IOWA
GEOLOGICAL
SURVEY

VOL. II

COAL DEPOSITS

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VOLUME II.

COAL DEPOSITS OF IOWA

BY

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DES MOINES:
PUBLISHED FOR THE IOWA GEOLOGICAL SURVEY.
1894.

PRINTED BY THE KENYON PRESS,
DES MOINES, IOWA.

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PREFACE.

No systematic investigation of Iowa's coal deposits has ever been accomplished. The state is regarded by her citizens and outsiders alike so preeminently agricultural that usually her mineral resources are almost entirely overlooked. Yet her geological features are none the less interesting scientifically, none the less important from an economic standpoint.

The mineral wealth of a community can only be developed through a liberal appreciation of its proper functions. Geology ranking first among the useful sciences, has for one of its leading objects the investigation of the natural resources of a region. It considers the character of the different soils and their capabilities for agricultural purposes; the extent and value of the different deposits of coal and lead, iron and other ores; the distribution, properties and uses of the exhaustless beds of valuable clays; the accurate determination of the areas for artesian waters; the analysis of the mineral, well and river waters; the relative value and durability of the numerous kinds of building stones; and all kindred subjects which are of the utmost importance to the great body of the people.

Agriculture and geology are daily becoming more and more intimate in their relations. Nowhere has this interdependence been more clearly understood and nowhere have the benefits been more apparent than in certain

European countries. Some of the older states of the Union, especially those along the Atlantic border, have followed the same line of work with the most happy results. For to-day it is almost universally conceded that a good geological map of the region is practically a soil map also. The proper appreciation of the close relations of the two sciences cannot fail therefore to impress the truth of the statement.

In pointing out the various mineral deposits of Iowa a knowledge of the distribution of the geological formations is of prime importance. The sequence of strata is measurably complete, and will be briefly considered farther on.

Although the greatest factor in her mineral wealth, the coal industry of Iowa has been allowed from the beginning to take care of itself. Until recently not a single area in the state had been accurately mapped, nor the extent, thickness and stratigraphical peculiarities of the deposits made out. Surprising as it may seem, carefully made estimates show that more money is wasted in many counties every year in ill-advised and poorly conducted efforts to discover coal and other minerals than would annually support a well conducted, systematic investigation of the entire state. Throughout the region are to be seen numberless abandoned diggings, most of them the fruitless attempts to obtain coal in places where success is as utterly hopeless as can be imagined. Deserted shafts tell of useless expenditure and loss of capital that might easily have been avoided had some authoritative information concerning the geological structure of the particular localities been accessible.

The subject of coal in Iowa is so important in its bearings upon the material prosperity of the state that it requires a careful treatment in all its numerous phases. This treatment is a work of great magnitude. It cannot be accomplished in a few months; for several years are required to make the observations, accumulate the facts, and carry on the proper tests.

There is contemplated, therefore, in this connection a series of publications, which will eventually resolve itself into four or five categories more or less closely related. Each of the groups of facts will probably be embraced in separate parts, the first of the series appearing with the present volume. There is proposed:

(1) A preliminary report, somewhat general in its character, perhaps, but something which will supply temporarily a great and ever increasing demand for information pertaining to the coal deposits of the state. This desire for authoritative accounts of the different portions of the great Iowa Coal field is shared not only by the citizens of the state but by many persons with means who now reside in distant parts of the Union, but who are desirous of making safe investments in the state, of starting new industries and of becoming soon, perhaps, residents.

(2) A detailed account of the geological features of the coal districts. This should embrace a full description of the different kinds of beds and their associations, the minute structure of the coal-bearing strata in all its details, the exact relations of the different seams, the distances from the surface that it is necessary to go in order to reach them, the pointing out of notable and easily recognized strata which will act as guides in searching for particular seams of coal, and all kindred information of practical import.

(3) A discussion of practical mining in the state, the methods employed and improvements to be made, the kinds of machinery used and its advantages, the best methods and apparatus for prospecting and like information tending toward a greater development of the industry, including the utilization of coal dust, slack and the lignites of the Cretaceous strata of northwestern Iowa.

(4) A description of the uses and properties of Iowa coals, together with chemical analyses of all the principal varieties from the different counties, the adaptabilities of the various kinds for steam, domestic, and metallurgical purposes and for gas-making.

