which have been stable for thousands of years, ever since the retreat of the last glacier from the surface of the United States. These bogs also serve to illustrate the situation of the beds of coal—basins of variable size and extent separated by considerable stretches of barren territory.

The beds of the Des Moines stage are usually divided in a broad way into three general divisions. These, as indicated in the section, are, from above downward, the Pleasanton, the Appanoose, with its equivalent beds farther northwest, and the Cherokee. Of these three the lower division, the Cherokee, is the most important, in Iowa as well as in Missouri and Kansas. This is true not only as regards areal extent, but still more markedly from an economic standpoint, since it is said that from eighty to ninety per cent of the coal mined in the Western Interior coal field comes from this member of the Lower Coal Measures. It will be seen from the section that shales are the preponderating element in this division, while sandstones are also quite important. Coal beds and fire clays play a minor part, although economically the former are exceedingly important. All these beds are wonderfully irregular in distribution. They thicken and thin with amazing rapidity and grade from one to another horizontally as well as vertically in a way to puzzle the most experienced of drillers as well as of geologists. The beds of coal vary in thickness up to seven feet with an average of about four feet. Their areal extent is usually not above a few hundred acres and many of them are much below this maximum. Many of them lie in depressions in the Saint Louis limestone and their limits are determined by this formation. The Cherokee beds form the eastern line of outcrop of the Lower Coal Measures from Van Buren to Webster counties. Their maximum thickness will probably average 500 feet, although over most of their area they are considerably thinner. The numerous outliers of Des Moines beds which are scattered over the eastern part of Iowa probably belong with the lower phase. For the most part these are related to the Iowa coal field, although a few, notably the large area in Muscatine and Scott counties, are extensions of the Illinois field.

The Appanoose formation is typically developed in Appanoose and neighboring counties, as well as across the state line in Missouri. The beds composing this division are much more regular in structure than those underlying them, and the coals, while thinner, are more continuous and dependable. The most important of these coals is the Mystic seam, which underlies an area of about 1,500 square miles in the two states. Although only about thirty inches thick on the average its persistency enables it to be economically and profitably mined while other coals as thick but occurring under less favorable conditions are of necessity left to supply more urgent needs.

Accompanying this coal seam are several relatively thin limestone beds marked, like the coal, by great continuity and uniformity of character. Some shales and a conglomerate are also present. As has already been indicated there are in several counties along the western exposure of the Lower Coal Measures, beds which correspond stratigraphically to these just described. If the correlation made in the accompanying section is correct the correspondence of strata is quite close and indicates more widespread uniformity of conditions than prevailed during Cherokee times. None of the coals of these western counties, however, rank in importance with the Mystic seam.

The upper division of the Des Moines, the Pleasanton, is not of great importance in Iowa. While in Kansas these beds attain a thickness of about 200 feet and carry some important coal seams, they thin to the north and in Iowa are characteristically barren of coal and scarcely distinguishable from the next lower division. They thin rapidly in Guthrie county and probably do not extend beyond the northern limit of this county.

It is not to be understood that these three divisions are sharply set off one from the other, for they are for the most part conformable each to each and hence there are no clear dividing lines. The divisions are made because each phase exhibits certain well-marked features which set it off in a general way from the others.

In the section certain counties are given with each number of the series to indicate where these members are best developed. They also indicate the correlation of beds which seems most probable. Of course the lower beds or their equivalents will pass under the next succeeding ones to the west and may be penetrated here by deep drillings. As coal prospecting is carried to deeper and deeper levels in the western portions of the coal field, those horizons which have proved so productive in the eastern counties are being reached and proven to be rich in their coal content. Naturally the Coal Measures thicken westward from their eastern outcrop and this thickening is maintained at least as far west as the margin of the Missouri and Cretaceous strata where these overlie the Des Moines beds. The thicknesses given for the various members represent their maximum and minimum development in the various parts of their exposures. The total thickness of the Des Moines stage is probably about one-half the maximum here given, or 750 feet. However, in few localities where the entire body of sediments has been penetrated is this maximum approached. Most of these show about 500-600 feet as belonging to this stage.

Attention is again called to the fact that the correlations here given are general and tentative. Only the important coal horizons are noted although many drill holes and other sections show from four to eight, ten or even twelve seams in vertical series. The succession of strata indicated is such as would be encountered in crossing the coal field from west to east rather than in penetrating the series from above downward at any given locality, although the correspondence would doubtless hold good to a fair extent even in the latter case.

		FEET.
32.	Sandstone, sandy shales and shales, with occasional limestone bands, one quite persistent, a little above the middle of the bed. These beds appear to thicken toward the south and west (equivalent of Pleasanton shales of Missouri and Kansas)	30 to 100
31.	Coal, the Lonsdale seam, sometimes divided by one or two clay partings	1 to 2½
	Warren, Guthrie, Dallas, Madison. (Nos. 31 to 23 constitute the equivalent of the Appanoose formation of southern Iowa and the Henrietta formation of Missouri. The Appanoose formation is marked by great persistence of the strata.)	

30. Shale, variegated, in places arenaceous, with very persistent seams of limestone and sandstone, a few inches to several feet in thickness................................25 to 100
Warren, Dallas, Madison, Guthrie.

29. Coal, in places split up by thin beds of shale, fire clay, etc. ....1 to 3
Guthrie, Warren, Madison.

28. Fire clay ....3 to 13
Warren, Guthrie.

27. Chariton conglomerate, in several beds alternatingly coarse and fine in character, the former more typical. Pebbles are chiefly limestone, with coal fragments and fossils, embedded in a matrix in part arenaceous, in part magnesio-calcareous ....15 to 25
Appanoose, Monroe. In Guthrie county one of the limestones of No. 26 shows rolled pebbles and the sandstones are ripple-marked, showing conditions similar to those which formed the Chariton conglomerate of the southeast.

26. Shales and limestones. In Appanoose county the shales are variable in color, gray to black, some arenaceous, bituminous or pyritiferous, in beds one to thirty feet thick; the limestones are gray, subcrystalline, in beds one to ten feet thick. In Dallas are two beds of sandstone, one to twenty feet thick and three or four persistent bands of limestone, some fragmentary and fossiliferous, one to four feet thick. In Guthrie there are thin limestone beds with shales and a heavy bed of sandstone.......................50 to 100
Appanoose, Dallas, Guthrie, Madison, Warren.

25. Coal, in Appanoose county the Mystic seam, one and one-half to three feet thick, usually divided by one or two clay partings two to six inches thick; in Dallas and Guthrie the Marshall seam, six to twenty inches thick......½ to 3
Appanoose, Dallas, Guthrie, Greene, Warren, Madison, perhaps represented in Polk by one of the thin seams above the "first vein."

24. Fire clay ....1 to 8
Appanoose, Guthrie, Madison, Polk.

23. Limestone, "bottom-rock," in Appanoose county one to five feet thick; in Dallas and Guthrie two beds alternating with heavy beds of shale, average..................15 to 35
Appanoose, Dallas, Guthrie, Warren.

22. Shales, sandstones, limestones; shales diversified, red, blue, gray, some fossiliferous bands, some transitional from sandstone, some sandstones heavily bedded. Limestone sometimes forming a "cap rock"..................25 to 130
Warren, Dallas, Polk, Guthrie, Boone.

21. Coal, in Dallas and Guthrie, the Redfield seam; in Polk probably one of the thin upper seams..............1 to 5
Warren, Dallas, Polk, Guthrie, Greene. Perhaps present in Boone as the upper horizon.

20. Fire clay ....1 to 5
Polk, Guthrie, Boone. The numbers below and also probably those from 22 to 20 correspond in general position and character to the Cherokee shales of Kansas.

19. Shales and sandstones alternating, the shale beds from two to twenty-five feet thick, the sandstones from two to five. Some calcareous layers and true limestones locally developed. Several thin veins of coal accompanied by beds of fire clay are present locally...................25 to 150
Appanoose, Monroe, Wapello, Polk, Dallas, Guthrie, Webster Boone.

18. Coal, doubtless represented in different counties by various seams. "First vein" of Polk county. Perhaps "upper vein" of Boone county where it is sometimes bipartite ....1 to 6
Appanoose, Warren, Guthrie, Dallas, Greene, Webster. The coal beds of Webster county are local. They may belong in this part of the Des Moines stage.

17. Fire clay ....1 to 15+
Polk, Warren, Webster, Boone.

16. Shales, black, light-colored, etc., limestone, in thin layers, sandstone ....25 to 80
Polk, Dallas, Guthrie, Webster, Boone.

15. Coal, "second vein" of Polk county...................2 to 5
Dallas, Guthrie, Webster, perhaps lower vein of Boone.

14. Fire clay ....1 to 8
Polk, Guthrie, Dallas, Webster, Boone.

13. Shales, black to gray, sandstone; thin bands of limestone ....20 to 70

12. Coal, "third vein" of Polk county, in places separated by bands of pyrite or shale. Probably deeper beds of Dallas and Guthrie. Perhaps represented in Webster county 3 to 8

11. Fire clay ....1 to 6
Polk, Dallas, Webster.

10. Shale, vari-colored; sandstone, ferruginous, etc., limestone locally developed................................5 to 50
Jefferson, Hardin, Polk, Wapello, Guthrie, Webster.

9. Shales, variegated, in places arenaceous; fire clay; in places some relatively thin seams of coal in the shales; local layers of limestone and sandstone...............25 to 180
Warren, Appanoose, Mahaska, Jefferson, Monroe, Polk, Jasper.

8. "Cap rock," an arenaceous limestone, locally developed . . 0 to 2
Jasper, Wapello.

7. Coal, in places a number of seams from a few inches to two feet thick, separated by a few to many feet of shale and sandstone of the overlying and underlying members . . 1 to 4
Wapello, Jefferson, Marshall, Warren, Jasper, Mahaska, Monroe, Appanoose.

6. Shales, black, gray, blue, etc. In some places sandstone layers are intercalated and locally a thin limestone bed is present . . . . 10 to 130
Appanoose, Wapello, Jefferson, Keokuk, Van Buren, Monroe, Warren.

5. "Cap rock," developed in places . . . . 1 to 2
Jasper, Wapello, Keokuk, Marion.

4. Coal; in places two or more seams are present, divided by several feet of shale. In places rests directly on St. Louis limestone . . . . 1 to 7
Keokuk, Van Buren, Jefferson, Mahaska, Wapello, Monroe, Appanoose.

3. Fire clay, in places rests directly on St. Louis limestone. In places absent . . . . 2 to 15
Van Buren, Keokuk, Wapello, Mahaska, Monroe.

2. Shales, of various colors, in places arenaceous. Locally true sandstones are developed as intercalated layers. In places all are absent . . . . 10 to 100
Van Buren, Wapello, Appanoose.

1. Sandstone, in places a gradation from arenaceous shales, not always present . . . . 0 to 25
Van Buren, Keokuk, Appanoose, Wapello.

THE CARBONIFEROUS SECTION OF SOUTHWESTERN IOWA

BY

GEORGE L. SMITH, M. D.

The Carboniferous Section of Southwestern Iowa

BY GEORGE L. SMITH, M. D.

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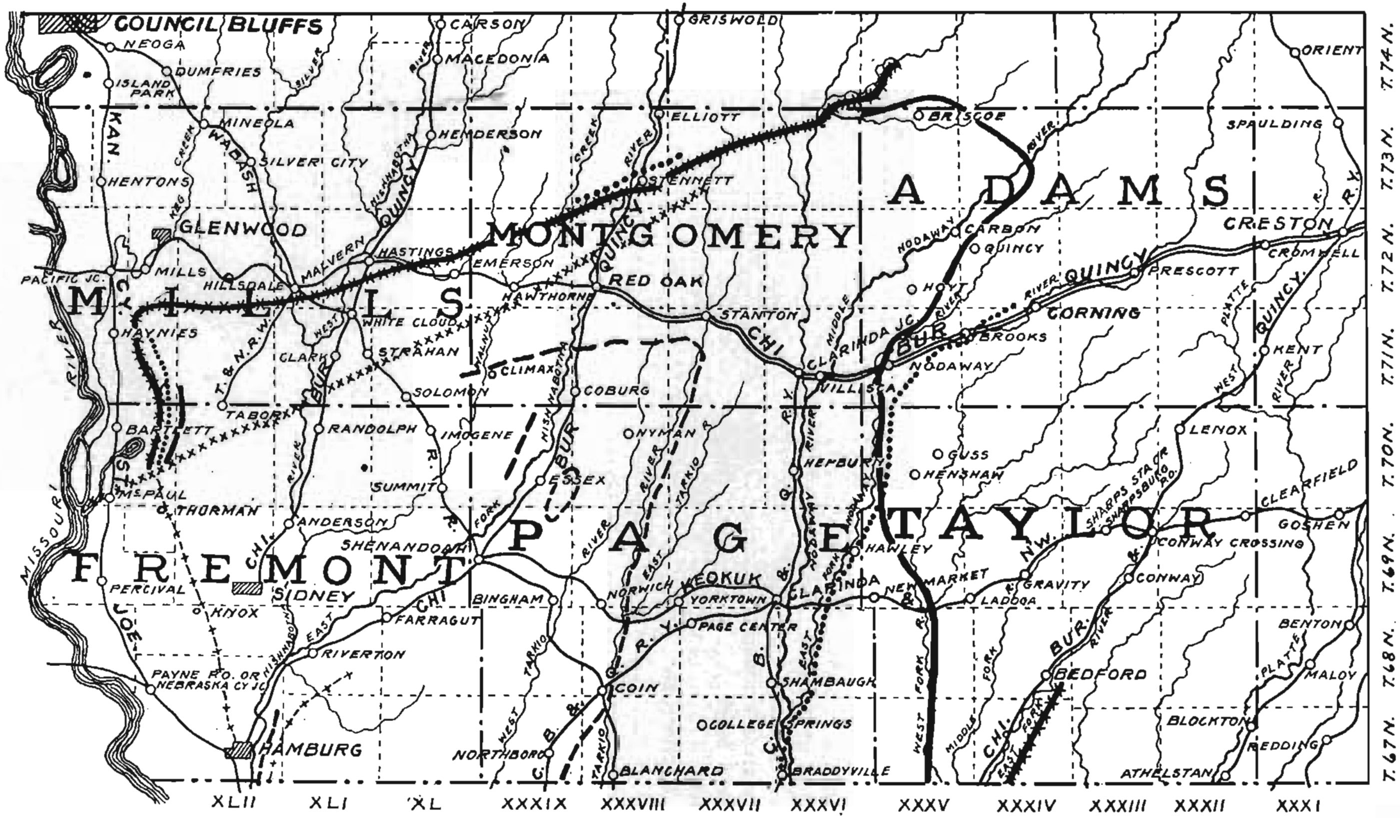


+–+–+ Mc KISSICKS GROVE SHALES.
— — — TARKIO LIMESTONES.
——— NODAWAY COAL.
•••••••• BRADDYVILLE LIMESTONES.
–x–x–x– FORBES LIMESTONE.
+ + + + LINE OF FAULT AT WILSON SECTION, PASSING INTO AN ANTICLINE TO THE NORTHEAST.

Map of southwestern Iowa showing outcrop of geological formations.

CHAPTER V

THE CARBONIFEROUS SECTION OF SOUTHWESTERN IOWA

INTRODUCTION

It is important from a scientific as well as an economic standpoint that an accurate and complete section of the Carboniferous of southwestern Iowa be made. Moreover recent investigation has shown that instead of being simple in its structure, deformations important and unusual for Iowa exist in this portion of the state.

Many prominent geologists have been workers in this field and have come to different conclusions as to the thickness and succession of the strata. There also has been in the last few years a great development of the coal mining industry and more than three hundred men are now employed in mines opened in the Nodaway coal seam in Adams, Page, and Taylor counties.

In the interest of this industry and for the guidance of prospectors in search of coal the stratigraphy and extent of this coal field should, as far as possible, be accurately worked out and published. To this end, in the preparation of this paper every effort has been made to avoid inaccuracies, and while minor changes may have to be made, it is believed that as a whole the results arrived at will be found to be substantially correct. All the critically important exposures have been examined in company with Professor Calvin, and the correlations arrived at by stratigraphy in nearly all instances have been confirmed by paleontological evidence.

AREA

The area covered by this report includes the six counties, Adams, Montgomery, Mills, Fremont, Page, and Taylor, situated in the southwestern corner of the state. It is bounded on the south by the state of Missouri and on the west by the Missouri river. It extends east from the Missouri river an average of seventy-five miles and north of the south boundary of the state forty miles, and contains approximately 3,000 square miles. It is drained by several considerable streams flowing to the southwest, all being tributary to the Missouri river. Commencing at the eastern boundary of the area and proceeding to the west we have the East and West Forks of the One Hundred and Two river, the many different branches of the Nodaway river, the two Tarkio creeks, the East Nishnabotna river, the West Nishnabotna river with its branches Walnut and Silver creeks, and Keg creek. Outside of the level river bottom lands the surface is quite undulating, the river valleys being excavated to the depth of one or two hundred feet.

GENERAL RELATIONS OF STRATA

In only a few instances have the stratified rocks influenced the topography of the country, since the stream erosion has been wholly in the Pleistocene, which is of considerable thickness. In many places on the divides between the streams it reaches to the depth of 200 feet.

The superficial loess is only a few feet in thickness in the eastern portion of the district, but this increases to the west until it reaches over one hundred feet in the Missouri river bluffs. In fact, there are exposures of twice that thickness, a great part of which, however, is caused by landslides in the steep face of the bluffs. In the bluffs of the Missouri river exposures of the drift are rare, and are not more than two or three feet in thickness. This great thickness of the loess does not reach much east of the West Nishnabotna river, where it becomes much reduced. Eastward of this river the drift deposits are often one to two hundred feet thick on the divides between the streams and in many cases reach below the water level in the adjacent rivers.

In the field work the want of a topographic map has often been felt, as the correlation of different exposures but a few miles apart was rendered difficult by not knowing the exact elevation of each. This difficulty is further increased in places by the heavy dip and faulting of the strata.

Lying unconformably on the Carboniferous in the northeast corner of Mills, nearly the whole of Montgomery, and the northwestern part of Adams counties are outliers of Cretaceous sandstones and shales, some of which reach the thickness of at least one hundred feet. Being composed of soft and incoherent materials they do not usually modify the topography.

The Missouri of southwestern Iowa is composed of shales, limestones and limited amounts of sandstone. The shales, which comprise much the greater part of the strata, are generally calcareous, so much so that even those in immediate contact with the coals effervesce readily with acid. The limestones occur in layers from an inch or two in thickness to ledges twenty feet thick. Usually the limestones are highly fossiliferous. In all the Coal Measures exposures of Adams, Montgomery, Page, and Taylor counties not a single sandstone is to be found. Deep drillings also show a total absence of sandstone in the Missouri in these counties. The only sandstone known in the Missouri of Page county is in the Johnston coal mine shaft west of Clarinda, where there are in the shales eighty feet above the Nodaway coal two thin sandstones a few inches thick, divided by a foot of shale. In Fremont county at the summit of the Carboniferous of Iowa there is found a conspicuous sandstone that is of great service in correlation. In the Missouri a large amount of the strata is difficult to classify, as it is often hard to state whether a certain rock is a limestone or a shale. Different observers are much governed by the personal equation. By the older geologists strata of this description were called marls, by more recent observers impure limestones or calcareous shales. In nearly all instances in weathering they break down into clay and should be classified as calcareous shales. Likewise it is often difficult to state whether a rock is a shaly sandstone or a sandy shale. In Broadhead's sections many sandstones are given which the writer would without hesitation pronounce to be sandy shales. In the Missouri the different strata are very persistent, especially along the strike, for miles showing but little change, and hence correlations can be made with confidence. Natural outcrops are few and are confined to the vicinity of the streams. This requires that wide correlations be made and many local dips complicate the situation. Paleontology affords much aid but the same fossils are found throughout the whole series of strata and the main dependence must be upon stratigraphy.

PREVIOUS GEOLOGICAL WORK

Nearly forty years ago C. A. White surveyed this part of Iowa and his Report of 1870 has been of much use in giving sections of outcrops that at the present time are much obscured. Reports have been published by the present Iowa Geological Survey on Montgomery county by E. H. Lonsdale, Page county by S. Calvin, and Mills and Fremont counties by J. A. Udden. These have been of much service and have been freely laid under contribution.

In considering the stratigraphy of a region it is indispensable that some standard classification be used and the General Section given by C. R. Keyes in his paper "Coal Measures of the Western Interior Basin," Volume 7, Proceedings Iowa Academy of Science, will be used with slight modifications. This section is believed to be the most accurate and satisfactory of any heretofore published on the Upper Coal Measure section from Kansas City to Omaha. The paper by J. E. Todd, "Some Variant Conclusions in Iowa Geology," Volume 13, Proceedings Iowa Academy of Science, describing the remarkable displacement of strata at Lake Wabonsie in Fremont county, is of great value in calling attention to an unusual feature of Iowa geology not found elsewhere in the state. Recent examinations of the exposures at Lake Wabonsie and in the vicinity of Thurman confirm the views of Todd and show that a short distance south of the Wilson section of White a fault of about 300 feet throw with an uplift to the north is present. In the same paper is given a general section of the Carboniferous as seen in natural outcrops in southwestern Iowa on the Missouri river, which agrees well with sections made from exposures examined farther east. This section of Todd's will be regarded as a type in the different correlations. Of the greatest aid and without which it would have been almost impossible to write this report has been the "Geology of Northwestern Missouri," in Part 2, Geological Survey of Missouri, "Iron Ores and Coal Fields," 1872, by G. C. Broadhead. In this report the author gives a section of the Upper Carboniferous from Kansas City to City Bluffs, now Burlington Junction, following the Missouri and Nodaway rivers, also a section of the strata of Atchison county, Missouri. It has been possible from exposures in Iowa to connect the City Bluffs beds with the Atchison county group, and complete the Missouri section to the summit of the Carboniferous in that state. This section by Broadhead is one of the earliest published and should be given full recognition by succeeding geologists. Many references will be made to this section and wherever it can be made applicable his geographic names will be used. Broadhead's section goes into much detail and many beds given in it are probably of only local importance. It is also possible there is some duplication of strata. Like nearly all sections made from exposures of the strata it shows much excess in thickness over what is found in core drillings. Broadhead gives the total thickness of the Upper Coal Measures in northwestern Missouri as being 1,317 feet, while in Iowa within a few miles of the south line of the state core drillings and outcrops show a thickness of about 950 feet, the Iowa section reaching fully as high as the section in Missouri.

In Iowa the area between the Westerville limestone, the uppermost of the Bethany limestones exposed on Grand river in Decatur county, and the Forbes limestone exposed on the East Fork river at Bedford is so deeply covered by the Pleistocene that it is almost devoid of exposures of the stratified rocks. On this account it would be impossible to make the connection between these two limestones without the aid of Broadhead's section and the records of deep core drillings.

GENERAL CHARACTER OF THE MISSOURI STAGE

In the six southwest counties of Iowa there is exposed in natural outcrop 400 feet of the Missouri, leaving 550 feet which is known only by deep core drilling. The Des Moines was penetrated 129 feet in the Clarinda drill hole, leaving an unknown amount beneath the bottom of the drilling. Deep core drill holes have been put down at Carbon, Clarinda, Coin, College Springs and Hamburg. The records of those at Clarinda, Coin, and College

Springs are available and will be correlated with the general section. At Glenwood two wells 2,000 feet deep have been drilled by the state of Iowa. This drilling was done by the cable rig method and the records of the two wells are not in agreement. Professor W. H. Norton gives the record of the first well in Volume VI, Iowa Geological Reports, and summarizes the formations as follows:

	THICKNESS IN FEET.
Pleistocene	175
Missouri	670
Des Moines	390
Mississippian	230
Devonian	135
Silurian	400

The first stratified rocks found beneath the Pleistocene at Glenwood are evidently the Plattsmouth limestones.

The general section of Keyes for the Missouri is as follows and will be correlated with Broadhead's section in parallel columns.

KEYES' GENERAL SECTION OF THE MISSOURI CORRELATED WITH BROADHEAD'S GENERAL SECTION FROM KANSAS CITY TO CITY BLUFFS, TOGETHER WITH THE ATCHISON COUNTY GROUP

KEYES.	THICKNESS IN FEET.	NUMBERS.	BROADHEAD.	THICKNESS IN FEET.
Atchison shales	500		Atchison county group	180
		224-216.	City Bluffs beds	105
		215.	Nodaway coal	
		214-187.	Limestones and shales	67
Forbes limestone	30	186.	Forbes limestone	15
Platte shales	150	185-153.	Shales, thin limestones and sandstones	179
Plattsmouth limestones	30	152-150.	Limestone	38
Lawrence shales	300	149-122.	Shales, thin limestones and sandstones	235
		121.	Limestone	18
		120-109.	Shales and sandstones	121
Stanton limestones	35	108.	Plattsburg limestone	18
Parkville shales	100	107- 99.	Sandstone, thin limestones and shales	83
Iola limestone	50	98.	Limestone	30
Thayer shales	75	97- 91.	Shales with two limestones	40
Bethany limestones	100	90- 74.	Limestones with interbedded shales	126
Total	1400	Total		1255

Broadhead was unable to make the connection between the City Bluffs beds and the Atchison county group and supposed there was an interval of fifty feet between them. Recent investigation in Iowa shows that the Atchison county group comes immediately on the City Bluffs beds with little if any hiatus. Keyes states that according to deep drilling north of St. Joseph the Iola limestone fails, bringing the Thayer and Parkville shales into contact with each other. The Clarinda drilling corroborates this and Broadhead's name "Parkville" will be used for the united shales. On the Missouri river the Lawrence shales are divided near the middle by an important limestone, Broadhead's number 121, to which Keyes has given the name "Iatan." The shale member beneath the limestone he has named "The Weston Shale" and the one above "The Andrew Shale." These names, often used by Broadhead, will be adopted here. Broadhead repeatedly speaks of the Plattsburg limestone and as it is the Missouri river section instead of the Kansas section under consideration his name will be used instead of "Stanton" as being the most appropriate.

Keyes' section modified to meet the conditions found in Iowa is as follows:

Atchison shales.
Forbes limestone.
Platte shales.
Plattsmouth limestones.
Andrew shale.
Iatan limestone.
Weston shale.
Plattsburg limestone.
Parkville shale.
Bethany limestones.

Todd's general section of the Carboniferous of southwestern Iowa as exposed on the Missouri river gives more detail and as it is believed to be accurate it will be given and correlated with Keyes' general section.

TODD'S MISSOURI RIVER SECTION.

			THICKNESS IN FEET.
Atchison shales, 307 feet	16.	Shales with two limestones two and four feet thick	19
	15.	Micaceous sandstone	10
	14.	Shales with a thin limestone	39
	13.	Limestone	12
	12.	Shales with five thin limestones and four sandstones	185
	11.	Shales, limestones, and coal	12
	10.	Shales with three limestones	30
Forbes limestone	9.	Limestone	20
Platte shales, 69 feet	8.	Shales with two thin limestones	12
	7.	Sandstone	12
	6.	Shales with three or four limestones	45
Plattsmouth limestone, 39 feet	5.	Limestone	20
	4.	Shale	5
	3.	Sandstone	4
	2.	Limestone	10
Andrew shales, 25 feet	1.	Shale	25
		Total	460

The horizon of the Nyman coal is in the upper part of No. 14 and the coal in No. 11 is the Nodaway coal. The Platte shales contain a large amount of limestone and the deep drilling in Page county shows that these limestones amount to at least one-third of the total thickness of this member. One layer often rivals the Forbes limestone in magnitude. It will be noted that the Plattsmouth limestone is divided by sandstone and shale, and is thus a double limestone as is shown in all the deep drilling in Page county. It is equivalent to numbers 150-151-152 of Broadhead's section. Keyes suggests that eventually the Atchison shales may have possibly the same formational rank as the Des Moines.

Above the Nodaway coal in the Carboniferous of Iowa a great change in the character of the strata takes place. Below this coal, in the Missouri, nearly one-half of the section is composed of thick heavy limestone, which occurs in layers up to thirty feet in thickness. The shales, except those of the thick Andrew shales, are usually thin and calcareous. In the Clarinda drilling not a single sandstone was found in the Missouri. The Carboniferous above the Nodaway coal reaches a thickness of 300 feet but has less than fifteen feet of regular and persistent limestone layers. The City Bluffs beds immediately overlying the cap rock of the Nodaway coal are at least 200 feet thick, but are composed wholly of shales. Even the Tarkio limestones are interbedded with shales that amount to three-fourths of their total thickness.

The Atchison shales of Keyes should be divided into subordinate formations for facility of description. The Braddyville limestones, City Bluffs beds, and Tarkio limestones are terms used in the Iowa and Missouri Geological Reports and these will be used here, their limits fixed and the terms definitely correlated with each other.

The following names will be used for the different formations of the Atchison shales.

	THICKNESS IN FEET.
McKissicks Grove shales	75
Tarkio limestones	25
City Bluffs shales	210
Braddyville limestones	50
	360

Several years ago a core drilling was done at Clarinda in search of coal seams below the Nodaway coal, which is mined at that place. The core has been preserved and was examined and measured by A. G. Leonard and Geo. L. Smith and the record published in Volume XII, Iowa Geological Survey.

RECORD OF THE CLARINDA DIAMOND DRILL HOLE IN THE NORTHEAST PART OF TOWN CORRELATED WITH THE GENERAL SECTION (SE. ¼ OF SEC. 30, TWP. 69 N., R. XXXVI W.)

			THICKNESS FEET.	DEPTH FEET.	BROAD-HEAD'S NOS.
	109.	Drift	43	43	
	108.	Shale, blue	5	48	
	107.	Limestone	4	52	
	106.	Shale, black	1	53	
Nodaway coal	105.	Coal	1¾	54¾	215
Braddyville limestones, 42 feet	104.	Fire clay	2¼	57	
	103.	Shale, gray, calcareous and fossiliferous	17	74	
	102.	Shale, dark	2	76	
	101.	Limestone	2¾	78¾	
	100.	Shale, calcareous	1¼	80	
	99.	Limestone	6	86	
	98.	Shale, calcareous	1 2-3	87 2-3	
	97.	Limestone	3	90 2-3	
	96.	Shale	6	96 2-3	
	95.	Coal	1-3	97	
Forbes limestone, 18 feet	94.	Limestone	18	115	186
Platte shale, 86 feet	93.	Shale	2	117	
	92.	Limestone	2	119	
	91.	Shale, dark, calcareous	2	121	
	90.	Limestone	2	123	
	89.	Shale, calcareous	15	138	
	88.	Limestone	4	142	
	87.	Shale, dark blue	36	178	
	86.	Limestone	7	185	
	85.	Shale, black	1	186	
	84.	Limestone	3	189	
	83.	Shale, black	12	201	
Plattsmouth limestone, 40 feet	82.	Limestone	7	208	152
	81.	Shale, blue	1	209	
	80.	Limestone	2	211	
	79.	Shale, dark blue	8	219	
	78.	Limestone, carrying fusulinas	22	241	150
Andrew shales, 172 feet	77.	Shale, dark blue	4	245	
	76.	Shale, calcareous	16	261	
	75.	Limestone	6	267	
	74.	Shale, calcareous	11	278	
	73.	Shale, red, green and blue	22	300	
	72.	Limestone	1	301	
	71.	Shale, dark blue	93	394	
	70.	Limestone	4	398	
	69.	Shale, dark blue, calcareous in part	15	413	
Iatan limestone, 16 feet	68.	Limestone	16	429	121

				THICKNESS FEET.	DEPTH FEET.	BROADHEAD'S NOS.
Weston shales, 76 feet		67.	Shale, black and green	13	442	
		66.	Limestone	2	444	
		65.	Shale, black	16	460	
		64.	Limestone	1	461	
		63.	Shale, black	1	462	
		62.	Limestone	1	463	
		61.	Shale, green and black	6	469	
		60.	Coal	½	469½	
		59.	Shale, green and black	6½	476	
		58.	Limestone, impure, argillaceous	6	482	
		57.	Shale, black	13	495	
		56.	Limestone	1	496	
		55.	Shale, black	4	500	
		54.	Limestone	2	502	
		53.	Shale	3	505	
Plattsburg limestone, 19 feet		52.	Limestone	19	524	108
Parkville shales, 22 feet		51.	Shale, gray and black	4	528	
		50.	Limestone	1	529	
		49.	Shale	8	537	
		48.	Limestone, argillaceous	4	541	
		47.	Shale, green and black	5	546	
Bethany limestone, 165 feet	Westerville limestone	46.	Limestone	10	556	90
		45.	Shale, dark blue	16	572	
		44.	Limestone	4	576	
		43.	Shale, dark blue	2	578	
	De Kalb limestone	42.	Limestone	22	600	
		41.	Shale, black and green	10	610	
	Winterset limestone	40.	Limestone	31	641	
		39.	Shale, black	8	649	
		38.	Limestone	2	651	
		37.	Shale	2	653	
	Earlham limestone	36.	Limestone	13	666	
		35.	Shale, black	3	669	
		34.	Coal	5-6	669 5-6	
		33.	Fire clay	2 1-6	672	
	Fragmental limestone	32.	Limestone	9	681	
		31.	Shale	4	685	
		30.	Limestone	5	690	
		29.	Shale	13	703	
		28.	Limestone	6	709	74
		27.	Shale	1	710	
		26.	Limestone	1	711	

			THICKNESS FEET.	DEPTH FEET.	BROAD-HEAD'S NOS.
	25.	Shale, gray..........	4	715	
	24.	Sandstone, micaceous	7	722	
	23.	Shale, sandy........	25	747	
	22.	Sandstone	1	748	
	21.	Shale	5	753	
	20.	Coal	1	754	
	19.	Shale	1	755	
	18.	Limestone, argillaceous	3	758	
	17.	Shale	1	759	
	16.	Sandstone	4	763	
	15.	Shale, black.........	1	764	
Des Moines, 129 feet......	14.	Sandstone, sandy shale, fine, micaceous	19	783	
	13.	Shale	9	792	
	12.	Limestone	1	793	
	11.	Shale	4	797	
	10.	Limestone	6	803	
	9.	Shale	5	808	
	8.	Limestone	2	810	
	7.	Shale, black.........	3	813	
	6.	Coal	1-3	813 1-3	
	5.	Sandstone	7	820 1-3	
	4.	Limestone	5 2-3	826	
	3.	Shale	3	829	
	2.	Limestone	2	831	
	1.	Shale	9	840	

In this section the Bethany limestones with their interbedded shales reach a thickness of 165 feet. The same limestones in Decatur county, according to H. F. Bain, have a thickness of 171 feet. The coal No. 34 is also found beneath the Earlham limestone in both Madison and Decatur counties. The base of the Missouri is placed at No. 26, below which there is a change in the strata that can not be adequately described or shown in a published section. To the depth of 711 feet no sandstones or even arenaceous shales are shown, while in the lower part of the record they become an important part of it. The shales become arenaceous and bituminous and are different in appearance from those higher in the record. Much less limestone is shown and that which does occur is darker in color and more argillaceous than the upper limestones. Anyone conversant with the Carboniferous of Iowa would at once place all below No. 26 in the Des Moines.

STRATIGRAPHY OF THE MISSOURI STAGE

No core drilling in southwestern Iowa has been deep enough to pass through the whole thickness of the Des Moines. The record shows a thickness of 129 feet, leaving an unknown amount beneath the bottom of the drill hole. As all of the outcrops of the Carboniferous in southwestern Iowa are confined to the immediate valleys of the streams the different exposures will be traced on each from the south boundary of the state northward, beginning in the eastern part of the territory under consideration. The different outcrops in each valley will be described and at least one representative section will be given and correlated with the general section.

ONE HUNDRED AND TWO RIVER DRAINAGE.

At Bedford on the East Fork of the One Hundred and Two river a twenty-foot ledge of limestone has been quarried, but at the present time the quarry is abandoned and the quarry pit is filled with water. Only a few of the upper layers can now be seen. In the opinion of Professor Calvin this limestone is to be referred to the Forbes limestone. It is in the line of strike of this limestone in the state of Missouri and without doubt may be correlated with it.

West of Hopkins, Missouri, the Nodaway coal has been mined on the One Hundred and Two river within a few miles of the Iowa state line. Broadhead states that in Missouri the One Hundred and Two river is the eastern limit of the Nodaway coal. In Iowa the West Fork river is probably the eastern limit of the coal to at least a short distance north of New Market.

Commencing one-half mile east of New Market and extending to a short distance east of the West Fork river is an important coal mining locality that for many years has done a large shipping trade in the well known New Market coal. This coal is mined from the Nodaway coal seam, the only coal bed in southwestern Iowa which is workable at the present time.

NODAWAY COAL AT THE CAMPBELL MINES ONE MILE EAST OF NEW MARKET

	Feet.	Inches.
7. Shale, light gray	80	
6. Limestone, light blue, in two layers	3	
5. Shale, gray, nonlaminated, with nodules of impure limestone	2	6
4. Coal		18
3. Shale, light gray, laminated	1	6
2. Limestone		8
1. Shale, light blue	12	
Total	101	2

In the roof and bottom shales of the coal the following fossils have been found: *Enteletes hemiplicata, Dielasma bovidens, Productus semireticulatus, Ambocelia planoconvexa, Derbya crassa, Allorisma granosum,* Aviculopecten, Pinna, and many plant remains.

No. 2 is called a sandstone by the miners but samples collected in the mines show it to be limestone. The dip of the strata at the New Market mines is to the southeast. The coal seam reaches a short distance east of the West Fork river and there ends beneath the superficial deposits. The Nodaway coal probably does not continue far north of New Market until its line of outcrop passes over to the valley of the East Nodaway river.

NODAWAY RIVER DRAINAGE.

On the Nodaway river about ten miles south of the Iowa state line, near Burlington Junction, Missouri, is the exposure of the City Bluffs beds to which Broadhead often refers. This excellent outcrop of the shales between the Nodaway coal and the Tarkio limestones is the most extensive known and is the type locality of the City Bluffs shales. The following section is from Calvin.

SECTION NEAR BURLINGTON JUNCTION, MISSOURI

	Feet.	Inches.
20. Shale, blue	10	
19. Shale, yellowish green, calcareous		3
18. Shale, marly, concretionary	2	
17. Shale, bluish green, not calcareous	3	
16. Shale, yellowish, calcareous, concretionary	1	6
15. Shale, greenish blue	1	
14. Sandstone, calcareous, ferruginous		6

		Feet.	Inches.
13.	Shale, sandy, with septarian nodules in the upper part	10	
12.	Limestone, impure, with obscure impressions of fossils		2
11.	Shale, sandy	2	
10.	Limestone, impure, in thin bands alternating with sandy shale which carries septarian nodules near the bottom; fossiliférous	5	
9.	Shale, gray	3	
8.	Thin layer showing cone-in-cone at top and bottom, structureless in the middle		7
7.	Shale, gray, with occasional large septarian nodules	25	
6.	Calcareous band, fossiliferous		4
5.	Shale, dark, with some calcareous bands, fossiliferous near top; down to level of water in river	25	
4.	Shale below level of river	30	
3.	Cap rock, limestone	2	
2.	Shale	4	
1.	Coal, Nodaway	1	6
	Total	127	

On the Nodaway river at Braddyville, a short distance from the south boundary of the state, is an outcrop of a series of limestones and shales well known as the Braddyville limestones. Between the Forbes limestone and the Nodaway coal in the state of Missouri Broadhead gives a sequence of sixty-seven feet of limestones and shales. This interval is not well seen in the outcrop in Iowa but core drillings show a thickness of forty to sixty feet of these limestones with their interbedded shales. At the present time a large part of the outcrop is much obscured and Professor Calvin was unable to give as full a section as earlier observers. Broadhead gives a section that does not correspond with either White or Calvin, whose sections agree with each other except in some minor details. White's section giving layers both above and below that of Calvin's is used.

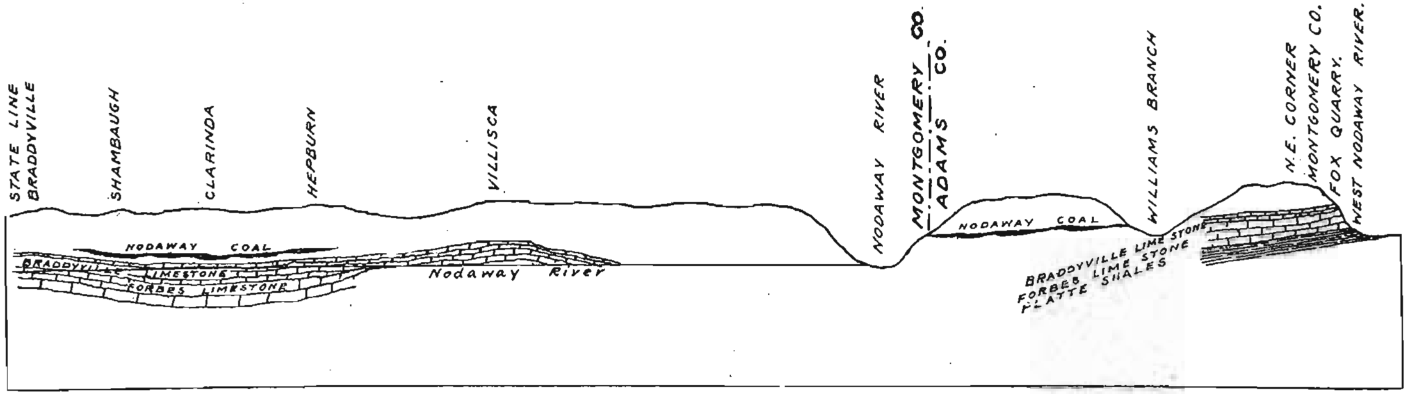
WHITE'S BRADDYVILLE SECTION

		Feet.	Inches.
7.	Yellowish shaly marl with occasional layers of impure limestone	5	6
6.	Layer of compact limestone		6
5.	Dark-colored carbonaceous shale passing upward into light blue clayey shale	2	6
4.	Layer of compact, bluish, impure limestone		6

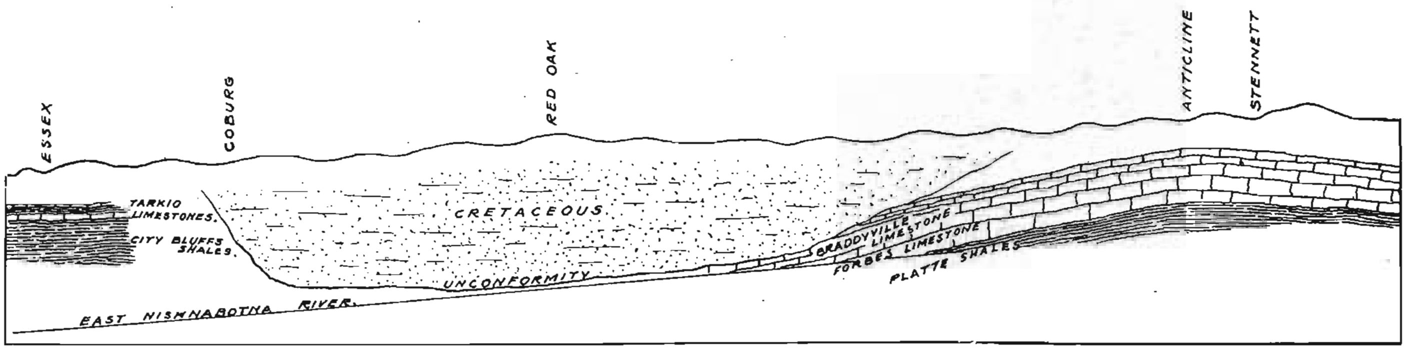
3. Bluish carbonaceous shale with thin calcareous seams	4	
2. Hard, bluish, impure limestone	2	6
1. Bluish concretionary and shaly limestone	1	6
Total	17	

This section is equivalent to numbers 99-103 of the Clarinda drill record. While the Braddyville section does not cover the whole interval between the Forbes limestone and the Nodaway coal, which at Clarinda is forty-two feet, at College Springs forty-five and one-half feet, and at Coin fifty-three feet, it is thought this series of limestones and shales should be raised to the rank of a formation. A complete exposure of these limestones and shales outcrops at Lake Wabonsie in Fremont county, but the term Wabonsie is preoccupied by the Wabaunsee of the Kansas geologists. It is therefore proposed that the limestones and shales between the Forbes limestone and the Nodaway coal be known by the name often used in the past, the Braddyville limestones.

The strata at Braddyville are at the crest of an anticline that has an amplitude of about twenty-five feet and cuts out the Nodaway coal at that place. The dip south into the state of Missouri is quite rapid and brings in the Nodaway coal within two miles of the state line. To the north the dip is but little more than the slope of the Nodaway river in the opposite direction so that the Nodaway coal appears low in the bank of the river at Shambaugh five miles north. The direction of this anticline is east of north and follows the course of the East Nodaway river. Exposures of the Braddyville limestone are found one mile north of Hawleyville and at Henshaw, where a dip of thirty-five feet in a quarter of a mile brings in the Nodaway coal at the same level as the limestone. This anticline is often spoken of as the Hawleyville anticline. Farther north in Adams county on the same stream the Nodaway coal is being mined northwest of the town of Nodaway. A short distance above this place the Braddyville limestone appears in the banks of the river and continues at intervals nearly to Corning above which place no outcrops are found on the East Nodaway river. At Shambaugh, five miles north of Braddyville, the Nodaway coal has been mined for many years. (Figure A, plate XX.)



A. Section, south to north from Braddyville to Fox quarry.



B. Section, south to north, Essex to Stennett.

One mile southeast of Clarinda in the east bank of the Nodaway river is an excellent exposure of the Nodaway coal which may be regarded as the type section of this coal.

NODAWAY COAL ONE MILE SOUTHEAST OF CLARINDA

		FEET.	INCHES.
10.	Yellow weathered shale	4	
9.	Black shale	1	
8.	Yellow shale	1	3
7.	Yellowish impure limestone in one or two layers	2	
6.	Black shale		6
5.	Gray shale, calcareous, nonlaminated and nonjointed; fossiliferous	2	
4.	Black shale		6
3.	Coal	1	6
2.	Drab shale, laminated	1	6
1.	Gray shale, down to water's edge	8	
	Total	22	3

At the south end of the exposure the black shale No. 4 wedges out and the gray shale No. 5 immediately overlies the coal. The gray, nonlaminated and nonjointed shale No. 5 is universally present in the roof shales of the Nodaway coal and by it and the contained fossils this coal horizon may be recognized with certainty. In Volume 2, "Coal Report," Iowa Geological Survey, this shale is classified as an impure limestone. It frequently has imbedded in it thin discontinuous layers and nodules of impure limestone that are called cement rock by the miners. The dip at Clarinda is on the west limb of the Hawleyville anticline and is very heavy to the west, amounting to sixty-five feet within two miles west of the Nodaway river.

Two miles west of Clarinda the coal is mined at the Johnston mine at the depth of 180 feet. Several mines are being actively worked in the vicinity of Clarinda and a large amount of coal is annually placed on the market. From Clarinda to Villisca no exposures of stratified rocks are known. No development of the Nodaway coal has been attempted in this distance, although the coal has been found two miles southwest of Hepburn at a depth of 130 feet. There has been an uprise of the strata in the vicinity of Villisca causing the Nodaway coal to be eroded at that place. A few feet of limestones and shales outcrop one mile east of the town, not sufficient for exact correlation, but without doubt they are to be referred to the Braddyville limestones. Eight miles north of Villisca the Nodaway coal sets in high in the hills along the Middle Nodaway river and continues on both sides of the valley nearly to Mount Etna above which place no exposures are known on this river.

At Carbon and in its vicinity a large mining industry has been in existence for nearly fifty years and the different openings in the coal are nearly innumerable. In an early day the coal was mined by drifts driven in from the outcrop, but at the present time shafts only are used. The coal seam at Carbon being the Nodaway coal differs from the type section near Clarinda only in having a bottom rock of limestone five feet in thickness.

NODAWAY COAL AT CARBON

	FEET.	INCHES.
7. Shales	20	
6. Limestone, cap rock	2	
5. Shale, black, bituminous		6
4. Shale, gray	1	6
3. Coal	1	6
2. Shale, gray	2	6
1. Limestone	5	
Total	33	

No exposures are known on the West Nodaway river above its mouth until Grant is reached, where there is an outcrop of limestone that in the opinion of Professor Calvin is the Forbes limestone. Less than one-half mile north of the northeast corner of Montgomery county is a better exposure of this limestone at the Fox quarry.

FOX QUARRY

	FEET.	INCHES.
12. Broken limestone, shales and residual clay	2	
11. Greenish shale	4	
10. Limestone, light gray to buff, two ledges	3	6
9. Calcareous shale	1	
8. Limestone, gray to brown	7	
7. Calcareous shale		5
6. Limestone, brown	1	
5. Shale, gray above, in lower portion bituminous	1	6
4. Limestone, dark gray		9

3. Shale, gray	1	4
2. Shale, lower part carbonaceous	2	6
1. Limestone		
Total	25	

Numbers 6-10 are the Forbes limestone, and numbers 1-5 are to be correlated with the Platte shales. Along the river for several miles above this place the same limestones are exposed at intervals.

One mile south of the Fox quarry on Williams branch the Nodaway coal was mined many years ago. Three miles east of the last named locality the coal is now being mined by shafts at Briscoe.

Several years ago parties at College Springs had core drilling done near that place in search of coal. Through the courtesy of the driller, Jesse Stump of Coin, the record of the drilling was secured.

RECORD OF CORE DRILLING SOUTHEAST OF COLLEGE SPRINGS. SOUTHEAST CORNER OF SEC. 17, AMITY TP., PAGE COUNTY, IOWA

67N, R37W

			FEET.	INCHES.
Pleistocene, 60 feet	63.	Soil	5	
	62.	White sand	2	
	61.	Yellow sand	4	
	60.	Clay and gravel	4	
	59.	Blue clay	25	6
	58.	Yellow clay	2	
	57.	Bowlders and gravel	7	
	56.	Yellow clay	5	
	55.	Blue clay	5	6
City Bluffs beds, 47 feet	54.	Limestone		8
	53.	Shale	7	8
	52.	Limestone		5
	51.	Shale	3	
	50.	Limestone		4
	49.	Shale	3	2
	48.	Calcareous shale	1	8
	47.	Shale		9
	46.	Limestone	1	4
	45.	Shale	28	
Nodaway coal	44.	Coal and shale in streaks	1	3

			Feet.	Inches.
Braddyville limestones, 45½ feet	43.	Shale	6	
	42.	Limestone	2	9
	41.	Shale		10
	40.	Limestone	2	6
	39.	Black shale	2	
	38.	Limestone	7	4
	37.	Shale	1	9
	36.	Limestone with shale partings	3	1
	35.	Shale	9	3
	34.	Limestone	1	6
	33.	Shale	4	1
	32.	Shaly limestone	1	
	31.	Shale	3	4
Forbes limestone, 9 feet 2 inches	30.	Limestone and flint	2	8
	29.	Limestone	6	6
Platte shales, 73½ feet	28.	Shale	2	6
	27.	Limestone	2	6
	26.	Black shale	1	4
	25.	Blue shale	1	6
	24.	Limestone	1	8
	23.	Shale	1	
	22.	Limestone	3	4
	21.	Shale	3	
	20.	Green shale	2	
	19.	Limestone	2	8
	18.	Green shale	3	
	17.	Limestone with shale partings	3	6
	16.	Green shale	3	
	15.	Gray shale	37	4
	14.	Limestone with shale partings	4	4
	13.	Shale	1	
Plattsmouth limestone, 26½ feet	12.	Limestone	4	2
	11.	Black shale		5
	10.	Limestone	1	
	9.	Black shale	4	3
	8.	Limestone	4	7
	7.	Black shale	1	4
	6.	Blue limestone	4	2
	5.	Shale		6
	4.	Limestone	1	4
	3.	Shale		8
	2.	Limestone with shale partings	2	9
	1.	Brown shale	1	3
		Total	260	

According to the record the limestone cap rock over the Nodaway coal is absent, which is unusual for this coal. Samples of the core from immediately above the coal prove it to be the gray calcareous non-laminated shale invariably found in the roof shales of the Nodaway coal. In this shale core were noted Aviculopecten and *Euomphalus rugosus*, usual fossils of this horizon. The bottom of the drilling evidently reaches into the Plattsmouth limestones.

TARKIO RIVER DRAINAGE.

A short distance north of the Chicago, Burlington and Quincy railroad bridge over Tarkio creek at Coin the Tarkio limestones are exposed on the east side of the creek well above the water level in the stream. The outcrop is much weathered and is obscured by landslides so that the succession of the strata cannot be well made out at this place. On the creek one-fourth mile above this outcrop a core drilling was done by the Black Diamond Coal Co. of Coin. In the record the terminology of the driller is unchanged.

DRILL HOLE ONE MILE NORTHEAST OF COIN, ONE-FOURTH MILE UP THE CREEK ABOVE THE PALMER EXPOSURE OF TARKIO LIMESTONE

		FEET.	INCHES.
24.	Clay	9	
23.	Bowlder	1	
22.	Light shale	16	8
21.	Gray shale	11	4
20.	Gray limestone, impure, shaly	9	6
19.	Gray shale	32	2
18.	Limestone, impure, shaly	6	
17.	Calcareous shale	2	
16.	Light shale	3	8
15.	Black shale	2	
14.	Coal		6
13.	Light shale	3	
12.	Black shale	2	8
11.	Gray limestone, impure, shaly	3	4
10.	Gray shale	8	
9.	Limestone, impure, shaly	2	
8.	Green shale	16	9
7.	Gray shale	37	3
6.	Gray limestone	1	2
5.	Gray shale	44	3
4.	Cap rock, limestone	4	10
3.	Black shale	4	
2.	Coal		18
1.	Light shale		10
	Total	223	5

At the time of the survey of Page county by Professor Calvin it was impossible to make the connection between the Nodaway coal and the Tarkio limestones, but the putting down of core drill holes and the sinking of shafts attending the development of the Nodaway coal at Coin renders it possible to fill the interval and complete the section. Number 22 in the drilling lies immediately below the lowest layer of the Tarkio limestones seen on the creek only a short distance away. The thick bed of shale that occupies the interval between the Nodaway coal and the Tarkio limestones reaches a thickness of 212 feet. This great body of shale, well known to the miners of southwestern Iowa as the "Big shale," should be raised to the rank of a formation and given a geographic name. Broadhead repeatedly speaks of the City Bluffs beds and gives a section of nearly one hundred feet of these shales near Burlington Junction, Missouri. Therefore it is proposed that the shale formation between the bottom shale of the Nodaway coal and the lowest layer of the Tarkio limestones be known by the old name of Broadhead's, the City Bluffs shale. It is evident that the Nodaway coal should be included in the overlying shales rather than in the Braddyville limestones. Two miles north of this locality a coal eight inches thick has been stripped low in the banks of the creek. This coal can be no other than number 14 in the drill record. It is also without doubt the same coal seam found in the Larrabee drilling northeast of Norwich. On a small creek just south of Coin a deep core drilling was carried to the depth of 450 feet in consequence of a rumor that a thick coal seam was to be found 150 feet below the Nodaway coal. The record is given below and correlated with the general section.

CORE DRILLING IN SOUTH PART OF COIN

			FEET.	INCHES.
Pleistocene, 32½ feet	51.	Surface clay	32	6
City Bluffs shales, 200 feet	50.	Gray shale	3	6
	49.	Yellow shale	2	
	48.	Gray shale	14	8
	47.	Yellow shale	11	9
	46.	Gray shale	28	4
	45.	Gray limestone	5	2
	44.	Light shale	5	6
	43.	Gray shale	1	6
	42.	Black shale	7	2
	41.	Light shale	29	5
	40.	Soft gray shale	8	4
	39.	Limestone		10
	38.	Gray shale	76	3
	37.	Gray limestone, cap rock	1	9
	36.	Gray shale	4	1
	35.	Coal		20

			Feet.	Inches.
Braddyville limestones, 53 feet	34.	Gray shale	10	8
	33.	Gray limestone	7	5
	32.	Black shale	2	
	31.	Limestone	1	2
	30.	Calcareous shale		6
	29.	Limestone		6
	28.	Calcareous shale		10
	27.	Soft limestone, shaly	4	6
	26.	Light shale	4	
	25.	Soft limestone, shaly	5	10
	24.	Gray shale	10	4
	23.	Limestone	1	4
	22.	Light gray shale	4	
Forbes limestones, 13½ feet	21.	Limestone	13	5
Platte shales, 84½ feet	20.	Black shale	5	2
	19.	Limestone	3	4
	18.	Gray shale	3	
	17.	Light shale	13	2
	16.	Limestone	4	1
	15.	Gray shale	26	10
	14.	Gray limestone	12	6
	13.	White limestone	6	11
	12.	Black shale		4
	11.	Gray shale	1	6
	10.	White limestone	1	5
	9.	Black shale	2	8
	8.	Blue-black shale	3	6
Plattsmouth limestones, 38 feet	7.	Limestone	12	11
	6.	Calcareous shale	4	6
	5.	Gray shale	10	7
	4.	Limestone	9	11
Andrew shales, 27½ feet	3.	Gray shale	22	2
	2.	Black shale	4	4
	1.	Limestone	1	
		Total	450	7

Since the discovery of coal at Coin several years ago a couple of shafts have been sunk and an important local trade supplied. The shafts are 230 feet deep and the coal is of much better thickness and quality than at its nearest outcrop at Shambaugh ten miles east.

During the past summer a new air shaft has been sunk at one of the mines and the excavated material from the shaft affords an excellent opportunity for the study of the paleontology of the City Bluffs shale. In the shales above the cap rock of the coal the most conspicuous feature is the great profusion of Bryozoa in the more calcareous shales. *Rhombopora lepidodendroides*, and the fan bryozoa *Septopora biserialis*, and *Polypora* *crassa*, are especially numerous. Aviculopectens are frequent throughout the whole thickness of the shales. Among the other fossils noted were *Productus semireticulatus, P. cora, P. costatus, P. nebrascensis, Chonetes granulifera, Athyris subtilita, Ambocelia planoconvexa, Derbya crassa, Spiriferina kentuckiensis, Enteletes hemiplicata, Dielasma bovidens, Allorisma subcuneatum, Nucula ventricosa, Pleurotomaria perhumerosa, P. tabulata, Bellerophon carbonarius, B. nodocarinatus, B. percarinatus, B. montfortianus, Euomphalus rugosus, Soleniscus brevis, Lophophyllum proliferum, Fistulipora nodulifera* and a small trilobite. The roof and bottom shales of the coal contain great numbers of plant remains, stems and leaves being abundant. Among the plants seen were Neuropteris, very common, Calamites, common and Pecopteris. In the roof shales were found *Derbya crassa, Ambocelia planoconvexa, Allorisma subcuneatum*, Aviculopectens and a Pinna, *Bellerophon carbonarius* and *Euomphalus rugosus*. In the Tarkio limestones at the old Palmer quarry were found *Productus semireticulatus, P. cora, P. pertenuis, P. longispinus, Athyris subtilita, Enteletes hemiplicata, Chonetes glabra, Derbya crassa, Myalina subquadrata, M. swallovi, M. perattenuata, Naticopsis altonensis*. The gray shales above the cap rock of the coal contain a great number of large septaria. One bed six feet thick was passed through in sinking the shafts at Coin. Probably some of the limestone layers in the drill records are of this character. The soft impure limestones are calcareous shales as is well shown in the outcrops of this shale bed. It will be noted that no sandstones are found in the City Bluffs shale at Coin.

NODAWAY COAL AT COIN

	FEET.	INCHES.
Limestone, cap rock, very hard, pinkish and crystalline	1	6
Shale, yellow	1	
Shale, gray, nonlaminated	2	6
Shale, black, bituminous, laminated		8
Coal		20
Shale, gray	10	
Total	17	4

Deep drilling south of Coin shows a rise of strata and the Tarkio limestones are absent in that direction. North of Coin the strata rise and the Tarkio limestones are frequently exposed in the hillsides of the creek.

Two miles northeast of Norwich many quarries in the limestones have been worked in past years. The following composite section by Professor Calvin of the different exposures in this vicinity may be taken as the type section of the Tarkio limestones.

TARKIO LIMESTONES NORTHEAST OF NORWICH

		FEET.	INCHES.
8.	Fusulina limestone	1	
7.	Shale	3 to 5	
6.	Limestone, soft		8
5.	Limestone, blue, hard and fine-grained	1	4
4.	Shale	12	
3.	Limestone, soft	1	6
2.	Shale	3	6
1.	Limestone, soft	2	
	Total	27	

The following fossils have been noted in the Tarkio limestones northeast of Norwich: *Fusulina cylindrica, Rhombopora lepidodendroides, Productus semireticulatus, P. cora, Enteletes hemiplicata, Chonetes granulifera, Athyris subtilita, Allorisma subcuneatum, Myalina subquadrata,* and a Pleurotomaria. The two lower soft impure limestones are not constant, as they often pass into a very calcareous shale. The layers do not wedge out but gradually grade into a shale. In this vicinity an upper thin coal seam has been worked by stripping, but its relation to the underlying limestone is not well shown. Two miles southeast of Nyman at the old Linquist mine both coal and limestone are well exposed in the same hillside.

COAL AT LINQUIST MINE

		FEET.	INCHES.
8.	Limestone, cap rock	3	
7.	Coal		10 to 15
6.	Shale	30	
5.	Fusulina limestone	1	
4.	Shale	3	
3.	Limestone, soft		8
2.	Limestone, blue		16
1.	Shale	6	
	Total	46	

In the cap rock, No. 8, *Spirifer cameratus* is abundant. The previous reports of the Iowa Geological Survey have named the coal, No. 7, the Linquist coal. This coal, the highest in the Carboniferous of Iowa, should be given a geographic name. In this locality the coal is generally known as the Nyman coal, which is believed to be the most appropriate name for it.

The extent of the Nyman coal on Tarkio creek is from east of Norwich thence north twelve miles to a short distance into Montgomery county. The Tarkio limestones are exposed at frequent intervals in the valley of Tarkio creek until within two miles of Stanton where they disappear high in the hillsides.

NISHNABOTNA RIVER DRAINAGE

No exposures of stratified rocks are known on the East Nishnabotna river above its mouth until the vicinity of Essex is reached. Two miles southeast of this place on Rocky branch is an excellent exposure of the Tarkio limestones. (Figure B, plate XX.)

TARKIO LIMESTONES NEAR ESSEX

		FEET.	INCHES.
7.	Fusulina limestone	1	
6.	Shale	3	
5.	Limestone, soft		8
4.	Shale		6
3.	Limestone, blue	1	4
2.	Shale, calcareous	7	
1.	Limestone, shaly, soft, impure	1	6
	Total	15	

The dip at this place is very heavy to the west.

Two miles north of Essex, in the hills on the west side of the East Nishnabotna river, the Tarkio limestones have been quarried on an extensive scale years ago. The face of the old quarry extends for upwards of one-half mile. At the present time the outcrop is much obscured and no detailed section can be given. From this last locality north to the northern boundary of Page county several outcrops of the limestone are to be found in the hills on the west side of the river. One mile south of the north county line at Franklin Grove the Nyman coal has been discovered in digging wells. The coal, however, is less than six inches in thickness.

From Coburg to Stennett the Carboniferous is deeply covered by the Cretaceous, which in places reaches a thickness of nearly one hundred feet. Carboniferous strata consisting of only single layers of limestone a foot or two thick, insufficient for correlation, are found at Coburg and one mile south of Red Oak.

The Forbes limestone and the basal portion of the Braddyville limestones with a few feet of the Platte shales are well exposed on both sides of the East Nishnabotna river at Stennett.

LIMESTONES AND SHALES AT STENNETT

	FEET.	INCHES.
13. Limestone, residual	5	6
12. Shale, calcareous		6
11. Limestone, gray, fine-textured	1	8
10. Shale, buff to gray, argillaceous	3	6
9. Limestone, variable, earthy below	5	
8. Shale, buff	1	
7. Limestone, blue above, cherty	6	
6. Shale parting		2
5. Limestone, variable	5	
4. Shale, argillaceous	1	6
3. Shale, black, bituminous	3	
2. Limestone, shaly	2	
1. Limestone	3	
Total	37	10

Numbers 1-4 belong with the Platte shales, numbers 5-9 are the Forbes limestones, above No. 9 is the lower part of the Braddyville limestones. A drift has been driven in the black shale No. 3 in search of coal, but without results. The different outcrops near Stennett for a distance of two miles have a heavy dip to the north. The line of disturbance if extended in a direction north of east through Jones Point on the Missouri river in Nebraska and south of the Wilson section at Lake Wabonsie in Fremont county would pass a short distance south of Stennett. The fault near Lake Wabonsie has, probably, in its eastward extension, become an anticline and the dip to the north at Stennett would indicate that the line of disturbance lies not far to the south of this place. The following fossils have been noted in the limestones at Stennett: *Fusulina cylindrica* in great profusion, Fenestella, plates and spines of Archæocidaris, *Spirifer cameratus, Meekella striatocostata, Orthis pecosi, Chonetes ver-*

ncuiliana, C. granulifera, Athyris subtilita, Productus semireticulatus, P. cora, P. costatus, Derbya crassa, Enteletes hemiplicata, Reticularia perplexa, Allorisma subcuneatum, Chaenomya minnehaha, Macrodon tenuistriatus, Bellerophon carbonarius, B. percarinatus and a Pleurotomaria.

No exposures of the Carboniferous are known on either Walnut creek or the West Nishnabotna river in Fremont county. The eastern half of this county is probably underlain immediately below heavy deposits of the Pleistocene by the City Bluffs shale, which being composed of soft and easily eroded material does not show in outcrops.

In the southwest corner of Montgomery county on Walnut creek at Climax is an exposure of limestones and shales much obscured at the present time. The following section is from Lonsdale.

LIMESTONES AND SHALES AT CLIMAX

	FEET.	INCHES.
6. Limestone, hard, drab, fine-textured	1	
5. Limestone and shale, marly	3	
4. Shale, argillaceous, gray	2	
3. Limestone, bluish, dull, earthy	1	
2. Shale, argillaceous, gray	1	
1. Limestone, blue, hard, dimension stone	1	6
Total	9	6

These limestones and shales can be referred to the Tarkio limestones, as they are in the line of strike of that formation and are only four miles distant from the exposures of these limestones on the East Nishnabotna river north of Essex. On Walnut creek five miles southwest of Stennett and in a line with the exposures at Grant, Stennett, and the Wilson section is an exposure of a nine-foot ledge of a very cherty limestone that without doubt is to be referred to the Forbes limestone. One mile south of Malvern on Silver creek the Forbes limestone is found as shown by the following section from Udden.

FORBES LIMESTONE ONE MILE SOUTH OF MALVERN

		Feet.	Inches.
6.	Shale, marly		6
5.	Limestone, grayish yellow, cherty	6	
4.	Limestone, grayish blue, compact		9
3.	Talus slope	2	
2.	Limestone, yellow, fragmental	2	
1.	Limestone, below water level of creek	3	
	Total	14	3

This outcrop is now much obscured, only number 5 being visible. Udden correctly correlates these limestones with the lower main limestone at the Wilson section.

Two miles south of Riverton on Mill creek is a critical exposure, as it is thought to be at the very summit of the Carboniferous in Iowa.

McKISSICKS GROVE SHALES ON MILL CREEK

		Feet.
6.	Shale, weathered, gray	10
5.	Limestone in five layers with shale partings. The upper layer, six inches thick, is a white and very hard limestone composed of fragments of shells and crinoid plates arranged in a horizontal position. The two lower layers, ten and four inches in thickness, are very dark, almost black limestones. They contain numerous round lumps of calcareous matter one-fourth inch in diameter	3
4.	Shale, calcareous, weathered yellow	3
3.	Shale, blue, contains several thin bands of sandstone; not well exposed	9
2.	Sandstone, blue, indurated, micaceous	2
1.	Shale, blue	8
	Total	35

Parties long resident in this vicinity report a seam of coal twenty feet below the sandstone. The following fossils were found in the limestone: *Fusulina cylindrica*, *Productus cora*, *Spirifer cameratus*, *Chonetes granulifera*, *C. glabra*, *Aviculopecten providencensis*, *Myalina swallovi* and *Bellerophon marcouanus*.

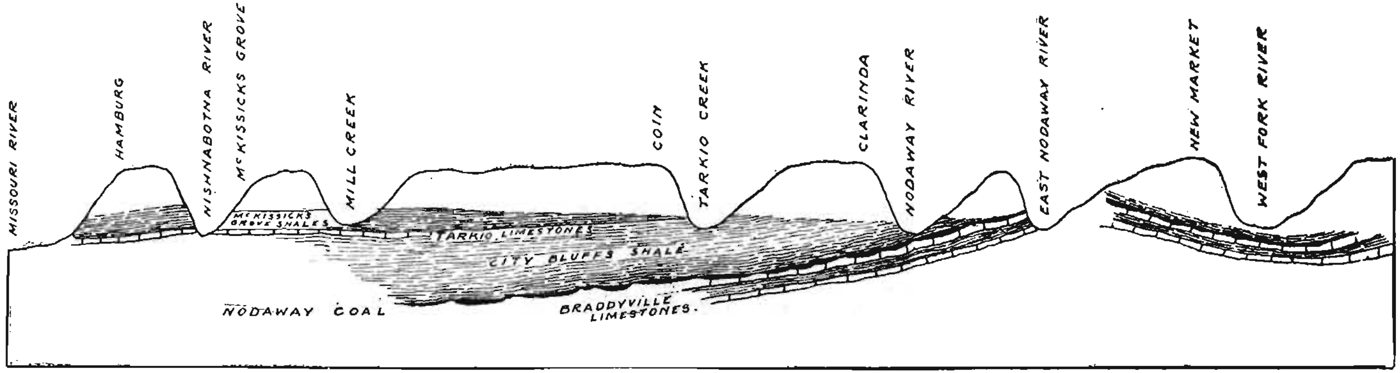
On a small creek in McKissicks Grove two miles northeast of Hamburg and about the same distance north of the south boundary of the state is one of the most extensive and important exposures in southwestern Iowa, showing the succession of strata above the Tarkio limestones to the last of the Carboniferous in Iowa. The different outcrops are seen on following the creek from the lower bridge on the bottom land to the forks of the creek and then up the north branch of the creek. The cap rock of the coal is also exposed under an old bridge on the south branch of the creek.

LIMESTONES AND SHALES AT McKISSICKS GROVE

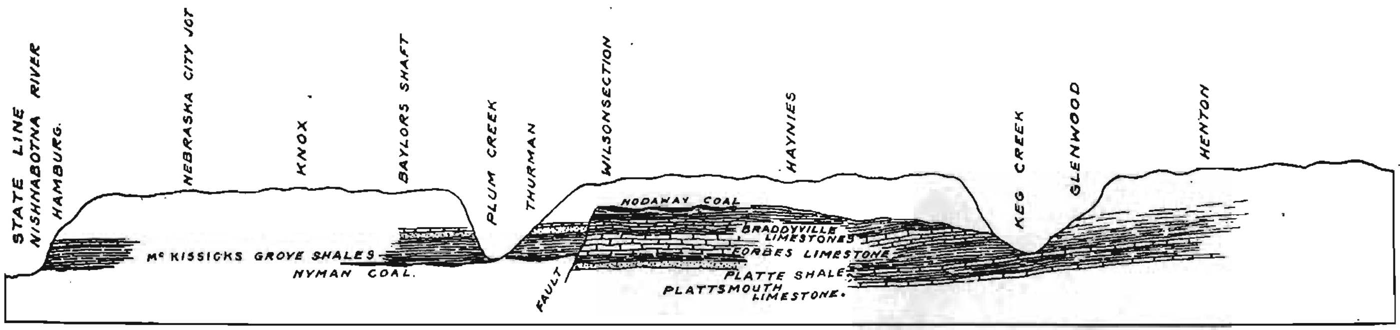
		FEET.	INCHES.
17.	Shale, gray	7	
16.	Limestone, weathered	1	
15.	Limestone, very dark, containing nodules about one-half inch in diameter	1	
14.	Shale, blue, sandy and micaceous, with several thin bands of sandstone	7	
13.	Sandstone, micaceous, blue weathering to yellow	3	
12.	Shale, gray	15	
11.	Limestone, compact, gray, with many specimens of *Productus semireticulatus*	1	
10.	Limestone, impure	1	
9.	Coal		9
8.	Shale	20	
7.	Limestone		6
6.	Shale, dark	3	6
5.	Limestone		6
4.	Shale, blue, weathering to yellow	8	
3.	Limestone in two or three heavy ledges crowded with very large specimens of *Fusulina cylindrica*, no other fossils recognized	4	
2.	Shale with occasional individuals of *Productus semireticulatus*	12	
1.	Limestone, dark gray	1	
	Total	86	3

Numbers 1-7 represent the Tarkio limestone, No. 9 is the Nyman coal and the upper part of the section is equivalent to the Mill creek section.

McKissicks Grove is a locality well known in southwestern Iowa and northwestern Missouri and has had much of historical interest in the early settlement of the country and during the civil war. The term Atchison could well be applied to the strata above the Tarkio limestones, but Broadhead's Atchison county group extends eighty feet below these limestones. Besides,



A. Section, west to east, from Hamburg to West Fork river.



B. Section, south to north, along the Missouri river bluffs.

Keyes has used the name Atchison to include all of the Missouri above the Forbes limestone to the Cottonwood limestone. The term McKissicks Grove shales can well be applied to the beds of the Missouri above the Tarkio limestones to the close of the Carboniferous as found in Iowa.

SANDSTONE AND SHALE ON SCHOOL GROUNDS AT HAMBURG

		FEET.
2.	Sandstone	3
1.	Shale, divided near the middle by a hard band three inches thick	20
	Total	23

The sandstone does not resemble the sandstone at McKissicks Grove, as it is of much coarser grain and contains but little mica. The underlying shale carries nodules of pyrite and many broken fragments of Aviculopectens, and has the appearance of some portions of the City Bluffs shale.

Nearly twenty years ago a core drilling one thousand feet deep was done a short distance north of Hamburg on the west side of the Nishnabotna river. The core has been lost and no record of the drilling has been preserved, but parties who were interested in the drilling state that the superficial deposits were seventy feet deep, and at ninety feet a seam of coal one foot thick was found. Udden gives the elevation of the surface where the drilling began at 998 feet A. T. The elevation of the base of the shales at the school grounds is approximately 935 feet, and the dip at this point, being strong to the north, would bring the shale down on the coal. The sandstone and shale at Hamburg can be correlated with the sandstone and shale at McKissicks Grove. According to the best information no other coal seams were found in this drilling.

MISSOURI RIVER BLUFFS.

Broadhead's Atchison county group will be given and correlated with the section found in Iowa. It will be noted Broadhead numbers the section from above downwards.

		Feet.	Inches.
1.	Bluff	250	
2.	Drift, thickness unknown beneath the bluff		
3.	Red shales	5	
4.	Sandstone and shales. Sandstone at top, upper three feet irregularly bedded and micaceous, green; below eight or ten feet, soft, brown; then thirty-five feet of shales and sandstone; red shales in upper part, thick bedded shales at bottom	47	
5.	Drab limestone, weathers brown		10
6.	Shaly limestone, contains fossils	3	2
7.	Blue concretionary limestone traversed by calc-spar veins	1	4
8.	Sandy shales or dark brown clay		2
9.	Impure coal and shales		2
10.	Ochery sandy shale		
11.	Sandy shales	22	
12.	Dark blue shaly limestone	1	6
13.	Red and green shales with nodules of limestone	1	6
14.	Limestone, upper part nodular, weathers brown, abounds in Fusulina	4	
15.	Blue and drab argillaceous shale	28	
16.	Bluish drab limestone	2	
17.	Blue fossiliferous shale		10
18.	Hard sandstone	2	6
19.	Soft sandstone	3	
20.	Calcareous sandstone		10
21.	Blue argillaceous shale, 6 to 13 feet	6	
22.	Fine-grained blue limestone	1	
23.	Shale	1	3
24.	Buff ochery decomposing limestone		10
25.	Buff and olive shale	2	
26.	Red shale	2	
27.	Clay and sandy shales	30	
28.	Shaly limestone		
	Total	417	

Below No. 14, which is the base of the Tarkio limestone, the section has a thickness of eighty feet. This added to one hundred and twenty-five feet of City Bluffs shale, exposed near Burlington Junction, gives a thickness of two hundred and five feet, about the normal thickness of this shale formation.

In this section Broadhead gives fifty feet of sandstones and shales above the Nyman coal No. 9 without any limestones corresponding to numbers 15 and 16 of the McKissicks Grove section. He gives a section at Halls bridge on the Nishnabotna river only a few miles south of the Iowa state line showing two limestones that are equivalent to these limestones.

SECTION AT HALLS BRIDGE, MISSOURI.

		FEET.
1.	Bluff	
2.	Hard silico-ferruginous limestone, weathers brown	1
3.	Sandstone, greenish drab, fine grained, slightly micaceous	3
4.	Coarse grained, brown and green silico-micaceous limestone	1
5.	Soft brown and buff sandstone	4
6.	Shales, the upper half sandy, the lower argillaceous	16
7.	Shales with nodules of brown and ferruginous limestone. No. 7 of general section	2
	Total	27

Broadhead also gives a section in the Missouri river bluffs at the state line:

		FEET.	INCHES.
1.	Ochery and blue banded clay shales in thin laminae. No. 5 of general section	2	
2.	Dark limestone, weathers brown		10
3.	Shaly limestone	2	
4.	Dark brown clay		2
5.	Coal		3
6.	Ochery sandy shales. No. 10 of general section	2	
7.	Ochery and blue sandy shales	17	
	Total	24	3

In the Missouri river bluffs north of Hamburg but few outcrops of stratified rocks are seen until within a couple of miles of Thurman. Three miles east of Nebraska City Junction is an exposure of sandstone above a few feet of shale, and a short distance south of Knox on a small stream that comes down out of the bluffs at this place is an outcrop of a three-foot ledge of limestone underlain by a sandstone that is not well exposed. Commencing two miles south of Thurman and extending north to the Mills county line is a series of exposures, the most important in southwestern Iowa, and one that affords a solution of the seeming inconsistencies found in the structure of the Carboniferous in this part of the state. Udden gives a composite section of the different exposures found two miles south of Thurman.

SECTION IN THE BLUFFS TWO MILES SOUTH OF THURMAN

		FEET.
6.	Bluish gray sandstone of fine texture	½
5.	Gray shale	10
4.	Dark gray limestone cut by straight and vertical joints into large blocks and containing numerous spheroidal calcareous lumps about one-fourth inch in diameter	3
3.	Soft bluish gray shale	2
2.	Grayish blue sandstone of fine texture, in straight layers below and ripple marked above	3
1.	Shale	
	Total	18½

This section in the opinion of Professor Calvin is at the very close of the Carboniferous in Iowa, nothing similar to it being found in the Missouri in the rest of the state. All the other strata of the Missouri in Iowa were deposited under deep sea conditions, while these are shore deposits, unfossiliferous, ripple marked. The limestone is composed of an aggregation of rounded nodules of calcareous matter, which indicates a shallowing of the Carboniferous sea together with the prevalence of beach conditions. The limestone is similar in structure to the upper limestone at McKissicks Grove in containing nodules of calcareous matter, and they, without doubt, are equivalent to each other. The limestone and sandstone in this section are exposed at intervals along the bluff road to within a half mile of Thurman. One-fourth mile east of the town on Plum creek is an exposure which shows:

		FEET.
4.	Shale, thickness undetermined, the slope above being sodded over	
3.	Impure limestone, broken into blocks	½
2.	Carbonaceous streak	
1.	Shale	10
	Total	10½

At this place all the beds are dipping strongly to the northwest. On the slope above the exposure are loose blocks of sandstone from some higher ledges. These beds belong immediately below the limestone and sandstone found on the bluff road less than one-half mile away. It is believed the limestone and sandstone south of Thurman belong to the close of the Carboniferous in Iowa, and are equivalent to the exposure on Mill creek, and the upper part of the McKissicks Grove section. In addition there is the further evidence of the finding of a coal seam fourteen inches thick in a shaft sunk on the farm of R. Baylor. The coal is about twenty feet below the outcrop near by and ten feet below the bluff road.

SHAFT ON BAYLOR FARM TWO MILES SOUTH OF THURMAN

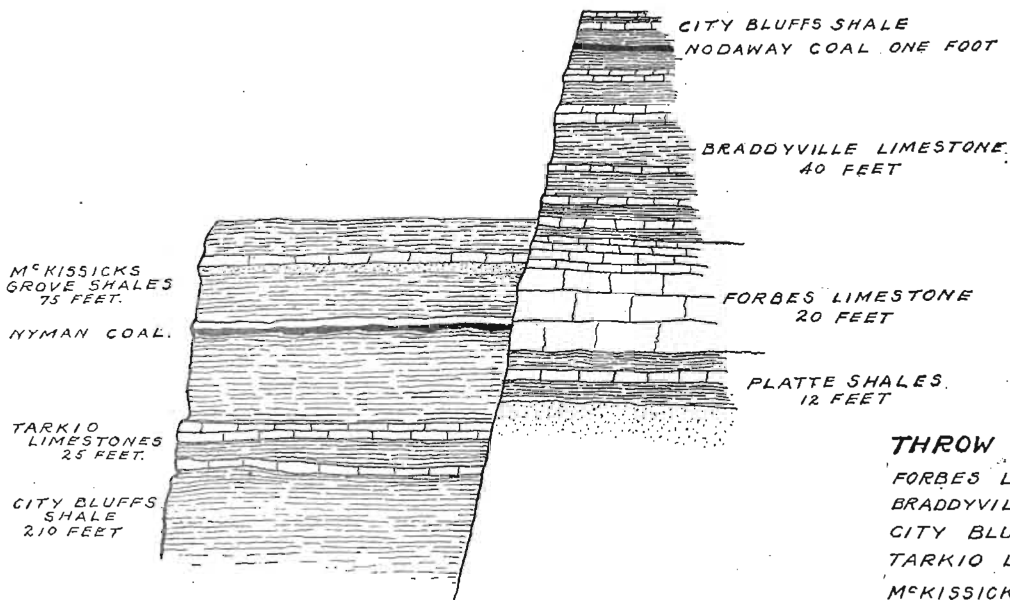
		FEET.	INCHES.
7.	Surface material		
6.	Blue limestone	3	
5.	Sandstone	5	
4.	Shale	20	
3.	Limestone, cap rock		6
2.	Coal		14
1.	Shale and sandstone		
	Total	29	8

West of the bluff road a point well was driven eighty feet deep without encountering rock of any kind.

This coal is without doubt the Nyman coal and the correlation becomes very positive. In the exposure near Thurman on Plum creek the coal is represented by the carbonaceous streak under the limestone.

Along the foot of the bluffs north of Thurman before reaching the Wilson section of White are two old quarries about one-half mile distant from each other. At the present time both are so covered by wash from the bluff above that not a single undisturbed layer can be seen. In the quarry farther north the rubbish shows slabs of a rough irregularly bedded blue limestone containing many specimens of *Productus cora*.

The following fossils have been observed in the McKissicks Grove shales at McKissicks Grove and Thurman: *Fusulina cylindrica, Rhombopora lepidodendroides,* Fenestella, plates and stems of crinoids, *Productus cora, P. longispinus, P. semireticulatus, Chonetes granulifera, C. glabra, Athyris subtilita, Pugnax uta, Hustedia mormoni, Allorisma subcuneatum, Edmondia nebrascensis, Myalina swallovi,* Aviculopectens and *Bellerophon carbonarius.*



THROW OF FAULT	FEET
FORBES LIMESTONE	15
BRADDYVILLE LIMESTONE	40
CITY BLUFFS SHALES	210
TARKIO LIMESTONE	25
McKISSICKS GROVE SHALE BELOW NYMAN COAL	30
	320

DOWNTHROW OF FAULT 320 Ft TO THE SOUTH.
DIRECTION OF FAULT N. 60° E.

FAULT NORTH OF THURMAN.

On the bluff road two miles north of Thurman is the Wilson section of White where a situation is met which is unparalleled by any similar condition to be found in the state of Iowa. A displacement in the strata has taken place between this point and Thurman with the uplift to the north of an amount of at least 300 feet. White and Udden have both given sections of the Wilson exposure, but the base of the outcrop at present is covered by talus, and as White's section includes several numbers that now are not visible it will be used.

WILSON SECTION OF WHITE

		FEET.	INCHES.
29.	Yellowish gray, impure limestone in thin layers....	2	
28.	Limestone in two layers with a three inch parting..	2	6
27.	Yellowish shaly marl..............................	1	3
26.	Black carbonaceous shale	1	9
25.	Bluish clayey shale	1	3
24.	Black carbonaceous shale.........................	1	
23.	Bluish marly shale with numerous fossils..........	1	6
22.	Coal		10
21.	Light bluish, fossiliferous, shaly clay..............	2	
20.	Compact bluish limestone, with shaly partings.....	4	
19.	Marly clay with calcareous concretions...........	6	
18.	Light gray limestone	4	
17.	Light yellowish, indurated marl.................	6	
16.	Compact limestone	1	6
15.	Light yellowish, indurated marl..................	4	
14.	Yellowish siliceous limestone with flinty concretions	2	6
13.	Yellowish marly shale with concretions of impure limestone	3	
12.	Compact limestone	1	
11.	Yellowish marly shale............................	2	
10.	Gray limestone in thick layers....................	3	
9.	Bluish clayey shale		6
8.	Yellowish siliceous limestone.....................	1	6
7.	Compact gray limestone with marly partings......	16	
6.	Bluish shaly clay	2	6
5.	Compact layer of limestone......................		9
4.	Bluish shaly clay	2	6
3.	Compact bluish limestone.........................	2	
2.	Bluish clayey shale..............................	4	
1.	Fine grained, micaceous sandstone................	1	
	Total	81	10

Numbers 1-6 belong with the Platte shale; numbers 7-10 are the Forbes limestone; numbers 11-21 are equivalent to the Braddyville limestones and the coal No. 22 is the Nodaway coal.

One mile north of the Wilson section on Indian creek a drift has been driven in on the coal in hopes that it might prove workable, but the enterprise has been abandoned.

NODAWAY COAL IN INDIAN CREEK

		Feet.	Inches.
10.	Black laminated shale	1	
9.	Yellow limestone		8
8.	Gray shale		8
7.	Yellow limestone	1	6
6.	Yellow shale	1	
5.	Black shale	2	
4.	Gray nonlaminated, nonjointed shale	1	4
3.	Black shale	1	
2.	Gray shale, similar to No. 4	1	6
1.	Coal	1	
	Total	11	8

The dull gray nonlaminated shale invariably found in the roof shales of the Nodaway coal is here divided by the black shale No. 3, and according to Professor Calvin bears the same fossils that are found in the shales over that coal. The correlation of White is accepted and no doubt is entertained that the coal in the Wilson section is identical with the Nodaway coal.

To Todd is due the credit of calling attention to the deformation of the Carboniferous strata that takes place between the Wilson section and Thurman, and causes the Forbes limestone at the Wilson section and the limestone and sandstone in the upper part of the McKissicks Grove shales at Thurman, to appear at the same elevation above the bottom lands of the Missouri river. The strata in the vicinity of Thurman as far north as Plum creek all have a slight dip to the north. As far as can be seen there is no disturbance or heavy dip of strata in the abandoned and wash covered quarries between Thurman and the Wilson section, which leads to the conclusion that the displacement of strata of about 300 feet with the uplift to the north takes place just south of the Wilson section and is due to a fault of

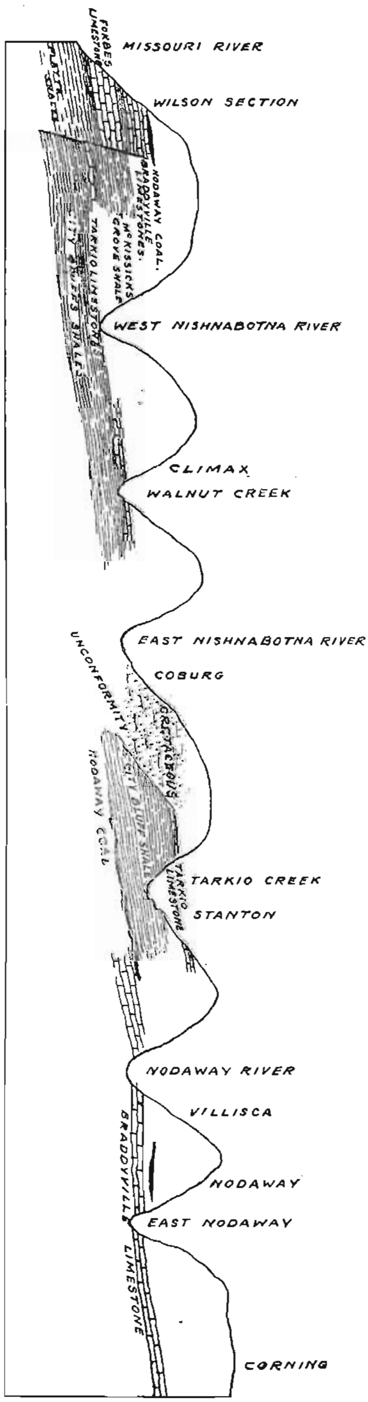


Figure 105. Section, west to east, from the Wilson section to Corning.

that amount with downthrow to the south. According to Todd, at Jones Point on the west side of the Missouri river in Nebraska, seven miles southwest of and in plain view of the Wilson section, is found a very heavy dip to the south of the Carboniferous series in which over 100 feet of strata disappear beneath the Missouri river in less than one mile. A continuation of the line of displacement from Jones Point to the Wilson section would pass south of the exposures of the Forbes limestone at Malvern, Stennett and Grant, and would thus give an explanation of the appearance of the limestone at those places.

To the north of Wabonsie creek the lower limestones of the Wilson section are exposed at frequent intervals in the foot of the bluffs to the old abandoned quarries east of Haynies.