Since the work of investigating the coal deposits of the state has been taken up, innumerable calls have been received from persons and corporations in more than two-thirds of the entire number of counties to look into their localities "first." In addition there has been a multitude of letters asking for special information and advice and numerous personal visits made by persons residing outside, as well as within, the limits of the state. All these demands have been satisfied as far as reliable information upon the particular phases of the question would permit. But, it was clearly manifest from the beginning that it would be an absolute physical impossibility to answer every earnest call in the manner that was perhaps expected. Nevertheless every effort has been made to give advice of practical importance in the specific cases. These inquiries indicate how deep and how active is the interest in regard to the greatest of Iowa's natural resources; how urgent is the need for organized work in determining the exact nature and extent of the mineral wealth of the state.

It was foreseen at the outset that but little progress could be made in extending the examination of the coal deposits to all parts of the state in which there was any likelihood of obtaining the mineral in quantities of commercial value unless the subject was taken up in a perfectly systematic way. With this object always in view localities were visited first, which, it was thought, would furnish most readily a key to the structure, character and disposition of the coal beds over large areas. After the geological features of these districts were thoroughly understood the investigations were extended in all directions into the neighboring regions as rapidly as was consistent with accurate work. In this way the extent of territory covered and the amount of practical information secured was far in excess of that which it would have been possible to obtain in any other way.

When it is remembered that the area of the Coal Measures in Iowa is over 20,000 square miles, and that the numerous Carboniferous outliers, or isolated basins, and the regions bordering the productive coal deposits which must be gone over in determining even approximately the limits of the formation, occupy fully 5,000 square miles more, the magnitude of the undertaking and the amount of labor that has been expended may be readily appreciated. Many details, of course, still remain to be brought out, yet within the limited time allowed it is not to be expected that the work could be made symmetrically complete. However, the report is comprehensive in its nature, giving all the leading facts connected with the industry, and the occurrence and distribution of the coal throughout the state.

Of special and practical import to prospector and miner alike are the facts brought out in regard to the stratigraphy of the coal bearing strata of the state. In this line of work the natural outcrops have been by far the most valuable. Records of shafts, diggings and borings have also been of value but not to the extent that might be supposed at first glance. These records have been kept by many different persons and their worth for geological purposes has varied greatly. Of the many hundreds, or thousands, of drill holes which have been made in the different parts of the state very few are of much use in checking geological observations. With the great majority of the holes put down in prospecting for coal no record of the strata passed through has been kept and as a rule only the presence or absence of coal noted. It does not appear to have occurred to many prospectors that other horizons are often just as valuable aids in the search for coal as the coal seams themselves. In nearly every coal district there are certain beds which are easily recognizable and which have a definite position in regard to the coal beds themselves; that is, their position is constantly a certain number of feet above particular coal veins. When these beds are encountered and recognized it is easy to calculate within a very short distance how far down it is necessary to go in order to reach the given coal horizon. When no attention is paid to such beds as are here considered it is possible that borings may be stopped within a few feet of a valuable coal seam without its presence being detected. The money spent in prospecting under such circumstances is of course wasted. In the same way carefully kept records of borings of artesian wells, and records of drillings for other purposes would be of great value to the community in pointing out the probable occurrence of particular mineral deposits.

There is another element in the uncertainty which usually surrounds the average drill record. Aside from the unfortunate employment of incompetent persons who really know little or nothing about the character of the rocks and the geology of the region the use of the ordinary churn drill is to be deplored. The claims of drillers are in most cases very extravagant. Even under the most favorable circumstances there is already great difficulty in ascertaining the exact thickness and the lithological character of the several strata passed through, so that only in a general way can the record be relied upon. At best every precaution must be taken to get even approximate results. The larger coal operators and those who are most successful in prospecting for coal on a large scale use the diamond drill altogether, which furnishes a core of the rocky layers passed through. By means of the core, which is essentially a small vertical column passing through the successive strata, all details relating to the composition and thickness of the different layers are readily obtained and may be referred to at all times by a simple examination of the section secured. All the important horizons may be determined, whether they are the coal veins themselves or the more persistent beds which are capable of serving as guides in determining the location of the seams. The cost of the diamond drill outfit is somewhat greater to be sure at first than that of ordinary drilling apparatus and this fact probably explains why, notwithstanding its many advantages, it is not more generally used. The record and information obtained, however, are very much more satisfactory and accurate than where other instruments are employed. There remains evidently the same ultimate cost of prospecting whatever form of apparatus be employed.