Udden's Section No. 4 may be correlated with the lower part of the Wilson section as given by White. At both localities these strata represent the upper members of the Platte shales.

PLATTE SHALES ONE MILE SOUTHEAST OF HAYNIES

		Feet.	Inches.
7.	Bluish gray shale	2	
6.	Dark limestone		3
5.	Blue shale		6
4.	Blue limestone	1	6
3.	Arenaceous and micaceous silt, yellow above and bluish green below	6	
2.	Greenish or bluish gray limestone	2	
1.	Yellow shale	3	
	Total	15	3

The sandstone No. 1 of the Wilson section is equivalent to No. 3 of the above.

On Keg creek near Glenwood and at Henton in the Missouri river bluffs are limited exposures of limestones and shales difficult of correlation, but their horizon is probably in the Platte shales. In the face of the bluff one-fourth of a mile south of the railroad bridge over the Missouri river at Nebraska City, Nebraska, less than one-half mile from the Iowa side of the river, is an exposure often referred to by geologists since the first observations of Meek and Hayden, and of Marcou, fifty years ago.

SECTION OF BLUFF AT NEBRASKA CITY

		Feet.
12.	Thin bedded limestone, impure, with shaly partings, some crinoid stems	4
11.	Yellow, very arenaceous shale	4
10.	Blue shale	5
9.	Heavy layer of limestone	2
8.	Thin seam of very carbonaceous matter, with plant impressions	¼
7.	Blue laminated and nonlaminated shale, micaceous and arenaceous in places. In part of the exposure divided by a thin band of more indurated shale, yellowish in color. Ten feet above the base of the shale is a thin band of limestone	40
6.	Limestone with *Pugnax uta*	2
5.	Shale	6
4.	Crinoidal limestone	1
3.	Shale	1
2.	Limestone, in two layers	1
1.	Shale, exposed in bed of small intermittent creek	
	Total	66¼

The lower part of the thick shale No. 7 is covered by a railroad embankment, but is known to occur as stated. Numbers 1-6 are exposed in the creek bed near the brick yard office.

This section corresponds very closely to that at McKissicks Grove, twelve miles southeast of this place, and without doubt they are equivalent. The lower limestones are fossiliferous, but the beds above them are very different from the same strata found in Iowa. In the shale pit Professor Calvin was unable to find a single marine fossil. The thick shale No. 7 throughout its whole thickness contains many plant remains. Some of the layers are well laminated, with vertical joints, while other portions seems to be but a mass of slickensided shale. Many of the layers are ripple marked and all of the beds above the lower limestones have been formed under shallow water conditions. The whole exposure resembles the Des Moines in many features.

A deep boring at the brick yard office began with No. 6 of the section and extended to the depth of 863 feet. The record of the drilling was furnished by C. A. Ingersoll, the driller. Drilling was done by the cable rig method. The terminology of the driller is unchanged.

RECORD OF NEBRASKA CITY DRILLING

	FEET.	TOTAL.
Soil	4	4
Lime	4	8
Shale	25	33
Lime	2	35
Red shale	5	40
Blue shale	15	55
Red shale	5	60
Blue shale	22	82
Lime	5	87
Blue shale	32	119
Red rock	6	125
Sand stone	2	127
Blue shale	73	200
Lime	9	209
Black shale	6	215
Lime—blue 5		
white 30		
blue 15	—50	265
Black shale with oil	2	267
White lime	15	282
Blue shale	8	290

	FEET.	TOTAL.
White lime	45	335
Blue shale	2	337
Lime	17	354
Blue shale	2	356
Black shale	9	365
Lime	15	380
Sand rock with mineral water, artesian	35	415
Blue shale	20	435
White lime	20	455
Red rock	3	458
Black shale	10	468
Lime	25	493
Blue shale	15	508
Sand stone with artesian mineral water	12	520
Black shale	10	530
White lime	40	570
Red rock	5	575
Lime, bottom sandy with water	40	615
Blue shale	2	617
White lime	60	677
Shale and lime	5	682
Shale	3	685
Limey shale	5	690
Lime	10	700
Black shale	10	710
Limey sand	15	725
Lime	25	750
Blue lime	10	760
Limey shale	25	785
Sand rock, very hard	8	793
Lime	20	813
Sand rock, very hard	5	818
Lime	5	823
Shale	10	833
Lime	10	843
Shale, blue	20	863

The limestone and black shale at the depth of 215 feet probably represent the cap rock and horizon of the Nodaway coal. The heavy bed of shale above 200 feet is the City Bluffs shale. No further attempts at correlation will be made, although it is evident the bottom of the drilling must be near the base of the Missouri.

COAL SEAMS.

Some practical conclusions on the area and availability of the coal seams of southwestern Iowa are of importance to miners and prospectors in the future development of the mining industry in this part of the state. The Nyman coal at the old Linquist mine [illegible] a thickness of ten to fifteen inches, and was of very good quality but difficulties attending a large amount of water and a bad roof caused its abandonment several years ago. At McKissicks Grove Udden reports a thickness of fourteen inches, which is greater than the average; the outcroppings usually show a thickness of six or eight inches. The drilling at Hamburg gives a thickness of one foot. In the bluff at Nebraska City it is but a mere carbonaceous streak. From Hamburg to Thurman, if correlations are correct, it should be found in the bluffs at a level not far different from the bluff road. In Baylor's shaft south of Thurman it is fourteen inches thick. On Plum creek near Thurman it is reduced to a mere streak hardly recognizable. Over most of its area the Nyman coal has been eroded in the valleys of the streams and will be found only in patches of limited extent. Although the Nyman coal is a well defined horizon in the Carboniferous of southwestern Iowa, its average thickness will probably not exceed six inches and with the exception of local basins of greater thickness it cannot be regarded as workable. It is believed that at the present time attempts to develop it will prove unsuccessful.

All the coal mines in this part of the state are now working in the Nodaway coal, the areal extent of which exceeds that of any other coal seam in Iowa. According to Broadhead it becomes thinner to the south in the state of Missouri and in places is much damaged by clay seams, as it is at Shambaugh, Iowa. The Nodaway coal is not of very high grade as it carries a large percentage of ash. It does not generally show much pyrite, and usually burns without clinker. The quality improves from the south toward the north, and the coal in Adams county is of superior quality to that in Taylor and Page counties. It is not in much request as a domestic coal, but is regarded as being a good steam coal. The coal is firm and hard and, always being mined by the longwall method, is free from slack; it stocks well and does not disintegrate on exposure to the weather. The coal varies in thickness from a minimum of six inches to a maximum of three feet. Its usual and average thickness is about sixteen inches, and it is rarely altogether absent from its horizon. The Nodaway coal is exceptional in not having an under bed of fire clay. It is, however, usually underlain by a gray shale, that often causes the mining of the coal to be attended with considerable difficulty. The coal seam holds its thickness well in passing west of its outcrops on the Nodaway river and is of greater thickness at Coin than at its nearest outcrop, ten miles away, at Shambaugh. Many years ago a drilling was done at Riverton on the hill and it is reported that a coal seam one foot thick was penetrated at the depth of 400 feet. The surface where the drilling started is at least 100 feet higher than the McKissicks Grove shales on Mill creek two miles south of Riverton. The horizon of the Nodaway coal is about 300 feet lower than the outcrop on Mill creek and the coal of the Riverton drilling is probably the Nodaway seam. If the records are correct the Nodaway coal is absent in the drillings at Hamburg and Nebraska City. From Hamburg to Thurman the coal is upwards of 300 feet deep and is probably too thin to be workable. North of the fault at the Wilson section it is too poor and thin to be available. Drilling at Tabor has found the coal at the depth of 260 feet, but it is not of workable thickness.

The mine at Coin is only seven miles east of the west line of Page county and it is thought the coal will be of sufficient thickness to be workable that far west. In Montgomery county the northern limit of the coal is south of the line of disturbance passing northeast from the Wilson section. The area east of these boundaries to the eastern outcrop of the coal in Adams and Taylor counties is believed to be underlain by the Nodaway coal, which in the valleys can be reached by shafts less than 300 feet deep.

ALTITUDE AND THICKNESS.

The altitude of the Nodaway coal at New Market is 980 feet A. T., or fifteen feet higher than the same coal at Clarinda. The altitude of the Nodaway coal at Clarinda is 965 feet A. T., at

Shambaugh 950 feet A. T. and at Coin 790 feet A. T. The dip of the coal from Shambaugh west to Coin, ten miles, is at the rate of sixteen feet to the mile. The dip from Clarinda southwest to Coin, thirteen miles, is thirteen and one-half feet to the mile. The altitude of the Tarkio limestones at Coin is 1,025 feet A. T., and at McKissicks Grove the same limestones have an elevation of 920 feet A. T. The dip west from Coin to McKissicks Grove, twenty miles, is about five feet to the mile. The altitude of the sandstone in the bluff at Hamburg is approximately 960 feet A. T. Near Thurman the same sandstone is at an elevation of about 970 feet A. T. At Nebraska City the sandy shale in the bluff is at an elevation of 960 feet A. T., making the sandstone practically horizontal for a distance of sixteen miles.

GENERAL SECTION OF THE CARBONIFEROUS IN SOUTHWESTERN IOWA

	FEET.
McKissicks Grove shales	75
Tarkio limestones	25
City Bluffs shale	210
Braddyville limestones	45
Forbes limestone	18
Platte shales	86
Plattsmouth limestones	40
Andrew shales	172
Iatan limestone	16
Weston shales	76
Plattsburg limestone	19
Parkville shales	22
Bethany limestones	165
Thickness of Missouri in Iowa	969
Des Moines in Clarinda drilling	129
Total	1,098

In round numbers 1,100 feet.

PALEONTOLOGY.

In the study of the paleontology of southwestern Iowa certain features in the distribution of the different species become apparent. While the greater number of forms range throughout the whole of the section, certain horizons are characterized by a fauna that is of value in correlation.

Fusulina cylindrica is common in all the limestones of the Missouri, and in the Forbes limestone and upper layer of the Tarkio limestones becomes especially abundant. There seem to be at least three different varietal forms of Fusulina. In the Forbes limestone a large portion of the Fusulinas are of a different form from the usual type, being of a robust, nearly globular variety. In the Tarkio limestones in Page county none of the globular variety are seen, and only the forms usually figured are found. In the Tarkio limestones at McKissicks Grove the prevailing forms are of a much elongated and curved variety. The different Bryozoa are abundant throughout the section in the calcareous shales. It is probable careful study would show that certain species are confined to particular horizons. Crinoidal remains are frequent in all the different strata. Disjointed stems and plates are all that have been found. A careful search has failed to discover a single perfect calyx. The spines and plates of Archaeocidaris are rather frequent in the Forbes limestone. The different species of Productus do not seem to be good horizon markers. Of the three species of Chonetes *C. verneuiliana* has been found only in the Forbes limestone where it is a long eared form with deep mesial sinus. *C. granulifera* and *C. glabra* range in abundance through the whole section. *Spirifer cameratus* is abundant in the cap rock of the Nyman coal and in the limestone in the upper part of the McKissicks Grove shales. It is frequently of the elongate eared form. *Meekella striatocostata* has been seen only in the Forbes limestone. *Ambocelia planoconvexa* is quite abundant in any of the weathered shales. *Athyris subtilita, Derbya crassa* and *Dielasma bovidens* range throughout the section and are valueless for correlation. *Orthis pecosi* and *Reticularia perplexa* seem to be confined to the Forbes limestone and Platte shales. *Spiriferina kentuckiensis* and *Productus nebrascensis* have been noticed only in the City Bluffs shale. *P. pertenuis* has been found only in the Tarkio limestones. *Euomphalus rugosus* has a great vertical range and is very abundant in the roof shales of the Nodaway coal. *Bellerophon carbonarius* ranges through all the section. The City Bluffs shale contains numerous specimens of at least four species of Bellerophon. The only horizon in which *Naticopsis altonensis* has been noted is the blue ledge of the Tarkio limestones. *Pleurotomaria perhumerosa* is very abundant in the City Bluffs shale. A single specimen of *P. tabulata* was found in these shales. In Page county the lower layers of the Tarkio limestone seem to be an important Myalina horizon as at least three, perhaps four different species are found in abundance.

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BIBLIOGRAPHY OF IOWA COALS

COMPILED BY

JAMES H. LEES

BIBLIOGRAPHY OF IOWA COALS

COMPILED BY JAMES H. LEES.

Adair county, coal in.
C. R. Keyes, in Iowa Geol. Surv., Vol. II, pp. 441-443. 1894.

Adams county, coal in.
C. R. Keyes, in Iowa Geol. Surv., Vol. II, pp. 445-450. 1894.
C. A. White, in First Ann. Rept. State Geol., p. 67, 1868.
——— in Geol. Iowa, Vol. I, pp. 342-344. 1870.

Appanoose county, coal in.
H. F. Bain, in Iowa Geol. Surv., Vol. V, pp. 409-434. 1895.
C. R. Keyes, in Iowa Geol. Surv., Vol. II, pp. 406-424. 1894.
C. A. White, in First Ann. Rept. State Geol., p. 40. 1868.

Armstrong, S. C.
Coal production in Iowa in 1883-84. U. S. Geol. Surv., Min. Res. of U. S., 1883-1884, pp. 12, 45-46.

Ashburner, Chas. A.
Coal production of Iowa in 1885. U. S. Geol. Surv., Min. Res. of U. S., 1885, pp. 11, 30.
—— —— —— in 1886, *Ibid.*, 1886, pp. 225 ff. 266-268.
—— —— —— in 1887. *Ibid.*, 1887, pp. 169, 171, 187, 245-253.
—— —— —— in 1888. *Ibid.*, 1888, pp. 169, 206, 262-269.

Atkinson, J. J.
Gases of coal mines. First Ann. Rept. State Mine Insp., 1880-81, pp. 108-118. 1882.

Bain, H. Foster.
Coal in Appanoose county. Iowa Geol. Surv., Vol. V, pp. 409-434. 1895.
—— In Carroll county. *Ibid.*, Vol. IX., p. 97. 1898.
—— In Decatur county. *Ibid.*, Vol. VIII, pp. 294-299. 1897.
—— In Guthrie county. *Ibid.*, Vol. VII, pp. 469-475. 1896.
—— In Keokuk county. *Ibid.*, Vol. IV, pp. 245-301. 1894.
—— In Mahaska county. *Ibid.*, Vol. IV, pp. 351-366. 1894.
—— In Plymouth county. *Ibid.*, Vol. VIII, pp. 361-365. 1897.
—— In Polk county. *Ibid.*, Vol. VII, pp. 352-366. 1896.
—— In Washington county. *Ibid.*, Vol. V, p. 162. 1895.
Explanation of certain irregularities encountered in working coal seams in Iowa. Mon. Rev. Iowa Weather and Crop Service, Vol. IV, No. 6, pp. 4-7. 1893.
Machine coal mining in Iowa. Min. Ind., Vol. IV, 1895, pp. 195-200.
Peculiarities of the Mystic coal seam. Am. Geol., Vol. XIII, pp. 407-411. 1894.

Structure of the Mystic coal basin. Iowa Acad. Sci., Vol. I, pt. 4, p. 33. 1893.

Western interior coal field. U. S. Geol. Surv., 22nd Ann. Rept. 1900-1901, pt. III, pp. 339-366.

—— Tilton, J. L., and.
Coal in Madison county. Iowa Geol. Surv., Vol. VII, pp. 537-539. 1896.

Beyer, S. W.
Chemical analyses of Iowa coals. Iowa Geol. Surv., Vol. XVII, p. 529. 1906.
Coal in Boone county. *Ibid.*, Vol. V, pp. 205-220. 1895.
—— In Hardin county. *Ibid.*, Vol. X, p. 289. 1899.
—— In Marshall county. *Ibid.*, Vol. VII, pp. 257-258. 1896.
—— In Story county. *Ibid.*, Vol. IX, pp. 216-219. 1898.
—— —— and Young, L. E. Coal in Monroe county. *Ibid.*, Vol. XIII, pp. 380-415. 1902.

Binks, Thomas.
Coal mines of southern Iowa. Bien. Rept. State Mine Insp., Third Rept., 1885-87, pp. 18-80. 1888.
—— —— —— *Ibid.*, Fourth Rept., 1887-89, pp. 8-61. 1889.
—— —— —— *Ibid.*, Fifth Rept., 1889-91, pp. 5-51. 1891.

Bissell, G. W.
Chemical analyses of Iowa coals. Iowa Geol. Surv., Vol. XVII, pp. 170 ff. 1906.

Boiler tests of Iowa coals at St. Louis testing station, 1904. L. P. Breckenridge, in Prof. Paper No. 48, U. S. Geol. Surv., pt. II, pp. 529-576, 947 ff.

Boone county, coal in.
S. W. Beyer, in Iowa Geol. Surv., Vol. V, pp. 205-220. 1895.
C. R. Keyes, in Iowa Geol. Surv., Vol. II, pp. 225-236. 1894.
D. D. Owen, in Geol. Surv. Wis., Ia. and Minn., p. 124. 1852.
C. A. White, in Geol. Iowa, Vol. II, p. 259. 1870.

Boonesboro, coal at.
C. A. White, in Second Ann. Rept. State Geol., p. 142. 1868.

Breckenridge, L. P.
Boiler tests of Iowa coals at St. Louis testing station, 1904. Prof. Paper No. 48, U. S. Geol. Surv., pt. II, pp. 529-576, 947 ff.

Briquetting Iowa coals.
James E. Mills, in Bull. No. 343, U. S. Geol. Surv., p. 52, 1908. Table only.

Briquetting tests of Iowa coals at St. Louis testing station, 1904. J. H. Pratt, in Prof. Paper No. 48, U. S. Geol. Surv., pt. III, pp. 1427, 1443 ff.

Bushnell, J. P.
Coal fields of Iowa. In "Iowa Resources and Industries," pp. 72, 74. Des Moines, 1885.

Calvin, Samuel.
Coal in Page county. Iowa Geol. Surv., Vol. XI, pp. 450-453. 1900.
Geological formations of Iowa. Stone, Vol. XXV, 1902, pp. 118-124.
Geology and Geological Resources of Iowa. Mines and Minerals, Vol. XXII, 1902, pp. 560-561.

Campbell, James A.
Coal mines in eastern Iowa. Bien. Rept. State Mine Insp., Twelfth Rept. 1903-05, pp. 71-79. 1905.
—— —— —— *Ibid.*, Thirteenth Rept., 1905-'06, pp. 60-68. 1906.
Coal mines in southern Iowa. *Ibid.*, Seventh Rept., 1893-'95, pp. 7-33. 1895.
—— —— —— *Ibid.*, Eighth Rept., 1895-'97, pp. 5-22. 1897.
—— —— —— *Ibid.*, Ninth Rept., 1897-'99, pp. 7-16. 1899.
—— —— —— *Ibid.*, Tenth Rept., 1899-1901, pp. 9-21. 1901.

Campbell, M. R.
Classification of coals collected for tests at St. Louis testing station, 1904. Prof. Paper No. 48, U. S. Geol. Surv., pt. I, pp. 156 ff.
Description of samples collected for tests at St. Louis testing station, 1904. *Ibid.*, pp. 74, 146, 151.

Canty, John W.
Coal mines in eastern Iowa. Sixth Bien. Rept. State Mine Insp., 1891-'93, pp. 40-59. 1893.

Carboniferous in central Iowa.
C. R. Keyes, in Bull. Geol. Soc. Amer., Vol. 2, p. 284. 1891.

Carroll county, coal in.
H. F. Bain, in Iowa Geol. Surv., Vol. IX, p. 97. 1898.

Cass county, coal in.
C. R. Keyes, in Iowa Geol. Surv., Vol. II, pp. 440-441. 1894.

Central Iowa, Carboniferous in.
C. R. Keyes, in Bull. Geol. Soc. Am., Vol. 2, p. 284. 1891.

Character and stratigraphical peculiarities of the southwestern Iowa coal field.
C. R. Keyes, in Eng. and Min. Jour., Vol. LXXIII, p. 661. 1902.

Chemical analyses of Iowa coals.
S. W. Beyer, in Iowa Geol. Surv., Vol. XVII, p. 529. 1906.
G. W. Bissell in Iowa Geol. Surv., Vol. XVII, pp. 170 ff. 1906.
Rush Emery, in Geol. Iowa, Vol. II, pp. 357-397. 1870.
G. Hinrichs, in Second Ann. Rept. State Geol., pp. 205-232, 248-268. 1868.
N. W. Lord, in Prof. Paper No. 48, U. S. Geol. Surv., pt. I, pp. 221-225, 270. 1906.
D. D. Owen, in Geol. Iowa, Wis. and Ill., p. 53. 1839.
G. E. Patrick, in Iowa Geol. Surv., Vol. II, pp. 504-509. 1894.

Chemical analyses and general character of Iowa coals.
J. D. Whitney, Geol. Iowa, Vol. I, pp. 397-415. 1858.

Coal, briquetting of.
James E. Mills, in Bull. 343, U. S. Geol. Surv., p. 52. 1909.

Coal, chemical analyses of.
S. W. Beyer, in Iowa Geol. Surv., Vol. XVII, p. 529. 1906.
G. W. Bissell, in Iowa Geol. Surv., Vol. XVII, pp. 170 ff. 1906.
Rush Emery, in Geol. Iowa, Vol. II, pp. 357-397. 1870.
Gustav Hinrichs, in Second Ann. Rept. State Geol., pp. 205-232, 248-268. 1868.
N. W. Lord, in Prof. Paper 48, U. S. Geol. Surv., pt. I, pp. 221-225, 270. 1906.
D. D. Owen, in Geol. Iowa, Wis. and Ill., p. 53. 1839.
G. E. Patrick, in Iowa Geol. Surv., Vol. II, pp. 504-509. 1894.
J. D. Whitney, in Geol. Iowa, Vol. I, pp. 397-415. 1858.

Coal, Trans-Mississippian, structure and geological position of.
C. R. Keyes, in Eng. and Min. Jour., Vol. LXV, pp. 253-254, 280-281. 1898. Vol. LXIX, pp. 528-529. 1900.

Coal at Boonesboro.
C. A. White, in Second Ann. Rept. State Geol., 142. 1868.
—— At Des Moines.
C. A. White, Second Ann. Rept. State Geol., pp. 167, 176. 1868.
—— At Fort Dodge.
C. A. White, Second Ann. Rept. State Geol., p. 140. 1868.

Coal deposits of Iowa.
C. R. Keyes, in Iowa Geol. Surv., Vol. II, 1894.
—— —— In U. S. Geol. Surv., Min. Res. of U. S., 1892, pp. 398-404.

Coal fields of Iowa.
J. P. Bushnell, Comm. of Immigration for Iowa, in Iowa Resources and Industries, pp. 72, 74. Des Moines, 1885.
James MacFarlane, in "The Coal Regions of America," pp. 446-463. New York, 1875.
Chiefly summary of Hall's and White's reports.

Coal fields of Iowa and Missouri.
David D. Owen, in Proc. Amer. Assoc., Vol. 5, 1851, pp. 119-131. Reviewed by H. S. Williams in Bull. 80, U. S. Geol. Surv., p. 143. 1891.

Coal horizons in Iowa.
O. H. St. John, in Geol. Iowa, Vol. I, pp. 273-283. 1870.

Coal in drift.
C. A. White, in Geol. Iowa, Vol. I, p. 97. Vol. II, p. 236. 1870.

Coal in Iowa.
A. R. Fulton, in "Iowa; The Home for Immigrants," p. 21, Des Moines, 1870.
D. D. Owen, in Geol. Iowa, Wis. and Ill., p. 53. 1839.
—— —— In Geol. Surv. of Wis., Ia. and Minn., p. 97. 1852.
—— —— In Proc. Am. Assoc. Adv. Sci., Vol. V, p. 127. 1851.
N. Howe Parker, in "Iowa as it is in 1855," pp. 39-43. Chicago, 1855.
—— —— The Iowa Handbook for 1857, pp. 32-35. Boston, 1857.
H. S. Reed, in "The Leading Industries of the West," pp. 7, 13. Chicago, 1883.
C. A. White, in Geol. Iowa, Vol. I, pp. 258-263. 1870.
History of Dallas county, p. 125. Des Moines, 1879.

Coal in Raccoon valley.
O. H. St. John, in Second Ann. Rept. State Geol., pp. 175-190. 1868.

Coal in United States, distribution of.
C. W. Hayes, in U. S. Geol. Surv., 22nd Ann. Rept., 1900-1901, pt. III, p. 12.

Coal in Adair county.
C. R. Keyes, in Iowa Geol. Surv., Vol. II, pp. 441-443. 1894.

—— In Adams county.
C. R. Keyes, in Iowa Geol. Surv., Vol. II, pp. 445-450. 1894.
C. A. White, in First Ann. Rept. State Geol., p. 67. 1868.
—— —— in Geol. Iowa, Vol. I, pp. 342-344. 1870.

—— In Appanoose county.
H. F. Bain, in Iowa Geol. Surv., Vol. V, pp. 409-434. 1895.
C. R. Keyes, in Iowa Geol. Surv., Vol. II, pp. 406-424. 1894.
C. A. White, in First Ann. Rept. State Geol., p. 40. 1868.
History of Appanoose county, p. 338. Chicago, 1878.

—— In Boone county.
S. W. Beyer, in Iowa Geol. Surv., Vol. IV, pp. 205-220. 1895.
C. R. Keyes, in Iowa Geol. Surv., Vol. II, pp. 223-236. 1894.
D. D. Owen, in Geol. Surv. Wis., Ia. and Minn., p. 124. 1852.
C. A. White, in Geol. Iowa, Vol. II, p. 259. 1870.

—— In Carroll county.
H. F. Bain, in Iowa Geol. Surv., Vol. IX, p. 97. 1898.

—— In Cass county.
C. R. Keyes, in Iowa Geol. Surv., Vol. II, pp. 440-441. 1894.

—— In Dallas county.
C. R. Keyes, in Iowa Geol. Surv., Vol. II, pp. 253-267. 1894.
A. G. Leonard, in Iowa Geol. Surv., Vol. VIII, pp. 92-101. 1897.
O. H. St. John, in Geol. Iowa, Vol. II, pp. 18 ff, 45. 1870.
History of Dallas county, pp. 281-284. Des Moines, 1879.

—— In Davis county.
C. R. Keyes, in Iowa Geol. Surv., Vol. II, pp. 424-429. 1894.
C. A. White, in Geol. Iowa, Vol. II, p. 271. 1870.

—— In Decatur county.
H. F. Bain, in Iowa Geol. Surv., Vol. VIII, pp. 294-299. 1897.
C. R. Keyes, in Iowa Geol. Surv., Vol. II, pp. 462-463. 1894.
C. A. White, in Geol. Iowa, Vol. I, p. 326. 1870.

—— In Des Moines county.
C. R. Keyes, in Iowa Geol. Surv., Vol. II, pp 483-484. 1894. *Ibid.*, Vol. III, pp. 483-485. 1893.

—— In Greene county.
C. R. Keyes, in Iowa Geol. Surv., Vol. II, pp. 219-225. 1894.
O. H. St. John, in Geol. Iowa, Vol. II, pp. 134-137. 1870.

—— In Guthrie county.
H. F. Bain, in Iowa Geol. Surv., Vol. VII, pp. 469-475. 1896.
C. R. Keyes, in Iowa Geol. Surv., Vol. II, pp. 242-253. 1894.
O. H. St. John, in Geol. Iowa, Vol. II, pp. 105 ff, 128. 1870.

—— In Hamilton county.
C. R. Keyes, in Iowa Geol. Surv., Vol. II, pp. 211-214. 1894.
C. A. White, in First Ann. Rept. State Geol., p. 25, 1868.
—— —— in Geol. Iowa, Vol. II, p. 257. 1870.

—— In Hardin county.
S. W. Beyer, in Iowa Geol. Surv., Vol. X, p. 289. 1899.
C. R. Keyes, in Iowa Geol. Surv., Vol. II, pp. 214-218. 1894.
C. A. White, in First Ann. Rept. State Geol., p. 22. 1868.
—— —— in Geol. Iowa, Vol. II, p. 258. 1870.
J. D. Whitney, in Geol. Iowa, Vol. I, pp. 269-271. 1858.

—— In Henry county.
C. R. Keyes, in Iowa Geol. Surv., Vol. II, pp. 480-483. 1894.
T. E. Savage, in Iowa Geol. Surv., Vol. XII, p. 298, 1901.
A. H. Worthen, in Geol. Iowa, Vol. I, pp. 211, 218. 1858.

—— In Humboldt county.
C. R. Keyes, in Iowa Geol. Surv., Vol. II, p. 196. 1894.

—— In Jasper county.
C. R. Keyes, in Iowa Geol. Surv., Vol. II, pp. 294-300. 1894.
C. A. White, in Geol. Iowa, Vol. II, p. 262. 1870.
J. D. Whitney, in Geol. Iowa, Vol. I, p. 272. 1858.
I. A. Williams, in Iowa Geol. Surv., Vol. XV, pp. 335-348. 1904.
History of Jasper county, p. 438. Chicago, 1878.

—— In Jefferson county.
C. R. Keyes, in Iowa Geol. Surv., Vol. II, pp. 393-402. 1894.
J. A. Udden, in Iowa Geol. Surv., Vol. XII, p. 433. 1901.
C. A. White, in Second Ann. Rept. State Geol., p. 94. 1868.
—— —— in Geol. Iowa, Vol. II, p. 273. 1870.
A. H. Worthen, in Geol. Iowa, Vol. I, pp. 233-237. 1858.

—— In Keokuk county.
H. F. Bain, in Iowa Geol. Surv., Vol. IV, pp. 295-301. 1894.
C. R. Keyes, in Iowa Geol. Surv., Vol. II, pp. 356-366. 1894.
C. A. White, in Geol. Iowa, Vol. II, p. 267. 1870.

—— In Lee county.
C. R. Keyes, in Iowa Geol. Surv., Vol. II, pp. 484-489. 1894. *Ibid.*, Vol. III, pp. 369-375. 1893.

—— In Lucas county.
C. R. Keyes, in Iowa Geol. Surv., Vol. II, pp. 366-374. 1894.
O. H. St. John, in Geol. Iowa, Vol. II, pp. 81 ff, 94. 1870.

—— In Madison county.
C. R. Keyes, in Iowa Geol. Surv., Vol. II, pp. 304-306. 1894.
J. L. Tilton & H. F. Bain, in Iowa Geol. Surv., Vol. VII, pp. 537-539. 1896.
C. A. White, in First Ann. Rept. State Geol., p. 72. 1868.
—— —— Geol. Iowa, Vol. I, pp. 313-316. 1870.

—— In Mahaska county.
H. Foster Bain, in Iowa Geol. Surv., Vol. IV, pp. 351-366. 1894.
C. R. Keyes, in Iowa Geol. Surv., Vol. II, pp. 340-356. 1894.
D. D. Owen, in Geol. Surv. Wis., Ia. and Minn., p. 114. 1852.
C. A. White, in Second Ann. Rept. State Geol., p. 91. 1868.
—— —— in Geol. Iowa, Vol. II, p. 265. 1870.

—— In Marion county.
C. R. Keyes, in Iowa Geol. Surv., Vol. II, pp. 317-340. 1894.
B. L. Miller, in Iowa Geol. Surv., Vol. XI, pp. 169-182. 1900.
D. D. Owen, in Geol. Surv. Wis., Ia. and Minn., pp. 115-117. 1852.
C. A. White, in Second Ann. Rept. State Geol., pp. 100-107. 1868.
—— —— In Geol. Iowa, Vol. II, p. 263. 1870.

—— In Marshall county.
S. W. Beyer, in Iowa Geol. Surv., Vol. VII, pp. 257-258. 1896.
C. R. Keyes, in Iowa Geol. Surv., Vol. II, pp. 237-239. 1894.
C. A. White, in Geol. Iowa, Vol. II, p. 260. 1870.
J. D. Whitney, in Geol. Iowa, Vol. I, p. 269. 1858.

—— In Monroe county.
S. W. Beyer and L. E. Young, in Iowa Geol. Surv., Vol. XIII, pp. 380-415. 1902.
C. R. Keyes, in Iowa Geol. Surv., Vol. II, pp. 374-383. 1894.
C. A. White, in Second Ann. Rept. State Geol., p. 93. 1868.
—— —— in Geol. Iowa, Vol. II, p. 267. 1870.

—— In Montgomery county.
C. R. Keyes, in Iowa Geol. Surv., Vol. II. pp. 443-445. 1894.
E. H. Lonsdale, in Iowa Geol. Surv., Vol. IV, p. 446. 1894.
C. A. White, in Geol. Iowa, Vol. I, p. 366. 1870.

—— In Muscatine county.
C. R. Keyes, in Iowa Geol. Surv., Vol. II, pp. 475-478. 1894.
J. A. Udden, in Iowa Geol. Surv., Vol. IX, p. 367. 1898.
C. A. White, in Geol. Iowa, Vol. II, p. 274. 1870.
J. D. Whitney, in Geol. Iowa, Vol. I, p. 277. 1858.

—— In Page county.
Samuel Calvin, in Iowa Geol. Surv., Vol. XI, pp. 450-453. 1900.
C. R. Keyes, in Iowa Geol. Surv., Vol. II, pp. 453-456. 1894.
C. A. White, First Ann. Rept. State Geol., p. 50, 1868.
—— —— Geol. Iowa, Vol. I, p. 352. 1870.
History of Page county, p. 332. Des Moines, 1880.

—— In Plymouth county.
H. F. Bain, in Iowa Geol. Surv., Vol. VIII, pp. 361-365. 1898.

—— In Polk county.
H. F. Bain, in Iowa Geol. Surv., Vol. VII, pp. 352-366. 1896.
J. M. Dixon, in Centennial History of Polk county, pp. 143-152. Des Moines, 1876.
C. R. Keyes, in Iowa Geol. Surv., Vol. II, pp. 267-294. 1894.
D. D. Owen, in Geol. Surv. Wis., Ia. and Minn., pp. 121-123, 129. 1852.
Will Porter, in Annals of Polk county, pp. 363, 901. 1898.
C. A. White, in Geol. Iowa, Vol. II, p. 261. 1870.
History of Polk county, pp. 273-276, 707. Des Moines, 1880.

—— In Poweshiek county.
C. R. Keyes, in Iowa Geol. Surv., Vol. II, pp. 301-304. 1894.

—— In Scott county.
C. R. Keyes, in Iowa Geol. Surv., Vol. II, pp. 470-475. 1894.
Wm. H. Norton, in Iowa Geol. Surv., Vol. IX, pp. 494-496. 1898.
D. D. Owen, in Geol. Ia., Wis. and Ill., p. 53. 1839.
C. A. White, in Geol. Iowa, Vol. II, p. 274. 1870.

—— In Story county
S. W. Beyer, in Iowa Geol. Surv., Vol. IX, pp. 216-219. 1898.
C. R. Keyes, in Iowa Geol. Surv., Vol. II, p. 236. 1894.

—— In Taylor county.
C. R. Keyes, in Iowa Geol. Surv., Vol. II, pp. 457-461. 1894.
C. A. White, First Ann. Rept. State Geol., p. 47, 1868.
—— —— Geol. Iowa, Vol. I, p. 347. 1870.

—— In Van Buren county.
C. H. Gordon, in Iowa Geol. Surv., Vol. IV, pp. 239-244. 1894.
C. R. Keyes, in Iowa Geol. Surv., Vol. II, pp. 429-434. 1894.
D. D. Owen, in Geol. Surv. Wis., Ia. and Minn., pp. 106-111. 1852.
C. A. White, in Second Ann. Rept. State Geol., p 112. 1868.
—— —— in Geol. Iowa, Vol. II, p. 271. 1870.
A. H. Worthen, in Geol. Iowa, Vol. I, pp. 222-226, 229. 1858.

—— In Wapello county.
C. R. Keyes, in Iowa Geol. Surv., Vol. II, pp. 383-393. 1894.
A. G. Leonard, in Iowa Geol. Surv., Vol. XII, pp. 477-489. 1901.
C. A. White, in Second Ann. Rept. State Geol., pp. 108-111. 1868.
—— —— in Geol. Iowa, Vol. II, pp. 268-270. 1870.
A. H. Worthen, in Geol. Iowa, Vol. I, pp. 250-254, 256. 1858.

—— In Warren county.
C. R. Keyes, in Iowa Geol. Surv., Vol. II, pp. 306-317. 1894.
D. D. Owen, in Geol. Surv. Wis., Ia. and Minn., p. 130. 1852.
O. H. St. John, in Geol. Iowa, Vol. II, pp. 50 ff, 74. 1870.
J. L. Tilton, in Iowa Geol. Surv., Vol. V, pp. 342-350. 1896.

—— In Washington county.
C. R. Keyes, in Iowa Geol. Surv., Vol. II, pp. 478-480. 1894.
C. A. White, in Geol. Iowa, Vol. II, p. 273. 1870.
A. H. Worthen, in Geol. Iowa, Vol. I, pp. 240, 246. 1858.

—— In Wayne county.
C. R. Keyes, in Iowa Geol. Surv., Vol. II, pp. 402-406. 1894.

—— In Webster county.
C. R. Keyes, in Iowa Geol. Surv., Vol. II, pp. 197-211. 1894.
D. D. Owen, in Geol. Surv. Wis., Ia. and Minn., p. 127. 1852.
C. A. White, in Geol. Iowa, Vol. II, p. 255. 1870.
F. A. Wilder, in Iowa Geol. Surv., Vol. XII, pp. 167-173. 1901.

Coal industry, extent of.
C. R. Keyes, in Iowa Geol. Surv., Vol. II, pp. 521-528. 1894.

Coal industry of Iowa, growth of.
C. R. Keyes, in Mon. Rev. Ia. Weather and Crop Service, Vol. IV, No. 12, pp. 5-7. 1893.

Coal measures of central Iowa.
Charles R. Keyes, in Am. Geol., Vol. II, pp. 396-404. 1888.

Coal measures of Iowa.
James Hall, in Geol. Iowa, Vol. I, pp. 120-141. 1858.
Discusses general character of rocks.
D. D. Owen, in Geol. Surv. Wis., Ia. and Minn., pp. 97 ff. 1852.
C. A. White, in Geol. Iowa, Vol. I, pp. 236-284. 1870.
Discusses general characters of rocks, with their beds of coal.
Park C. Wilson, in First Ann. Rept. State Mine Insp., 1880-'81, pp. 81-93. 1882.

—— record of drillings in.
Park C. Wilson, in Bien. Rept. State Mine Insp., First Rept., 1881-'83, pp. 57-74. 1883.
—— —— *Ibid.*, Sec. Rept., 1883-'85, pp. 110-116. 1885.

Coal mines of Iowa.
Park C. Wilson, in First Ann. Rept. State Mine Insp., 1880-'81, pp. 6-79. 1882.
—— —— in First Bien. Rept. State Mine Insp., 1881-'83, pp. 12-41. 1883.
—— —— *Ibid.*, Sec. Rept., 1883-'85, pp. 19-62. 1885.

Coal mines of eastern Iowa.
J. A. Smith, in Bien. Rept. State Mine Insp., Third Rept., 1885-'87, pp. 87-99. 1888.
James Gildroy, *Ibid.*, Fourth Rept., 1887-'89, pp. 70-114. 1889.
—— —— *Ibid.*, Fifth Rept., 1889-'91, pp. 62-80. 1891.
John W. Canty, *Ibid.*, Sixth Rept., 1891-'93, pp. 40-59. 1893.
J. W. Miller, *Ibid.*, Seventh Rept., 1893-'95, pp. 41-55. 1895.
—— —— *Ibid.*, Eighth Rept., 1895-'97, pp. 27-38. 1897.
John Verner, *Ibid.*, Ninth Rept., 1897-'99, pp. 23-30. 1899.
—— —— *Ibid.*, Tenth Rept., 1899-1901, pp. 31-47. 1901.
Edward Sweeney, *Ibid.*, Eleventh Rept., 1901-'03, pp. 51-60. 1903.
James A. Campbell, *Ibid.*, Twelfth Rept., 1903-'05, pp. 71-79. 1905.
—— —— *Ibid.*, Thirteenth Rept., 1905-'06, pp. 60-68. 1906.
R. T. Rhys, *Ibid.*, Fourteenth Rept., 1906-'08, pp. 74-82. 1908.

Coal mines of north-central Iowa.

J. E. Stout, in Bien. Rept. State Mine Insp., Third Rept., 1885-'87, pp. 124-160. 1888.

—— —— *Ibid.*, Fourth Rept., 1887-'89, pp. 119-143. 1889.

M. G. Thomas, *Ibid.*, Fifth Rept., 1889-'91, pp. 96-116. 1891.

—— —— *Ibid.*, Sixth Rept., 1891-'93, pp. 71-90. 1893.

—— —— *Ibid.*, Seventh Rept., 1893-'95, pp. 69-94. 1895.

—— —— *Ibid.*, Eighth Rept., 1895-'97, pp. 53-59. 1897.

James W. Miller, *Ibid.*, Ninth Rept., 1897-'99, pp. 44-56. 1899.

—— —— *Ibid.*, Tenth Rept., 1899-1901, pp. 69-93. 1901.

—— —— *Ibid.*, Eleventh Rept., 1901-'03, pp. 69-80. 1903.

Edward Sweeney, *Ibid.*, Twelfth Rept., 1903-'05, pp. 85-98. 1905.

—— —— *Ibid.*, Thirteenth Rept., 1905-'06, pp. 75-86. 1906.

—— —— *Ibid.*, Fourteenth Rept., 1906-'08, pp. 89-97. 1908.

Coal mines of southern Iowa.

Thomas Binks, in Bien. Rept. State Mine Insp., Third Rept., 1885-'87, pp. 18-80. 1888.

—— —— *Ibid.*, Fourth Rept., 1887-'89, pp. 8-61. 1889.

—— —— *Ibid.*, Fifth Rept., 1889-'91, pp. 5-51. 1891.

John Verner, *Ibid.*, Sixth Rept., 1891-'93, pp. 4-35. 1893.

James A. Campbell, *Ibid.*, Seventh Rept., 1893-'95, pp. 7-33. 1895.

—— —— *Ibid.*, Eight Rept., 1895-'97. pp. 5-22. 1897.

—— —— *Ibid.*, Ninth Rept., 1897-'99, pp. 7-16. 1899.

—— —— *Ibid.*, Tenth Rept., 1899-1901, pp. 9-21. 1901.

John Verner, *Ibid.*, Eleventh Rept., 1901-'03, pp. 15-39. 1903.

—— —— *Ibid.*, Twelfth Rept., 1903-'05, pp. 15-55. 1905.

—— —— *Ibid.*, Thirteenth Rept., 1905-'06, pp. 13-37. 1906.

—— —— *Ibid.*, Fourteenth Rept., 1906-'08, pp. 9-11, 25-49. 1908.

Coal mining, waste in.

C. R. Keyes, in Iowa Geol. Surv., Vol. II, pp. 511-520. 1894.

Coal production in Iowa in 1870.

Ninth census U. S., 1870, Vol. on Industry and Wealth, pp. 761, 767, 775. (Tables only.)

—— In 1880.

Frederick Prime, Jr., in Tenth Census U. S., 1880. Vol. on Mining Industries, pp. 616, 650, 681 ff. Gives maps of production.

Census of Iowa, 1880, pp. 94-97. (Tables only.)

—— In 1882.

Albert Williams, Jr., U. S. Geol. Surv., Min. Res. U. S., 1882, pp. 4 ff, 55-56. Describes Coal Measures briefly.

—— In 1883-1884.

S. C. Armstrong, *Ibid.*, 1883-1884, pp. 12, 45-46. Describes Coal Measures briefly.

—— In 1885.

Chas. A. Ashburner, *Ibid.*, 1885, pp. 11, 30.

—— In 1886.

—— —— *Ibid.*, 1886, pp. 225 ff, 266-268.

—— In 1887.

—— —— *Ibid.*, 1887, pp. 169, 171, 187, 245-253.

—— In 1888.

—— —— *Ibid.*, 1888, pp. 169, 206, 262-269.

—— In 1889.

John H. Jones, in Eleventh Census U. S., 1890, Min. Ind., pp. 345 ff, 376-378.

Discusses labor, expenses, etc.

—— In 1889-1890.

E. W. Parker, in U. S. Geol. Surv., Min. Res. U. S., 1889-1890, pp. 147, 170, 215-217.

—— In 1891.

—— —— *Ibid.*, 1891, pp. 179 ff, 233-243.

—— In 1892.

—— —— *Ibid.*, 1892, pp. 265, *et seq.*, 390-398.

W. B. Phillips, in Min. Ind., Vol. I, 1892, pp. 76-79. (Tables only.)

—— In 1893.

E. W. Parker, U. S. Geol. Surv., Min. Res. U. S., 1893, pp. 189 *et seq.*, 285-294.

H. S. Fleming, in Min. Ind., Vol. II, 1893, p. 217. (Tables only.)

—— In 1894.

E. W. Parker, in U. S. Geol. Surv., 16th Ann. Rept., 1894-1895, pt. IV. pp. 7 ff, 112-121.

Includes papers on Iowa Coal Fields, H. F. Bain, and on Coal Mining in Iowa, G. A. Davis.