The statistics of the Iowa coal production during past years have been published independently by the statistical department of the United States Geological Survey and by the Iowa State Mine Inspectors. The former does not take into consideration country banks, and consequently a very considerable percentage of the coal production is not noted, while more than a quarter of the total number of counties producing coal are not mentioned at all. According to law the State Mine Inspectors confine their labors to only those mines working more than ten men, so that here too a very considerable portion of the annual production is overlooked. The importance of the country bank is much greater than is commonly regarded. The leading coal producing districts of to-day are in many cases simply the localities where twenty-five years ago only a few country banks were operated. The development of these fields has been in large part made possible through the building of railroads over which the product of the mines may be shipped to less favored localities. The country banks thus often determine the line along which railroad building is to be carried. The location of the deserted mines is also of importance as indicating the presence of coal. The abandonment of the old openings do not necessarily imply that the seams have been entirely exhausted. In the majority of cases, mines of this class often suggest rather that the work has been interfered with, or that the territory owned or leased, being somewhat limited, has been exhausted.

In most cases it has been found unadvisable to designate by special names the different coal seams as is done in the fields of the Eastern United States. In only a few instances are the Iowa coal seams extensive enough to warrant the application of distinctive names; though whenever they assume sufficient prominence they are called after the leading places where they are mined.

To Professor Calvin sincere thanks are due for many kind suggestions in connection with the work. In the preparation of the chapters on the coal mines operated in the various districts the field notes of the different members of the Survey have been freely drawn upon. Messrs. E. H. Lonsdale, A. C. Spencer, A. J. Jones, C. H. Gordon, and especially H. F. Bain, have contributed liberally in the descriptive matter. The drawings illustrating the work were made chiefly by Mr. F. C. Tate. The chemical analyses have been made by Prof. G. E. Patrick, chemist to the Survey. A few other analyses have been included, among them those made by Profs. Whitney and Emory.

CHAPTER I.

INTRODUCTION.

In his essay on "What Knowledge is the Most Worth," Herbert Spencer has arranged human activities in five classes. The first and most important are those which minister directly to self preservation. Providing of food and fuel comes prominently into this category. The former faculty is shared by all animals alike; the latter is possessed by mankind alone. The first utilization of fuel marks perhaps the most important epoch in the entire history of the human race. For it was the discovery and use of fire that raised primeval man above his brute companions. Ever since that early pre-historic time fire has been among the foremost factors in the advancement of humanity, until to-day it forms the one great element of man's material progress.

Possessed, in its childhood days, of a force so subtile, so powerful, so effective, little wonder is it that mankind should have felt so deeply such an influence; an influence pervading all its doings, entering every act of its daily life, guiding even its spiritual course. The hidden powers of fire, its magic effects and marvelous results ranked it with the early races among the forces supernatural. Fire, therefore, in its seeming potency so far beyond that human, early became an object of veneration and of worship. Before it whole nations bowed themselves trembling and offered up their humble supplications. It was regarded as the giver of all life. The human soul itself was thought to be identical. With the literatures and philosophies which are coupled with the dawn of history, fire has a prominent place among the first causes. The Vedas taught of its tutelary guidance in the daily conduct of man. The Zend-Avesta of the Persians makes fire emblematic of the Supreme power. Long before history records exact dates the religious tenets of the fire worshipers were brought from ancient Bactria and the far East into western Asia. Here more than 600 years B. C. the Greeks found the famous race of the Medes erecting on the mountain tops their altars from which rose the eternal flames so sacred in their belief. Zoroaster is said to be the founder of this celebrated sect of fire worshipers whose descendants flourish to the present day in Persia and western India, where they are known as Guebres and Parsees. Among the Aztecs of ancient Mexico fire was the oldest of divinities, the parent of all gods. With the North American Indians it held an important place in the sacred ceremonies of many tribes. Thus in the early youth of nearly every human race the leading factor of man's material progress was intimately intertwined with his religious creed, completely interwoven with his spiritual life and happiness.

For a long period after man began to be a fire-using animal all the necessary fuel was supplied by the surrounding forests. But as these commenced to disappear rapidly with the advance of civilization attention was turned necessarily towards new sources for the furnishing of heat and light. Mineral supplies were naturally looked for as the living vegetable stores became exhausted. Thus the stored up carbon of bygone ages began to be drawn upon. From the burning of woods and charcoals man rapidly and readily changed to the use of mineral coals.