Frederick Hobart, in Min. Ind., Vol. III, 1894, p. 130. (Tables only.)

—— In 1895.

E. W. Parker, in U. S. Geol. Surv., 17th Ann. Rep., 1895-1896, pt. III, pp. 421-429.

Mineral Industry, Vol. IV, 1895, p. 125. (Tables only.)

Census of Iowa, 1895, p. 708. (Tables only.)

—— In 1896.

E. W. Parker in U. S. Geol. Surv., 18th Ann. Rept., 1896-1897, pt. V, pp. 354 ff, 515-524.

Discusses cost of coal at various centers.

The Mineral Industry, Vol. V, 1896, p. 139. (Tables only.)

—— In 1897.

E. W. Parker, in U. S. Geol. Surv., 19th Ann. Rept., 1897-1898, pt. VI, pp. 278 ff, 419-429.

Analyzes rates paid for mining coal.

The Mineral Industry, Vol. VI, 1898, p. 161. (Tables only.)

—— In 1898.

E. W. Parker, in U. S. Geol. Surv., 20th Ann. Rept., 1898-1899, pt. VI, pp. 300 ff, 417-420.

Discusses labor conditions and machine mining.

The Mineral Industry, Vol. VII, 1899, pp. 161, 164.

—— In 1899.

E. W. Parker, in U. S. Geol. Surv., 21st Ann. Rept., 1899-1900, pt. VI, pp. 325 ff, 446-449.

The Mineral Industry, Vol. VIII, 1900, p. 113. (Tables only.)

—— In 1900.

E. W. Parker, in U. S. Geol. Surv., Min. Res. U. S., 1900, pp. 276, 383-387.

The Mineral Industry, Vol. IX, 1901, p. 136. (Tables only.)

—— In 1901.

E. W. Parker, in U. S. Geol. Surv., Min. Res. U. S., 1901, pp. 287 *et seq.*, 379-383.

The Mineral Industry, Vol. X, 1902, p. 125. (Tables only.)

—— In 1902.

E. W. Parker, in U. S. Geol. Surv., Min. Res. U. S., 1902, pp. 293 ff, 374-377. Gives output from 1840, labor statistics, etc.

—— —— In Twelfth Census of U. S., 1900. Special Report on Mines and Quarries, 1902, pp. 677, 680, 686.
Discusses capitalization, production, etc.

The Mineral Industry, Vol. XI, 1903, p. 134. (Tables only.)

—— In 1903.

E. W. Parker, in U. S. Geol. Surv., Min. Res. U. S., 1903, pp. 353 ff, 461-465. (Chiefly tables.)

Samuel Sanford, in Min. Ind., Vol. XII, 1904, p. 48. (Tables only.)

—— In 1904.

E. W. Parker, in U. S. Geol. Surv., Min. Res. U. S., 1904, pp. 385 ff, 480-485.
Gives brief sketch of coal fields.

Frederick Hobart, in Min. Ind., Vol. XIII, 1905, p. 73. (Tables only.)

—— In 1905.

E. W. Parker, in U. S. Geol. Surv., Min. Res. U. S., 1905, pp. 459 ff, 592-599.
Includes shipments by railroads, analyses, etc.

Frederick Hobart, in Min. Ind., Vol. XIV, 1906. pp. 80, 88.

—— In 1906.

E. W. Parker, in U. S. Geol. Surv., Min. Res. U. S., 1906, pp. 571 ff, 671-675.
Sketches labor conditions, etc.

Floyd W. Parsons, in Min. Ind., Vol. XV, 1907, pp. 124, 133.

—— In 1907.

E. W. Parker, in U. S. Geol. Surv., Min. Res. of U. S., 1907, pp. 13 ff, 121-125. Discusses market conditions, etc.

James H. Lees, in Min. Ind., Vol. XVI, 1908, p. 192.

—— In 1908.

E. W. Parker, in U. S. Geol. Surv., Min. Res. of U. S., 1908, pp. 117-120.

James H. Lees, in Eng. & Min. Jour., Vol. 87, p. 87. 1909.

Also in Min. Ind., 1908, Vol. XVII, 1909, pp. 138-139.

Coal region of Iowa, geology of.
C. R. Keyes, in Iowa Geol. Surv., Vol. II, pp. 99-193. 1894.

Coal seams, explanation of certain irregularities encountered in.
H. F. Bain, in Mon. Rev. Iowa Weather and Crop Service, Vol. IV, No. 6, pp. 4-7. 1893.

Coal supplies of Polk county.
Floyd Davis, in Eng. & Min. Jour., Vol. 59, p. 149. 1895.

Coals of Iowa.
C. R. Keyes, in Iowa Geol. Surv., Vol. I, pp. 93, 110, 123. 1893. *Ibid.*, Vol. II, 1894.
Discusses geology of coal region, character of coal beds, mining, composition of coals, etc.

Coals west of the Mississippi river, names of.
C. R. Keyes, in Ia. Acad. Sci., Vol. VIII, pp. 128-137.

Coking tests of Iowa coals at St. Louis testing station, 1904.
F. W. Stammler, in Prof. Paper No. 48, U. S. Geol. Surv., pt. III, pp. 1340-1344.

Composition of Iowa coals.
C. R. Keyes, in Iowa Geol. Surv., Vol. II, pp. 491-503. 1894.

Dallas county, coal in.
C. R. Keyes, in Iowa Geol. Surv., Vol. II, pp. 253-267. 1894.
A. G. Leonard, in Iowa Geol. Surv., Vol. VIII, pp. 92-101. 1897.
O. H. St. John, in Geol. Iowa, Vol. II, pp. 18 ff, 45. 1870.
History of Dallas county, pp. 281-284. Des Moines, 1879.

Davis, Floyd.
Coal Supplies of Polk county, Eng. & Min. Jour., Vol. 59, p. 149. 1895.

Davis county, coal in.
C. R. Keyes, in Iowa Geol. Surv., Vol. II, pp. 424-429.
C. A. White, in Geol. Iowa, Vol. II, p. 271. 1870.

Decatur county, coal in.
H. F. Bain, in Iowa Geol. Surv., Vol. VIII, pp. 294-299. 1897.
C. R. Keyes, in Iowa Geol. Surv., Vol. II, pp. 462-463. 1894.
C. A. White, in Geol. Iowa, Vol. I, p. 326. 1870.

Des Moines, coal at.
C. A. White, Second Ann. Rept. State Geol., pp. 167, 176. 1868.

Des Moines county, coal in.
C. R. Keyes, in Iowa Geol. Surv., Vol. II, pp. 483-484. 1894.
Ibid., Vol. III, pp. 483-485. 1893.

Distribution of coal in United States.
C. W. Hayes, in U. S. Geol. Surv., 22d Ann. Rept., 1900-1901, pt. III, p. 12.

Dixon, J. M.
Coal in Polk county. Centennial History of Polk county, pp. 143-152. Des Moines, 1876.

Drift, coal in.
C. A. White, in Geol. Iowa, Vol. I, p. 97; *Ibid.*, Vol. II, p. 236. 1870.

Dust explosions.
John Verner, in Tenth Bien. Rept. State Mine Insp., 1899-1901, pp. 53-61. 1901.
—— —— in Fourteenth Bien. Rept. State Mine Insp., 1906-'08, pp. 20-25. 1908.

Emery, Rush.
Chemical analyses of Iowa coals. Geol. Iowa. Vol. II, pp. 357-397. 1870.

Explanation of Certain Irregularities Encountered in Working Coal Seams in Iowa.
H. F. Bain, in Mon. Rev. Iowa Weather and Crop Service, Vol. IV, No. 6, pp. 4-7. 1893.

Explosions in mines.
John Verner, in Ninth Bien. Rept. State Mine Insp., 1897-'99, pp. 33-37, 1899.

Fernald, Robert H.
Producer-gas tests of Iowa coals, U. S. Geol. Surv., Bull. 316, 1906, pt. II, pp. 441 ff. (Table only.)
———— Prof. Paper No. 48, U. S. Geol. Surv., pt. III, pp. 1122-1132.

Fleming, H. S.
Coal production in Iowa in 1893. Min. Ind., Vol. II, 1893, p. 217.

Fort Dodge, coal at.
C. A. White, Second Ann. Rept. State Geol., p. 140. 1868.

Fuel supply of Iowa.
C. R. Keyes, in Mon. Rev. Iowa Weather and Crop Service, Vol. IV, No. 7, p. 11. 1893.

Fulton, A. R.
Coal in Iowa. In "Iowa, the Home for Immigrants," p. 21. Des Moines, 1870.

Gases met with in mines.
J. J. Atkinson, in First Ann. Rept. State Mine Insp., 1880-'81, pp. 108-118. 1882.
Park C. Wilson, in Sec. Bien. Rept. State Mine Insp., 1883-'85, pp. 64-70. 1885.

Geological Formations of Iowa.
Samuel Calvin, in Stone, Vol. XXV, 1902, pp. 118-124.

Geology and Geological Resources of Iowa.
Samuel Calvin, in Mines and Minerals, Vol. XXII, 1902, pp. 560-561.

Geology of Des Moines valley.
A. H. Worthen, Geol. Iowa, Vol. I, pp. 147-182. 1858.

Gildroy, James.
Coal mines in eastern Iowa. Bien. Rept. State Mine Insp., Fourth Rept., 1887-'89, pp. 70-114. 1889.
—— —— —— *Ibid.*, Fifth Rept., 1889-'91, pp. 62-80. 1891.
Mine ventilation, Fifth Bien. Rept. State Mine Insp., 1889-'91, pp. 85-92. 1891.

Gordon, C. H.
Coal in Van Buren county, Iowa Geol. Surv., Vol. IV, pp. 239-244. 1904.

Greene county, coal in.
C. R. Keyes, in Iowa Geol. Surv., Vol. II, pp. 219-225. 1894.
O. H. St. John, in Geol. Iowa., Vol. II, pp 134, 137. 1870.

Growth of Iowa's coal industry.
C. R. Keyes, in Mon. Rev. Iowa Weather and Crop Service, Vol. IV, No. 12, pp. 5-7. 1893.

Guthrie county, coal in.
H. F. Bain, in Iowa Geol. Surv., Vol. VII, pp. 469-475. 1896.
C. R. Keyes, in Iowa Geol. Surv., Vol. II, pp. 242-253. 1894.
O. H. St. John, in Geol. Iowa, Vol. II, pp. 105 ff, 128. 1870.

Hall, James.
Coal Measures of Iowa. Geol. Iowa, Vol. I, pp. 120-141. 1858.

Hamilton county, coal in.
C. R. Keyes, in Iowa Geol. Surv., Vol. II, pp. 211-214. 1894.
C. A. White. in First Ann. Rept. State Geol., p. 25, 1868.
—— —— in Geol. Iowa, Vol. II, p. 257. 1870.

Hardin county, coal in.
S. W. Beyer, in Iowa Geol. Surv., Vol. X, p. 289. 1899.
C. R. Keyes, in Iowa Geol. Surv., Vol. II, pp. 214-218. 1894.
C. A. White, in First Ann. Rept. State Geol., p. 22, 1868.
—— —— in Geol. Iowa, Vol. II, p. 258. 1870.
J. D. Whitney, in Geol. Iowa, Vol. I, pp. 269-271. 1858.

Hayes, C. W.
Distribution of coal in United States. U. S. Geol. Surv., 22d Ann. Rept., 1900-1901, pt. III, p. 12.

Henry county, coal in.
C. R. Keyes, in Iowa Geol. Surv., Vol. II, pp. 480-483. 1894.
T. E. Savage, in Iowa Geol. Surv., Vol. XII, p. 298. 1901.
A. H. Worthen, in Geol. Iowa, Vol. I, pp. 211, 218. 1858.

Hinrichs, Gustav. Chemical analyses of Iowa coals. Second Ann. Rept. State Geol., pp. 205-232, 248-268. 1868.

Hobart, Frederick.
Coal production in Iowa in 1894. Min. Ind., Vol. III, 1894, p. 130.
—— In 1904, *Ibid.*, Vol. XIII, 1905, p. 73. (Tables only.)
—— In 1905, *Ibid.*, Vol. XIV, 1906, pp. 80, 88.

Humboldt county, coal in.
C. R. Keyes, in Iowa Geol. Surv., Vol. II, p. 196. 1894.

Hygiene of coal mines.
    Raymond, R. W., in Sec. Bien. Rept. State Mine Insp., 1883-'85, pp. 86-109. 1885.

Iowa coal.
    Joseph Sharp, in Fourteenth Bien. Rept. State Mine Insp., 1906-'08, p. 115. 1908.

—— —— Briquetting of.
    James E. Mills, in Bull. No. 343, U. S. Geol. Surv., p. 52.

—— —— Composition of.
    C. R. Keyes, in Iowa Geol. Surv., Vol. II, pp. 491-503. 1894.

—— —— Producer gas tests of.
    Robert H. Fernald, in Bull. 316, U. S. Geol. Surv., 1906, pt. II, pp. 441 ff. (Tables only.)
    —— —— In Prof. Paper No. 48, U. S. Geol. Surv., pt. III, pp. 1122-1132.

—— —— Tests made at St. Louis testing station, 1904.
    M. R. Campbell and others in Prof. Paper No. 48, U. S. Geol. Surv.

Iowa coal beds.
    C. R. Keyes, in Mon. Rev. Iowa Weather and Crop Service, Vol. IV, No. 1, pp. 3-5. 1893.

Iowa coal-field.
    C. A. White, Second Ann. Rept. State Geol., pp. 163-165. 1868.

Iowa division of Illinois coal-field.
    R. C. Taylor, in "Statistics of Coal," 1855, p. 581.
    Chiefly quoted from Owen's Report of 1852.

Iowa's pioneer coal operators.
    M. G. Thomas, in Eighth Bien. Rept. State Mine Insp., 1895-'97, pp. 72-78. 1897.

Jasper county, coal in.
    C. R. Keyes, in Iowa Geol. Surv., Vol. II, pp. 294-300. 1894.
    C. A. White, in Geol. Iowa, Vol. II, p. 262. 1870.
    J. D. Whitney, in Geol. Iowa, Vol. I, p. 272. 1858.
    I. A. Williams, in Iowa Geol. Surv., Vol. XV, pp. 335-348. 1904.
    History of Jasper county, p. 348. Chicago, 1878.

Jefferson county, coal in.
    C. R. Keyes, in Iowa Geol. Surv., Vol. II, pp. 393-402. 1894.
    J. A. Udden, in Iowa Geol. Surv., Vol. XII, p. 433. 1901.
    C. A. White, in Second Ann. Rept. State Geol., p. 94. 1868.
    —— —— —— In Geol. Iowa, Vol. II, p. 273, 1870.
    A. H. Worthen, in Geol. Iowa, Vol. I, pp. 233-237. 1858.

Jones, John H.
    Coal production in Iowa in 1889. Eleventh Census U. S., 1890, Min. Ind., pp. 345 ff, 376-378.

Keokuk county, coal in.
    H. F. Bain, in Iowa Geol. Surv., Vol. IV, pp. 295-301. 1894.
    C. R. Keyes, in Iowa Geol. Surv., Vol. II, pp. 356-366. 1894.
    C. A. White, in Geol. Iowa, Vol. II, p. 267. 1870.

Keyes, C. R.

Carboniferous in central Iowa. Bull. Geol. Soc. Am., Vol. II, p. 284. 1891.

Character and stratigraphical peculiarities of the southwestern Iowa coal fields. Eng. & Min. Jour., Vol. LXXIII, p. 661. 1902.

Coal deposits of Iowa. Iowa Geol. Surv., Vol. II. 1894.

—— —— —— U. S. Geol. Surv., Min. Res. U. S., 1892, pp. 398-404.

Coal Measures of central Iowa. Am. Geol., Vol. II, pp. 396-404. 1888.

Coal mining, waste in, Iowa Geol. Surv., Vol. II, pp. 511-520. 1894.

Coal regions of Iowa, geology of. *Ibid.*, pp. 99-193. 1894.

Coal in Adair county. *Ibid.*, pp. 441-443. 1894.

—— In Adams county. *Ibid.*, pp. 445-450.

—— In Appanoose county. *Ibid.*, pp. 406-424.

—— In Boone county. *Ibid.*, pp. 225-236.

—— In Cass county. *Ibid.*, pp. 440-441.

—— In Dallas county. *Ibid.*, pp. 253-267.

—— In Davis county. *Ibid.*, pp. 424-429.

—— In Decatur county. *Ibid.*, pp. 462-463.

—— In Des Moines county. *Ibid.*, pp. 483-484. Vol. III, pp. 483-485. 1893.

—— In Greene county. *Ibid.*, pp. 219-225.

—— In Guthrie county. *Ibid.*, pp. 242-253.

—— In Hamilton county. *Ibid.*, pp. 211-214.

—— In Hardin county. *Ibid.*, pp. 214-218.

—— In Henry county. *Ibid.*, pp. 480-483.

—— In Humboldt county. *Ibid.*, p. 196.

—— In Jasper county. *Ibid.*, pp. 294-300.

—— In Jefferson county. *Ibid.*, pp. 393-403.

—— In Keokuk county. *Ibid.*, pp. 356-366.

—— In Lee county. *Ibid.*, pp. 484-489. Vol. III, pp. 369-375. 1893.

—— In Lucas county. *Ibid.*, pp. 366-374.

—— In Madison county. *Ibid.*, pp. 304-306.

—— In Mahaska county. *Ibid.*, pp. 340-356.

—— In Marion county. *Ibid.*, pp. 317-340.

—— In Marshall county. *Ibid.*, pp. 237-239.

—— In Monroe county. *Ibid.*, pp. 374-383.

—— In Montgomery county. *Ibid.*, pp. 443-445.

—— In Muscatine county. *Ibid.*, pp. 475-478.

—— In Page county. *Ibid.*, pp. 453-456.

—— In Polk county. *Ibid.*, pp. 267-294.

—— In Poweshiek county. *Ibid.*, pp. 301-304.

—— In Scott county. *Ibid.*, pp. 470-475.

—— In Story county. *Ibid.*, p. 236.

—— In Taylor county. *Ibid.*, pp. 457-461.

—— In Van Buren county. *Ibid.*, pp. 429-434.

—— In Wapello county. *Ibid.*, pp. 383-393.

—— In Warren county. *Ibid.*, pp. 306-317.

—— In Washington county. *Ibid.*, pp. 478-480.

—— In Wayne county. *Ibid.*, pp. 402-406.

—— In Webster county. *Ibid.*, pp. 197-211.
Coals of Iowa. *Ibid.*, Vol. I, pp. 93, 110, 122. 1893; Vol. II, 1894.
Composition of Iowa coals. *Ibid.*, Vol. II, pp. 491-503. 1894.
Extent of coal industry in Iowa. *Ibid.*, pp. 521-528.
Fuel supply of Iowa. Mon. Rev. Iowa Weather and Crop Service, Vol. IV, No. 7, p. 11. 1893.
Geological position of trans-Mississippian coals, Eng. and Min. Jour., Vol. LXIX, pp. 528-529. 1900.
Growth of Iowa's coal industry. Mon. Rev. Iowa Weather and Crop Service, Vol. IV, No. 12, pp. 5-7. 1893.
Iowa coal beds. Mon. Rev. Iowa Weather and Crop Service, Vol. IV, No. 1, pp. 3-5. 1893.
Names of coals west of the Mississippi river. Ia. Acad. Sci., Vol. VIII, pp. 128-137. 1900.
Southwestern Iowa coal fields. Eng. and Min. Jour., Vol. LXXIII, p. 661. 1902.
Structure of the coal deposits of the trans-Mississippian field. Eng. and Min. Jour., Vol. LXV, pp. 253-254, 280-281. 1898.

Lee county, coal in.
C. R. Keyes, in Iowa Geol. Surv., Vol. II, pp. 484-489. 1894.
Ibid., Vol. III, pp. 369-375. 1893.

Lees, James H.
Coal production in Iowa in 1907. Min. Ind., Vol. XVI, 1908, p. 192.
—— —— —— in 1908. Eng. and Min. Jour., Vol. 87, p. 87. 1909.
——— Mineral Industry in 1908, Vol. XVII, pp. 138-139, 1909.

Leonard, A. G.
Coal in Dallas county. Iowa Geol. Surv., Vol. VIII, pp. 92-101. 1897.
Coal in Wapello county. *Ibid.*, Vol. XII, pp. 477-489. 1901.

Lonsdale, E. H.
Coal in Montgomery county. Iowa Geol. Surv., Vol. IV, p. 446. 1894.
Upper Carboniferous of southwestern Iowa. Iowa Acad. Sci., Vol. II, p. 197. 1894.

Lord, N. W.
Chemical analyses of Iowa coals. Prof. Paper 48, U. S. Geol. Surv., pp. 221-225, 270.

Lucas county, coal in.
C. R. Keyes, in Iowa Geol. Surv., Vol. II, pp. 366-374. 1894.
O. H. St. John, in Geol. Iowa, Vol. II, pp. 81 ff, 94. 1870.

MacFarlane, James.
Coal fields of Iowa, in "Coal Regions of America," pp. 446-463. New York, 1875.

Machine coal mining in Iowa.
H. Foster Bain, in Min. Ind., Vol. IV, 1895, pp. 195-200.

Madison county, coal in.

C. R. Keyes, in Iowa Geol. Surv., Vol. II, pp. 304-306. 1894.

J. L. Tilton and H. F. Bain, in Iowa Geol. Surv., Vol. VII, pp. 537-539. 1896.

C. A. White, in First Ann. Rept. State Geol., p. 72. 1868.

—— —— in Geol. Iowa., Vol. I, p. 313-316. 1870.

Mahaska county, coal in.

H. F. Bain, in Iowa Geol. Surv., Vol. IV, pp. 351-366. 1894.

C. R. Keyes, in Iowa Geol. Surv., Vol. II, pp. 340-356. 1894.

D. D. Owen, in Geol. Surv. Wis., Ia. and Minn., p. 114. 1852.

C. A. White, in Second Ann. Rept. State Geol., p. 91. 1868.

—— —— in Geol. Iowa, Vol. II, p. 265. 1870.

Marion county, coal in.

C. R. Keyes, in Iowa Geol. Surv., Vol. II, pp. 317-340. 1894.

B. L. Miller, in Iowa Geol. Surv., Vol. XI, pp. 169-182. 1900.

D. D. Owen, in Geol. Surv. Wis., Ia. and Minn., pp. 115-117. 1852.

C. A. White, in Second Ann. Rept. State Geol., pp. 100-107. 1868.

—— —— in Geol. Iowa, Vol. II, p. 263. 1870.

Marshall county, coal in.

S. W. Beyer, in Iowa Geol. Surv., Vol. VII, pp. 257-258. 1896.

C. R. Keyes, in Iowa Geol. Surv., Vol. II, pp. 237-239. 1894.

C. A. White, in Geol. Iowa, Vol. II, p. 260. 1870.

J. D. Whitney, in Geol. Iowa, Vol. I, p. 269. 1858.

Miller, B. L.

Coal in Marion county. Iowa Geol. Surv., Vol. XI, pp. 169-182. 1900.

Miller, James W.

Coal mines in eastern Iowa. Bien. Rept. State Mine Insp., Seventh Rept., 1893-'95, pp. 41-55. 1895.

—— —— —— *Ibid.*, Eighth Rept., 1895-'97, pp. 27-38. 1897.

Coal mines in north-central Iowa. Bien. Rept. State Mine Insp., Ninth Rept., 1897-'99, pp. 44-56. 1899.

—— —— —— *Ibid.*, Tenth Rept., 1899-1901, pp. 69-93. 1901.

—— —— —— *Ibid.*, Eleventh Rept., 1901-'03, pp. 69-80. 1903.

Mills, James E.

Briquetting Iowa coals. Bull. No. 343, U. S. Geol. Surv., p. 52. 1908.

Mine economy.

Park C. Wilson, in First Bien. Rept. State Mine Insp., 1881-'83, pp. 42-46. 1883.

Mine ventilation.

James Gildroy, in Fifth Bien. Rept. State Mine Insp., 1889-'91, pp. 85-92. 1891.

Park C. Wilson, in First Ann. Rept. State Mine Insp., 1880-'81, pp. 97-107. 1882.

Monroe county, coal in.
S. W. Beyer and L. E. Young, in Iowa Geol. Surv., Vol. XIII, pp. 380-415. 1902.
C. R. Keyes, in Iowa Geol. Surv., Vol. II, pp. 374-383. 1894.
C. A. White, in Second Ann. Rept. State Geol., p. 93. 1868.
—— —— in Geol. Iowa, Vol. II, p. 267. 1870.

Montgomery county, coal in.
C. R. Keyes, in Iowa Geol. Surv., Vol. II, pp. 443-445. 1894.
E. H. Lonsdale, in Iowa Geol. Surv., Vol. IV, p. 446. 1894.
C. A. White, in Geol. Iowa, Vol. I, p. 366. 1870.

Muscatine county, coal in.
C. R. Keyes, in Iowa Geol. Surv., Vol. II, pp. 475-478. 1894.
J. A. Udden, in Iowa Geol. Surv., Vol. IX, p. 367. 1898.
C. A. White, in Geol. Iowa, Vol. II, p. 274. 1870.
J. D. Whitney, in Geol. Iowa, Vol. I, p. 277. 1858.

Mystic coal basin, structure of.
H. F. Bain, in Iowa Acad. Sci., Vol. I, pt. 4, p. 33. 1893.

Mystic coal seam, peculiarities of.
H. F. Bain, in Am. Geol., Vol. XIII, pp. 407-411. 1894.

Norton, Wm. H.
Coal in Scott county. Iowa Geol. Surv., Vol. IX, pp. 494-496. 1898.

Owen, D. D.
Chemical analysis of Iowa Coals. Geol. Iowa, Wis. and Ill., p. 53. 1839.
Coal fields of Iowa and Missouri. Proc. Amer. Assoc. Adv. Sci., Vol. 5, pp. 119-131. 1851.
Coal in Iowa. Geol. Iowa, Wis. and Ill., p. 53. 1839.
—— —— —— Proc. Amer. Assoc. Adv. Sci., Vol. V, p. 127. 1851.
—— —— —— Geol. Surv. Wis., Ia. and Minn., p. 97. 1852.
Coal in Boone county. *Ibid.*, p. 124.
—— In Mahaska county. *Ibid.*, p. 114.
—— In Marion county. *Ibid.*, pp. 115-117.
—— In Polk county. *Ibid.*, pp. 121-123, 129.
—— In Scott county. Geol. Iowa, Wis. and Ill., p. 53. 1839.
—— In Van Buren county. Geol. Surv. Wis., Ia. and Minn., pp. 106-111. 1852.
—— In Warren county. *Ibid.*, p. 130.
—— In Webster county. *Ibid.*, p. 127.
Coal Measures of Iowa. *Ibid.*, pp. 97 ff.

Page county, coal in.
Samuel Calvin, in Iowa Geol. Surv., Vol. XI, pp. 450-453. 1900.
C. R. Keyes, in Iowa Geol. Surv., Vol. II, pp. 453-456. 1894.
C. A. White, in First Ann. Rept. State Geol., p. 50. 1868.
—— —— —— In Geol. Iowa, Vol. I, p. 352. 1870.
History of Page county, p. 332. Des Moines, 1880.

Parker, E. W.

Coal production in Iowa in 1889-1890. U. S. Geol. Surv., Min. Res. U. S. 1889-1890, pp. 147, 170, 215-217.

——— ——— ——— In 1891. *Ibid.*, 1891, pp. 179 ff, 233-243.

——— ——— ——— In 1892. *Ibid.*, 1892, pp. 265 *et seq.*, 390-398.

——— ——— ——— In 1893. *Ibid.*, 1893, pp. 189 ff, 285-294.

——— ——— ——— In 1894. U. S. Geol. Surv., 16th Ann. Rept., 1894-1895, pt. IV, pp. 7 ff, 112-121.

——— ——— ——— In 1895. *Ibid.*, 17th Ann. Rept., 1895-1896, pt. III, pp. 421-429.

——— ——— ——— In 1896. *Ibid.*, 18th Ann. Rept., 1896-1897; pt. V, pp. 354 ff, 515-524.

——— ——— ——— In 1897. *Ibid.*, 18th Ann. Rept., 1897-1898, pt. VI, pp. 278 ff, 419-429.

——— ——— ——— In 1898. *Ibid.*, 20th Ann. Rept., 1898-1899, pt. VI, pp. 300 ff, 417-420.

——— ——— ——— In 1899. *Ibid.*, 21st Ann. Rept., 1899-1900, pt. VI, pp. 325 ff, 446-449.

——— ——— ——— In 1900, U. S. Geol. Surv., Min. Res. U. S., 1900, pp. 276, 383-387.

——— ——— ——— In 1901. *Ibid.*, 1901, pp. 287 *et seq.*, 379-283.

——— ——— ——— in 1902. *Ibid.*, 1902, pp. 293 ff, 374-377.

Twelfth Census of U. S., 1900, Spec. Rept. on Mines and Quarries, pp. 677, 680, 686. 1902.

——— ——— ——— In 1903. U. S. Geol. Surv., Min. Res. U. S., 1903, pp. 353 ff, 461-465.

——— ——— ——— In 1904. *Ibid.*, 1904, pp. 385 ff, 480-485.

——— ——— ——— In 1905. *Ibid.*, 1905, pp. 459 ff, 592-599.

——— ——— ——— In 1906. *Ibid.*, 1906, pp. 571 ff, 671-675.

——— ——— ——— In 1907. *Ibid.*, 1907, pp. 13 ff, 121-125.

——— ——— ——— In 1908. *Ibid.*, 1908, pp. 27 ff, 117-120.

Parker, N. Howe.

Coal in Iowa. In "Iowa as it is in 1855," pp. 39-43. Chicago.

Coal in Iowa. In Iowa Handbook for 1857, pp. 32-35. Boston.

Parsons, Floyd W.

Coal production in Iowa in 1906. Min. Ind., Vol. XV, 1907, pp. 124-133.

Patrick, G. E.

Chemical analyses of Iowa coals. Iowa Geol. Surv., Vol. II, pp. 504-509. 1894.

Phillips, Wm. B.

Coal production in Iowa in 1892. Min. Ind., Vol. I, 1892, pp. 76-79.

Polk county, coal in.

H. F. Bain, in Iowa Geol. Surv., Vol. VII, pp. 352-366. 1896.

J. M. Dixon, in Centennial History of Polk county, pp. 143-152. Des Moines, 1876.

C. R. Keyes, in Iowa Geol. Surv., Vol. II, pp. 267-294. 1894.

D. D. Owen, in Geol. Surv. Wis., Ia. and Minn., pp. 121-123, 129. 1852.

Will Porter, in "Annals of Polk county," pp. 363, 901. 1898.
C. A. White, in Geol. Iowa, Vol. II, p. 261. 1870.
History of Polk county, pp. 273-276; 707. Des Moines, 1880.

Polk county, coal supplies of.
Floyd Davis, in Eng. & Min. Jour., Vol. 59, p. 149. 1895.

Porter, Will.
Coal in Polk county, in "Annals of Polk county," pp. 363, 901. 1898.

Poweshiek county, coal in.
C. R. Keyes, in Iowa Geol. Surv., Vol. II, pp. 301-304. 1894.

Pratt, Joseph Hyde.
Briquetting tests of Iowa coals at St. Louis testing station, 1904. Prof. Paper No. 48, U. S. Geol. Surv., pt. III, pp. 1427, 1443 ff.

Prime, Frederick, Jr.
Coal production in Iowa in 1870. Ninth Census U. S., 1870, Vol. on Industry and Wealth, pp. 761, 767, 775.
—— —— —— In 1880. Tenth Census U. S., 1880, Vol. on Mining Industries, pp. 616, 650, 681 ff.

Producer-gas tests of Iowa coals.
Robert H. Fernald, in Bull. 316, U. S. Geol. Surv., 1906, pt. II, pp. 441 ff. Table only.
—— —— —— In Prof. Paper No. 48, U. S. Geol. Surv., pt. III, pp. 1122-1132.

Raccoon valley, coal in.
O. H. St. John, in Second Ann. Rept. State Geol., pp. 175-190. 1868.

Raymond, R. W.
Hygiene of coal mines. Sec. Bien. Rept. State Mine Insp., 1883-'85, pp. 86-109. 1885.

Reed, H. S.
Coal in Iowa. "The Leading Industries of the West," pp. 7, 13. Chicago, 1883.

Rhys, R. T.
Coal mines in eastern Iowa. Fourteenth Bien. Rept. State Mine Insp., 1906-'08, pp. 74-82. 1908.

St. John, O. H.
Coal horizons in Iowa. Geol. Iowa, Vol. I, pp. 273-283. 1870.
Coal in Raccoon valley. Second Ann. Rept. State Geol., pp. 175-190. 1868.
Coal in Dallas county. Geol. Iowa, Vol. II, pp. 18 ff, 45. 1870.
—— In Greene county. *Ibid.*, pp. 134, 137.
—— In Guthrie county. *Ibid.*, pp. 105 ff, 128.
—— In Lucas county. *Ibid.*, pp. 81 ff, 94.
—— In Warren county. *Ibid.*, pp. 50 ff, 74.

Sanford, Samuel.
Coal production in Iowa in 1903. Min. Ind., Vol. XII, 1904, p. 48. Tables only.

Savage, T. E.
Coal in Henry county, Iowa Geol. Surv., Vol. XII, p. 298. 1901.
Report of tests of Iowa coals made at St. Louis testing station, 1904, *Ibid.*, Bull. No. 2, pp. 22-38, 1905.

Scott county, coal in.
C. R. Keyes, in Iowa Geol. Surv., Vol. II, pp. 470-475. 1894.
Wm. H. Norton, in Iowa Geol. Surv., Vol. IX, pp. 494-496. 1898.
D. D. Owen, in Geol. Surv. Iowa, Wis. and Ill., p. 53. 1839.
C. A. White, in Geol. Iowa, Vol. II, p. 274. 1870.

Sharp, Joseph.
Iowa coal. Fourteenth Bien. Rept. State Mine Insp., 1906-'08, p. 115. 1908.

Smith, J. A.
Coal mines in eastern Iowa. Third Bien. Rept. State Mine Insp., 1885-'87, pp. 87-99. 1888.

Southwestern Iowa coal fields, character and stratigraphical peculiarities of.
C. R. Keyes, in Eng. & Min. Jour., Vol. LXXIII, p. 661. 1902.

Stammler, F. W.
Coking tests of Iowa coals at St. Louis testing station, 1904. Prof. Paper No. 48, U. S. Geol. Surv., pt. III, pp. 1340-1344. 1906.

Story county, coal in.
S. W. Beyer, in Iowa Geol. Surv., Vol. IX, pp. 216-219. 1898.
C. R. Keyes, in Iowa Geol. Surv., Vol. II, p. 236. 1894.

Stout, J. E.
Coal mines in north-central Iowa. Bien. Rept. State Mine Insp., Third Rept., 1885-'87, pp. 124-160. 1888.
—— —— —— *Ibid.*, Fourth Rept., 1887-'89, pp. 119-143. 1889.

Sweeney, Edward.
Coal mines in eastern Iowa. Bien. Rept. State Mine Insp., Eleventh Rept., 1901-'03, pp. 51-60. 1903.
Coal mines in north-central Iowa. *Ibid.*, Twelfth Rept., 1903-'05, pp. 85-98. 1905.
—— —— —— *Ibid.*, Thirteenth Rept., 1905-'06, pp. 75-86. 1906.
—— —— —— *Ibid.*, Fourteenth Rept., 1906-'08, pp. 89-97. 1908.

Taylor, R. C.
Iowa division of Illinois coal field. Statistics of Coal, 1855, p. 481.

Taylor county, coal in.
C. R. Keyes, in Iowa Geol. Surv., Vol. II, pp. 457-461. 1894.
C. A. White, in First Ann. Rept. State Geol., p. 47. 1868.
—— —— —— In Geol. Iowa, Vol. I, p. 347. 1870.

Tests of Iowa coals made at St. Louis testing station, 1904.
M. R. Campbell and others, in Prof. Paper No. 48, U. S. Geol. Surv., 1906.
T. E. Savage, in Ia. Geol. Surv., Bull. No. 2, pp. 22-38. 1905.

Thomas, M. G.

Coal mines in north-central Iowa. Bien. Rept. State Mine Insp., Fifth Rept., 1889-'91, pp. 96-116. 1891.

——— ——— ——— *Ibid.*, Sixth Rept., 1891-'93, pp. 71-90. 1893.

——— ——— ——— *Ibid.*, Seventh Rept., 1893-'95, pp. 69-94. 1895.

——— ——— ——— *Ibid.*, Eighth Rept., 1895-'97, pp. 53-59. 1897.

Iowa's pioneer coal operators. Eighth Bien. Rept. State Mine Insp., 1895-'97, pp. 72-78. 1897.

Tilton, John L.

Coal in Warren county. Iowa Geol. Surv., Vol. V, pp. 342-350. 1895.

——— ——— ——— and Bain, H. F.

Coal in Madison county. Iowa Geol. Surv., Vol. VII, pp. 537-539. 1896.

Udden, J. A.

Coal in Jefferson county. Iowa Geol. Surv., Vol. XII, p. 433. 1901.

Coal in Muscatine county. Iowa Geol. Surv., Vol. IX, p. 367. 1898.

Upper Carboniferous of Southwestern Iowa.

E. H. Lonsdale, in Iowa Acad. Sci., Vol. II, p. 197. 1894.

Van Buren county, coal in.

C. H. Gordon, in Iowa Geol. Surv., Vol. IV, pp. 239-244. 1894.

C. R. Keyes, in Iowa Geol. Surv., Vol. II, pp. 429-434. 1894.

D. D. Owen, in Geol. Surv. Wis., Ia. and Minn., pp. 106-111. 1852.

C. A. White, in Second Ann. Rept. State Geol., p. 112. 1868.

——— ——— in Geol. Iowa, Vol. II, p. 271. 1870.

A. H. Worthen, in Geol. Iowa, Vol. I, pp. 222-226, 229. 1858.

Verner, John.

Coal mines in eastern Iowa. Bien. Rept. State Mine Insp., Ninth Rept., 1897-'99, pp. 23-30. 1899.

——— ——— ——— *Ibid.*, Tenth Rept., 1899-1901, pp. 31-47. 1901.

Coal mines in southern Iowa, *Ibid.*, Sixth Rept., 1891-'93, pp. 4-35. 1893.

——— ——— ——— *Ibid.*, Eleventh Rept., 1901-'03, pp. 15-39. 1903.

——— ——— ——— *Ibid.*, Twelfth Rept., 1903-'05, pp. 15-55. 1905.

——— ——— ——— *Ibid.*, Thirteenth Rept., 1905-'06, pp. 13-37. 1906.

——— ——— ——— *Ibid.*, Fourteenth Rept., 1906-'08, pp. 9-11, 25-49. 1908.

Dust explosions. Bien. Rept. State Mine Insp., Tenth Rept., 1899-1901, pp. 53-61. 1901.

——— ——— ——— *Ibid.*, Fourteenth Rept., 1906-'08, pp. 20-25. 1908.

Explosions in mines. *Ibid.*, Ninth Rept., 1897-'99, pp. 33-37. 1899.

Wapello county, coal in.

C. R. Keyes, in Iowa Geol. Surv., Vol. II, pp. 383-393. 1894.

A. G. Leonard, in Iowa Geol. Surv., Vol. XII, pp. 477-489. 1901.

C. A. White, in Second Ann. Rept. State Geol., pp. 108-111. 1868.

——— ——— ——— In Geol. Iowa, Vol. II, pp. 268, 270. 1870.

A. H. Worthen, in Geol. Iowa, Vol. I, pp. 250-254, 256. 1858.

Warren county, coal in.

C. R. Keyes, in Iowa Geol. Surv., Vol. II, pp. 306-317. 1894.

D. D. Owen, in Geol. Surv. Wis., Ia. and Minn., p. 130. 1852.

O. H. St. John, in Geol. Iowa, Vol. II, pp. 50 ff, 74. 1870.

J. L. Tilton, in Iowa Geol. Surv., Vol. V, pp. 342-350. 1896.

Washing tests of Iowa coals at St. Louis testing station, 1904.
John H. Wick in Prof. Paper No. 48, U. S. Geol. Surv., pt. III, pp. 1469, 1470. 1906.

Washington county, coal in.
H. F. Bain, in Iowa Geol. Surv., Vol. V, p. 162. 1896.
C. R. Keyes, in Iowa Geol. Surv., Vol. II, pp. 478-480. 1894.
C. A. White, in Geol. Iowa, Vol. II, p. 273. 1870.
A. H. Worthen, in Geol: Iowa, Vol. I, pp. 240, 246. 1858.

Wayne county, coal in.
C. R. Keyes, in Iowa Geol. Surv., Vol. II, pp. 402-406. 1894.

Webster county, coal in.
C. R. Keyes, in Iowa Geol. Surv., Vol. II, pp. 197-211. 1894.
D. D. Owen, in Geol. Surv. Wis., Ia. and Minn., p. 127. 1852.
C. A. White, in Geol. Iowa, Vol. II, p. 235. 1870.
F. A. Wilder, in Iowa Geol. Surv., Vol. XII, pp. 167-173. 1901.

Western interior coal field.
H. Foster Bain, in U. S. Geol. Surv., 22d Ann. Rept., 1900-1901, pt. III, pp. 339-366.

White, C. A.
Coal at Boonesboro. Second Ann. Rept. State Geol., p. 142. 1868.
—— At Des Moines. *Ibid.*, pp. 167, 176.
—— At Ft. Dodge, *Ibid.*, p. 140.
—— In drift, Geol. Iowa, Vol. I, p. 97; Vol. II, p. 236. 1870.
—— In Iowa. Geol. Iowa, Vol. I, pp. 258-263. 1870.
—— In Adams county, First Ann. Rept. State Geol., p. 67. 1868.
Idem. Geol. Iowa, Vol. I, pp. 342-344. 1870.
—— In Appanoose county. First Ann. Rept. State Geol., p. 40. 1868.
—— In Boone county. Geol. Iowa, Vol. II, p. 259. 1870.
—— In Davis county. *Ibid.*, p. 271.
—— In Decatur county. *Ibid.*, Vol. I, p. 326. 1870.
—— In Hamilton county. First Ann. Rept. State Geol., p. 25. 1868.
Idem. Geol. Iowa, Vol. II, p. 257. 1870.
—— In Hardin county. First Ann. Rept. State Geol., p. 22. 1868.
Idem. Geol. Iowa, Vol. 2, p. 258. 1870.
—— In Jasper county. Geol. Iowa, Vol. II, p. 262. 1870.
—— In Jefferson county. Second Ann. Rept. State Geol., p. 94. 1868.
Idem. Geol. Iowa, Vol. II, p. 273. 1870.
—— In Keokuk county. Geol. Iowa, Vol. II, p. 267. 1870.
—— In Madison county. First Ann. Rept. State Geol., p. 72. 1868.
Idem. Geol. Iowa, Vol. I, pp. 313-316. 1870.
—— In Mahaska county. Second Ann. Rept. State Geol., p. 91. 1868.
Idem. Geol. Iowa, Vol. II, p. 265. 1870.
—— In Marion county. Second Ann. Rept. State Geol., pp. 100-107. 1868.
Idem. Geol. Iowa, Vol. II, p. 263. 1870.
—— In Marshall county. Geol. Iowa, Vol. II, p. 260. 1870.
—— In Monroe county. Second Ann. Rept. State Geol., p. 93. 1868.
Idem. Geol. Iowa, Vol. II, p. 267. 1870.

—— In Montgomery county. Geol. Iowa, Vol. I, p. 366. 1870.
—— In Muscatine county. Geol. Iowa, Vol. II, p. 274. 1870.
—— In Page county. First Ann. Rept. State Geol., p. 50. 1868.
Idem. Geol. Iowa, Vol. I, p. 352. 1870.
—— In Polk county. Geol. Iowa, Vol. II, p. 261. 1870.
—— In Scott county. Geol. Iowa, Vol. II, p. 274. 1870.
—— In Taylor county. First Ann. Rept. State Geol., p. 47. 1868.
Idem. Geol. Iowa, Vol. I, p. 347. 1870.
—— In Van Buren county. Second Ann. Rept. State Geol., p. 112. 1868.
Idem. Geol. Iowa, Vol. II, p. 271. 1870.
—— In Wapello county. Second Ann. Rept. State Geol., pp. 108-111. 1868.
Idem. Geol. Iowa, Vol. II, pp. 268, 270. 1870.
—— In Washington county. *Ibid.*, p. 273.
—— In Webster county. *Ibid.*, p. 255.
Coal Measures of Iowa. *Ibid.*, Vol. I, pp. 236-284. 1870.
Iowa coal field. Second Ann. Rept. State Geol., pp. 163-165. 1868.

Whitney, J. D.
Chemical analyses and general character of Iowa coals. Geol. Iowa, Vol. I, pp. 397-415. 1858.
Coal in Jasper county. *Ibid.*, p. 272.
—— In Hardin county. *Ibid.*, pp. 269-271.
—— In Marshall county. *Ibid.*, p. 269.
—— In Muscatine county. *Ibid.*, p. 277.

Wick, John D.
Washing tests of Iowa coals at St. Louis testing station, 1904. Prof. Paper No. 48, U. S. Geol. Surv., pt. III, pp. 1469, 1470.

Wilder, Frank A.
Coal in Webster county. Iowa Geol. Surv., Vol. XII, pp. 167-173. 1901.

Williams, Albert, Jr.
Coal production in Iowa in 1882. U. S. Geol. Surv., Min. Res. U. S., 1882, pp. 4 ff, 55-56.

Williams, H. S.
Review of "Coal Fields of Iowa and Missouri," by D. D. Owen. Bull. 80, U. S. Geol. Surv., p. 143. 1891.

Williams, I. A.
Coal in Jasper county. Iowa Geol. Surv., Vol. XV, pp. 335-348. 1904.

Wilson, Park C.
Coal Measures of Iowa. Bien. Rept. State Mine Insp., First Rept., 1880-1881, pp. 81-93. 1882.
Coal mines of Iowa. *Ibid.*, First Rept., 1880-'81, pp. 6-79. 1882.
—— —— —— *Ibid.*, First Bien. Rept., 1881-'83, pp. 12-41. 1883.
—— —— —— *Ibid.*, Sec. Rept., 1883-'85, pp. 19-62. 1885.
Gases met with in mines. *Ibid.*, Sec. Rept., 1883-'85, pp. 64-70. 1885.
Mine economy. *Ibid.*, First Rept., 1881-'83, pp. 42-46. 1883.

Mine ventilation. *Ibid.*, First Rept., 1880-'81, pp. 97-107. 1882.
Record of drillings in Coal Measures. *Ibid.*, 1881-'83, pp. 57-74. 1883.
—— —— —— *Ibid.*, Sec. Rept., 1883-'85, pp. 110-116. 1885.

Worthen, A. H.
Coal in Henry county. Geol. Iowa, Vol. I, pp. 211, 218. 1858.
—— In Jefferson county. *Ibid.*, pp. 233-237.
—— In Van Buren county. *Ibid.*, pp. 222-226, 229.
—— In Wapello county. *Ibid.*, pp. 250-254, 256.
—— In Washington county. *Ibid.*, pp. 240, 246.
Geology of Des Moines valley. *Ibid.*, pp. 147-182.

Young, L. E., Beyer, S. W., and.
Coal in Monroe county. Iowa Geol. Surv., Vol. XIII, pp. 380-415. 1902.

PEAT DEPOSITS IN IOWA

BY

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CONTENTS

PEAT AND PEAT DEPOSITS IN IOWA

Introduction. During the summer of 1905 the Iowa Geological Survey detailed Mr. L. H. Wood to locate and determine the area and thickness of the leading peat swamps in Iowa. On the basis of Mr. Wood's notes, Mr. T. E. Savage, then Assistant State Geologist, prepared "A Preliminary Report on the Peat Resources of Iowa" which appeared early in 1906 as Bulletin 2 of the Survey. Several of the county reports published before the appearance of the bulletin casually mentioned the peat deposits within their borders, and all of those published since having to do with counties within the peat area mention and some describe their peat resources.

Several attempts have been made to utilize Iowa peat, notably near Dows in Franklin county and at Goose Lake near Fertile in Worth county. Both plants have not yet passed the experimental stage. Interest in the possibilities of the state's resources in peat has been stimulated greatly by the preliminary work of the Survey, and hence the reason for the present more extended inquiry.

During portions of the summers of 1907 and 1908 Mr. W. F. Coover, assisted by Mr. F. A. Knowles during 1908, mapped and sampled the more important bogs in the state. The work of sampling was made difficult because of the protracted wet weather during the field seasons. Bogs containing less than forty acres were not sampled, as a rule, and no samples were saved in those where the vegetable debris averaged less than three feet in thickness. A two-inch common auger was used both for testing depth and securing samples. In general, all of the borings of a hole were mixed and constituted but a single sample. Where considerable changes in character and quality of material were noted an additional sample was sometimes taken. The samples were numbered and shipped to headquarters for further study and analysis.

Peat Defined. Ordinary vegetable matter according to standard authorities is composed of two compounds, cellulose ($C_6H_{10}O_5$) or vegetable fiber, and lignin ($C_{35}H_{24}O_{20}$) or ordinary wood fiber. Nitrogen in small quantities is generally associated with the two preceding.

Both cellulose and lignin are unstable under atmospheric conditions and tend to break down to much more simple compounds, chief of which are members of the marsh gas series, carbonic acid gas and water. In air the destruction of vegetable matter is almost complete, leaving behind only the inorganic residue, similar in character to the ash residue which remains after burning wood. In fact, slow oxidation in air under natural conditions produces results practically parallel to those produced by rapid oxidation through burning. In the case of plant remains which accumulate under water, the process of simplification is interfered with and only a partial chemical breaking down is the result. The principal changes which take place are a relative loss in oxygen and hydrogen and an increase in carbon. The resultant partially decayed plant debris is known as peat. From the above it is evident that the physical constitution and chemical composition must be highly variable. Physically peat varies from a highly fibrous, heterogeneous lace work of almost unchanged plant remains to a fiberless, homogeneous, structureless muck or mud. In the first the original plants are easily identified, while in the latter the organic origin can be determined only through the assistance of the compound microscope.

In composition the variation is important but less easily marked. The carbon percentage ranges from about forty to over sixty. In color Iowa peat ranges from a light brown through various shades of brown to almost jet black in the nonfibrous varieties. The latter often show shades of gray and blue due to the presence of clay and remains of fresh water shells.

Properties of Peat. Peat when freshly removed from the bog holds from seventy-five to eighty-five or even ninety per cent of water. Even air dried peat retains from ten to twenty-five per cent of water, the amount varying with climatic conditions and the purity and physical constitution of the peat. In general, the freer from impurities and more fibrous the peat, the more water retained. It was early observed that animal organisms imbedded in peat were preserved indefinitely. It is due to this antiseptic property that peat itself is preserved from decay.

Occurrence. Most of the peat deposits in Iowa occur in shallow depressions, but occasional peat deposits may be found on gently sloping hillsides, marking a line of seeping springs. The latter are usually of too small extent to be commercially considered. The first type only receives attention in this paper. Various terms have been and are being applied to peat deposits in Iowa. Perhaps the most common are bog, marsh and swamp. The late Professor N. S. Shaler used the term morass in his published writings for similar deposits. Professor C. A. Davis in his report on the Michigan* Peat Deposits uses the above terms for certain specific types of undrained areas. He defines a bog "as an area of wet, porous land on which the soil is made up principally of decayed and decaying vegetable matter, so loosely consolidated, and containing so much water, that the surface shakes and trembles as one walks over it. The vegetation upon the surface is variable, but it is characteristically either some species of moss or of sedge, or grass, or a combination of two or more of these with shrubs and even small trees." A marsh he states "has a firm soil that is not easily shaken when walked upon, although it may be soft and very wet, even submerged, and the vegetation upon it is principally grass-like, that is, with long narrow leaves, and weak, short-lived aerial stems. Shrubs may occur upon marshes, and where they are present not infrequently form thickets." A swamp as described by Davis "has trees and shrubby plants as the most important part of the vegetation, the soil being, as in the case of the marsh, firm, but wet, even, at times, to flooding." It is apparent even to casual observers that there can be no sharp line of separation according to Davis' definitions between the bog, the marsh, and the swamp.

In many cases two or even all of the above types may be represented in the same basin. Practically all of the Iowa peat accumulations worthy of mention belong to the bog type. Swamps as defined by Professor Davis are unknown in Iowa, at least in the peat producing district. All of the peat bogs of

*Annual Report, Geological Survey of Michigan, 1906, pp. 108, *et seq.*

commercial importance are confined to the Wisconsin drift sheet, and by far the most important bogs are within the Altamont morainal belt on the east side of the Wisconsin lobe. The bogs vary greatly in area and depth. They range in area up to 1,500 acres and in depth to more than thirty-five feet. The deepest bogs tested are in those morainal tracts where the surface is most broken. Away from the morainal belt the basins become shallower and the peat thinner and as a general rule poorer in quality.

Mode of Accumulation. In many of the shallower basins water plants grow directly from the bottom and peat is accumulated through the successive generations of plants. Most of the bogs in the interior of the Wisconsin drift lobe are of this type. In the deeper bogs the filling is done by the growth of plants from the edges and to some extent from plants which grow on top of the water. The plant border extends itself as a mat over the surface of the water and eventually covers the entire surface of the lake or pond with a floating vegetable mat. Bear Lake in Winnebago county is an example of a lake being slowly transformed into a bog by the extension of the border mat. Sample holes put down at some distance from the open water disclosed a heavy fibrous layer underlain by a very soft peaty mud. The usual sequence in the deeper bogs is a brown, highly fibrous layer or surface mat resting on a non-fibrous to slightly fibrous brownish black mud or muck. In many instances this sequence is repeated, and below the peat mud is a second brown fibrous horizon followed by a second layer of peaty mud. Marly to clayey layers are not infrequently interspersed with the purer peat.

Peat Plants. Professor L. H. Pammel has prepared a list of the leading plants which contribute to the production of Iowa peat deposits. Suffice it to say that while in high latitudes and high altitudes the club mosses, Sphagnums and Hypnums contribute very largely toward the accumulation of peat, grasses and sedges are much more important in Iowa peat bogs. Mosses are present occasionally, but play a secondary role. Michigan and Wisconsin bogs support heavy growths of timber in many cases, but Iowa bogs are remarkably free from the growth of trees and shrubs.

Rate of Growth. The rate of accumulation is variable, but must be extremely slow, especially where the smaller plants predominate and there is but little increase through wash. In Iowa, as the chief deposits are in the Wisconsin drift, the filling has probably been going on since the retreat of that ice sheet. The deepest bogs probably exceed thirty-five feet but little. Assuming the minimum time estimate since the disappearance of the Wisconsin ice and the maximum thickness of bog, the maximum rate of accumulation would be about one foot of peat in about two hundred years. The average rate is undoubtedly much less.

Composition of Iowa Peat. Both chemical and calorimetric analyses were made of the peat samples collected. Chemically, Iowa peat runs high in ash and comparatively low in the combustible elements. The leading impurities are quartz sand, and clay, and lime carbonate derived from the remains of small fresh water molluscs.

The Goose Lake peat bog near Fertile in Worth county may be considered fairly representative of the best grade of Iowa peat bogs. An average sample of the air-dried machine peat put upon the market by the Fertile Peat and Clay Company gave the following composition:

Moisture	9.59 per cent
Volatile carbons	27.50 per cent
Fixed carbon	39.17 per cent
Ash	23.74 per cent
Total	100.00 per cent

An analysis of ash from the above sample gave the following results:

Silica	10.98 per cent
Ferric oxide and alumina	8.42 per cent
Lime	2.87 per cent
Magnesia	0.60 per cent
	22.87 per cent
Total ash	23.74 per cent

In this particular case the leading impurity is clay with some lime. On account of the prevailingly high percentages of ash, the heat values run correspondingly low.

The high percentage of ash in Iowa peat as compared with Michigan, Ontario and Maine peat, as well as the increase in ash toward the southwest in the Iowa field, is believed to be due largely to wind blown silt and clay. The prairie character of the Iowa bogs would interfere less with wind work than the timbered areas to the north and east.

The Heat Value of Iowa Peat. Davis in his work on Michigan peat shows that, in general, the heat value of peat varies inversely as the amount of ash present, but that there are many exceptions to the rule. The same rule applies to Iowa peat. A casual inspection of the analyses appended herewith is convincing and the dependence of heat value to ash is obvious. The range is from about 8,400 British Thermal Units down to peats so low in combustible matter that the charge fails to explode in the calorimeter. The average Iowa peat has about one-half the heat value of the average Iowa coal.

METHODS OF PREPARING PEAT FOR THE MARKET

Cut Peat. In Western Europe peat has long been used as a fuel by the common people. The method earliest employed and still used extensively was to cut the peat into rectangular blocks which were ricked up on or near the bog and permitted to air dry. This method involves no treatment whatever, and the product is known as cut peat. Only the fibrous varieties can be used in this way. On account of the bulkiness of the product and loss in handling, the use of cut peat is limited to the immediate vicinity of the bog. The cut peat retains from twenty to forty per cent of moisture.

Machine Peat. The essential features in the production of machine peat are that the peat is treated either in the bog or after its removal from the bog, with or without the addition of water, and then moulded by hand or by machinery. The simplest possible method is where the peat after being cut loose is worked into a pulp by the tramping of men or animals. Then it is moulded into blocks of convenient size and shape and dried in air. Machine peat generally means the use of machinery, and in those plants considered up-to-date, the removal from the pit, the reduction to a peat pulp, and the final moulding into blocks are all done by machinery. A considerable number of excavators, conveyors, tempering and moulding machines have been invented and are in use in western and northern Europe. Some of these have been imported, modified, and are in use on the North American continent. The leading foreign types take the names of their inventors, and are the Schlickeysen,* R. Dolberg, A. Heinen, L. Lucht, A. Anrep, Svedala, and Akerman. In all of the above the peat is reduced to a pulp by passing through a machine resembling either the disintegrater or the pug mill, or both, used in preparing clay in ordinary brick plants. The peat plant near Fertile in Worth county has installed a Heinen machine.

In all of the above machines the peat pulp issues as a continuous bar, is received on pallets, is cut into convenient lengths and removed to the drying field or drier. As a rule artificial heat is not used in the drying of machine peat. The air dried machine peat retains from fifteen to thirty per cent of moisture.

Briquetted Peat. In both cut peat and machine peat the low density and consequent bulkiness and low fuel value of the product, its high moisture content and friable character not only render transportation and repeated handling unprofitable, but practically prohibit them. To overcome these difficulties, a number of briquetting machines have been devised and put into use. The fundamental processes in briquetting consist of first removing a portion of the water from the peat, after which it is passed through a disintegrator, screened, thoroughly dried in a rotary or plate drier, and then put through the briquette machine. A plunger working in a die subjects each briquette momentarily to a pressure of from 15,000 to 30,000 pounds per square inch. The resultant product possesses nearly the density of bituminous coal and is but slowly affected by the weathering agencies.

Attempts have been made to briquette peat direct from the pit, but without success. No mechanical device has yet been found by which the water can be removed directly.

*Peat and Lignite, their Manufacture in Europe; by E. Nystrom, Canada Department of Mines, Mines Branch, pp. 58-84; Ottawa, 1908.

USES OF PEAT

As a Fuel. The principal use of peat has been and is as a fuel. It may be used direct as cut peat, machine peat, or briquettes, or may be transformed into coke, half coke, producer gas, or powder before burning. The latter two methods deserve most consideration at present for Iowa peat. Producer gas has been used much more extensively in western Europe than in the United States, and especially is this true of producer gas generated from peat. The gas obtained from peat compares very favorably in quality and heat value with that obtained from coal. Nystrom* reports that peat used as a powder and containing seventeen per cent of water gave nearly the same energy as the same weight of Newcastle coal. Peat as a source of producer gas must be of interest to north central Iowa where other fuel is scarce.

In the production of producer gas from peat, tar and ammonium sulphate may be recovered as by-products.

Minor Uses of Peat. On account of its high absorbent power it is used as stable litter, as a deodorizer and disinfectant, as an antiseptic and absorbent in surgery. It is also used as a fertilizer for lands deficient in humus. Fibrous peat is used as a packing material, for paving and building block, and artificial lumber, and for the manufacture of paper, and even woven into cloth.

USES OF IOWA PEAT

As a Fuel. From a casual inspection of the table of chemical analyses it is obvious that a great majority of the samples of Iowa peat analyzed carry upwards to twenty-five per cent of ash. According to Davis in his report on Michigan peat bogs, peat carrying more than twenty or twenty-five per cent of ash is too low grade to be considered commercially. Samples carrying up to thirty or thirty-five per cent burn readily and may be considered a serviceable fuel where other fuels are scarce. Such low grade fuel could not be shipped far from the bog in competition with Iowa and Illinois coals. It is possible that ways and means may be found to transform the peat into power through the producer gas engine and transmit it electrically to points where needed, or into a gas and pipe it from the bog to the consumer.

*Peat & Lignite, Etc.; Canada Dept. Mines, pp. 171 and 172, and 198 *et seq.*; Ottawa, 1908.

Davis reports that a ton of peat carrying twenty to twenty-five per cent of moisture treated by the Ziegler process yields 6,650 cubic feet of gas, while the best English cannel coals yield scarcely twice as much gas. The cost per thousand feet is decidedly in favor of the peat. The peat coke is far superior to the gas coke on account of its freedom from sulphur and other objectionable impurities.

The ordinary gas producers now on the market in the United States are not adapted for the use of peat. Several of the large manufacturers of producers are at work on the problem and a producer which will successfully use peat is confidently expected in the near future.

The peat machined at Fertile and Dows kindles readily, burns without clinkers, and gives fair satisfaction for domestic purposes.

For Other Purposes. A sample of peat from the Fertile plant was sent to the Pilgrim Paper Company, Capac, Michigan, for examination, but was pronounced unsuited for the manufacture of paper pulp. The brown, highly fibrous layer found in the majority of Iowa bogs ought to furnish material sufficiently fibrous for a paper pulp. This superficial layer varies from two or three feet up to eight or ten feet in thickness. On account of its high absorptive capacity, it ought to find a ready sale for litter and packing material as straw and excelsior become scarcer.

TABLE I

Shows location by county, township, and section; acreage, average depth, and character of drainage of the more important Iowa peat bogs. The last column contains sample numbers representing each bog and corresponding to sample numbers in two tables following.

County	Township	Section	Acreage	Average depth in feet	Character of Drainage	Sample Nos.
Cerro Gordo	Clear Lake	26	-----	6	-----	628
Cerro Gordo	Clear Lake }	35	225	6	Fair	594, 599–602
	Union }	2				614–617
Cerro Gordo	Grant	34 & 35	70	6	Fair	590, 595
Cerro Gordo	Grant	25	35	7	Fair	605–607
Cerro Gordo	Grant	15	40	5	Fair	608–609
Cerro Gordo	Grant	22 & 27	60	5	Fair	610–611
Cerro Gordo	Grant	31	-----	6	Poor to Fair	613
Cerro Gordo	Grimes	19 & 20	40	15	Good	405–407
Cerro Gordo	Grimes	28	50	8	Good	409, 410
Cerro Gordo	Lake	19	125	8	Fair	584–586, 597
Cerro Gordo	Lake	29 & 30	125	6	Fair	583, 587, 598, 591
Cerro Gordo	Mt. Vernon	5 & 8	80	5	Poor	592, 593, 596
Cerro Gordo	Union	11, 12, 13, 14	375	6	Fair	614–617
Cerro Gordo	Union	24	210	6	Good	618–620
Cerro Gordo	Union }	31 & 35	175	15	Good	401–404
	Grimes }	2 & 3				478, 479, 408
Cerro Gordo	Union	20	-----	5	-----	627
Clay	Freeman	23	-----	4	-----	640P, 641P
Clay	Freeman	11	-----	4	-----	642P
Dickinson	Richland	17	50	3	-----	638
Emmet	Iowa Lake	34	400	4	Fair	629–632
Franklin	Lee	18	40	10	Poor	356–360
Franklin	Lee }	6				
	Morgan }	36	125	8	Fair	361–365
	Oakland }	1				
Franklin	Morgan	11	25	5	Good	366
Franklin	Morgan	27 & 28	120	9	Good	350–354
Franklin	Oakland	2 & 3	70	5	Poor	355
Franklin	Oakland	11 & 12	20	8	Good	369, 370, 381
		13 & 14	60	8	Good	
Franklin	Scott	33	100	7	Fair	375–377
Franklin	Scott	29	30	4	Fair	378
Hamilton	*					
Hancock	Crystal }	23, 24, 25,				
	}	26, 35, 36	1,500	3–4	Poor to Fair	647, 686–688
	Britt }	1 & 2				
Hancock	Concord	5	-----	6	-----	574
Hancock	Crystal	2	70	8	Poor	550, 551
Hancock	Crystal	14	50	6	Poor	555
Hancock	Garfield	22 & 23	120	9	Good	576–579
Hancock	Garfield	18 & 19	600	7	Fair	580–581
Hancock	Garfield	10	-----	5	-----	572
Hancock	German	33	40	12	Good	414–415
Hancock	German }	4, 5 & 9	600	8	Fair	416–423
	Garfield }	32 & 33				
Hancock	German	5	40	5	Fair	474–476
Hancock	Madison	16, 17, 20, 21	350	3	Poor	689–690
Hancock	Madison	19	140	3	Poor	648
Hancock	Twin Lake	29 & 32	70	15	Fair	398–400
Hancock	Twin Lake	23	-----	4		
Hancock	Twin Lake	11	60	10	Fair	411–413
Hancock	Twin Lake	4	100	8	Poor	
Kossuth	Greenwood	11	75	5	Poor	624–626
Kossuth	Ramsay	26	300	4	Poor	621, 623, 622
Kossuth	Sherman	10, 15, 14	250	4	Fair	634P–639P
		23, 26, 25				

*Several areas of thin peat, Iowa Lake perhaps the most important.

TABLE I—CONTINUED

County	Township	Section	Acreage	Average depth in feet	Character of Drainage	Sample Nos.
Kossuth	Swea	4		4		633
Palo Alto	Lost Island	11		3		643P-645P
Webster	Burnside	31				
	Clay	36				
	Lost Grove	1	600	3	Good	649, 691, 692, 650
	Dayton	6				
Webster	Lost Grove	13 & 24	200	3	Fair to Poor	693-694
Winnebago	Center	3 & 4	90	8	Poor	491, 500, 494
	Norway	33				
Winnebago	Center	29	70	7	Fair	498, 502
Winnebago	Center	10, 11, 13, 14 & 15	700	10	Poor to Fair	501, 499, 504, 511 514, 517, 538. 539
Winnebago	Center	24, 25, 26,			Poor to Fair	520, 525, 530, 512
		27, 34, 35, 36	1,500	12		523, 524, 515, 518
	Mt. Valley	1, 2, 3, 11				516, 540, 541
Winnebago	King	15 & 22	80	6	Poor	556
Winnebago	Linden	14, 15, 22, 23	160	5	Fair	544-546
Winnebago	Linden	29 & 32	80	6	Fair	542
Winnebago	Logan	24	50	10	Poor to Fair	534, 547
Winnebago	Logan	14, 15, 22, 23	200	5	Poor to Fair	535-537
Winnebago	Mt. Valley	28, 29, 32, 33	100	10	Poor to Fair	549, 551, 554
Winnebago	Mt. Valley	5 & 6	90	6	Poor to Fair	557, 558
Winnebago	Mt. Valley	15 & 22	50	6	Poor	559, 560
Winnebago	Mt. Valley	8, 9, 16, 17 19, 18, 20, 21	900	8	Poor	561-571, 573
Winnebago	Norway	34 & 35	350	8		487, 488, 505
	Center	3				
Winnebago	Norway	14, 15, 22, 23	225	10	Fair	497, 507, 508
Winnebago	Norway	7, 17, 18	40	6	Fair	509
Winnebago	Norway	17 & 18	70	6	Fair	503
Worth	Bristol	6	120	8	Poor	489, 490
Worth	Bristol	17, 18, 20, 29	200	6	Poor to Fair	513, 515, 532
Worth	Bristol	27 & 28	90	7	Fair	519, 522, 531
Worth	Fertile	19	120	10	Fair	424-426
Worth	Fertile	21, 22, 26, 27 & 28	600	12	Good	
Worth	Hartland	29	40	6	Poor	533
Worth	Hartland	20	30	4	Poor	
Worth	Silver Lake	7 & 8	100	5	Fair	
Worth	Silver Lake	10 & 11	40	10	Poor	492, 495
Worth	Silver Lake	13 & 14	40	12	Poor	350, 351
Worth	Silver Lake	22	60	7	Poor	493, 496
Wright	Belmond	35 & 36	80	4	Good	379, 383, 384
Wright	Belmond	16 & 17	75	8	Fair	469, 470
Wright	Belmond	7 & 8	75	8	Good	471-473
Wright	Blaine	27, 34, 35	600	3-4	Good	368
Wright	Grant	6 & 31	100	12	Good	393-397
	Lake	1				
Wright	Iowa	22 & 15	12	6	Poor	385
Wright	Iowa	14 & 23	35	12	Good	386, 388, 390, 477
Wright	Iowa	5,8, 9, 16, 17	300	6	Fair	391, 389, 392
Wright	Wall Lake	12		5		367
Wright	Wall Lake	2	250	3-4	Good	372-374

TABLE II

Contains laboratory number, detailed location, and detailed description for each peat sample studied.

Lab. No.	*County*	*Detailed Location of Sample*	*Description of Section*
350	Franklin	Morgan Twp., Sec. 28. Near west end of bog	4 ft. brown, fibrous. 4 ft. brownish black, less fibrous. 8 ft. sand and peat.
351	Franklin	Morgan Twp., Sec. 28. Near pit of Iowa Peat Plant	3.5 ft. brown, fibrous. 4 ft. brown and black mingled.
352	Franklin	Morgan Twp., Sec. 28. 200 yds. Se. sample No. 351.	5.5 ft. brown, fibrous. 5 ft. brownish black, but slightly fibrous.
353	Franklin	Morgan Twp., Sec. 28. 200 yds. S. of east of sample No. 352	6.5 ft. brown, fibrous. 2 ft. brownish black, non-fibrous. 1.5 ft. brown, fibrous
354	Franklin	Morgan Twp., Sec. 27. 320 yds. S. of east of sample No. 353	8 ft. brown, fibrous. 2 ft. brownish black, non-fibrous. Blue clay below.
355	Franklin	Oakland Twp., Sec. 3. 300 yds. from Ne. corner	6.5 ft. brown, fibrous. A thin layer of non-fibrous below.
356	Franklin	Lee Twp., Sec. 18. On north line	2.5 ft. brown, fibrous. 3 ft. brownish black, non-fibrous.
357	Franklin	Lee Twp., Sec. 18. On ½ Sec. line, 125 yds. from edge of bog	8 ft. brown, fibrous. 2 ft. brownish black, non-fibrous. 5 ft. brown, fibrous.
358	Franklin	Oakland Twp., Sec. 11. On Sec. line (Secs. 11 and 12)	8 ft. brown, fibrous. 9 ft. brownish black, non-fibrous. Thin clay seam at 14 ft.
359	Franklin	Oakland Twp., Sec. 11. Near south end of bog	7 ft. brown, fibrous. 7.5 ft. brownish black, non-fibrous. Gravel below.
360	Franklin	Oakland Twp., Sec. 12. East of sample No. 359	7 ft. brown, fibrous. 7.5 ft. brownish black, non-fibrous.

TABLE II—CONTINUED

Lab. No.	*County*	*Detailed Location of Sample*	*Description of Section*
361	Franklin	Oakland Twp., Sec. 1. 400 yds. E. ½ Sec. line	7.5 ft. brown, fibrous. 3.5 ft. brownish black, non-fibrous.
362	Franklin	Oakland Twp., Sec. 1. South side of bog	7 ft. brown, fibrous. 4.5 ft. brownish black, non-fibrous.
363	Franklin	Oakland Twp., Sec. 1. Near east line section	7 ft. brown, fibrous. 8 ft. brownish black, non-fibrous. 5.5 ft. brown, fibrous.
364	Franklin	Morgan Twp., Sec. 36, Se. ¼. 125 yds. from east edge of bog	11 ft. brown, fibrous. 1 ft. brownish black, non-fibrous. Clay parting at 8 ft.
365	Franklin	Morgan Twp., Sec. 36. 125 yds. W. of sample No. 364	11 ft. brown, fibrous. 2.5 ft. brownish black.
366	Franklin	Morgan Twp., Sec. 11. On road 500 yds. south of corner	2.5 ft. brown, fibrous. 3.5 ft. brownish black.
367	Wright	Wall Lake Twp., Sec. 12. ⅜ mi. S. north line, along ditch	3 ft. brown, fibrous. 3.5 ft. brownish black.
368	Wright	Blaine Twp., Sec. 27. Near Nw. corner Sw. quarter	2.5 ft. brown, fibrous. 4 ft. brownish black.
369	Franklin	Oakland Twp., Sec. 11. Southeast corner	7 ft. brown, fibrous. 3.5 ft. brownish black. 3.5 ft. brown, fibrous.
370	Franklin	Oakland Twp., Sec. 11. 300 yds. W. of north of sample No. 369	7 ft. brown, fibrous. 3 ft. brownish black.
371	Franklin	Oakland Twp., Sec. 11. 125 yds. west of sample No. 370	8 ft. brownish black. 5.5 ft. lighter colored peat.
372	Wright	Blaine Twp., Sec. 35. 225 yds. south of middle N. line	2.5 ft. brown, fibrous. 3.5 ft. brownish black.
373	Wright	Blaine Twp., Sec. 35. Near center Nw. ¼ of Ne. ¼	2 ft. brown, fibrous. 3 ft. brownish black.
374	Wright	Blaine Twp., Sec. 35. 140 yds. Sw. sample No. 373, along fence	2 ft. brown, fibrous. 1.5 ft. brownish black.

TABLE II—CONTINUED

Lab. No.	*County*	*Detailed Location of Sample*	*Description of Section*
375	Franklin	Scott Twp., Sec. 33. North section line road	2 ft. brown, fibrous. 5.5 ft. brownish black.
376	Franklin	Scott Twp., Sec. 33. 100 yds. from middle east edge of bog	3 ft. brown, fibrous. 3 ft. brownish black. 1 ft. bluish peaty mud.
377	Franklin	Scott Twp., Sec. 33. Near middle south side of bog	2 ft. brown, fibrous. 3 ft. brownish black. 1 ft. marly layer. 2 ft. brown, fibrous.
378	Franklin	Scott Twp., Sec. 29. Near Nw. corner at bridge	3.5 ft. brown, fibrous.
379	Wright	Belmond Twp., Sec. 35. 100 yds. north of road on south line	3 ft. brown, fibrous.
380	Wright	Belmond Twp., Sec. 35. 400 yds. north of road, east side bog	2 ft. brown, fibrous. 2 ft. peat and grit.
381	Wright	Belmond Twp., Sec. 35. 100 yds. directly west of sample No. 380	4 ft. brownish black peat.
382	Wright	Belmond Twp., Sec. 35. 150 yds. Ne. from sample No. 381	4.5 ft. brownish black.
383	Wright	Belmond Twp., Sec. 36. Ne. corner Ne. ¼ of Sw. ¼	2 ft. brown, fibrous. 2.5 ft. brownish black.
383.5	Wright	Belmond Twp., Sec. 35. West of sample No. 379	2 ft. brown, fibrous. 3 ft. brownish black.
384	Wright	Belmond Twp., Sec. 35. On road south end of bog	2 ft. brown, fibrous. 2.5 ft. brownish black.
385	Wright	Iowa Twp. line, Secs. 15 and 22. About 200 yds. E. of Sw. corner	5 ft. brown, fibrous. 2 ft. brownish black. 1 ft. peaty clay. 2 ft. brownish black. 1 ft. brown, fibrous.
386	Wright	Iowa Twp., Sec. 23. Near Nw. corner Ne. ¼ of Nw. ¼	5 ft. dark brown. 4.5 ft. marly peat, on gravel.

TABLE II—CONTINUED

Lab. No.	*County*	*Detailed Location of Sample*	*Description of Section*
387	Wright	Iowa Twp., Sec. 23. 150 yds. south of sample No. 386	5 ft. brownish black, almost non-fibrous. 1.5 ft. peaty marl. 13.5 ft. brown, fibrous.
388	Wright	Iowa Twp., Sec. 23. 175 yds. due east sample No. 387.	2.5 ft. brownish black. 9.5 ft. peaty marl.
389	Wright	Iowa Twp., between Secs. 9 and 16. At bridge	5.5 ft. brown, fibrous. 3 ft. peaty clay.
390	Wright	Iowa Twp., Sec. 23. Near middle north side of Nw. ¼.	2.5 ft. brownish black. 11 ft. peaty grit and clay to clayey peat.
391	Wright	Iowa Twp., between Secs. 8 and 17. Near west edge of bog	2 ft. brown, fibrous, to black peat mud.
392	Wright	Iowa Twp., between Secs. 9 and 16. 60 yds. east of sample No. 389	5.5 ft. brown, fibrous. 3 ft. peaty clay.
393	Wright	Lake Twp., on E. line Sec. 1. Lake at bridge near south edge of bog	3.5 ft. brown, fibrous. 9.5 ft. brownish black. Sand and gravel below.
394	Wright	Lake Twp., Sec. 1. About middle of bog	5.5 ft. brown, fibrous. 14 ft. brownish black. Grades downward into black peaty mud.
395	Wright	Lake Twp., Sec. 1. Near north edge of bog	4.5 ft. brown, fibrous. 13.5 ft. brownish black, very sticky below.
396	Wright	Lake Twp., Sec. 1. Along dredge ditch near north edge of bog	4.5 ft. brown, fibrous. 7 ft. brownish black. Gravel and sand below.
397	Wright	Lake Twp., Sec. 1. Along ditch 150 yds. south of sample No. 396	6 ft. brown, fibrous. 18 ft. brownish black. Bottom not reached.
398	Hancock	Twin Lakes Twp., Sec. 29. Near south edge, 300 yds. from E. end of bog	4 ft. brown, fibrous. 6.5 ft. brownish black. 2.5 ft. brown, fibrous. 3.5 ft. peaty marl and clay.
399	Hancock	Twin Lakes Twp., Sec. 29. Due north sample No. 398, near edge	2 ft. brown, fibrous. 22 ft. brownish black, variable. Bottom not reached.

TABLE II—CONTINUED

Lab. No.	*County*	*Detailed Location of Sample*	*Description of Section*
400	Hancock	Twin Lakes Twp., line Secs. 29 and 32. Near east edge of bog	5 ft. brown, fibrous. 2.5 ft. brownish black. 11.5 ft. reddish brown.
401	Cerro Gordo	Grimes Twp., Sec. 2. 150 yds. from west line of section	5 ft. brown, fibrous. 6 ft. brownish black. 2 ft. reddish brown.
402	Cerro Gordo	Grimes Twp., Sec. 2. 75 yds. N. of sample No. 401 and at center of bog	7 ft. brown, fibrous. 4 ft. brown, non-fibrous. 6 ft. lighter brown.
403	Cerro Gordo	Grimes Twp., Sec. 3. Near east edge bog on Nw. ¼	5 ft. brown, fibrous. 4 ft. brown, less fibrous. 7 ft. lighter brown.
404	Cerro Gordo	Grimes Twp., Sec. 3. Along drain at middle of bog. North of sample No. 403	5 ft. brown, fibrous. 5 ft. brown, non-fibrous. 12 ft. lighter brown.
478	Cerro Gordo	Grimes Twp., Sec. 3. North of sample No. 404 near north edge	3.5 ft. brown, fibrous. 8 ft. brownish black, becoming clayey below. 13 ft. light brown.
405	Cerro Gordo	Grimes Twp., line Secs. 19 and 20. Bridge near S. edge of bog	9 ft. brown, fibrous, becoming marly below. 8 ft. light brown.
406	Cerro Gordo	Grimes Twp., north of sample No. 405 near middle of bog	3 ft. brown, fibrous, grading into 7 ft. brownish black, marly below. 13 ft. light brown to grayish peat.
408	Cerro Gordo	Union Twp., Sec. 34. Sw. ¼, near Ne. corner	5.5 ft. brown, fibrous. 4 ft. brown, non-fibrous. 1.5 ft. reddish brown. 8 ft. grayish brown, clayey.
409	Cerro Gordo	Grimes Twp., Sec. 28. Se. ¼ of Nw. ¼	3 ft. brown, fibrous. 1 ft. brownish black. Gravel and sand below.
410	Cerro Gordo	Grimes Twp., Sec. 28. Se. ¼ of Nw. ¼	3 ft. brown, fibrous. 2 ft. brownish black.
	Cerro Gordo	Grimes Twp., Sec. 28. Due east of sample No. 410	5 ft. brown, fibrous. 5.5 ft. brownish black. 5.5 ft. reddish brown. 7.5 ft. grayish brown, marly.

TABLE II—CONTINUED

Lab. No.	*County*	*Detailed Location of Sample*	*Description of Section*
411	Hancock	Twin Lakes Twp., Sec. 11. Sw. ¼ south, middle of bog	4 ft. brown, coarsely fibrous Gravel below.
412	Hancock	Twin Lakes Twp., Sec. 11. Sw. ¼ near center of bog	5 ft. brown, coarsely fibrous. 8 ft. brownish black. 2 ft. grayish brown. 6 ft. reddish brown. Sand below.
413	Hancock	Twin Lakes Twp., Sec. 11. Sw. ¼. North of middle	5 ft. brown, coarsely fibrous. 5 ft. brownish black. .5 ft. grayish to reddish brown.
414	Hancock	German Twp., Sec. 33. E. ½ of Sw. ¼. Near east edge of bog	2 ft. brown, coarsely fibrous. 7 ft. brownish black. Clayey peat below.
415	Hancock	German Twp., Sec. 33. E. ½ of Sw. ¼. Near west edge	2.5 ft. brown, coarsely fibrous. 15.5 ft. brownish black to reddish gray below. Bored into a piece of wood at 18 ft. and could go no deeper.
416	Hancock	German Twp., on line between Secs. 4 and 9, and 100 yds. east of edge of bog	3.5 ft. brown, fibrous. 3.5 ft. brownish black.
417	Hancock	German Twp., Sec. 9. Along ditch 400 yds. S. sample No. 416	5.5 ft. brown, coarsely fibrous.
418	Hancock	German Twp., on line between Secs. 4 and 9 at middle of bog	7 ft. brown, fibrous. 9.5 ft. brownish black. 15.5 ft. red to grayish brown. Bottom not reached.
419	Hancock	German Twp., on line between Secs. 4 and 9. 120 yds. from W. edge	4.5 ft. brown, fibrous.
420	Hancock	German and Garfield Twp. line, Secs. 4 and 33 respectively. 100 yds. from island on east side	5 ft. brown, fibrous. 2 ft. brownish black.
421	Hancock	German and Garfield Twp. line. West of sample No. 420, near middle of bog	7 ft. brown, fibrous. 1.5 ft. brownish black.

TABLE II—CONTINUED

Lab. No.	*County*	*Detailed Location of Sample*	*Description of Section*
511	Winnebago	Center Twp., Sec. 15. Sw. ¼ of Ne. ¼	9 ft. brown, fibrous. 4.5 ft. dark brown. Clayey peat at bottom.
514	Winnebago	Center Twp., Sec. 13. Northeast corner of Nw. ¼ of Nw. ¼	9 ft. brown, fibrous. 2 ft. dark brown.
517	Winnebago	Center Twp., Sec. 14. Center of Se. ¼ of Ne. ¼	11 ft. brown, fibrous. 4 ft. dark brown. 4 ft. reddish brown.
512	Winnebago	Center Twp., Sec. 35. Near north line of Sec. west of dredge ditch	9 ft. brown, fibrous. 2 ft. fine, brown, fibrous. 4 ft. dark brown.
523	Winnebago	Center Twp., Sec. 34. 175 yds. east ½ section line	5 ft. brown, fibrous. 6 ft. brown, slightly fibrous. 10 ft. light brown. 2 ft. reddish brown. 1 ft. light brown. Did not reach bottom.
524	Winnebago	Center Twp., Sec. 34. 200 yds. east of center	5 ft. brown, fibrous. 4 ft. brown, slightly fibrous. 14 ft. light brown.
515	Worth	Bristol Twp., Sec. 17. Sw. ¼ of Sw. ¼ 225 yds. north of Sw. corner	8.5 ft. brown, fibrous.
518	Winnebago	Center Twp., Sec. 26. Nw. ¼ of Se. ¼	11 ft. brown, fibrous. 4 ft. brown. 10 ft. reddish brown. Did not reach bottom.
516	Winnebago	Center Twp., Sec. 35. Se. ¼ of Se. ¼. Center of north line	7 ft. brown, fibrous. 10 ft. brown.
520	Winnebago	Center Twp., Sec. 35. S. side 125 yds. Nw. from bridge over dredge ditch	9 ft. brown, fibrous. 7 ft. brown.
526	Winnebago	Mt. Valley Twp., Sec. 2. Ne. ¼ of Nw. ¼. E. of dredge ditch, 250 yds. south of road	11 ft. brown, fibrous. 6 ft. brown. 10.5 ft. reddish brown.
521	Winnebago	Mt. Valley Twp., Sec. 2. Nw. ¼ of Sw. ¼, 200 yds. from road	9 ft. brown, fibrous. 6 ft. brown. 4 ft. light gray.

TABLE II—CONTINUED

Lab. No.	*County*	*Detailed Location of Sample*	*Description of Section*
527	Winnebago	Mt. Valley Twp., Sec. 2. Se. ¼ of Nw. ¼, 100 yds. W. of north and south ½ section line	11 ft. brown, fibrous. 2 ft. black. 4 ft. brown.
528	Winnebago	Mt. Valley Twp., Sec. 2. Sw. ¼ of Ne. ¼, 175 yds. E. of north and south ½ section line	11 ft. brown, fibrous. 6 ft. brown. 6 ft. reddish brown. 3 ft. brown.
525	Winnebago	Center Twp., Sec. 25. Ne. ¼ of Ne. ¼, near W. line	9 ft. brown, fibrous. 4 ft. black.
529	Winnebago	Center Twp., Sec. 24. Sw. ¼ of Se. ¼ near center	11 ft. brown, fibrous. 6 ft. dark brown. 2 ft. reddish brown.
530	Winnebago	Center Twp., Sec. 24. Se. ¼ of Se. ¼, 100 yds. S. of Ne. corner	11 ft. brown, fibrous. 4 ft. brown. 11 ft. reddish brown.
513	Worth	Bristol Twp., Sec. 20. 300 yds. Nw. from road along dredge ditch	9 ft. brown, fibrous. 1 ft. brown.
519	Worth	Bristol Twp., Sec. 28. S. side Sec. 150 yds. from road, and 250 yds. from W. line	9 ft. dark brown (somewhat fibrous clayey peat underlying above).
522	Worth	Bristol Twp., Sec. 28. 200 yds. due N. of No. 519	5 ft. dark brown, somewhat fibrous. 4 ft. dark brown. 2 ft. reddish brown.
531	Worth	Bristol Twp., Sec. 27. 125 yds. Nw. of center of Sw. ¼	5 ft. dark brown, somewhat fibrous. 7 ft. dark brown.
532	Worth	Bristol Twp., Sec. 20. Sw. ¼, near middle	9 ft. brown, fibrous.
538	Winnebago	Center Twp., Sec. 14. Se. ¼ of Sw. ¼, near Nw. corner	9 ft. brown, fibrous. 6 ft. dark brown. 7 ft. reddish brown.
539	Winnebago	Center Twp., Sec. 14. Se. ¼ of Sw. ¼, near Nw. corner	6.5 ft. dark brown, slightly fibrous.
540	Winnebago	Center Twp., Sec. 24. Nw. ¼ of Se. ¼, 200 yds. Ne. from Sw. corner	9 ft. brown, fibrous. 2 ft. dark brown.

TABLE II—CONTINUED

Lab. No.	*County*	*Detailed Location of Sample*	*Description of Section*
541	Winnebago	Center Twp., Sec. 24. Center Nw. ¼	9 ft. brown, fibrous. 7 ft. brown, slightly fibrous.
533	Worth	Hartland Twp., Sec. 29. Ne. ¼ of Nw. ¼, near Ne. corner	9 ft. brown, fibrous.
544	Winnebago	Linden Twp., Sec. 22. Near middle north line	5 ft. brown, fibrous. 2 ft. brown, slightly fibrous. 6 ft. black.
545	Winnebago	Linden Twp., Sec. 14. 100 yds. S. of center of Sw. ¼ of Sw. ¼	5 ft. brown, fibrous.
546	Winnebago	Linden Twp., Sec. 14. Se. corner of Sw. ¼ of Sw. ¼	4.5 ft. brown, fibrous, changing to black.
556	Winnebago	King Twp., Sec. 22. Center of Sw. ¼ of Ne. ¼	5 ft. brown, fibrous. 3 ft. dark brown. 4 ft. black.
542	Winnebago	Linden Twp., Sec. 29. Center of Nw. ¼ of Se. ¼	5 ft. brown, fibrous. 2 ft. dark brown. 2 ft. black.
547	Winnebago	Logan Twp., Sec. 24. 150 yds. Ne. from Sw. corner of Sw. ¼ of Sw. ¼	9 ft. brown, fibrous. 15 ft. brown. Did not reach bottom of peat.
534	Winnebago	Logan Twp., Sec. 24. Center of Sw. ¼	7 ft. brown, fibrous. 2 ft. black. Gravel bottom.
535	Winnebago	Logan Twp., Sec. 23. 150 yds. Sw. of center	5 ft. brown, fibrous. 1 ft. black.
536	Winnebago	Logan Twp., Sec. 23. 200 yds. Nw. of center	6 ft. brown, fibrous. 1 ft. black.
537	Winnebago	Logan Twp., Sec. 23. Nw. ¼, 200 yds. from road	8.5 ft. dark brown, slightly fibrous. Gravel bottom.
550	Hancock	Crystal Twp., Sec. 2. Near Sec. line, 100 yds. from W. edge of bog	5 ft. brown, fibrous. 9 ft. brown. Peat mud continues.
548	Hancock	Crystal Twp., Sec. 2. On ¼ Sec. line east side of bog near section line	5 ft. brown, fibrous. 4 ft. brown, gradually becoming poorer.