Although the use of mineral coal as a fuel is very ancient its mining on an extensive scale dates back only to a comparatively modern period. From the earliest times the Chinese used mineral coal for metallurgical purposes and also obtained illuminating gas from it. Accurate accounts of its properties were given by the Greeks as early as the fourth century, B. C. For a long time previous to this the inhabitants around the northern shores of the Mediterranean knew of its use. Before the Christian era coal was known to the ancient Britons who were using it at the time of the Roman invasion under Julius Cæsar. From these early times, when coal was used only sparingly for smithing purposes by the Britons and Lycurgians the use of the mineral as a fuel spread over Europe and continued to increase until about the middle of the eighteenth century when an unparalleled development of the industry took place through the invention of the steam engine.

"Coal," says Newberry, "is entitled to be considered as the mainspring of civilization. By the power developed in its combustion, all the wheels of industry are kept in motion, commerce is carried on with rapidity and certainty over all portions of the earth's surface, the useful metals are brought from the deep caves in which they have hidden themselves, and are purified and wrought to serve the purposes of man. By coal, night is, in one sense, converted into day, winter into summer, and the life of man, measured by its fruits, greatly prolonged. Wealth with all its comforts, the luxuries and triumphs it brings, is its gift. Though black, sooty and often repulsive in its aspects, it is the embodiment of a power more potent than that attributed to the genii in oriental tales. Its possession is, therefore, the highest material boon that can be craved by a community or nation. Coal is also not without its poetry. It has been formed under the stimulus of the sunshine of long past ages, and the light and power its holds are nothing else than such sunshine stored in the black casket, to wait the coming, and serve the purposes of man. In the process of formation it composed the tissues of those strange trees that lifted up their scaled trunks and waved their feathery foliage over the marshy shores of the Carboniferous continent where not only no man was, but gigantic salamanders and mail-clad fishes were the monarchs of the animated world."

Playing such an important rôle in the material advancement of our modern civilization coal must long rank first among the mineral resources to be desired in a country or region; and fortunate indeed is the community possessing deposits sufficient to supply its wants.

Being one of the prairie states with a situation on the border of the "Great Plains," having a surface with no marked contrasts of altitude, and possessing a soil unrivaled in fertility by any country on the face of the earth, it has been customary to regard Iowa as a strictly agricultural province. Annually the state compares herself with her sister states and the countries of the world as to her rank in supplying various farm products. She finds that as a producer of corn, oats and potatoes she stands first on the list among the states of the Union; of flax, barley, and hay second, and correspondingly high in other crops. She immediately concludes that she is a great farming country; and indeed she is, for the total valuation of her farm products every year is nearly half a billion dollars.

With just pride Iowa, "lovely land," commands the attention of the world to her agricultural wealth and capacities.

But in a moment of righteous enthusiasm the fair State has all but forgotten that she has other resources as boundless as those she has extolled: resources which half the nations of the globe would consider priceless worth if they did but possess them; riches which Nature hath bestowed with lavish hand; wealth which only can hasten the onward progress of humanity. These are her mineral resources. They are the inherited possessions which are bound up in the coals, the clays and the metallic ores.

Foremost among these natural products are the deposits of mineral fuel. The coal fields of Iowa embrace upwards of 20,000 square miles. Fully one-half of this area may be considered as underlain with workable coal seams, much of it by several beds, so that it is safe to say that there are not less than 10,000 square miles, or nearly one-fifth of the entire areal mileage of the state, which is capable of supplying coal in quantities of commercial importance.

It has been seen that, in the case of her agricultural products, Iowa enjoys making comparisons with other states and countries. Why should she not do the same with some of her mineral products? Curious as it may seem, however, Iowa has allowed her mineral industries to take care of themselves. In the half century of her existence as a state she has extended practically no aid whatever in developing her greatest sources of mineral wealth. Her lead deposits, which once afforded the chief supplies of this country, are now scarcely noticed. Her zinc has received but little attention. Her iron ores have never been investigated. With clays enough of all kinds to supply the world for ages, she has purchased the manufactured products from other states.

These comparisons are not instituted here to depreciate Iowa's mineral capacities. Far from it. They are made rather to show that there lies within her boundaries latent resources and undeveloped possibilities, the extent of which has not been suspected heretofore by the majority of her citizens and the character of which has been entirely unknown to the people of other states.

In her coal she has been somewhat more fortunate than with her other minerals for as a producer she ranks to-day first among the states west of the Mississippi and fifth among the states of the Union.

A glance at the nations of Europe shows that if they were arranged in order as they are powerful and prosperous their respective ranks correspond in a general way with the amounts of coal each of them produces, for upon this fuel depends largely their manufacturing industries.