TABLE II—CONTINUED

Lab. No.	*County*	*Detailed Location of Sample*	*Description of Section*
549	Winnebago	Mt. Valley Twp., Sec. 33. Nw. ¼ of Nw. ¼	5.5 ft. brown, fibrous.
575	Winnebago	Mt. Valley Twp., Sec. 33. 300 yds. E. and 300 yds. S. of Nw. corner	24 ft. brown, fibrous peat, changing to slightly fibrous.
551	Winnebago	Mt. Valley Twp., Sec. 33. 250 yds. N. and 50 yds. E. of No. 575	7 ft. dark brown, fibrous. 7 ft. brown, slightly fibrous.
552	Winnebago	Mt. Valley Twp., Sec. 32. Nw. ¼ of Nw. ¼, 100 yds. west and 150 yds. S. of Ne. corner	11 ft. brown, fibrous, changing to slightly fibrous.
553	Winnebago	Mt. Valley Twp., Sec. 29. Se. ¼ of Se. ¼, 150 yds. from road and midway between quarter and section lines	15 ft. brown, fibrous, changing to slightly fibrous.
554	Winnebago	Mt. Valley Twp., Sec. 29. 125 yds. N. of sample No. 553	24 ft. brown, fibrous, changing to slightly fibrous.
555	Hancock	Crystal Twp., Sec. 14. Ne. ¼, near north edge of bog	6 ft. brown, fibrous. 3 ft. black.
576	Hancock	Garfield Twp., Sec. 23. 200 yds. S. and 100 E. of Nw. corner	5 ft. brown, fibrous.
577	Hancock	Garfield Twp., Sec. 23. 300 yds. south of No. 576	9 ft. brown, fibrous. 3 ft. brown, somewhat fibrous. A peat mud continues 14 ft.
578	Hancock	Garfield Twp., Sec. 23. 300 yds. south of No. 577	9 ft. brown, fibrous. 3 ft. fine, brown, somewhat fibrous.
579	Hancock	Garfield Twp., Sec. 23. Near center of Sw. ¼ of Sw. ¼	5 ft. brown, fibrous. 1 ft. brown.
580	Hancock	Garfield Twp., Sec. 18. On quarter section line	9 ft. brown, fibrous. 4 ft. black.
581	Hancock	Garfield Twp., Sec. 18. 175 yds. directly W. of No. 580	5 ft. brown, fibrous.

TABLE II—CONTINUED

Lab. No.	*County*	*Detailed Location of Sample*	*Description of Section*
584	Cerro Gordo	Lake Twp., Sec. 19. 100 yds. S. and 100 yds. W. of Ne. corner Ne. ¼ of Sw. ¼	14 ft. brown, fibrous, gradually changing to less fibrous.
597	Cerro Gordo	Lake Twp., Sec. 19. Nw. ¼ of Sw. ¼, 75 yds. S. of center	4.5 ft. brown, fibrous.
585	Cerro Gordo	Lake Twp., Sec. 19. 220 yds. from S. line and 125 yds. from W. edge of bog	9 ft. brown, fibrous, changing to slightly fibrous.
586	Cerro Gordo	Lake Twp., Sec. 19	7 ft. brown, fibrous.
583	Cerro Gordo	Lake Twp., on line between Secs. 29 and 30, near south side	4 ft. brown, fibrous.
587	Cerro Gordo	Lake Twp., Sec. 29. Center Nw. ¼ of Sw. ¼	7 ft. brown, fibrous, gradually changing to less fibrous.
598	Cerro Gordo	Lake Twp., Sec. 29. Near middle north line of Sw. ¼ of Sw. ¼	7 ft. brown, fibrous, gradually changing to less fibrous.
591	Cerro Gordo	Lake Twp., Sec. 29. South side at center of neck of bog where it crosses road	5 ft. brown, fibrous.
592	Cerro Gordo	Mt. Vernon Twp., section line between 5 and 8 near middle	5 ft. brown, fibrous.
593	Cerro Gordo	Mt. Vernon Twp. 225 yds. due west of No. 592	5 ft. brown, fibrous.
596	Cerro Gordo	Mt. Vernon Twp., Sec. 8. 300 yds. Se. of No. 593	4 ft. brown, fibrous.
594	Cerro Gordo	Clear Lake Twp., Sec. 35. Near center Sw. ¼ of Sw. ¼	7 ft. brown, fibrous, gradually changing to less fibrous.
599	Cerro Gordo	Union Twp., Sec. 2. Near center Nw. ¼ of Nw. ¼	8 ft. brown, fibrous. Peat mud continues to a greater depth.
600	Cerro Gordo	Union Twp., Sec. 2. 175 yds. Ne. No. 599	3.5 ft. brown, fibrous.

TABLE II—CONTINUED

Lab. No.	*nty*	*Detailed Location of Sample*	*Description of Section*
601	Cerro Gordo	Union Twp., Sec. 2. 150 yds. Se. of Nw. corner of Ne. ¼	5 ft. brown, fibrous.
602	Cerro Gordo	On Union-Clear Lake Twp. line, between sections 2 and 35. 200 yds. west of middle	5 ft. brown, fibrous.
614	Cerro Gordo	Union Twp. 200 yds. W. of center of Sec. 12	5 ft. brown, fibrous.
615	Cerro Gordo	Union Twp. Sw. ¼ of Nw. ¼ of Sec. 12	5 ft. brown, fibrous, low grade.
616	Cerro Gordo	Union Twp., Sec. 11. Se. ¼ of Se. ¼, near center	7 ft. brown, fibrous.
617	Cerro Gordo	Union Twp., Sec. 12. Sw. ¼ of Sw. ¼, near center	7 ft. brown, fibrous. Low grade peat continues down to 12 ft.
618	Cerro Gordo	Union Twp. Center of neck of bog on north line, 220 yds. from road on east line	4 ft. brown, fibrous.
619	Cerro Gordo	Union Twp. Near center of Se. quarter	8 ft. brown, fibrous.
620	Cerro Gordo	Union Twp. On ½ Sec. line near road on east	6 ft. brown, fibrous, underlaid with blue clay.
621	Kossuth	Ramsay Twp., Sec. 26.	4 ft. brown, fibrous, changing to black peaty mud.
622	Kossuth	Ramsay Twp., Sec. 26. North side near center of bog	2.5 ft. brown, fibrous. 2.5 ft. black peaty mud. Peaty mud continues below 8 ft.
623	Kossuth	Ramsay Twp., Sec. 35. 250 yds. Nw. of center of section and at center of bog	2 ft. brown, fibrous. 2 ft. black peaty mud.
624	Kossuth	Greenwood Twp., Sec. 11. Ne. corner of bog, 100 yds. west on ¼ Sec. line	5 ft. brown, fibrous, grading downward into black peaty mud.
625	Kossuth	Greenwood Twp., Sec. 11. 100 yds. west of sample No. 624	6 ft. brown, fibrous, grading downward into black peaty mud.

TABLE II—CONTINUED

Lab. No.	County	Detailed Location of Sample	Description of Section
626	Kossuth	Greenwood Twp., Sec. 11. At center of bog	6.5 ft. brown, fibrous, grading downward into black peaty mud.
634P	Kossuth	Sherman Twp., Sec. 14. Sw. corner, 50 yds. N. and 275 yds. E. of Sec. line	3 ft. brown, fibrous. 3 ft. black peaty mud.
635P	Kossuth	Sherman Twp., Sec. 23. 150 yds. Nw. of center of Sec.	3 ft. brown, fibrous. 2 ft. black peaty mud.
636P	Kossuth	Sherman Twp., Sec. 26. 325 yds. west from E. line and 200 yds. N. of ¼ line	4 ft. brown, fibrous. 1 ft. dark brown.
637P	Kossuth	Sherman Twp., Sec. 26. On east line near middle	4 ft. brown, fibrous.
638P	Kossuth	Sherman Twp., Sec. 25. Middle of neck of bog in Sw. ¼	4 ft. brown, fibrous.
639P	Kossuth	Sherman Twp., Sec. 26. Near bridge on north line road	5 ft. brown, fibrous.
640P	Clay	Freeman Twp., Sec. 23. 250 yds. Nw. center of Sec.	4 ft. brown, fibrous. Becomes darker below.
641P	Clay	Freeman Twp., Sec. 23. Center of Nw. ¼	4 ft. brown, fibrous.
642P	Clay	Freeman Twp., Sec. 11. Near middle on S. line	4 ft. brown, fibrous. Very soft below.
643P	Palo Alto	Lost Island Twp., Sec. 11. 125 yds. from N. edge of bog	3 ft. brown, fibrous.
644P	Palo Alto	Lost Island Twp., Sec. 11. 200 yds. E. of sample No. 643P	3 ft. brown, fibrous.
645P	Palo Alto	Lost Island Twp., Sec. 11. Se. ¼, 440 yds. S. of lake and 150 yds. from road	3 ft. brown, fibrous.
638	Dickinson	Richland Twp., Sec. 17. Ne. ¼ of Se. ¼ near center of bog	3 ft. brown, fibrous.

TABLE II—CONTINUED

Lab. No.	*County*	*Detailed Location of Sample*	*Description of Section*
639	Wright	Belmond Twp., Sec. 17. 300 yds. S. of Ne. corner	5 ft. brown, fibrous.
640	Hancock	Twin Lake Twp., Sec. 32. On E. and W. Sec. line and 100 yds. from edge of bog	4.5 ft. brown, fibrous.
641	Hancock	Twin Lake Twp., Sec. 32. 100 yds. N. of S. line of Sec. and 125 yds. from E. edge of bog	4.5 ft. brown, fibrous.
422	Hancock	German and Garfield Twp. line. 150 yds. E. of W. ditch	8.5 ft. brown, fibrous. 4 ft. brownish black. 6 ft. reddish brown.
423	Hancock	German & Garfield Twp. line. On west ditch	8.5 ft. brown, fibrous. 2.5 ft. brownish black. 6 ft. lighter brown.
424	Worth	Fertile Twp., Sec. 19. Se. ¼ near S. line	6 ft. brown, fibrous. 14 ft. brownish black.
425	Worth	Fertile Twp., Sec. 19. 150 yds. E. of N. of sample No. 424	10 ft. brown, fibrous, darker below. 1 ft. marly peat. 5 ft. brownish black.
426	Worth	Fertile Twp., Sec. 19. 200 yds. E. of N. of sample No. 425	12 ft. brown, fibrous, darker below. 4 ft. marly peat. 3 ft. brownish peat, hard.
427	Worth	Silver Lake Twp., on line of Secs. 13 and 14. At south bridge	25 ft. brown, fibrous, becoming darker and less fibrous below. Did not reach bottom.
428	Winnebago	Mt. Valley Twp., Sec. 25. Near middle south line	7 ft. brown, fibrous. 7 ft. brownish black. 5 ft. soft, non-fibrous peaty mud.
429	Worth	Silver Lake Twp., on line Secs. 13 and 14. At north bridge	Same as sample No. 427. Reached grit at 19 ft.
469	Wright	Belmond Twp., Sec. 16. Near north edge on east line	4.5 ft. brown, fibrous. 3.5 ft. brownish black.
470	Wright	Belmond Twp., Sec. 16. 375 yds. S. of sample No. 469	5 ft. brown, fibrous. 5.5 ft. brownish black.

TABLE II—CONTINUED

Lab. No.	*County*	*Detailed Location of Sample*	*Description of Section*
471	Wright	Belmond Twp., on line Secs. 7 and 8, 150 yds. from S. edge bog	3.5 ft. brown, fibrous. 8.5 ft. light brown. .5 ft. peaty mud. 5.5 ft. reddish brown. Did not reach bottom.
472	Wright	Belmond Twp., on line Secs. 7 and 8; middle of bog, N. of sample No. 471	4 ft. brown, fibrous. 7 ft. brown peat. Gravel below.
473	Wright	Belmond Twp., Sec. 7. Ne. ¼ near road	2.5 ft. brown, fibrous.
474	Hancock	German Twp., Sec. 5. 100 yds. S. of middle line and 100 yds. from E. side of bog	4 ft. brown, fibrous. 1.5 ft. brownish black.
475	Hancock	German Twp., Sec. 5. Middle of bog west of sample No. 474	4 ft. brown, fibrous. 3 ft. brownish black.
476	Hancock	German Twp., Sec. 5. Near west edge of bog in line with No. 474 and 475	3 ft. brown, fibrous. 1.5 ft. brownish black.
477	Wright	Iowa Twp., Sec. 23	The peaty marl from the lower portion of No. 388.
478	Cerro Gordo	Grimes Twp., Sec. 3. Along drain and due N. sample No. 404	3.5 ft. brown, fibrous. 8 ft. brownish black, grading into gray. 13 ft. reddish brown.
479	Cerro Gordo	Union Twp., Sec. 34, W ½	5.5 ft. brown, fibrous. 4 ft. brown. 1.5 ft. reddish brown. 8 ft. grayish brown, marly.
484	Hancock	German Twp., Sec. 33. 100 yds. due west of sample No. 414	2.5 ft. brown, fibrous. 5.5 ft. brownish black. 3 ft. grayish brown, marly. 7 ft. reddish brown.
485	Worth	Silver Lake Twp., Sec. 22. 600 yds. W. of E. line and 150 yds. N. of bridge	3 ft. brown, fibrous. 2 ft. brownish black. 6 ft. brown to light brown below.
486	Worth	Silver Lake Twp., Sec. 10. 100 yds. E. and 200 S. of Nw. corner of Se. ¼ of Se. ¼	5.5 ft. brownish black, fibrous above. No. 486 is lower part only.

TABLE II—CONTINUED

Lab. No.	*County*	*Detailed Location of Sample*	*Description of Section*
487	Winnebago	Norway Twp., Sec. 35. Nw. ¼	5 ft. brown, fibrous. 2.5 ft. brown, non-fibrous.
488	Winnebago	Norway Twp., Sec. 35. Same bog as sample No. 487	5 ft. brown, fibrous. 4.5 ft. brownish black.
489	Worth	Bristol Twp., Sec. 6. Sw. corner of Nw. ¼	7.5 ft. brown, fibrous. 3.25 ft. brownish black.
490	Worth	Bristol Twp., Sec. 6. About 150 yds. N. of sample No. 489	15.5 ft. brown, fibrous. darker and finer below.
491	Winnebago	Center Twp., Sec. 4. Sw. corner Nw. ¼ of Ne. ¼	3 ft. brown, fibrous. 3 ft. brownish black.
492	Worth	Silver Lake Twp., Sec. 10	Upper portion sample No. 486.
493	Worth	Silver Lake Twp., Sec. 22. 600 yds. W. of E. line and 150 yds. Nw. of bridge	3 ft. brown, fibrous. 2 ft. brownish black. 6 ft. brown, lighter below.
494	Winnebago	On Twp. line Norway and Center, Sec. 33, Norway and Sec. 4, Center Twp. At center of neck	5 ft. brown, fibrous. 10 ft. brown, non-fibrous. 6 ft. reddish brown.
495	Worth	Silver Lake Twp., Sec. 10. About 250 yds. Se. of No. 486	5.5 ft. brownish black. 4 ft. grayish brown. 3 ft. reddish brown. 7 ft. grayish brown, marly. Bottom not reached.
496	Worth	Silver Lake Twp., Sec. 22. 250 yds. Nw. of No. 493	4 ft. brown, fibrous. 1.5 ft. brownish black. 3.5 ft. light brown.
497	Winnebago	Norway Twp., on line between Secs. 22 and 23. 100 yds. from S. edge of bog	3 ft. brown, fibrous. 3.5 ft. brownish black. 4 ft. light brown.
498	Winnebago	Center Twp., Sec. 29. 150 yds. from Sw. corner Nw. ¼	5 ft. brown, fibrous. 2 ft. brownish black. 2 ft. brown, non-fibrous.
499	Winnebago	Center Twp., on line Secs. 10 and 11. 300 yds. S. of road	9 ft. brown, fibrous. 2 ft. brownish black.
500	Winnebago	Center Twp., Sec. 4. 150 yds. Nw. of sample No. 491	3 ft. brown, fibrous. 6 ft. brownish black. 7 ft. reddish brown.

TABLE II—CONTINUED

Lab. No.	*County*	*Detailed Location of Sample*	*Description of Section*
501	Winnebago	Center Twp., Sec. 10. 125 yds. E. of road and 100 yds. from ditch	9 ft. brown, fibrous. 4.5 ft. brownish black.
502	Winnebago	Center Twp., Sec. 29. 150 yds. due east from sample No. 498	5 ft. brown, fibrous. 4 ft. brownish black.
503	Winnebago	Norway Twp., on line between Secs. 17 and 18. Middle of bog	5 ft. brown, fibrous. 2 ft. brownish black.
504	Winnebago	Center Twp., Sec. 14. Center Nw. ¼ of Nw. ¼	9 ft. brown, fibrous. 6 ft. dark brown. 9 ft. reddish brown. Bottom not reached.
505	Winnebago	Norway Twp., Sec. 35. Center Nw. ¼	5 ft. brown, fibrous. 4 ft. brown, non-fibrous. 8 ft. brownish black to reddish below. 6 ft. grayish brown, marly.
506	Winnebago	Norway Twp., Sec. 35. Sw. ¼. E. of sample No. 488 and 150 yds. from east edge	6.5 ft. brown, fibrous. 1 ft. brownish black.
507	Winnebago	Norway Twp., on line between Secs. 22 and 23. 150 yds. from north side of sections	5 ft. brown, fibrous. 4 ft. brownish black. 3.5 ft. reddish brown.
508	Winnebago	Norway Twp., on road between Secs. 14 and 15. 100 yds. N. of middle line	5 ft. brown, fibrous. 4 ft. brownish black. 4 ft. brown, non-fibrous. 2 ft. reddish brown. 5 ft. grayish, peaty marl.
509 (Top)	Winnebago	Norway Twp., on line Secs. 7 and 8. Middle of bog	3 ft. brown, fibrous. 2 ft. brownish black. 4 ft. grayish brown, marly
510	Winnebago	Norway Twp. Same as sample No. 509	Same as No. 509, lower part of section.
689	Hancock	Madison Twp., Sec. 16. Se. ¼ of Sw. ¼ near Nw. corner	4 ft. brown, fibrous.
690	Hancock	Madison Twp., Sec. 20. Near Ne. corner	3.5 ft. brown, fibrous.
691	Webster	Clay Twp., Sec. 36. 150 yds. S. of middle of W. line of Ne. ¼ of Ne. ¼	3 ft. brown, fibrous.

TABLE II—CONTINUED

Lab. No.	*County*	*Detailed Location of Sample*	*Description of Section*
692	Webster	Burnside Twp., Sec. 31. 200 yds. Sw. of center of section	2 ft. brown, fibrous.
693	Webster	Lost Grove Twp., on section line Secs. 13 and 24, near middle	3 ft. brown, fibrous.
557	Winnebago	Mt. Valley Twp., Sec. 6. Middle of W. side of Ne. ¼ of Se. ¼	8 ft. brown, fibrous. Gray, marly peat below.
558	Winnebago	Mt. Valley Twp., Sec. 6. Near Ne. corner	8 ft. brown, fibrous. 1 ft. brown.
559	Winnebago	Mt. Valley Twp., Sec. 22. 100 yds. Sw. from Ne. corner Nw. ¼ of Nw. ¼	9 ft. brown, fibrous. 1 ft. brownish black.
560	Winnebago	Mt. Valley Twp., Sec. 22. Center Ne. ¼ of Ne. ¼	9 ft. brown, fibrous. 1 ft. brown.
561	Winnebago	Mt. Valley Twp., Sec. 17. Center Nw. ¼ of Nw. ¼	7 ft. brown, fibrous. 6 ft. brown.
562	Winnebago	Mt. Valley Twp., Sec. 17. Middle N. line of Sw. ¼ of Nw. ¼	9 ft. brown, fibrous. 6 ft. brown. Clayey, sandy peat below.
563	Winnebago	Mt. Valley Twp., Sec. 17. Se. corner Sw. ¼ of Nw. ¼	8 ft. brown, fibrous. Peat continued down 25 ft. but too soft to sample.
564	Winnebago	Mt. Valley Twp., Sec. 17. Center Ne. ¼ of Nw. ¼	9 ft. brown, fibrous. 9 ft. brown, non-fibrous. Peat continues down more than 30 ft.
565	Winnebago	Mt. Valley Twp., Sec. 8. Center Se. ¼ of Se. ¼	7 ft. brown, fibrous. 3 ft. brownish black. Darker below.
566	Winnebago	Mt. Valley Twp., Sec. 8. 100 yds. Nw. of Se. corner of Sw. ¼ of Se. ¼	5 ft. brown, fibrous. 4 ft. brownish black.
567	Winnebago	Mt. Valley Twp., Sec. 16. Center Se. ¼ of Sw. ¼	8 ft. brown, fibrous.
568	Winnebago	Mt. Valley Twp., Sec. 16 100 yds. Nw. from Se. corner of Nw. ¼ of Sw. ¼	7 ft. brown, fibrous.

TABLE II—CONTINUED

Lab. No.	*County*	*Detailed Location of Sample*	*Description of Section*
(069)	Winnebago	Mt. Valley Twp., Sec. 16. 150 yds. Sw. from sample No. 568	7 ft. brown, fibrous.
569	Winnebago	Mt. Valley Twp., Sec. 17. Center Se. ¼ of Sw. ¼	7 ft. brown, fibrous.
570	Winnebago	Mt. Valley Twp., Sec. 17. Center Nw. ¼ of Se. ¼	7 ft. brown, fibrous 6 ft. brown, non-fibrous.
571	Winnebago	Mt. Valley Twp., Sec. 17. 200 yds. N. Sec. line	7 ft. brown, fibrous.
573	Winnebago	Mt. Valley Twp., Sec. 17. Center Sw. ¼ of Se. ¼	13 ft. brown, fibrous, becoming less fibrous below.
572	Hancock	Garfield Twp., Sec. 10. Center Ne. ¼ of Se. ¼	5 ft. brown, fibrous. 1 ft. brownish black.
574	Hancock	Concord Twp., Sec. 5. 100 yds. Sw. from Ne. corner of Nw. ¼ of Ne. ¼	8 ft. brown, fibrous. 1 ft. brown, non-fibrous.
590	Cerro Gordo	Grant Twp., line between Secs. 34 and 35, near middle	9 ft. brown, fibrous.
595	Cerro Gordo	Grant Twp., Sec. 25. 200 yds. south sample No. 590	5 ft. brown, fibrous.
605	Cerro Gordo	Grant Twp., Sec. 25. 300 yds. E. of center of section	5 ft. brown, fibrous. 4 ft. brown, non-fibrous. 5 ft. reddish brown.
606	Cerro Gordo	Grant Twp., Sec. 25. 150 yds. E. from center of section	5 ft. brown, fibrous. 3 ft. brown, non-fibrous. 4 ft. marly peat.
607	Cerro Gordo	Grant Twp., Sec. 25. 400 yds. S. and 200 yds. W. of Ne. corner of Nw. ¼	4 ft. brown, fibrous. 4 ft. brownish black.
608	Cerro Gordo.	Grant Twp., Sec. 15. 200 yds. S. and 200 yds. W. of Ne. corner of section	5 ft. brown, fibrous. 3 ft. brown, non-fibrous. 2 ft. reddish brown.
609	Cerro Gordo	Grant Twp., Sec. 15. 250 yds. W. of sample No. 608	4 ft. brown, fibrous.
610	Cerro Gordo	Grant Twp., Sec. 22. Center Nw. ¼ of Sw. ¼	7 ft. brown, fibrous. 3 ft. brown, non-fibrous.

TABLE II—Continued

Lab. No.	*County*	*Detailed Location of Sample*	*Description of Section*
611	Cerro Gordo	Grant Twp., Sec. 22. 250 yds. S. from sample No. 610	5 ft. brown, fibrous. 1 ft. brown, non-fibrous.
613	Cerro Gordo	Grant Twp., Sec. 31. 200 yds. E. from center of section	5 ft. brown, fibrous. 3 ft. brown, non-fibrous.
627	Cerro Gordo	Union Twp., Sec. 20. 200 yds. S. of Ne. corner of Se. ¼	6 ft. brown, fibrous.
628	Cerro Gordo	Clear Lake Twp., Sec. 26. 400 yds. N. of center of Se. ¼	5 ft. brown, fibrous. 4 ft. brown, non-fibrous.
629	Emmet	Iowa Lake Twp., Sec. 34. Center Nw. ¼ of Se. ¼	3 ft. brown, fibrous.
630	Emmet	Iowa Lake Twp., Sec. 34. Center Sw. ¼ of Ne. ¼	5 ft. brown, fibrous.
631	Emmet	Iowa Lake Twp., Sec. 34. Center of Sw. ¼	5 ft. brown, fibrous.
632	Emmet	Iowa Lake Twp., Sec. 34. Center Nw. ¼ of Nw. ¼	4 ft. brown, fibrous.
633	Kossuth	Swea Twp., Sec. 4. Center Nw. ¼ of Ne. ¼	4 ft. brown, fibrous.
642	Wright	Lake Twp., Sec. 1. 500 yds. from Sec. line and 125 yds. from N. side of bog	4 ft. brown, fibrous. Thin sand seam below.
643	Wright	Lake Twp., Sec. 1. 125 yds. from S. edge of bog along ditch	4 ft. brown, fibrous.
644	Hancock	German Twp., Sec. 4. Sw. ¼, on N. line 100 yds. W. of ditch	4 ft. brown, fibrous.
645	Hancock	German Twp., Sec. 4, Sw. ¼	Same as No. 644, taken below 4 ft. down to 6.5. Brownish black peat.
646	Hancock	German Twp., Sec. 9. 200 yds. S. of Sec. line on ditch	2.5 ft. brown, fibrous.

TABLE II—CONTINUED

Lab. No.	*County*	*Detailed Location of Sample*	*Description of Section*
647	Hancock	Crystal Twp., Sec. 23. On N. and S. ½ Sec. line, 150 yds. from S. side of bog	3.5 ft. brown, fibrous.
648	Hancock	Madison Twp., Sec. 19. 200 yds. east of middle, S. line of Sw. ¼ of Nw. ¼	4 ft. brown, fibrous.
649	Webster	Clay Twp., Sec. 36. On N. line 250 yds. W. of the middle	4 ft. brown, fibrous.
650	Webster	Burnside Twp., Sec. 31. Near middle south line	2 ft. brown, fibrous.
685	Wright	Belmond Twp., Sec. 17. On east line, 300 yds. S. of corner	5 ft. brown, fibrous.
686	Hancock	Crystal Twp., Sec. 35. Center Ne. ¼	4 ft. brown, fibrous.
687	Hancock	Crystal Twp., Sec. 25. 200 yds. NNe. from Sw. corner	3.5 ft. brown, fibrous.
688	Hancock	Crystal Twp., Sec. 25. 250 yds. S. of Nw. corner	4 ft. brown, fibrous.

TABLE III

Gives laboratory number, proximate chemical analyses of air dried samples, and calorimetric analyses of Iowa peats.

Laboratory Number	*Proximate Analysis*				*Calorimetric Analysis in B. T. Us.*
	Moisture	*Volatile and Combustible Matter*	*Fixed Carbon*	*Ash*	
350	6.33	44.16	8.26	41.25	5535
351	7.49	47.53	11.52	33.46	6815
352	6.61	40.59	5.66	47.14	4878
353	7.13	49.31	11.13	32.43	6234
354	8.66	52.47	15.38	23.49	7699
355	5.05	32.10	5.41	57.44	----------
356	4.40	42.39	6.65	46.56	4691
357	4.31	30.83	5.03	59.83	----------
358	5.36	24.21	5.88	64.55	----------
359	4.87	39.85	6.35	48.93	4973
360	5.67	47.67	6.03	40.63	4894
361	4.84	29.42	4.83	60.91	----------
362	5.48	31.90	7.77	54.85	4317
363	6.60	40.86	4.34	48.20	5626
364	3.99	50.45	5.31	40.25	4863
365	5.63	53.55	8.31	32.51	6047
366	2.03	10.33	.18	87.46	----------
367	3.76	20.27	3.51	72.46	----------
368	4.49	39.00	4.42	52.09	----------
369	3.80	35.84	2.75	57.61	----------
370	3.91	34.99	3.57	57.53	----------
371	3.64	32.90	1.50	61.96	----------
372	2.91	19.21	1.99	75.89	----------
373	5.80	33.83	5.16	55.21	----------
374	5.82	28.94	6.43	58.81	----------
375	3.28	15.04	.07	81.61	----------
376	3.08	26.54	1.61	68.77	----------
377	4.12	35.41	2.97	57.50	----------
378	2.94	11.85	.80	84.41	----------
379	3.07	17.37	2.15	77.41	----------
380	1.86	13.90	.95	83.29	----------
381	2.27	12.21	.57	84.95	----------
382	3.43	8.65	.03	87.89	----------
383	3.37	11.80	.54	84.29	----------
383.5	4.47	17.40	1.87	76.26	----------
384	3.66	14.99	2.75	78.60	----------
385	4.00	23.92	1.85	70.23	----------
386	4.07	12.05	.94	82.94	----------
387	2.85	12.50	.56	84.09	----------
388	2.58	9.47	.00	87.95	----------
389	2.59	19.89	.00	77.52	----------
390	1.86	11.90	.32	85.92	----------
391	2.60	13.27	.35	83.78	----------
392	2.71	15.08	.86	81.35	----------
393	3.28	18.10	1.00	77.62	----------

TABLE III—CONTINUED

Laboratory Number	Proximate Analysis				Calorimetric Analysis in B. T. Us.
	Moisture	Volatile and Combustible Matter	Fixed Carbon	Ash	
394	3.90	25.98	2.82	67.30	----------
395	3.31	20.81	1.77	74.11	----------
396	3.82	25.66	3.31	67.21	----------
397	3.48	25.09	3.46	67.97	----------
398	2.80	26.85	1.97	68.38	----------
399	3.52	26.34	1.43	68.71	----------
400	4.04	30.36	3.03	62.57	----------
401	2.97	24.26	1.72	71.05	----------
402	4.03	36.92	2.73	56.32	----------
403	3.76	39.65	2.99	53.60	----------
404	4.12	34.36	2.19	59.33	----------
405	3.40	22.79	1.24	72.57	----------
406	3.66	30.23	1.00	65.11	----------
407	3.66	29.56	1.86	64.92	----------
408	3.68	40.85	4.89	50.58	4333
409	4.65	35.26	7.40	52.69	----------
410	5.93	36.45	10.37	47.25	5018
411	5.83	40.52	9.77	43.88	----------
412	3.61	33.25	2.20	60.94	----------
413	2.98	23.61	3.40	70.01	----------
414	3.36	20.33	2.03	74.28	----------
415	2.90	20.76	1.83	74.51	----------
416	2.89	19.45	3.05	74.61	----------
417	6.62	43.28	7.87	42.23	5018
418	2.91	24.23	1.17	71.69	----------
419	6.22	44.98	13.03	35.77	5922
420	7.00	45.70	14.29	33.01	6312
421	7.24	49.87	14.14	28.75	6686
422	3.97	27.67	3.56	64.80	----------
423	4.88	30.78	2.56	61.78	----------
424	4.67	26.93	3.60	64.80	----------
425	4.53	27.05	5.13	63.29	----------
426	4.60	45.05	2.83	47.52	4551
427	5.78	44.99	7.40	41.83	5096
428	5.48	43.58	6.01	44.93	4582
429	6.02	45.05	10.93	38.00	5829
469	8.97	25.49	3.73	61.81	----------
470	7.50	21.87	.96	69.67	----------
471	7.58	24.96	1.43	66.03	----------
472	9.78	36.10	3.32	50.80	----------
473	12.10	44.43	6.72	36.75	----------
474	10.45	31.23	5.47	52.85	----------
475	9.64	27.49	2.24	60.63	----------
476	6.99	18.14	.15	74.72	----------
477	5.32	7.60	.65	86.43	----------
478	6.71	36.67	2.64	53.98	----------
479	7.73	45.65	3.84	42.78	4676
484	5.00	23.29	.80	70.91	----------
485	6.44	18.09	9.76	65.71	----------

TABLE III—CONTINUED

Laboratory Number	Proximate Analysis: Moisture	Volatile and Combustible Matter	Fixed Carbon	Ash	Calorimetric Analysis in B. T. Us.
486	13.22	40.31	4.28	42.19	----------
487	12.84	45.79	11.03	30.34	----------
488	17.04	49.04	7.83	26.09	----------
489	19.74	49.60	12.18	18.48	6624
490	19.61	48.07	13.49	18.83	6764
491	13.76	36.55	7.32	42.37	----------
492	18.26	49.57	13.03	19.14	6889
493	13.00	37.98	8.92	40.10	----------
494	10.12	35.30	2.53	52.05	----------
495	8.76	37.62	2.18	51.44	----------
496	9.30	31.72	3.44	55.54	----------
497	7.46	28.51	.90	63.13	----------
498	10.55	33.91	5.04	50.50	4270
499	10.85	50.71	13.29	25.15	7169
500	7.54	34.08	5.28	53.10	----------
501	8.51	51.16	7.80	32.53	5876
502	6.48	33.46	5.11	54.95	----------
503	5.83	24.45	1.01	68.71	----------
504	7.68	50.55	4.67	37.10	5081
505	7.26	39.03	2.69	51.02	----------
506	8.25	45.04	10.18	36.53	5720
507	5.96	30.07	1.22	62.75	----------
508	7.19	41.10	3.38	48.33	4239
509	8.85	35.43	6.67	49.05	4177
510	2.80	34.68	0.00	62.52	----------
511	9.39	51.25	6.67	32.69	5346
512	10.19	40.00	5.23	44.58	4629
513	10.62	41.63	7.06	40.69	4847
514	10.07	55.10	14.65	20.18	7418
515	10.75	49.59	14.38	25.28	7060
516	6.34	50.79	3.86	39.01	4582
517	9.04	45.67	11.68	33.61	6483
518	6.32	47.54	6.00	40.14	5144
519	5.77	25.44	8.17	60.62	----------
520	6.67	42.08	1.80	49.45	4052
521	4.95	42.27	2.45	50.33	----------
522	7.88	36.39	4.27	51.46	----------
523	6.24	35.86	10.85	47.05	4005
524	5.76	45.98	1.00	47.26	3943
525	7.74	47.59	6.77	37.90	5330
526	6.52	47.60	4.25	41.63	5034
527	4.71	37.74	1.84	55.71	----------
528	3.85	38.87	.36	56.92	----------
529	8.94	45.26	6.27	39.53	5284
530	6.72	46.89	8.75	37.64	6312
531	4.90	30.38	3.49	61.23	----------
532	8.48	42.20	10.68	38.64	5751
533	11.27	51.18	13.32	24.23	6951
534	5.35	41.04	3.03	50.58	----------
535	6.83	34.61	8.29	50.27	----------

TABLE III—CONTINUED

Laboratory Number	*Proximate Analysis*				*Calorimetric Analysis in B. T. Us.*
	Moisture	*Volatile and Combustible Ma*	*Fixed Carbon*	*Ash*	
536	8.94	49.02	13.33	28.71	6764
537	8.90	46.36	10.42	34.32	6078
538	4.39	48.45	3.24	43.92	4442
539	13.91	44.41	12.44	29.24	6203
540	8.04	39.03	6.70	46.23	4691
541	6.16	46.07	2.10	45.67	4052
542	6.71	41.95	8.13	43.21	5159
543	5.38	39.06	7.11	48.45	4800
544	3.44	30.11	1.68	64.77	----------
545	6.73	46.90	18.22	28.15	6483
546	5.56	38.00	5.47	50.97	----------
547	3.62	40.88	1.08	54.42	----------
548	5.83	39.90	.03	54.24	----------
549	4.40	29.65	4.65	61.30	----------
550	3.30	37.18	1.35	58.17	----------
551	6.88	46.54	5.50	41.08	4956
552	8.03	51.10	11.03	29.84	6702
553	9.50	48.86	10.62	31.02	5844
554	5.49	53.51	4.49	36.51	5050
555	4.26	27.96	4.13	63.65	----------
556	2.35	28.01	4.38	65.26	----------
557	6.92	52.41	5.17	35.50	5408
558	5.16	44.60	2.88	47.36	4364
559	7.45	47.62	13.75	31.18	6655
560	4.55	49.29	6.97	39.19	5377
561	5.74	44.10	10.82	39.34	5626
562	5.75	51.00	9.70	33.55	6000
563	5.89	63.59	16.39	14.13	8431
564	5.97	49.89	6.01	38.13	4863
565	6.38	44.31	8.70	40.61	5455
566	4.50	42.30	12.20	41.00	5953
567	6.53	51.10	12.82	29.55	6421
568	5.29	38.83	11.69	44.19	5564
569	6.60	49.70	11.60	32.10	6405
570	5.99	49.82	6.37	37.82	5392
571	6.44	50.29	13.87	29.40	7044
572	7.49	44.44	12.81	35.26	6109
573	7.85	53.41	3.36	35.38	5253
574	8.09	51.50	13.39	27.02	7138
575	7.52	55.53	3.03	33.92	4863
576	9.13	52.75	14.87	23.25	7247
577	6.98	46.27	9.08	37.67	5657
578	3.70	39.59	4.64	52.07	----------
579	17.65	38.42	11.96	31.97	6499
580	5.12	40.77	5.62	48.49	4691
581	4.71	23.96	4.34	66.99	----------
582	4.35	35.20	2.31	58.14	----------
583	8.20	45.35	14.57	31.88	6094
584	6.98	46.12	6.90	39.995	5455

TABLE III—CONTINUED

Laboratory Number	*Proximate Analysis*				*Calorimetric Analysis in B. T. Us.*
	Moisture	*Volatile and Combustible Matter*	*Fixed Carbon*	*Ash*	
585	4.67	49.53	8.12	37.68	5408
586	6.02	50.96	11.14	31.88	6078
587	4.49	46.04	10.22	39.25	5595
588	6.62	34.44	7.57	51.37	----------
589	5.85	40.16	4.38	49.61	4005
590	7.90	47.86	14.12	30.12	6546
591	8.17	47.46	18.24	26.14	6857
592	10.25	32.25	7.14	50.36	----------
593	9.03	51.57	10.93	28.47	6063
594	7.30	50.71	17.10	24.89	6452
595	7.97	52.94	16.60	22.49	7122
596	7.99	52.61	15.47	23.93	6904
597	11.91	50.23	17.02	20.84	6966
598	11.81	45.03	23.51	19.66	6125
599	8.25	35.47	16.45	39.83	4676
600	7.08	43.65	11.88	37.39	6031
601	7.78	47.55	4.83	39.84	4333
602	6.87	47.82	4.52	40.79	4785
603	10.42	43.24	12.57	33.77	5517
604	7.38	38.05	9.05	45.52	4722
605	7.72	42.78	8.71	40.79	5096
606	11.86	48.31	9.80	30.03	5735
607	6.73	42.22	2.90	48.15	5907
608	8.11	41.32	8.46	42.11	4894
609	10.61	38.20	13.46	37.73	5533
610	9.52	43.09	9.62	37.77	5096
611	7.98	39.55	15.43	37.04	6078
613	9.37	41.03	12.44	37.16	----------
614	12.35	45.78	10.20	31.67	5517
615	8.69	36.34	6.52	48.45	5813
616	9.89	43.39	11.72	35.00	4255
617	9.86	45.07	10.17	34.90	5548
618	11.11	43.72	10.98	34.19	5330
619	10.31	44.55	7.44	37.70	5795
620	9.41	42.54	7.24	40.81	4856
621	11.73	49.50	12.31	26.46	6390
622	9.65	43.47	7.72	39.16	4863
623	9.34	34.71	5.90	50.05	----------
624	5.42	20.71	3.35	70.52	----------
625	4.80	15.87	2.13	77.20	----------
626	5.02	19.49	2.80	72.69	----------
627	7.43	30.91	6.22	55.44	----------
628	7.87	39.19	8.40	44.54	4722
629	6.04	33.34	8.02	52.60	----------
630	9.00	42.78	12.06	36.16	6140
631	6.39	43.05	11.87	38.69	5876
632	7.75	33.08	8.73	50.44	----------
633	6.75	31.79	7.58	53.88	----------
634P	8.56	23.96	3.69	63.79	----------

TABLE III—CONTINUED

Laboratory Number	Proximate Analysis				Calorimetric Analysis in B. T. Us.
	Moisture	Volatile and Combustible Matter	Fixed Carbon	Ash	
635P	11.63	40.59	21.72	26.06	6390
636P	10.51	51.61	13.80	24.09	6811
637P	9.58	38.03	8.24	44.15	4707
638P	10.71	44.98	8.01	36.30	5159
639P	11.33	45.19	11.35	32.13	6031
640P	9.31	46.35	8.84	35.50	5096
641P	9.73	40.51	9.00	40.76	4894
642P	12.64	43.46	14.82	29.08	6296
643P	11.65	38.88	11.68	37.79	5986
644P	9.91	56.68	7.07	26.34	5798
645P	9.97	50.28	10.47	29.28	6099
638	6.60	40.19	9.01	44.20	5628
639	8.89	45.60	8.17	37.34	5549
640	7.36	41.58	7.63	43.43	4987
641	5.90	40.40	10.90	42.80	6079
642	6.15	49.09	17.51	27.25	5440
643	5.22	46.59	15.96	32.23	6655
644	9.78	53.48	13.64	23.10	7169
645	6.03	34.66	5.46	53.85	----------
646	6.88	49.49	13.60	30.03	6492
647	7.55	54.57	15.67	22.21	7278
648	7.77	49.36	15.46	27.41	7013
649	6.77	47.69	14.27	31.27	6468
650	7.53	40.40	11.06	41.01	5720
651	5.97	21.63	1.59	70.81	----------
652	5.07	12.95	.47	81.51	----------

BIBLIOGRAPHY OF IOWA PEAT

COMPILED BY JAMES H. LEES.

Adair county, ancient peat bed in.
C. A. White, in Geol. Iowa, Vol. I, p. 339. 1870.

Buchanan county, peat in.
S. Calvin, in Ia. Geol. Surv., Vol. VIII, p. 247. 1897.

Beyer, S. W.
Briquetting of peat. Ia. Geol. Surv., Vol. XVIII, p. 28. 1907.

Calvin, S.
Fuel value of peat. Ia. Geol. Surv., Vol. XVII, p. 3. 1906.
Peat in Buchanan county. Ibid., Vol. VIII, p. 247. 1897.
Peat in Cerro Gordo county. Ibid., Vol. VII, p. 192. 1896.
Peat in Chickasaw county. Ibid., Vol. XIII, p. 289. 1902.
Peat in Pleistocene deposits of Iowa. Bull Geol. Soc. Am., Vol. 20, pp. 133-152. 1909.

Cerro Gordo county, peat in.
S. Calvin, in Ia. Geol. Surv., Vol. VII, p. 192. 1896.

Chemical analyses of peat.
Rush Emery, in Geol. Iowa, Vol. II, pp. 397-402. 1870.
I. A. Williams, in Iowa Geol. Surv., Vol. XVI, p. 505. 1905.

Chickasaw county, peat in.
S. Calvin, in Ia. Geol. Surv., Vol. XIII, p. 289. 1902.

Davenport, ancient peat bed near.
W. H. Pratt, in Proc. Davenport Acad. Sci., Vol. I, pp. 96-99. 1876.
C. A. White, in Geol. Iowa, Vol. I, p. 119. 1870.

Emery, Rush.
Chemical analyses of peat. Geol. Iowa, Vol. II, pp. 397-402. 1870.

Forest bed in northeastern Iowa.
W J McGee, in U. S. Geol. Surv., Eleventh Ann. Rept., pp 486-496. 1889-90.

Franklin county, peat in.
I. A. Williams, in Iowa Geol. Surv., Vol. XVI, pp. 495, 504. 1905.

Fulton, A. R.
Peat in Iowa. Iowa: The Home for Immigrants, p. 24. Des Moines, 1870.

Humboldt county, peat in.
T. H. Macbride, in Ia. Geol. Surv., Vol. IX, p. 145. 1898.

Iowa City, ancient peat bed near.
C. A. White, in Geol. Iowa, Vol. I, p. 120. 1870.

Keyes, C. R.
Peat, formation of. Ia. Geol. Surv., Vol. II, p. 50. 1894.

Macbride, T. H.
Peat in Humboldt county. Ia. Geol. Surv., Vol. IX, p. 145. 1898.
Pre-Kansan peat bed. Ia. Acad. Sci., Vol. IV, pp. 63-66. 1896.

McGee, W J.
Forest bed in northeastern Iowa. U. S. Geol. Surv., Eleventh Ann. Rept., pp. 486-496. 1889-90.

Peat, briquetting of.
S. W. Beyer, in Iowa Geol. Surv., Vol. XVIII, p. 28. 1907.

Peat, chemical analyses of.
Rush Emery, in Geol. Iowa, Vol. II, pp. 397-402. 1870.
I. A. Williams, in Ia. Geol. Surv., Vol. XVI, p. 505. 1905.

Peat, formation of.
C. R. Keyes, in Ia. Geol. Surv., Vol II, p. 50. 1894,

Peat, fuel value of.
S. Calvin, in Iowa Geol. Surv., Vol. XVII, p. 3. 1906.

Peat bed, ancient, in Adair county.
C. A. White, in Geol. Iowa, Vol. I, p. 339. 1870.

————, near Davenport.
W. H. Pratt, in Proc. Davenport Acad. Sci., Vol. I, pp. 96-99. 1876.
C. A. White, in Geol. Iowa, Vol. I, p. 119. 1870.

————, near Iowa City.
C. A. White, in Geol. Iowa, Vol. I, p. 120. 1870.

Peat bed, buried.
T. E. Savage, in Iowa Acad. Sci., Vol. XI, pp. 103-109. 1903.

Peat bed, pre-Kansan.
T. H. Macbride, in Ia. Acad. Sci., Vol. IV, pp. 63-66. 1896.

Peat in Iowa.
A. R. Fulton, in Iowa: The Home For Immigrants, p. 24. Des Moines, 1870.
C. A. White, in Second Ann. Rept. State Geol., pp. 121-135. 1868.
———— in Geol. Iowa, Vol. II, pp. 275-288. 1870.
History of Dallas county, p. 126. Des Moines, 1879. Also in several other county histories.
History of Davis county, p. 130. Des Moines, 1882. Also in several other county histories.

Peat in Pleistocene deposits of Iowa.
S. Calvin, in Bull. Geol. Soc. Am., Vol. 20, pp. 133-152. 1909.

Peat in Buchanan county.
S. Calvin, in Iowa Geol. Surv., Vol. VIII, p. 247. 1897.

Peat in Cerro Gordo county.
S. Calvin, Ibid., Vol. VII, p. 192. 1896.

Peat in Chickasaw county.
S. Calvin, Ibid., Vol. XIII, p. 289. 1902.

Peat in Franklin county.
I. A. Williams, Ibid., Vol. XVI, pp. 495, 504. 1905.

Peat in Humboldt county.
T. H. Macbride, Ibid., Vol. IX, p. 145. 1898.

Peat in Worth county.
I. A. Williams, Ibid., Vol. X, p. 375. 1899.

Peat resources of Iowa.
T. E. Savage, Ibid., Bull. 2, pp. 5-21. 1905.

Pratt, W. H.
Peat bed, ancient, near Davenport. Proc. Davenport Acad. Sci., Vol. I, pp. 96-99. 1876.

Pre-Kansan peat bed.
T. H. Macbride, in Iowa Acad. Sci., Vol. IV, pp. 63-66. 1896.

Savage, T. E.
Buried peat bed. Ia. Acad. Sci., Vol. XI, pp. 103-109. 1903.
Peat resources of Iowa. Ia. Geol. Surv., Bull. 2, pp. 5-21. 1905.

White, C. A.
Peat bed, ancient, in Adair county. Geol. Iowa, Vol. I, p. 339. 1870.
—— near Iowa City. Ibid., p. 120.
—— near Davenport. Ibid., p. 119.
Peat in Iowa. Sec. Ann. Rept. State Geol., pp. 121-135. 1868.
Peat in Iowa. Geol. Iowa, Vol. II, pp. 275-288. 1870.

Williams, I. A.
Chemical analysis of peat. Ia. Geol. Surv., Vol. XVI, p. 505. 1905.
Peat in Franklin county. Ibid., Vol. XVI, pp. 495-504. 1905.
Peat in Worth county. Ibid., Vol. X, p. 375. 1899.

Worth county, peat in.
I. A. Williams, in Ia. Geol. Surv., Vol. X, p. 375. 1899.

FLORA NORTHERN IOWA PEAT BOGS

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CONTENTS

CHAPTER VII

FLORA OF NORTHERN IOWA PEAT BOGS

The subject of plants that occur in peat bogs has been discussed in a considerable number of papers both in Europe and America. The most exhaustive and best of recent articles is that by Charles A. Davis on Peat in Michigan.[1] Some of the earlier important publications in the same line were by Shaler on the Fresh Water Morasses of the United States,[2] by Lesquereux on the Dismal Swamp,[3] and by Kearney on the same swamp.[4]

Many of the geological text books refer to the formation of peat by sphagnum mosses; but, as stated by Davis, few geologists have heretofore realized the importance of other plants in the formation of peat. Winchell is, however, an exception to these and, as early as 1860, recognized the fact that many other aquatic plants take part in peat making.

Few American botanists have made so detailed a study of the peat flora as has Davis. Of the more important contributions on the subject from botanists in our own country, mention may be made of the papers by Cowles,[5] Coulter,[6] MacMillan,[7] Whitford,[8] Kearney,[9] Atkinson,[10] Mills,[11] Pieters,[12] Transeau,[13], Harshberger,[14] Olsson-Seffer,[15] and Weld.[16] A number of European investigators have made quite exhaustive studies of peat bog floras; of these we may mention Schimper,[17] Früh,[18] Koller,[19] Eiseln,[20] Sendtner,[21] Fischer-Benzon,[22] Weber,[23] Christ,[24] Drude,[25] and Jens Holmboe, the Scandinavian, who has given an excellent review of the work done in this line by Blytt, Nathorst, Rekstad, Gunnar, Anderson, Sernander, Schulz, and others.

On the subject of bog flora in Iowa, the writer,[26] has contributed two notes; there are also notes by Cratty,[27] and by Shimek.[28]

Davis in his paper on Peat makes three classifications of peat formations. The first according to the form of land surface upon which they have been formed. A second classification given by him is based on the development of the deposit. The third classification given by Davis is based on the kinds of plants found in the bog. He records the following types in Michigan.

(1) Elm and Black Ash swamps.
(2) Tamarack swamps, marshes and bogs.
(3) Cedar (Arbor Vitæ) swamps.
(4) Spruce swamps.
(5) Willow and Alder swamps.
(6) Heath (Blueberry, Cranberry and Cassandra) swamps, marshes or bogs.
(7) Grass and Sedge marshes and bogs.
(8) Rush marshes (Cat-tail and Bullrush marshes belong here).
(9) Moss bogs (including Sphagnum bogs).

A classification of the Iowa bogs in the area studied by the writer would include the following:

(1) The Quaking Aspen bog.
(2) Willow bog.
(3) Grass and Sedge marshes.
(4) Rush marshes.
(5) Moss bogs.

It is clear, however, that all of these bogs contain a mixed vegetation of many aquatic or semi-aquatic and even dry land plants.

Transeau, who has made a study of the bog plants of North America, after eliminating those which are merely local, numbers the following fifteen plants: Buckbean (*Menyanthes trifoliata*), Tall Sedge (*Dulichium arundinaceum*), Cowberry (*Potentilla palustris*), *Scheuchzeria palustris,* Tall Cotton Grass (*Eriophorum viridi-carinatum*), Sundew (*Drosera rotundifolia*), Pitcher Plant (*Sarracenia purpurea*), Small Cranberry (*Vaccinium oxycoccus*), Creeping Snowberry (*Chiogenes hispidula*), Wild Rosemary (*Andromeda polifolia*), Leather-leaf (*Chamaedaphne calyculata*), Labrador Tea (*Ledum groenlandicum*), Laurel (*Kalmia latifolia*), Swamp Birch (*Betula pumila*), and Tamarack (*Larix laricina*). In commenting upon this list, Harshberger finds that ten, only, are present in Europe in similar habitats. The *Dulichium, Sarracenia purpurea,* and *Kalmia* are endemic. The larch and birch are represented in the Old World by closely related species. From the evidence, it is apparent that these plants originated as circumpolar species during pre-glacial times. In Northern Europe, they have found a succession of species. In the lower parts of the bogs, occur traces of an artic flora. The Scotch pine and white birch are also found in the lower layers. In a Wisconsin bog, the writer found a white ash (*Fraxinus americana*); occasionally some wood has been found in Iowa bogs, this evidently being of post-glacial origin. In a study of the peat flora of the western Wisconsin drift area, but few plants were found to be common to the list given by Transeau. These are *Menyanthes, Dulichium, Potentilla, Scheuchzeria,* and *Eriophorum.* In addition to these the peat bogs of Wisconsin have *Drosera, Sarracenia, Chiogenes, Betula pumila,* and *Larix.* While true bogs may be confined to the Northern Hemisphere, Darwin, however, discovered in the Southern Hemisphere, a bog formation of *Astelia pumila,* a species of rush.

Harshberger mentions the formation of peat bogs on Roan Mountain in North Carolina, Slide Mountain in the Catskills, Mt. Marcy in the Adirondacks, Mt. Mansfield in Vermont, Mt. Washington in New Hampshire, Mt. Katahdin in Maine, and Sierra de Ajusco in Mexico. These are by no means all of the same origin. The writer has found peat bogs of small extent in the Uintah Mountains at 13,000 feet elevation. The bog-forming species were a dwarf birch, *Betula glandulosa, Eriophorum, Carex,* and species of *Hypnum.* No sphagnum was found in any of these mountains.

Louis A Weld[16] has given us a picture of the formation of a peat bog and moraine lake in the Huron River Valley of Michigan. He recognizes five zones as follows: (1) Potamogeton zone represented chiefly by the *P. luceus;* (2) Nuphar zone, the *Nuphar advena* giving character to the zone, the *Nymphaea odorata* being sparingly or recently introduced, and *Ceratophyllum demersum* and *Chara* being present; (3) Carex and Sphagnum zone, *Carex* with six species predominating; the flora of this zone is varied, there being about thirty species such as *Dulichium, Eleocharis, Carex filiformis, Potentilla palustris, Eupa-*

torium perfoliatum, etc.; (4) Cassandra zone, advance of shrubs of which Cassandra (*Chamaedaphne*) is most conspicuous, and with this, the Sphagnums are active in raising the marsh; also *Glyceria nervata, Aspidium noveboracense, Sarracenia purpurea, Drosera, Pogonia,* etc.; (5) Forest zone, the only tree enduring these conditions being the Tamarack, which advances into the Cassandra zone. Peat does not decompose very readily; it owes its antiseptic properties to the presence of ulmic and humic acids. Hilgard states, in his work on Soils, that the acid reaction is due to ulmic acid which is readily soluble in caustic and carbonated alkalies, and forms insoluble salts with the earths and metals: the other part, ulmin, is insoluble in these but through oxidation becomes soluble.

The antiseptic property present during the early stage of peat formation stops the action of bacteria and thus we have a chemical process suggested at this point.

The Iowa peat bogs in the Wisconsin drift area are very different in character than those given for Wisconsin. The *Menyanthes, Comarum, Eriophorum, Dulichium* and *Scheuchzeria* are the typical plants mentioned by Transeau.

Elm and Black Ash bogs, as well as Tamarack swamps, Cedar swamps, Spruce swamps, Heath swamps, marshes, and bogs, Alder marshes and Sphagnum bogs are entirely absent in the region under consideration. The bogs of this region by no means have the same origin. Generally speaking trees and woody plants form only a small part of the bog flora.

THE QUAKING ASPEN BOG

The bogs of Cerro Gordo and Worth counties may be compared with some very typical swamps in Wright and Hamilton counties. Both of these counties are in the Wisconsin drift area, and the swamps are in a more advanced stage than in the north and east. These swamps have materially changed since the surrounding country has been brought into cultivation. That these swamps were once lakes, receiving the water from the surrounding country, admits of no doubt. The old beach line is plainly evident. In the larger of these lakes the outer beach was covered with trees and shrubs. Of this arboreal vegetation we may mention *Quercus macrocarpa, Ulmus fulva, U. americana, Fraxinus pennsylvanica,* var. *viridis* and *Tilia americana.* There are a few shrubs,—*Corylus americana, Rhus glabra, R. toxicodendron* and *Symphoricarpos occidentalis.* The smaller lakes are not surrounded by timber or shrubs. The outer beach line, which consists of a sandy gravel and humus, contains *Oenothera serrulata, Ceanothus americanus, Onosmodium occidentale, Verbena stricta, V. bracteosa, Lithospermum canescens, L. angustifolium, Castilleia sessiliflora, Solidago rigida, S. nemoralis.*

Figure 106. Larger Blue Flag (*Iris versicolor* L.), a characteristic bog plant of Iowa.

Poa pratensis is abundantly naturalized. The second beach is thickly covered with *Scirpus atrovirens, Glyceria nervata, Thalictrum revolutum, Juncus tenuis, Verbena hastata,* and *Hordeum jubatum.* Formerly *Cypripedium candidum* was common. The third beach is thickly covered with *Carex, Iris versicolor, Lathyrus palustris, Eleocharis palustris, Eupatorium perfoliatum, E. purpureum,* and *Asclepias incarnata.* The fourth beach is mostly made up of *Calamagrostis canadensis, Carex, Lobelia kalmii,* *Bromus kalmii,* and *Scutellaria galericulata.* This beach is followed by abundant growth of *Phragmites communis, Scirpus validus, Typha latifolia, Menyanthes trifoliata* and *Zizania aquatica.* Formerly the center of the swamp was a lake in which *Nymphaea advena* and *Castalia tuberosa* abounded, but owing to drying of the lakes these have in most instances disappeared. During the spring and early summer months there is an abundance of water in the small depressions, containing diatoms, desmids and other fresh water algæ. The willows, especially *Salix discolor* and *S. rostrata,* and *S. candida* form an integral part of the flora. The Quaking Aspen occurs in the somewhat higher situations of the bog.

Figure 107. Cat-tail (*Typha latifolia* L.) on border of swamp in central Iowa. Photo by Charlotte M. King.

THE WILLOW BOG

Throughout the Wisconsin and Iowan drift area, willow bogs are frequent but they form only a small part of the peat bog flora. In the Iowan drift or in the driftless area in northeastern

Iowa in Clayton, Allamakee, and Winneshiek counties, the most important species are the Beaked Willow (*Salix rostrata*); *S. discolor* are usually found along small runs or ditches which have been cut through these marshes or along roadsides. The Myrtle Willow (*S. pedicellaris*) and *S. candida,* when occurring, are widely scattered over the bog and are therefore a much more integral part of the bog flora than are the other species.

MARSH AND SEDGE BOGS

The peat bog near Fertile contains many of the same plants found in the bogs east of Hanlontown. The most conspicuous is the *Carex filiformis* which is a prevailing and predominant species. Much of the peat is derived from this plant. Associated with this Carex mat there is an abundance of Water Marigold (*Bidens trichosperma*), Marsh Marigold (*Caltha palustris*), *Parnassia carolinana,* Swamp Thistle (*Cirsium muticum*), Lobelia (*Lobelia kalmii*), Lousewort (*Pedicularis lanceolata*), Gentian (*Gentiana andrewsii*), Fowl Meadow Grass (*Glyceria nervata*), Spike Rush (*Eleocharis palustris*), Fringed Gentian (*Gentiana crinita*), Boneset (*Eupatorium perfoliatum*), *Saxifraga pennsylvanica,* White Bellflower (*Campanula aparinoides*), *Galium trifidum,* Purple Boneset (*Eupatorium purpureum*), Poison Hemlock (*Cicuta bulbifera* and *C. maculata*), Water Parsnip (*Sium cicutaefolium*), Wild Timothy (*Muhlenbergia racemosa*), Greater Dock (*Rumex britannica*), Meadow Rue (*Thalictrum purpurascens*), Dulichium (*Dulichium arundinaceum*), False Dragon Head (*Physostegia virginiana*), Skullcap (*Scutellaria galericulata* and *S. lateriflora*), Ladies Tresses (*Spiranthes cernua*), Goldenrod (*Solidago riddellii*), Aster (*Aster junceus*), Bromegrass (*Bromus kalmii* and *B. ciliatus*), Buckbean (*Menyanthes trifoliata*), Cottongrass (*Eriophorum viridicarinatum*), St. John's Wort (*Hypericum virginicum*), Beech Fern (*Aspidium thelypteris*), Fragrant Orchis (*Habenaria leucophaea*), and an abundance of Blue Joint Grass (*Calamagrostis canadensis* and *C. inexpansa*). Many other plants occur and no doubt partake in the formation of the peat. Of recent introductions mention may be made of Smaller Ragweed (*Ambrosia artemisiifolia*), Smartweed (*Polygonum pennsylvanicum* and *P. lapathifolium*), Sunflower (*Heli-

anthus grosseserratus), Bluegrass (*Poa pratensis*), Red Top (*Agrostis alba*), Boot Jack (*Bidens frondosa*), Aster (*Aster salicifolius, A. novae-angliae, A. novi-belgii*), *Solidago serotina.*

When the drainage has been carried on to a much further extent as in some of the bogs in Winnebago and Hancock counties, it may become densely covered with *Bidens cernua.* One

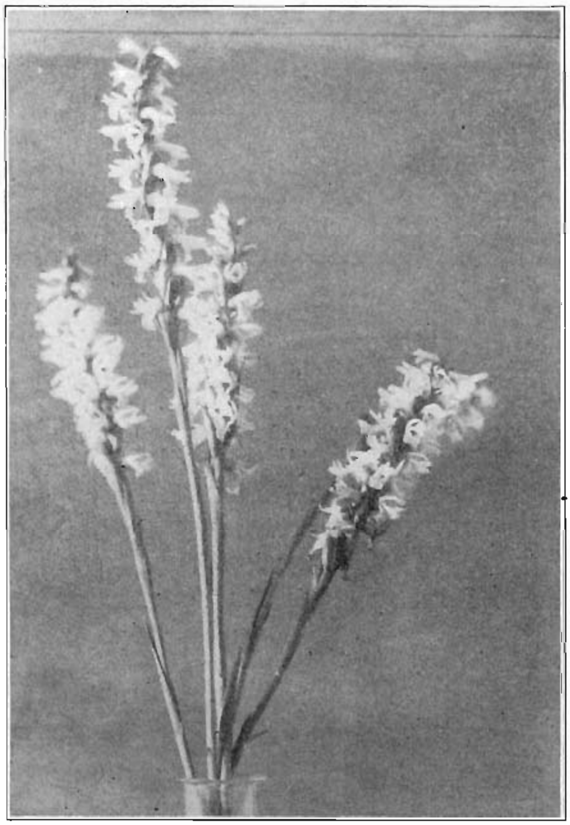

Figure 108. Ladies' Tresses (*Spiranthes cernua* (L.) Richard.), a bog plant of northern Iowa.

whole bog, acres of it, was a golden yellow by the growth of this plant. With it occurred a little of the *Cicuta bulbifera.*

Although the plants of the various bogs of this type are by no means the same, the most typical plant is the *Carex filiformis* which was commonly found in the bogs of Hamilton, Wright, Worth, Winnebago, Cerro Gordo, and Emmet counties. The following plants also occur in all of these bogs: *Cicuta bulbifera, Pedicularis lanceolata, Gentiana crinita, Scutellaria galericulata, Gentiana andrewsii, Campanula aparinoides, Bidens beckii, Menyanthes trifoliata, Hypericum virginicum, Glyceria canadensis, Galium trifidum,* Loosestrife (*Lythrum alatum*).

The bogs of Worth, Cerro Gordo, and Winnebago counties had in addition *Cirsium muticum* and *Saxifraga pennsylvanica, Salix pedicellaris,* and eastward the *S. candida.*

RUSH BOGS

These bogs are somewhat limited in extent. The whole of the bog near Fertile had been so sufficiently drained that little of the Greater Rush (*Scirpus validus*) occurred; however, in numerous small bogs in Hamilton, Winnebago, and Wright counties, this rush formed an important part of the flora. Associated with this rush is the Wild Rice (*Zizania aquatica*) which is abundant in Winnebago, Emmet, and Hamilton counties. In these bogs the water is from a few inches to a foot or more in depth and often it gives away like a regular sphagnum bog, forming a well matted system of roots. The Greater Reed Grass (*Phragmites communis*) is abundant. The Yellow Water Lily (*Nymphaea advena*), and White Water Lily (*Castalia tuberosa*) are abundant, occasionally also Pickerel-weed (*Pontederia cordata*) and Crowfoot (*Ranunculus delphinifolius* and *R. aquatilis* var. *capillaceus*), Saggitaria, *Eleocharis palustris*, and the *E. acicularis* growing in mud, and *Cicuta bulbifera.* The *Zizania, Phragmites, Scirpus validus, Nymphaea* and *Castalia* are characteristic.

MOSS BOGS

There are none of the typical moss bogs found in this state. The moss found in this state belongs to the genus *Hypnum.* Sphagnum has not been found anywhere in the bogs of northern Iowa.

DRAINAGE AND THE CHARACTER OF PLANTS

Drainage of the peat bogs has been attempted in many places in Iowa and in such places a large number of introduced plants have made their appearance. The Small Ragweed (*Ambrosia artemisiifolia*), Goosefoot (*Chenopodium album*), Old Witch Grass (*Panicum capillare*), Pennsylvania Smartweed (*Polygonum pennsylvanicum*), Pigweed (*Amarantus retroflexus*), Five-finger (*Potentilla monspeliensis*), Milkweed (*Asclepias syriaca*), Boot Jack (*Bidens frondosa*), and *B. discoidea,* are representative types. These plants originally did not constitute a part of the bog flora, except in dry years when they appeared. These are seldom found in the sedge mat where the Marigold (*Bidens trichosperma*) and Swamp Thistle (*Cirsium muticum*), Myrtle-leaved Willow (*Salix pedicellaris*) and *Lobelia kalmii* grow in abundance.

THE IOWA AND WISCONSIN BOGS COMPARED

Peat bogs like those found in northern Iowa are common in Wisconsin and Minnesota. Many of the Wisconsin bogs do not have shrubs. The *Carex filiformis, Cirsium muticum, Saxifraga pennsylvanica, Parnassia parviflora, Pedicularis lanceolata, Caltha palustris, Valeriana edulis, Salix rostrata, S. discolor* are the most characteristic features, with an abundant growth of *Symplocarpus foetidus* and *Cornus stolonifera.* In other bogs the Sphagnum, *Drosera rotundifolia, Sarracenia purpurea, Rynchospora alba, Calopogon pulchellus* and *Pogonia ophioglossoides* are characteristic. A third type is characterized in western Wisconsin by *Larix laricina, Cornus stolonifera, Smilacina bifolia, Symplocarpus foetidus;* northward with Black Spruce, Balsam Fir, and Arbor Vitæ. Another type is characterized by the presence of Swamp Ash and Elm. The best comparison may be obtained from the accompanying table for different areas in Iowa, Wisconsin and Michigan.

In various bogs both in Wisconsin and Michigan, as well as Iowa, occur plants that are really not typical bog plants; in some instances the species may be a bog plant in Wisconsin, Minnesota, and Michigan, and yet does not occur in bogs in this state.

Two of the best illustrations of this character are the Common High Bush Cranberry (*Viburnum opulus*) and the *Pyrus arbutifolia* which in this state are common upon the limestone rocks along the Yellow river in Allamakee county and along with it such plants as the Balsam Fir (*Abies balsamea*) and Aconitum. The two species of Dogwood (*Cornus amomum* and *C. paniculata*) though occasionally occurring in bogs associated with willows are really not bog plants. The Hop (*Humulus lupulus*) is abundant in some of the peat bogs along streams in Wisconsin and the *Allium tricoccum* or Onion is one of the most abundant plants in peat bogs in proximity to the willows in Wisconsin and Minnesota. The Lady Slipper (*Cypripedium parviflorum* var. *pubescens*), *Populus grandidentata, Ribes floridum,* the Virginia Creeper (*Psedera quinquefolia*), and the Soft Maple (*Acer saccharum*) are to be regarded as accidental plants rather than a true constituent of the bog flora. The Orchid (*Liparis liliifolia*) reported from Michigan is likewise more commonly found on higher ground. These plants probably represent later stages of the development of the bog.

For the sake of convenience, I have followed the nomenclature of the Robinson-Fernald edition of Gray's Manual. Miss Harriette Kellogg has compared for me the names used in this work and has arranged the bibliography.

NAME OF PLANT.	Wheelerwood, Cerro Gordo Co.	Fertile, Worth Co.	Lake Mills, Winnebago Co.	Forest City, Winnebago Co.	Armstrong, Emmet Co.	Belmond, Wright Co.	Jewell Junction, Hamilton Co.	La Crosse, Wisconsin.	Southern Mich.	Northern Mich.	Dismal Swamp, Virginia.	Winneshiek Co.
Bryophyta												
Riccia fluitans	----	----	+	+	+	----	+	+	+	----	+	----
Musci												
Hypnum fluitans ? No fruit	+	+	+	+	+	----	----	----	+	----	----	----
Sphagnum sp.	----	----	----	----	----	----	----	+	+	+	+	----
Pteridophyta												
Equisetaceæ												
Equisetum fluviatile (L.) Pipes	+	+	+	+	+	+	+	+	+	+	----	----
Equisetum arvense L.	+	+	+	+	+	+	+	+	+	+	----	+
Polypodiaceæ												
Aspidium thelypteris (L.) Sw.	+	+	+	+	----	----	----	+	+	+	----	----
Aspidium cristatum (L.) Sw.	----	----	----	----	----	----	----	+	+	+	----	----
Woodwardia virginica (L.) Sm.	----	----	----	----	----	----	----	----	+	----	+	----
Onoclea sensibilis L.	+	+	+	+	----	----	+	+	+	+	----	+
Osmundaceæ												
Osmunda regalis L.	----	----	----	----	----	----	----	+	+	+	+	----
Osmunda cinnamomea L.	----	----	----	----	----	----	----	+	+	+	+	----
Ophioglossaceæ												
Ophioglossum vulgatum L.	----	----	----	----	----	----	----	----	+	+	----	----
Lycopodiaceæ												
Lycopodium inundatum L.	----	----	----	----	----	----	----	----	----	+	+	----
Spermatophyta												
Gymnosperms												
Pinaceæ												
Larix laricina (Du Roi) Kock.	----	----	----	----	----	----	----	+	+	+	----	----
Picea mariana (Mill.) BSP.	----	----	----	----	----	----	----	----	+	+	----	----
Abies balsamea (L.) Mill.	----	----	----	----	----	----	----	----	----	+	----	+
Chamæcyparis thyoides (L.) BSP.	----	----	----	----	----	----	----	----	----	----	+	----
Thuja occidentalis L.	----	----	----	----	----	----	----	----	+	+	----	----
Juniperus communis L. var	----	----	----	----	----	----	----	----	----	+	----	----
depressa Pursh	----	----	----	----	----	----	----	----	+	+	----	----
Typhaceæ												
Typha latifolia L.	+	+	+	+	+	+	+	+	+	+	+	+
Sparganium simplex Huds.	----	----	----	----	+	----	----	----	----	+	----	----
Sparganium eurycarpum Engelm.	----	----	----	----	+	----	----	----	+	----	----	+
Sparganium minimum Fries.	----	----	----	----	----	----	----	----	----	+	----	----
Angiospermae												
Najadaceæ												
Potamogeton natans L.	+	----	----	----	+	----	----	----	----	+	----	----
Potamogeton amplifolius Tuckerm.	----	----	----	----	+	----	----	----	----	----	----	----
Potamogeton americanus C. & S.	----	----	----	----	+	----	----	----	----	----	----	----

Name of Plant.	Wheelerwood, Cerro Gordo Co.	Fertile, Worth Co.	Lake Mills, Winnebago Co.	Forest City, Winnebago Co.	Armstrong, Emmet Co.	Belmond, Wright Co.	Jewell Junction, Hamilton Co.	La Crosse, Wisconsin.	Southern Mich.	Northern Mich.	Dismal Swamp, Virginia.	Winneshiek Co.
Potamogeton heterophyllus Schreb.	----	----	----	----	+	----	----	----	+	----	----	----
Potamogeton illinoensis Morong.	----	----	----	----	+	----	----	----	----	----	----	----
Potamogeton perfoliatus L.	----	----	----	----	+	----	----	----	+	----	----	----
Potamogeton zosterifolius Schum.	----	----	----	----	+	----	----	----	+	----	----	----
Potamogeton foliosus Raf.	----	----	----	----	+	----	----	----	+	----	----	----
Potamogeton prælongus Wulf.	----	----	----	----	+	----	----	----	+	----	----	----
Potamogeton pusillus L.	----	----	----	----	+	----	----	----	+	----	----	----
Potamogeton pectinatus L.	----	----	----	----	+	----	----	----	+	----	----	----
Najas flexilis (Willd.) Rostk. & Schmidt	----	----	----	----	+	----	----	----	+	+	----	----
Juncaginaceæ												
Triglochin maritima L.	----	----	----	----	+	----	----	----	+	----	----	----
Scheuchzeria palustris L.	+?	+?	+?	+?	+	----	----	+	+	----	----	----
Alismaceæ												
Sagittaria arifolia Nutt.	+	----	----	----	+	----	----	+	+	----	----	----
Sagittaria latifolia Willd.	----	----	----	----	+	----	----	+	+	+	----	+
Sagittaria heterophylla Pursh.	----	----	----	----	+	----	----	+	+	----	----	----
Sagittaria graminea Michx.	----	----	----	----	+	----	----	----	----	----	+	----
Lophotocarpus calycinus (Engelm.) J. G. Sm.	----	----	----	----	----	----	----	+	+	----	----	----
Alisma plantago-aquatica L.	+	+	+	+	+	+	+	+	+	+	----	+
Vallisneriaceæ												
Vallisneria spiralis L.	----	----	----	----	----	----	----	----	----	----	----	+
Elodea canadensis Michx.	+	+	+	+	+	+	+	+	+	+	----	+
Glumifloræ												
Gramineæ												
Erianthus saccharoides Michx.	----	----	----	----	----	----	----	----	----	----	+	----
Echinochloa crusgalli (L.) Beauv.	+	+	+	+	+	+	+	+	+	+	+	+
Zizania aquatica L.	+	+	+	+	+	+	+	+	+	+	+	+
Leersia oryzoides (L.) Sw.	+	+	+	+	+	+	+	+	+	+	+	+
Phalaris arundinacea L.	+	+	+	+	+	+	+	+	+	----	----	----
Hierochloe odorata (L.) Wahlenb.	----	----	----	----	+	+	+	+	+	+	----	----
Muhlenbergia racemosa (Michx.) BSP.	+	+	+	+	+	+	+	+	+	+	----	+
Alopecurus geniculatus L.	----	----	----	----	+	----	----	+	+	+	+	+
Agrostis alba L.	+	+	+	+	+	+	+	+	+	+	+	+
Calamagrostis candensis (Michx.) Beauv.	+	+	+	+	+	+	+	+	+	+	----	+
Calamagrostis inexpansa Gray	+	+	+	+	+	+	+	+	+	----	----	----
Cinna arundinacea L.	+	+	+	+	+	+	+	+	+	+	----	+

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Spartina cynosuroides (L.) Roth.	+	+	+	+	+	+	+	+	+	+	----	+
Phragmites communis Trin.	+	+	+	+	+	+	+	+	+	+	+	+
Eragrostis hypnoides (Lam.) BSP	+	+	+	+	+	+	+	+	+	+	----	+
Poa triflora Gilib	+	+	+	+	+	+	+	+	+	+	----	----
Scolochloa festucacea (Willd.) Link	----	----	----	----	+	----	----	----	----	----	----	----
Glyceria canadensis (Michx.) Trin	----	----	----	----	----	----	----	+	----	+	----	----
Glyceria nervata (Willd.) Trin.	+	+	+	+	+	+	+	+	+	+	----	+
Glyceria fluitans (L.) R. Br.	+	+	+	+	+	+	+	+	+	+	----	----
Glyceria grandis Wats	----	----	----	----	+	----	+	----	----	+	----	+
Bromus kalmii Gray	+	+	+	+	----	----	+	+	+	+	----	+
Bromus ciliatus L.	+	+	+	+	+	+	+	+	+	+	----	+
Cyperaceæ												
Cyperus diandrus Torr	+	+	+	+	+	+	+	+	+	+	+	+
Cyperus esculentus L.	+	+	+	+	+	+	+	+	+	----	+	+
Cyperus aristatus Rottb	+	----	----	----	+	----	----	----	+	----	----	----
Cyperus ferax Rich	----	----	----	----	----	----	----	+	----	----	----	----
Cyperus strigosus L.	+	+	+	+	+	----	----	+	----	----	+	----
Dulichium arundinaceum (L.) Britt	+	+	+	+	+	+	+	+	+	+	+	----
Eleocharis acicularis (L.) R. S.	+	+	+	+	+	+	+	+	+	+	----	+
Eleocharis palustris (L.) R. S.	+	+	+	+	+	+	+	+	+	+	----	+
Eleocharis intermedia (Muhl.) Schultes	----	----	----	----	----	----	----	----	+	----	----	----
Scirpus validus Vahl	+	+	+	+	+	+	+	+	+	+	+	+
Scirpus atrovirens Muhl.	+	+	+	+	+	+	+	+	+	----	----	+
Scirpus fluviatilis (Torr.) Gray.	+	+	+	+	+	+	+	+	+	+	----	----
Scirpus cyperinus (L.) Kunth.	----	----	----	----	----	----	+	+	+	+	----	----
Scirpus lineatus Michx	----	----	----	----	----	----	+	+	+	+	----	----
Scirpus americanus Pers.	----	----	----	----	----	----	----	----	+	----	+	+
Scirpus atrocinctus Fernald.	----	----	----	----	----	----	----	+	----	+	----	----
Scirpus subterminalis Torr.	----	----	----	----	----	----	----	----	+	----	----	----
Eriophorum angustifolium Roth.	----	----	----	----	+	----	+	----	----	----	----	----
Eriophorum virginicum L.	----	----	----	----	----	----	----	----	+	+	+	----
Eriophorum gracile Roth.	----	----	----	----	+	----	----	+	+	----	----	----
Eriophorum callitrix Cham.	----	----	----	----	----	----	----	+	----	+	----	----
Rynchospora alba (L.) Vahl.	----	----	----	----	----	----	----	+	+	----	----	----

NAME OF PLANT.	Wheelerwood, Cerro Gordo Co.	Fertile, Worth Co.	Lake Mills, Winnebago Co.	Forest City, Winnebago Co.	Armstrong, Emmet Co.	Belmond, Wright Co.	Jewell Junction, Hamilton Co.	La Crosse, Wisconsin.	Southern Mich.	Northern Mich.	Dismal Swamp, Virginia.	Winneshiek Co.
Rynchospora fusca (L.) Ait.	----	----	----	----	----	----	----	----	+	----	----	----
Rynchospora cymosa Ell.	----	----	----	----	----	----	----	----	----	----	+	----
Carex verrucosa Muhl.	----	----	----	----	----	----	----	----	----	----	+	----
Carex trisperma Dewey	----	----	----	----	+	----	----	----	+	+	----	----
Carex limosa L.	----	----	----	----	+	----	----	----	+	+	----	----
Carex canescens L.	----	----	----	----	----	----	----	----	+	+	+	----
Carex stricta Lam.	----	----	----	----	+	----	+	----	+	+	+	+
Carex pauciflora Lightft.	----	----	----	----	+	----	----	----	+	+	----	----
Carex riparia W. Curtis	----	----	----	----	+	----	----	----	+	+	----	----
Carex filiformis L.	+	+	+	+	+	+	+	+	+	+	----	----
Carex vulpinoidea Michx.	+	----	----	----	+	----	----	+	+	+	+	+
Carex oligosperma Michx.	----	----	----	----	----	----	----	----	+	+	----	----
Carex tenella (Schkuhr.)	----	----	----	----	----	----	----	----	+	+	----	----
Carex leptalea Wahlenb.	----	----	----	----	----	----	----	----	+	+	----	----
Carex lupulina Muhl.	----	----	----	----	+	----	+	+	+	----	+	+
Carex grayii Carey	+	+	+	+	+	+	+	+	+	----	----	----
Carex rostrata (Stokes) var. utriculata (Boot) Bailey	----	----	----	----	----	----	----	----	+	----	----	----
Araceæ												
Peltandra virginica (L.) Kunth.	----	----	----	----	----	----	----	+	+	----	+	----
Calla palustris L.	----	----	----	----	----	----	----	+	+	+	----	----
Symplocarpus foetidus (L.) Nutt.	----	----	----	----	----	----	----	+	+	+	----	+
Acorus calamus L.	+	+	+	----	+	+	+	+	+	+	+	+
Lemnàceæ												
Spirodela polyrhiza (L.) Schleid.	----	----	----	----	+	----	----	+	+	----	+	+
Lemna trisulca L.	----	----	----	----	+	----	----	+	+	----	----	+
Eriocaulaceæ												
Eriocaulon articulatum (Huds.) Morong.	----	----	----	----	----	----	----	----	+	+	----	----
Pontederiaceæ												
Pontederia cordata L.	----	----	----	----	----	----	+	+	+	+	+	----
Heteranthera dubia (Jacq.) Mac M.	+	+	+	+	+	+	+	+	+	----	----	----
Juncaceæ												
Juncus nodosus L.	+	+	+	+	+	+	+	+	----	----	----	+
Juncus torreyi Coville	----	----	----	----	+	----	+	----	+	----	----	+
Juncus effusus L.	----	----	----	----	----	----	----	----	----	+	+	----
Liliaceæ												
Allium tricoccum Ait.	----	----	----	----	+	----	----	+	+	----	----	+
Lilium canadense L.	+	+	+	----	+	+	+	+	+	----	----	+
Lilium philadelphicum L. var. andinum	----	----	----	----	+	----	+	+	----	----	----	----
Smilacina trifolia (L.) Desf.	----	----	----	----	----	----	----	+	+	+	----	----
Maianthemum canadense Desf.	----	----	----	----	----	----	----	+	+	+	----	----

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Iridaceæ												
Iris versicolor L..........	+	+	+	+	+	+	+	+	+	+	----	+
Orchidaceæ												
Cypripedium candidum Muhl.	----	----	----	----	+	----	+	+	----	----	----	+
Cypripedium hirsutum Mill.	----	----	----	----	----	----	----	+	+	+	----	+
Cypripedium acaule Ait..	----	----	----	----	----	----	----	+	+	+	+	----
Habenaria leucophaea (Nutt.) Gray...........	+	+	+	+	+	+	+	+	+	----	----	+
Habenaria psycodes (L.) Sw.	----	----	----	----	----	----	----	+	+	+	----	----
Habenaria hyperborea (L.) R. Br.................	----	----	----	----	----	----	----	+	----	+	----	----
Habernaria dilatata (Pursh.) Gray.........	----	----	----	----	----	----	----	+	----	+	----	----
Pogonia ophioglossoides (L.) Ker.	----	----	----	----	----	----	----	+	+	+	+	----
Calopogon pulchellus (Sw.) R. Br................	----	----	----	----	----	----	----	+	+	+	----	----
Arethusa bulbosa L.......	----	----	----	----	----	----	----	----	----	+	----	----
Spiranthes cernua (L.) Richard	+	+	+	+	+	+	+	+	+	+	----	+
Liparis loeselii (L.) Richard	----	----	----	----	----	----	----	----	+	----	----	----
Calypso bulbosa (L.) Oakes	----	----	----	----	----	----	----	----	----	+	----	----
Piperaceæ												
Saururus cernuus L.......	----	----	----	----	----	----	----	----	----	----	+	----
Salicaceæ												
Salix lucida Muhl.........	----	----	----	----	----	----	----	+	+	+	----	+
Salix cordata Muhl.......	+	+	+	+	+	+	+	+	+	----	----	+
Salix discolor Muhl.......	+	+	+	+	+	+	+	+	+	----	----	+
Salix petiolaris Sm.......	+	+	+	+	+	+	+	+	----	----	----	+
Salix rostrata Richards...	+	+	+	+	+	+	+	+	+	+	----	----
Salix candida Fluegge....	+	+	----	----	----	----	----	+	+	+	----	----
Salix pedicellaris Pursh...	+	+	+	+	+	----	----	+	----	+	----	----
Salix sericea Marsh.......												
Populus tremuloides Michx.	+	----	----	+	----	----	+	+	+	+	----	+
Myricaceæ												
Myrica gale L...........	----	----	----	----	----	----	----	----	----	+	----	----
Betulaceæ												
Betula pumila L.........	----	----	----	----	----	----	----	+	+	+	----	----
Betula nigra L..........	----	----	----	----	----	----	----	+	----	----	----	----
Betula lutea Michx. f.....	----	----	----	----	----	----	----	----	+	+	----	----
Betula lenta L..........	----	----	----	----	----	----	----	+	----	+	----	----
Alnus incana (L.) Moench.	----	----	----	----	----	----	----	+	+	+	----	+
Urticaceæ												
Ulmus americana L......	+	+	+	+	+	+	+	+	+	+	+	+
Humulus lupulus L.......	----	----	----	----	----	----	----	+	----	----	----	----
Boehmeria cylindrica (L.) Sw.	----	----	----	----	----	----	----	----	+	----	+	----

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Polygonaceæ												
Rumex britannica L......	+	+	+	+	+	+	+	+	+	+	----	+
Rumex persicarioides L...	+	+	+	+	+	+	+	+	+	----	----	----
Polygonum lapathifolium L.	+	+	+	+	+	+	+	+	+	----	----	+
Polygonum pennsylvanicum L................	+	+	+	+	+	+	+	+	+	+	+	+
Polygonum amphibium L.	+	+	+	+	+	+	+	+	+	+	----	+
Polygonum amphibium var. hartwrightii (Gray) Bissel	+	----	----	----	+	----	+	+	+	+	----	----
Polygonum muhlenbergii (Meis.) Wats.	+	+	+	+	+	+	+	+	+	----	----	+
Polygonum hydropiper L..	----	----	----	----	----	----	----	+	----	----	----	+
Polygonum acre HBK.....	+	+	+	+	+	+	+	+	+	+	----	+
Polygonum hydropiperoides Michx............	----	----	----	----	----	----	----	----	----	----	+	----
Polygonum sagittatum L..	----	----	----	----	----	----	----	+	+	+	+	+
Polygonum arifolium L...	----	----	----	----	----	----	----	+	+	----	+	----
Amaranthaceæ												
Acnida tamariscina (Nutt.) Wood..........	+	+	+	+	+	+	+	+	----	----	----	----
Caryophyllaceæ												
Stellaria longifolia Muhl..	----	----	----	----	+	----	+	+	+	+	----	+
Ceratophyllaceæ												
Ceratophyllum demersum L.	----	----	----	----	----	----	+	+	+	+	----	----
Nymphæaceæ												
Nymphæa advena Ait.....	+	+	+	+	+	+	+	+	+	+	+	+
Castalia odorata (Ait.) Woodville & Wood......	----	----	----	----	----	----	----	----	----	+	+	+
Castalia tuberosa (Paine) Green.	----	----	----	----	+	----	----	+	+	+	----	----
Brasenia schreberi Gmel..	----	----	----	+	----	----	+	----	+	----	----	----
Ranunculaceæ												
Ranunculus aquatilis L. var. capillaceus DC.....	+	+	+	+	+	+	+	+	+	+	----	+
Ranunculus cymbalaria Pursh.	----	----	----	----	----	+	+	----	+	+	----	----
Ranunculus delphinifolius Torr.	+	+	+	+	+	+	+	+	+	+	----	----
Ranunculus sceleratus L..	+	+	+	+	+	+	+	+	+	+	+	----
Ranunculus septentrionalis Poir.	+	+	+	+	+	+	+	+	+	+	----	+
Ranunculus pennsylvanicus L. f................	----	----	----	----	----	----	+	+	+	----	----	+
Thalictrum revolutum DC.	+	+	+	+	+	+	+	+	+	+	+	+
Anemone canadensis L....	+	+	+	+	+	+	+	+	+	+	----	+
Caltha palustris L........	+	+	+	+	+	+	+	+	+	+	----	+
Coptis trifolia (L.) Salisb.	----	----	----	----	----	----	----	+	+	+	----	----
Lauraceæ												

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Persea pubescens (Pursh.) Sarg.	----	----	----	----	----	----	----	----	----	----	+	----
Cruciferæ												
Radicula nasturitium-aquatica (L.) Britton & Rendle.	+	----	----	----	----	----	----	+	+	+	----	+
Radicula palustris (L.) Moench.	+	+	+	+	+	+	+	+	+	+	----	+
Radicula aquatica (Eat.) Robinson	----	----	----	----	----	----	----	+	+	----	----	+
Cardamine bulbosa (Schreb.) BSP.	+	+	+	+	+	+	+	+	+	+	+	+
Sarraceniaceæ												
Sarracenia purpurea L.	----	----	----	----	----	----	----	+	+	+	----	----
Sarracenia flava L.	----	----	----	----	----	----	----	----	+	----	----	----
Droseraceæ												
Drosera rotundifolia L.	----	----	----	----	----	----	----	+	+	+	----	----
Drosera longifolia L.	----	----	----	----	----	----	----	----	+	----	----	----
Crassulaceæ												
Penthorum sedoides L.	+	+	+	+	+	+	+	+	+	----	----	+
Saxifragaceæ												
Saxifraga pennsylvanica L.	+	+	----	----	----	----	----	+	+	+	----	+
Mitella nuda L.	----	----	----	----	----	----	----	----	+	+	----	----
Chrysosplenium americanum Schw.	----	----	----	----	----	----	----	+	+	+	----	----
Chrysosplenium tetrandrum Fries.	----	----	----	----	----	----	----	----	----	----	----	+
Parnassia parviflora DC.	+	+	+	+	+	+	+	+	+	----	----	+
Ribes floridum L'Her.	+	+	+	+	+	+	+	+	+	----	----	+
Ribes prostratum L'Her.	----	----	----	----	----	----	----	----	----	+	----	----
Ribes lacustre (Pers.) Poir.	----	----	----	----	----	----	----	----	----	+	----	----
Rosaceæ												
Spiræa salicifolia L.	+	+	+	+	----	----	----	+	+	+	----	+
Spiræa tomentosa L.	----	----	----	----	----	----	----	----	+	----	+	----
Pyrus arbutifolia (L.) L. f.	----	----	----	----	----	----	----	+	+	+	+	
Pyrus americana (Marsh.) DC.	----	----	----	----	----	----	----	----	----	+	----	----
Potentilla monspeliensis L.	+	+	+	+	+	+	+	+	+	+	+	+
Potentilla rivalis Nutt. var. millegrana Eng. & Watson	----	----	----	----	+	----	+	+	----	----	----	----
Potentilla paradoxa Nutt.	----	----	----	----	----	----	----	----	+	----	----	----
Potentilla palustris (L.) Scop.	+	+	+	+	+?	----	----	+	+	+	----	----
Potentilla fruticosa L.	----	----	----	----	----	----	----	----	+	+	----	+
Potentilla anserina L.	----	----	----	----	----	----	+	+	+	----	----	----
Geum strictum Ait.	+	----	----	----	----	+	+	+	+	----	----	----
Geum macrophyllum Willd.	----	----	----	----	----	----	----	+	+	----	----	+
Rubus triflorus Richards.	----	----	----	----	----	----	----	+	+	+	----	+
Rosa carolina L.	----	----	----	----	----	----	----	----	+	----	+	----

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Leguminosæ												
Trifolium repens L........	+	+	+	+	+	+	+	+	+	+	+	+
Trifolium pratense L......	+	+	+	+	+	+	+	+	+	+	+	+
Trifolium hybridum L....	+	+	+	+	+	+	+	----	+	----	+	+
Lathyrus palustris L......	+	+	+	+	+	+	+	+	+	+	----	+
Lathyrus venosus Muhl...	+	+	+	+	+	+	+	+	+	----	----	+
Apios tuberosa Moench....	+	+	+	+	+	+	+	+	+	----	+	+
Oxalidaceæ												
Oxalis corniculata L......	+	+	+	+	+	+	+	+	+	----	----	+
Polygalaceæ												
Polygala incarnata L......	----	----	----	----	----	----	+	----	----	----	----	----
Polygala sanguinea L.....	+	+	+	+	+	+	+	+	----	----	----	+
Callitrichaceæ												
Callitriche palustris L....	----	----	----	----	+	----	----	+	+	+	----	----
Callitriche autumnalis L..	----	----	----	----	----	----	----	----	----	+	----	----
Anacardiaceæ												
Rhus vernix L...........	----	----	----	----	----	----	----	+	+	+	+	----
Rhus toxicodendron L....	+	+	+	+	+	+	+	+	+	+	+	+
Aquifoliaceæ												
Ilex glabra (L.) Gray....	----	----	----	----	----	----	----	----	----	----	+	----
Ilex verticillata (L.) Gray.	----	----	----	----	----	----	----	----	+	+	+	----
Nemopanthus mucronata (L.) Trel.	----	----	----	----	----	----	----	+	+	+	+	----
Aceraceæ												
Acer rubrum L..........	----	----	----	----	----	----	----	+	+	+	+	----
Acer saccharinum L......	----	----	----	----	----	----	----	+	+	+	----	+
Balsaminaceæ												
Impatiens biflora Walt....	+	+	+	+	+	+	+	+	+	+	+	+
Rhamnaceæ												
Berchemia scandens (Hill) Trel.	----	----	----	----	----	----	----	----	----	----	+	----
Rhamnus alnifolia L'Her..	----	----	----	----	----	----	----	----	----	+	----	+
Vitaceæ												
Psedera quinquefolia (L.) Green	+	+	+	----	----	+	+	+	+	+	+	----
Vitis vulpina L...........	+	----	+	----	----	+	+	+	+	----	----	+
Vitis rotundifolia Michx..	----	----	----	----	----	----	----	----	----	----	+	----
Hypericaceæ												
Hypericum virginicum L..	+	+	+	+	+	----	----	+	+	+	----	----
Hypericum petiolatum Walt.	----	----	----	----	----	----	----	----	----	----	+	----
Violaceæ												
Viola cucullata Ait........	+	+	+	+	+	+	+	+	+	+	----	+
Viola nephrophylla Green.	----	----	----	----	----	----	----	----	----	+	----	----
Viola blanda Willd.......	----	----	----	----	----	----	----	+	+	+	----	----
Viola renifolia Gray......	----	----	----	----	----	----	----	----	----	+	----	----
Viola conspersa Reichenb.	----	----	----	----	----	----	----	+	----	----	----	----
Lythraceæ												
Decodon verticillatus (L.) Ell.	----	----	----	----	----	----	----	----	+	+	+	----
Lythrum alatum Pursh...	+	+	+	+	+	+	+	+	+	+	----	+

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Lythrum lineare L.	----	----	----	----	----	----	----	----	----	----	+	----
Melastomaceæ												
Rhexia ciliosa Michx.	----	----	----	----	----	----	----	----	----	----	+	----
Rhexia virginica L.	----	----	----	----	----	----	----	----	----	----	+	----
Rhexia mariana L.	----	----	----	----	----	----	----	----	----	----	+	----
Onagraceæ												
Jussiæa decurrens (Walt) DC.	----	----	----	----	----	----	----	----	----	----	+	----
Ludvigia alternifolia L.	----	----	----	----	----	----	----	----	+	----	----	----
Ludvigia polycarpa Short & Peter	+	+	+	+	+	+	+	+	+	----	----	+
Ludvigia palustris (L.) Ell.	----	----	----	----	----	----	----	+	+	----	----	----
Epilobium coloratum Muhl.	+	+	+	+	+	+	+	+	+	+	----	+
Epilobium densum Raf.	+	+	+	+	+	+	+	+	+	+	----	----
Haloragidaceæ												
Myriophyllum verticillatum L. var. pectinatum Wallr.	----	----	----	----	+	----	----	----	+	----	+	----
Proserpinaca palustris L.	----	----	----	----	----	----	----	+	+	----	+	+
Hippuris vulgaris L.	----	----	----	----	----	----	----	----	----	+	----	----
Umbelliferæ												
Cicuta maculata L.	+	+	+	+	+	+	+	+	+	+	+	+
Cicuta bulbifera L.	+	+	+	+	+	+	----	+	+	+	----	----
Cicuta curtissii Coulter & Rose	----	----	----	----	----	----	----	----	----	----	----	----
Berula erecta (Huds.) Coville	----	----	----	----	----	----	----	----	----	----	----	----
Sium cicutæfolium Schrank.	+	+	+	+	+	+	+	+	+	+	+	+
Oxypolis rigidior (L.) Coulter & Rose	----	----	----	----	----	----	+	----	----	----	----	----
Angelica atropurpurea L.	----	----	----	----	----	----	----	+	+	+	----	----
Cornaceæ												
Cornus stolonifera Michx.	----	----	----	----	+	----	----	+	+	+	----	+
Cornus amomum Mill.	+	+	+	+	+	+	+	----	+	+	----	----
Cornus paniculata L'Her.	+	+	+	+	+	----	+	+	+	+	----	----
Cornus canadensis L.	----	----	----	----	----	----	----	----	+	+	----	----
Nyssa aquatica L.	----	----	----	----	----	----	----	----	----	----	+	----
Nyssa silvatica Marsh, var. biflora (Walt.) Sarg.	----	----	----	----	----	----	----	----	----	----	+	----
Ericaceæ												
Clethra alnifolia L.	----	----	----	----	----	----	----	----	----	----	+	----
Pyrola asarifolia Michx.	----	----	----	----	----	----	----	----	+	+	----	----
Ledum groenlandicum Oeder	----	----	----	----	----	----	----	----	----	+	----	----
Kalmia latifolia L.	----	----	----	----	----	----	----	----	----	----	+	----
Kalmia polifolia Wang.	----	----	----	----	----	----	----	----	+	+	----	----
Leucothoe axillaris (Lam.) D. Don	----	----	----	----	----	----	----	----	----	----	+	----
Andromeda polifolia L.	----	----	----	----	----	----	----	----	+	+	----	----

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Andromeda glaucophylla Link.	----	----	----	----	----	----	----	----	+	+	----	----
Lyonia nitida (Bartr.) Fernald	----	----	----	----	----	----	----	----	----	----	+	----
Lyonia mariana (L.) D. Don.	----	----	----	----	----	----	----	----	----	----	+	----
Lyonia ligustrina (L.) DC.	----	----	----	----	----	----	----	----	----	----	+	----
Chamædaphne calyculata (L.) Moench.	----	----	----	----	----	----	----	----	+	+	----	----
Gaultheria procumbens L.	----	----	----	----	----	----	----	+	+	+	----	----
Chiogenes hispidula (L.) Torr. & Gray	----	----	----	----	----	----	----	+	----	+	----	----
Gaylussacia baccata (Wang.) C. Koch.	----	----	----	----	----	----	----	+	+	+	----	----
Vaccinium corymbosum L.	----	----	----	----	----	----	----	----	+	+	----	----
Vaccinium macrocarpon Ait.	----	----	----	----	----	----	----	+	+	+	----	----
Vaccinium oxycoccus L.	----	----	----	----	----	----	----	----	----	+	----	----
Primulaceæ												
Lysimachia thyrsiflora L.	+	+	+	+	+	+	+	+	+	+	----	----
Steironema lanceolatum (Walt.) Gray	+	+	+	+	+	----	+	+	----	----	+	----
Oleaceæ												
Fraxinus americana L.	+	+	----	+	+	----	+	+	+	+	----	+
Fraxinus carolinana Mill.	----	----	----	----	----	----	----	----	----	----	+	----
Fraxinus nigra Marsh.	----	----	----	----	----	----	----	----	+	+	----	----
Chionanthus virginica L.	----	----	----	----	----	----	----	----	----	----	+	+
Loganiceæ												
Gelsemium sempervirens (L.) Ait. f.	----	----	----	----	----	----	----	----	----	----	+	----
Gentianaceæ												
Sabatia lanceolata (Walt.) T. & G.	----	----	----	----	----	----	----	----	----	----	+	----
Gentiana crinita Froel.	+	+	+	+	+	+	+	+	+	+	----	+
Gentiana quinquefolia L.	+	+	+	+	+	----	+	+	----	----	----	+
Gentiana andrewsii Griseb.	+	+	+	+	+	----	+	----	+	----	----	+
Bartonia virginica (L.) BSP.	----	----	----	----	----	----	----	----	----	----	+	----
Menyanthes trifoliata L.	+	+	+	+	+	+	+	+	+	+	----	----
Aclepiadaceæ												
Aclepias incarnata L.	+	+	+	+	+	----	+	+	+	+	+	+
Aclepias syriaca L.	+	+	+	+	+	----	+	+	+	----	----	+
Aclepias lanceolata Walt.	----	----	----	----	----	----	----	----	----	----	+	----
Convolvulaceæ												
Cuscuta gronovii Willd.	+	+	+	+	+	+	+	+	+	----	+	+
Cuscuta obtusiflora Hbk.	+	+	+	+	+	+	+	+	+	+	----	----
Polemoniaceæ												
Phlox glaberrima L.	----	----	----	----	----	----	+	+	----	----	----	----
Hydrophyllacæ												
Ellisia nyctelea L.	+	+	+	+	+	+	+	+	----	----	----	+
Verbenaceæ												

Name of Plant.	Wheelerwood, Cerro Gordo Co.	Fertile, Worth Co.	Lake Mills, Winnebago Co.	Forest City, Winnebago Co.	Armstrong, Emmet Co.	Belmond, Wright Co.	Jewell Junction, Hamilton Co.	La Crosse, Wisconsin.	Southern Mich.	Northern Mich.	Dismal Swamp, Virginia.	Winneshiek Co.
Verbena urticæfolia L....	+	+	+	+	+	+	+	+	+	----	+	+
Verbena hastata L........	+	+	+	+	+	+	+	+	+	----	----	+
Labiatæ												
Teucrium canadense L....	+	+	+	+	+	+	+	+	+	----	----	+
Teucrium occidentale Gray	+	+	+	+	+	+	+	----	----	----	----	----
Scutellaria lateriflora L...	+	+	+	+	+	----	+	+	+	+	+	+
Scutellaria galericulata L.	+	+	+	+	+	----	+	+	+	+	----	----
Physostegia virginiana (L.) Benth.	+	+	+	+	+	+	+	+	+	----	+	+
Stachys palustris L.......	+	+	+	+	+	----	+	+	+	----	----	+
Stachys tenuifolia Willd. var. asper (Michx.) Fernald	+	+	+	+	----	+	+	+	----	+	----	+
Lycopus virginicus L......	+	+	+	+	+	----	+	+	+	----	+	+
Lycopus uniflorus Michx..	----	----	----	----	----	----	----	+	+	----	----	----
Lycopus rubellus, Moench.	----	----	----	----	----	----	+	----	----	----	+	----
Lycopus americanus, Muhl	+	+	+	+	+	----	+	+	+	+	----	+
Mentha arvensis L. var. canadensis (L.) Briquet.	+	+	+	+	+	+	+	+	+	+	----	----
Mentha spicata L........	----	----	----	----	----	----	----	+	+	+	+	----
Mentha piperita L........	----	----	----	----	----	----	----	+	+	+	----	----
Solanaceæ												
Solanum nigrum L......	+	+	----	----	+	----	+	+	----	----	+	+
Solanum dulcamara L....	----	----	----	----	----	----	----	----	----	----	+	----
Scrophulariaceæ												
Chelone glabra L.........	+	+	+	+	----	+	+	+	+	----	----	+
Mimulus ringens L.......	+	+	+	+	+	+	+	----	+	+	----	+
Limosella aquatica L. var. tenuifolia (Wolf.) Pers..	----	----	----	----	----	----	----	----	+	----	----	----
Ilysanthes dubia (L.) Barnh.	+	+	+	+	+	----	+	+	+	+	+	----
Veronica americana Schwein	+	+	+	+	+	----	+	+	+	----	----	+
Veronica virginicum L....	+	+	+	+	+	+	+	+	+	----	----	+
Veronica anagallis-aquatica L............	----	----	----	----	----	----	----	----	----	----	----	----
Gerardia paupercula (Gray) Britton	----	----	----	----	+	----	+	+	----	----	+	+
Gerardia aspera Dougl....	----	----	----	----	+	----	+	+	+	----	+	+
Castilleja coccinea (L.) Spreng.	----	----	----	----	----	----	----	+	+	----	----	+
Pedicularis lanceolata Michx.	+	+	+	+	+	----	+	+	+	+	----	+
Lentibulariaceæ												
Utricularia vulgaris L....	----	----	----	----	+	----	+	+	+	----	----	+
Utricularia biflora Lam...	----	----	----	----	----	----	----	+	----	----	----	----
Utricularia minor L......	----	----	----	----	+	----	----	----	+	----	----	----
Utricularia intermedia Hayne.	----	----	----	----	+	----	----	----	+	----	----	----
Plantaginaceæ												

NAME OF PLANT.	Wheelerwood, Cerro Gordo Co.	Fertile, Worth Co.	Lake Mills, Winnebago Co.	Forest City, Winnebago Co.	Armstrong, Emmet Co.	Belmond, Wright Co.	Jewell Junction, Hamilton Co.	La Crosse, Wisconsin.	Southern Mich.	Northern Mich.	Dismal Swamp, Virginia.	Winneshiek Co.
Plantago rugelii Dcne....	+	+	+	+	+	----	+	+	+	+	+	+
Rubiaceæ												
Galium trifidum L........	+	+	+	+	+	----	+	+	+	+	----	----
Galium claytoni Michx....	----	----	----	----	----	----	----	----	----	----	+	----
Galium tinctorium L......	----	----	----	----	+	----	+	----	----	----	----	----
Cephalanthus occidentalis L.	----	----	----	----	----	----	+	+	+	----	+	----
Caprifoliaceæ												
Lonicera oblongifolia (Goldie) Hook.........	----	----	----	----	----	----	----	----	+	+	----	----
Lonicera sempervirens L..	----	----	----	----	----	----	----	----	----	----	+	----
Linnæa borealis L. var. americana (Forbes) Rehder	----	----	----	----	----	----	----	+	+	+	----	+
Viburnum opulus L. var. americanum (Mill.) Ait.	----	----	----	----	----	----	----	+	+	+	----	+
Viburnum nudum L......	----	----	----	----	----	----	----	----	----	----	+	----
Viburnum lentago L......	----	----	----	----	+	----	----	+	+	----	----	+
Valerianaceæ												
Valeriana edulis Nutt.....	----	----	----	----	----	----	----	+	+	+	----	----
Campanulaceæ												
Campanula aparinoides Pursh.	+	+	+	+	+	----	+	+	+	+	----	+
Lobelia cardinalis L......	----	----	----	----	----	----	+	+	+	----	+	----
Lobelia siphilitica L......	+	+	+	+	+	----	+	+	+	+	----	----
Lobelia kalmii L.........	+	+	+	----	----	----	----	+	+	----	----	----
Lobelia dortmanna L.....	----	----	----	----	----	----	----	----	----	+	----	----
Compositæ												
Vernonia fasciculata Michx	+	+	+	+	+	+	+	+	+	----	----	+
Vernonia noveboracensis Willd.	----	----	----	----	----	----	----	----	----	----	+	----
Eupatorium perfoliatum L.	+	+	+	+	+	+	+	+	+	+	+	+
Eupatorium purpureum L. var. maculatum (L.) Darl.	+	+	+	+	+	+	+	+	+	+	+	+
Solidago canadensis L.....	+	+	+	+	+	----	+	+	+	+	+	+
Solidago serotina Ait......	+	+	+	+	+	----	+	+	+	+	----	+
Solidago riddellii Frank..	+	+	+	+	+	+	+	+	+	----	----	+
Boltonia asteroides (L.) L'Her.	+	+	+	+	+	+	+	+	+	----	----	+
Aster junceus Ait........	+	+	+	+	----	----	----	+	+	+	----	----
Aster puniceus L.........	----	----	----	----	----	----	+	+	+	----	+	+
Aster novae-angliae L.....	+	+	+	+	+	+	+	+	+	+	----	+
Aster vimineus Lam......	----	----	----	----	----	----	----	----	----	----	+	----
Aster, salicifolius Ait.....	+	+	+	+	----	+	+	+	+	----	----	+
Aster longifolius Lam.....	----	----	----	----	----	----	----	----	+	----	----	----
Aster preuanthoides Muhl.	+	+	+	+	----	+	+	+	+	----	----	+
Aster umbellatus Mill.....	+	+	+	+	----	----	+	+	----	----	----	+
Erigeron philadelphicus L.	+	+	+	+	+	+	+	+	----	----	----	+
Helianthus grosseserratus Martens	+	+	+	+	+	+	+	+	+	----	----	+

Name of Plant.	Wheelerwood, Cerro Gordo Co.	Fertile, Worth Co.	Lake Mills, Winnebago Co.	Forest City, Winnebago Co.	Armstrong, Emmet Co.	Belmond, Wright Co.	Jewell Junction, Hamilton Co.	La Crosse, Wisconsin.	Southern Mich.	Northern Mich.	Dismal Swamp, Virginia.	Winneshiek Co.
Bidens discoidea (T. & G.) Britton	+	+	----	+	+	----	----	+	----	----	----	----
Bidens frondosa L........	+	+	+	+	+	----	+	+	+	----	+	+
Bidens beckii Torr.......	----	----	----	----	----	+	+	+	+	+	----	----
Bidens connata Muhl......	+	+	+	+	+	+	+	+	+	----	----	+
Bidens coronata (L.) Fisch.	----	----	----	----	----	----	----	----	----	----	+	----
Bidens cernua L..........	+	+	+	+	+	+	+	+	+	+	+	+
Bidens trichosperma (Michx.) Britton	+	+	+	+	----	----	----	----	----	----	+	----
Helenium autumnale L.....	+	+	+	+	+	+	+	+	+	+	----	+
Erechtites hieracifolia (L.) Raf.	+	+	+	+	+	+	+	+	+	----	+	+
Senecio palustris (L.) Hook.	----	----	----	----	+	----	----	----	----	----	----	+
Senecio aureus L.........	+	+	+	+	+	+	+	+	+	----	----	+
Cirsium muticum Michx..	+	+	+	+	----	----	----	+	+	----	----	+
Taraxacum officinale Weber.	+	+	+	+	+	+	+	+	+	----	----	+
Prenanthes racemosa Michx.	+	+	+	+	+	+	+	+	----	----	----	+

REMARKS ON SOME OF THE CHARACTERISTIC BOG PLANTS

Aspidium thelypteris. This fern is common in the tamarack bogs, also in the drier sedge bogs of Wisconsin, Michigan, and in northeastern Iowa, as far west as Worth and Winnebago counties. It is infrequent or rare westward. This species, then, may be called a typical peat bog fern. The allied *A. cristatum* does not occur in the peat bogs of northern Iowa, although it is not uncommon in the tamarack bogs of western Wisconsin in Trempleau county and some parts of La Crosse county.

Osmunda cinnamomea L., the Cinnamon Fern, is common in the bogs in Wisconsin, Minnesota, and Michigan, but does not occur, so far as I know, anywhere in the bogs of Allamakee, Clayton, Cerro Gordo, Worth and Winnebago counties. The same may be said of the Royal Fern (*O. regalis*).

Ophioglossum vulgatum L., though reported both in northern and southern Michigan has not been reported from western Wisconsin or eastern Minnesota, nor from any of the bogs of northern Iowa.

Lycopodium inundatum has been reported from Michigan and is more abundant in bogs eastward but especially northward.

Larix laricina (Du Roi), Koch., the Tamarack, has not been reported from any point in the state of Iowa, although there is a small grove in Houston county across the line in Minnesota and isolated groves in Wisconsin near La Crosse. This is practically the only conifer found in the bogs of that region. Further northward in Wisconsin, Minnesota, and Michigan, the Black Spruce, the Balsam Fir, and Arbor Vitæ occur and eastward in the Dismal Swamp country and as far north as Massachusetts the White Cedar is also a predominant species of the peat bog flora. Strange as it may seem the Balsam Fir, although native to Allamakee county in Iowa is found on cold, wet, limestone rocks, the rocks being covered with Hypnum and other mosses. Nowhere in the state does the Juniper occur and yet in parts of Wisconsin and Michigan there are certain types of bogs in which the Juniper is a common species.

Salix candida Fl., the White Bog Willow, is one of the most interesting of the willows in Iowa. It is not nearly so widely distributed as some of the other species but is characteristic of some of the bogs in Worth, Cerro Gordo and Clayton counties and is likewise abundant in the tamarack and sphagnum bogs of western Wisconsin and southern Minnesota. It does not occur in Hamilton or Emmet counties nor in the bogs near Forest City or in Wright county.

Salix pedicellaris Pursh. This willow, like the preceding, grows in many of the bogs in Cerro Gordo, Winnebago, Worth

Figure 109. Hoary Willow (*Salix candida Fluegge*), a bog plant of Worth county.

and Emmet counties, always growing where there is a large supply of water, like the preceding species.

Salix lucida Muhl., the Shining Willow, is less widely distributed than the preceding species; in this state it occurs in a few bogs in Buchanan county and in Linn county, according to Lazell, and occasionally eastward. It is fairly abundant in the sphagnum bogs in the vicinity of La Crosse, Wisconsin.

Salix rostrata Richards, the Beaked Willow, is nearly as widely distributed as the *Salix discolor* (Muhl.) or the Glaucous Willow. These willows are common throughout northern Iowa, especially in bogs near springs and where excavations have been made or ditches run through the bogs. They are adapted to somewhat drier conditions than the willows mentioned previ-

Fig. 110

Fig. 111

Figure 110. Bog Willow (*Salix pedicillaris* Pursh.). Drawn by Ada Hayden.
Figure 111. Beaked Willow (*Salix rostrata* Richards). Drawn by Ada Hayden.

ously. These willows are characteristic of some bogs as far south as Boone and Story counties but rarer southward.

Populus tremuloides Michx., the Quaking Asp, is rather frequent on the islands and high grounds adjacent to the peat bogs near Lake Mills, Forest City, Fertile, and other places in northern Iowa. It is a typical constituent of the bog near Wheelerwood, being associated with *S. discolor* and *S. rostrata.* Davis also mentioned its occurrence in the bogs of southern Michigan and along with it he also mentions the *Populus grandidentata* which though common in northern Iowa, especially northeastward, does not occur in bogs.

Rumex britannica L., the Great Water Dock, is easily recognized during midsummer and late fall by its long fruiting panicles above the sedges and other smaller plants. This dock was common in all the bogs in the counties mentioned above and it is also common eastward in Butler, Chickasaw, Clayton counties in Iowa, and La Crosse county in Wisconsin.

Of the grasses perhaps the most interesting and abundant in the Iowa bogs are *Glyceria nervata, Calamagrostis inexpansa, Bromus kalmii, Zizania aquatica, Phragmites communis, Glyceria fluitans* and *G. grandis*. These species are common in Wisconsin, Minnesota, and Michigan as well as Iowa.

Glyceria nervata (Wild.) Trin., the Fowl Meadow Grass, is abundant in moist meadows throughout the region and much more abundant than the two preceding species and is much more important in the formation of peat.

Glyceria fluitans (L.) R. Br., like the Reed Grass, is found in shallow water and although abundant in many places is not so important in the formation of peat as Wild Rice or Reed Grass. It is common throughout the region and extends much farther southward. Along with it we also found frequently, in conditions that do not bespeak of peat, the *Glyceria grandis* Wats.

Zizania aquatica L. Wild Rice was once quite common in the bogs throughout northern Iowa and may still be found in shallow water under much more moist conditions than the willows or thistle, in Cerro Gordo, Hamilton, Emmet, Worth, Wright, and Winnebago counties. Where this plant occurs the bog assumes the character of a quaking bog.

Phragmites communis Trin. This Reed Grass grows in situations similar to Wild Rice, often where water stands through the entire season. It has long rootstocks running under the surface of the ground for considerable distances and these form an important constituent of the peat.

Of the sedges in bogs the most important in northern Iowa is the *Carex filiformis,* along with *C. stricta, C. trisperma,* and other species. These constitute perhaps the most important bog sedges in this state. These species likewise constitute an important part of the bog flora of Michigan and Wisconsin.

Figure 112. Dulichium (*Dulichium arundinaceum* (L.) Britton). Drawn by Ada Hayden.

Carex filiformis L. This Sedge is the most important of the bog plants, forming extensive mats which give away as one walks over them. This species has long, tough, narrow leaves, tapering to a thread-like point and forming a horizontal rhizome which during the spring, when there is an abundance of moisture, is partially aquatic. These rhizomes increase in length by bearing a terminal bud at the end. The method of formation, along with that of other sedges, has been described by Davis.* This sedge was found in Cerro Gordo, Worth, Winnebago, Wright, Hamilton, and Emmet counties, also in northeastern Iowa and western Wisconsin. Other species of sedges grow in the same manner and produce similar mats. The species occurring in northern Iowa are given under the table.

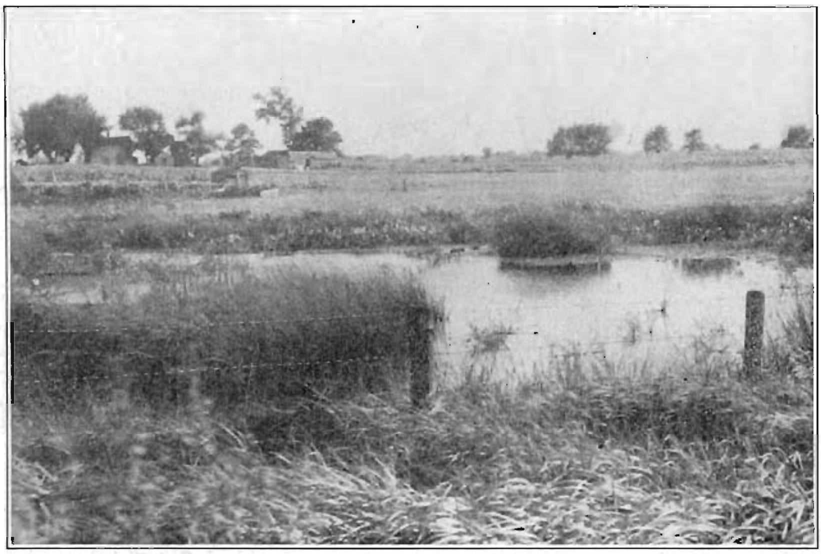

Figure 113. Great Bullrush (*Scirpus validus* Vahl.) on margin of pond in central Iowa. Photograph by Charlotte M. King.

Dulichium arundinaceum, common everywhere in bogs and moist places in Wisconsin, is confined particularly in this state to the peat bog regions, although there are small peat bogs in the vicinity of Ames where this species is not present. It reaches its greatest development from Cerro Gordo county eastward.

Scirpus validus, typical everywhere in bogs, especially where there is standing water in this state, is quite as characteristic in Wisconsin and Minnesota as it is in Iowa. We have only to mention here two other sedges with grass-like leaves, the *Eleo-*

*Loc. cit., p. 136.

charis acicularis, which is confined more especially to the muddy flats where there is a considerable mixture of grass and trees, while the *E. palustris* is more widely distributed.

The Cotton Grass is represented in Iowa by two species, while there are four eastward. Rynchospora is not represented in the peat bogs although abundant in the sphagnum bogs of Wisconsin.

Some members of the family Liliaceæ are entirely absent from the state. The Wild Turk's-cap (*Lilium canadense*) and *L. philadelphicum* occur less frequently in these bogs than in the Wisconsin bogs. In that state there occur not only these lilies, but also the *Allium tricoccum* and the *Smilacina* and *Maianthimum.*

The Wisconsin bogs have three Cypripediums, and three or four Habenarias. The *H. psychodes* is entirely absent from the bogs of northern Iowa, though occurring, according to Mr. Lazell, in Linn county. The Pogonia and Calopogon are abundant and characteristic of sphagnum bogs of Wisconsin and Michigan but do not generally occur in Iowa though reported from Linn county by Mr. Lazell. Of the Smartweed Family the *Rumex britannica* is characteristic of all the bogs in Wisconsin, Michigan and northern Iowa but in Hamilton county is not as abundant. The *Polygonum acre* is common in all of our Iowa bogs while the Shoe-string or Tan Weed occurs under somewhat drier conditions. The *Polygonum amphibium* is abundant not only in Wisconsin but in northern Iowa and Michigan. Two species of Polygonum, *P. sagittatum* and *P. arifolium,* are not recorded for the bogs of northern Iowa, although abundant for the bogs of Wisconsin, Minnesota, and Michigan. The former is found occasionally in Iowa as in Linn county where it has been reported by Mr. Lazell.

One may look upon certain members of the Rose Family as characteristic of the bogs and of these plants mention may be made of the Chokeberry (*Pyrus arbutifolia*), common in the bogs northward and in Minnesota, Wisconsin and Michigan, occurring on limestone rocks in Iowa. The Shrubby Cinquefoil (*Potentilla fruticosa*) is common in some bogs in Wisconsin, Michigan, and

Minnesota, but not in Iowa, although occasionally found in Winneshiek county, according to Shimek.

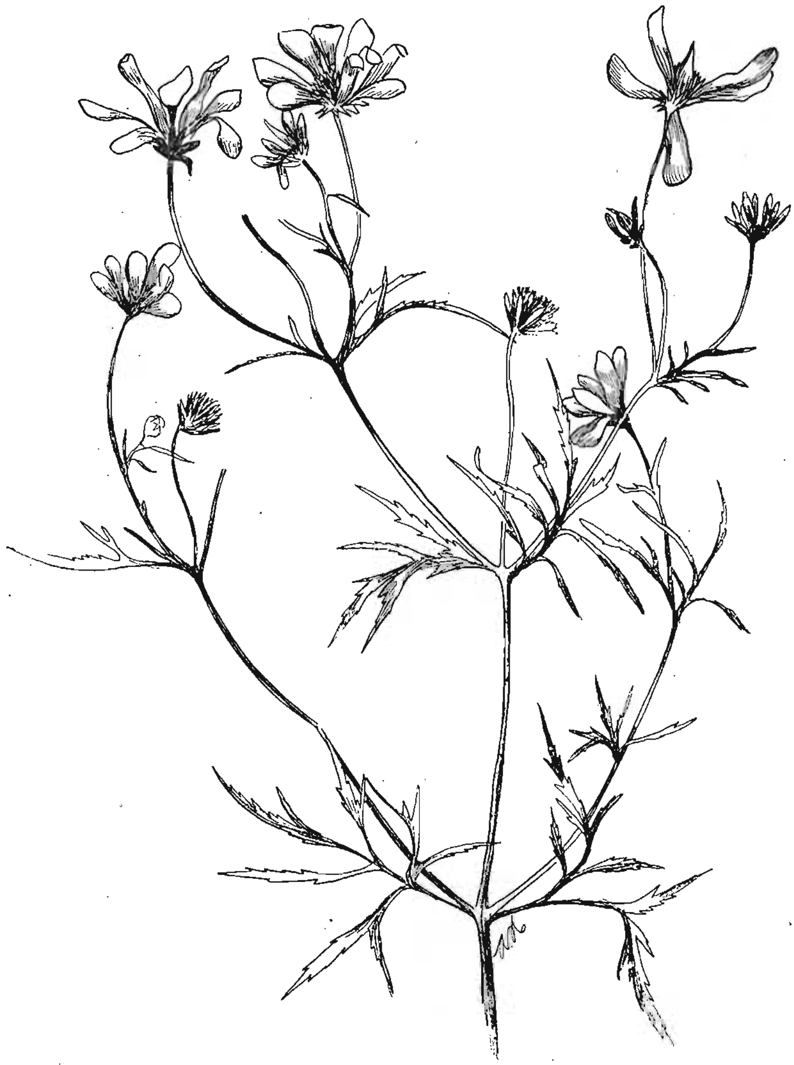

Figure 114. Tickseed Sunflower (*Bidens trichosperma* (Michx.) Britton). Drawn by Ada Hayden.

Potentilla palustris. The Marsh Cinquefoil is common throughout the region in Iowa from Winnebago, Emmet, and Worth counties, extending to Cerro Gordo county, and is abundant in the bogs of southern Minnesota, western Wisconsin, and Michigan. This is one of the most typical Iowa bog plants and is fairly abundant. The same may be said of the Sphagnum bogs of Wisconsin. It is rather interesting to note that it does not occur on the higher bogs where the *Cirsium muticum, Valeriana edulis, Castilleja coccinea* occur in western Wisconsin.

Figure 115. Water Marigold (*Bidens beckii* Torr.). Drawn by Ada Hayden.

Spiraea salicifolia, the Meadow Sweet, is common in some bogs of northeastern Iowa, but does not reach as far south as Hamilton county, or for that matter is not common in any of the bogs in Cerro Gordo, Worth, and Winnebago counties.

Saxifraga pennsylvanica. This Saxifrage is common in the drier bogs of western Wisconsin and also occurs in the bogs of

Cerro Gordo, Worth, and Winnebago counties, along with *Lobelia kalmii, Epilobium molle,* and *Cicuta bulbifera.* It also occurs in Linn county (Lazell).

Figure 116. Swamp Thistle (*Cirsium muticum* Michx.). Drawn by Ada Hayden.

Sarracenia purpurea, Drosera rotundifolia, Rhus vernix and *Nemopanthus mucronata,* though characteristic of the Sphagnum bogs of Wisconsin and Minnesota, are not represented in this state.

Bidens trichosperma, the Marsh Marigold, occurs in nearly all peat bogs in many of the northern counties of the state, notably in Cerro Gordo, Winnebago, Worth and Hamilton counties. It is so characteristic that without the presence of any other plant one is certain that peat occurs. It does not, however, occur in Emmet county. This same plant is common in the peat bogs of Wisconsin and southern Minnesota.

Cirsium muticum Michx., the Swamp Thistle, is characteristic of the type of bog occurring in Cerro Gordo county, near Wheelerwood, also near Fertile and near Lake Mills in Winnebago county, but it does not occur in Emmet, Hamilton, and Wright counties. It also occurs in the drier bogs of southern Minnesota and near La Crosse, Wisconsin.

Bidens cernua L. This plant is rather common in many of the peat bogs, more abundant where they have been drained than in other situations. In one case more than 160 acres were a mass of golden yellow. Otherwise it usually occurs on higher and drier ground. The *B. connata* is also of frequent occurrence near brooks and in moist soil.

Eupatorium perfoliatum L. The common Boneset is one of the most characteristic plants of all the bogs. This is true not only of the drier bogs in Wisconsin but of those throughout northern Iowa. The *E. purpureum* L. is another characteristic bog plant in all the bogs considered in Iowa and Wisconsin, though somewhat more rare in the Sphagnum and Tamarack bogs.

Aster junceus Ait. The Marsh Aster is characteristic of the larger bogs in Worth and Winnebago counties and is likewise characteristic of the bogs in Wisconsin.

Solidago riddelli Frank. The species is rather common in central and northern Iowa and abundant in the peat bogs of northern Iowa.

A COMPARISON OF IOWA PEAT BOGS AND THOSE OF OTHER PLACES

In a general survey as given in the table of plants from these different regions it is evident that a large number of the more typical of the peat bog plants of the more northern region are replaced by plants of a totally different character. For instance, the peat bogs of the higher and drier types such as we find in Wisconsin, are almost characteristic of the peat bogs of northern Iowa, with the exception of the abundance of *Salix candida* and *S. pedicellaris* which do not occur in these bogs although they are abundant in the moist bogs adjacent to the other bogs. The species of willow found in Wisconsin in the bogs are much the same as in Iowa with the exception of the Shining Willow which occurs in a few bogs in the Iowan drift

Figure 117. Pondweed (*Potamogeton ephihydrus* Raf.). Drawn by Ada Hayden.

area in Buchanan, Linn, and Black Hawk counties. The absence of sphagnum and most of the orchids and ferns with the exception of the *Aspidium thelypteris* is another distinctive feature of the Iowa peat bog flora.

The algal and bacterial flora as well as many other aquatic plants like *Scirpus validus* and *Zizania aquatica* are typical for all the regions of northern Iowa and western Wisconsin and so need not be considered in this connection.

SHRUBS IN IOWA BOGS

It is rather remarkable that so few of the shrubs have developed in the peat bogs of northern Iowa. The *Cornus stolonifera* which is so abundant on the edges and borders of tamarack bogs and other peat bogs of Wisconsin is confined to upland banks near lakes and streams in Emmet and the northern Iowa counties. Occasionally two species of Dogwood are found in the drained bogs of this state, namely the *Cornus paniculata* and *C. amomum.* In the Dismal Swamp region these are represented by Nyssa and members of the Heath Family. It is rather remarkable to note the absence of heaths in the bogs particularly of northern Iowa; not a single species is represented and yet near La Crosse, Wisconsin, we have one species each of Kalmia, Galussaccia and Gaultheria and one species of the Cranberry (*Vaccinium macrocarpon*). These same species occur in the peat bogs of Michigan and there is an increase in other species, like Clethra, Andromeda, and Ledum.

INTRODUCED PLANTS IN BOGS

Drainage of the peat bogs has been attempted in many places in Iowa and in such places a large number of introduced plants have made their appearance. The Small Ragweed (*Ambrosia artemisiifolia*), Goosefoot (*Chenopodium album*), Old Witch Grass (*Panicum capillare*), Pennsylvania Smartweed (*Polygonum pennsylvanicum*), Pigweed (*Amarantus retroflexus*), Five-finger (*Potentilla monspeliensis*), Milkweed (*Asclepias syriaca*), Boot Jack (*Bidens frondosa*) and *B. discoidea,* are representative types. These plants originally did not constitute a part of the bog flora, except in dry years, when they appeared. These are seldom found in the sedge mat where the Marigold (*Bidens beckii*), Swamp Thistle (*Cirsium muticum*), Myrtle-leaved Willow (*Salix pedicellaris*) and *Lobelia kalmii* grow in abundance.

BIBLIOGRAPHY

1. Davis, Charles A.........Peat: Essays on its Origin, Uses, and Distribution in Michigan. From Rept. State Bd. Geol. Sur. Michigan, 1906. 95-395. *pl. 13-31. f. 2-25.* Lansing, 1907.
2. Shaler, N. S.............Fresh Water Morasses of the United States. Rept. U. S. Geol. Sur. 10. 1890.
3. Lesquereux, L...........Torfbildung im grosses Dismal Swamp. Zeitsch. der deutsch. Geol. Gesellsch. 4. 1852.
4. Kearney, T. H...........Report on the Botanical Survey of the Great Dismal Swamp Region. Cont. U. S. Nat. Herbarium 5: 321-585.
5. Cowles, H. C.............The Physiographic Ecology of Chicago and Vicinity. Bot. Gaz. 31: 73-108.
6. Coulter, S. M............An Ecological Comparison of Some Typical Swamp Areas. Rept. Mo. Bot. Gar. 15: 39-72. *pl. 1-24.*
7. MacMillan, Conway......On the Occurrence of Sphagnum Atolls in Central Minnesota. Minn. Bot. Studies. Geol. and Nat. Hist. Sur. of Minn. Bull. 9: 13.
9. Whitford, H. N..........The Genetic Development of the Forests of Northern Michigan. Bot. Gaz. 31: 289-325.
10. Atkinson, G. F...........Elementary Botany. 444. New York. 1898.
11. Mills, W. M..............A Physiographic and Ecological Study of the Lake Eagle Region, Indiana. Ann. Rept. Dept. Geol. and Nat. Resources of Ind. 28: (1905).
12. Pieters, A. J............Plants of Lake St. Clair. Bull. Mich. Fish Com. 2. (1904.)
13. Transeau, E. N...........On the Geographic Distribution and Ecological Relation of the Bog Plant Societies of Northern North America. Bot. Gaz. 36: 401-420. *3 m.*
14. Harshberger, J. W........Bogs, their Nature and Origin. Plant World. 12: 34-41: 53-61. *5 f.*
15. Olsson-Seffer, Pehr.......Examination of Organic Remains in Post-glacial Deposits. Am. Nat. 37: 785-797.
16. Weld, Louis A...........Botanical Survey of the Huron River Valley. II. A Peat Bog and Moraine Lake. Bot. Gaz. 37: 36-52.
17. Schimper, A. F. W.......Plant Geography upon a Physiological Basis. Trans. by W. R. Fisher. Rev. and Ed. by P. Groom and I. B. Balfour. 839. Oxford. 1903.
18. Fruh, J. and Schroeter, C.Die Moore der Schweiz mit Berucksichtigung der Gesamten Moorfrage. Beitr. Geol. Schweiz. Goetsch. Ser. 3. Bern. 1904.
19. Koller, T................Die Torfindustrie. Wein. 1898.
20. Eiseln, J. C..............Handbuch, oder....Anléitung zur Kenntniss des Torfwesens. Berlin. 1802.

21. Sendtner, O..............Die Vegetationsverhaltnisse Sud-Bayerns. Munch. 1854.

22. Fischer-Benzon, R........Die Moore der Provinz Schleswig-Holstein. Abhandl. d. naturw. Vereins zur Hamburg. 11. 1891.

23. Weber, C. A..............Ueber die Vegetation des Moores von Augsumal bei Heydekrug. Mitth. d. Vereins zur Forderung d. Moorcultur im Deutschen Reiche. 9. 1894.

24. Christ, H................Das Pflanzenleben der Schweiz. Basel. 1879.

25. Drude, O................Bericht uber die Fortschritte in der Geographie der Pflanzen. 1901-1904. Geographisches Jahrbuch 28: 214-219. 1905. Reviewed by Harshberger, see N. 14.

26. Pammel, L. H............A Comparative Study of the Vegetation of Swamp, Clay, and Sandstone Areas in Western Wisconsin, Southeastern Minnesota, Northeastern, Central, and Southern Iowa. Proc. Dav. Acad. Sci. 10: 33-126.

Old Lake Vegetation in Hamilton County, Iowa. Pl. World. 2: 42-45.

27. Cratty, R. I..............Flora of Emmet County, Iowa. Proc. Ia. Acad. Sci. 11: 201-251.

28. Shimek, B..............Flora of Winneshiek County, Iowa. Ia. Geol. Sur. 16: 147-234.

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