The latest information from Europe indicates the annual coal product in tons to be, in round numbers, for:

Great Britain	190,000,000
Germany	85,000,000
France and Belgium	45,000,000
Austria	9,000,000
Russia	6,000,000
Spain	1,000,000
Italy	400,000
Sweden	300,000

England the richest and the most powerful of European countries owes her high position almost entirely to her manufactures; and from her little isle she has extended her possessions around the globe. The annual coal production of Great Britain is now in the neighborhood of 200,000,000 tons. As recently estimated by a leading authority: "A very short calculation will suffice to show what an important contribution this makes to her national wealth. The power developed in the combustion of a pound of coal, is reckoned by engineers as equal to 1,500,000 foot-pounds. The power exerted by a man of ordinary strength during a day of labor is about the same; so that a pound of coal may be regarded as equivalent to a day's labor of a man. Hence, three hundred pounds will represent the labor of a man for a year. It was estimated some time ago that upwards of 20,000,000 tons of the annual coal product of Great Britain are devoted to the development of motive power, and that this is equivalent to the labor of 133,000,000 men. These men, in this calculation, are considered as exerting merely brute force; but since they may all be regarded as producers only, and not consumers—the profit on the balance of her coal product fully covering all expenses—we are safe in estimating the contribution made to the wealth of Great Britain, by her annual coal product, as equal to that of 133,000,000 skilled operatives laboring for her enrichment." Now England has an area about the same as Iowa. The United Kingdoms have coal fields which approximate 10,000 square miles which is the estimated extent of Iowa's coal bearing territory, counting on a basis that only one-half of her entire Coal Measure area is capable of producing coal in commercial quantities. Great Britian has of course a much larger population and is near the densely populated districts of the continent. She has also probably a much larger quantity of coal included in her strata than Iowa; but granting all this, the discrepancy cannot be at all near what the difference in the annual production of the two districts would indicate, for Iowa's is only about one-fortieth that of England. It is also to be remembered that there is no deep mining carried on in Iowa. Rarely do shafts penetrate more than 125 or 150 feet. In the Lancashire coal field of England pits are sunk to a depth of 2,800 feet and in the Somersetshire and Durham regions 1,500 and 2,000 feet are not uncommon depths. Some of the Belgium pits have been carried down 3,400 feet. While it is not probable that these great depths will ever be reached by the shafts of this state there is abundant reason to believe that in many portions only the surface coal has yet been touched. With deeper mining Iowa is certain to increase enormously her known coal supplies. Indeed in a number of places which have long been regarded as territory completely "worked out" the penetration of only fifty feet deeper has rekindled the industry with vigor far greater than ever before.

Germany contains the celebrated coal fields of Saarbrück and Westphalia, besides a number of minor importance, embracing altogether possibly 3,000 square miles. The coal-bearing rocks of the Ardennes in Belgium and the north of France and of the St. Etienne field of the central plateau of France together with numerous smaller areas aggregate only about 2,500 square miles. The other countries of Europe with the exception perhaps of Spain have coal areas very much smaller still.

Coming back now to Iowa she is found to possess coal fields whose areal mileage exceeds that of the greatest of European nations; surpasses by three, four or many more times the total area in any of the other great countries of the eastern hemisphere. To be sure the geological conditions in the British Isles, for instance, have not been exactly the same as here, and England perhaps has in the aggregate greater deposits of mineral fuel than Iowa, but the fact still remains that Iowa has latent mineral wealth within her boundaries which has never been appreciated anywhere near to the extent that it should be. Besides if there is anything which should be especially emphasized in connection with the present investigation it is the fact that the actual supply of coal in Iowa is many times greater than it has been usually considered and that she is almost infinitely richer in this regard than it was possible even to estimate before definite information on the subject had been collected. Instead of single coal horizons, or two or three perhaps as in some cases, six, eight and even a dozen have been recognized at a single locality. In corroboration only one of many examples will suffice. In Polk county it is the opinion of many that the coal is "practically worked out." Not three seams, as commonly recognized, but half a dozen or more distinct beds have been made out. It would doubtless be a conservative estimate to say that the amount of workable coal now in the county is equivalent to a bed four feet thick over every square mile of its area. This, and only the upper or surface one-third of the vertical depth of the coal-bearing strata yet explored.

Certainly Iowa has not suffered by the comparison of her possibilities in coal wealth with that of other regions.

Outside of a few limited areas in several of the counties very little detailed information has been published concerning the relations of the different coal seams both to one another and to the associated layers.

Among the earliest reliable references to the coal of Iowa are those of D. D. Owen, who made a geological reconnoissance of the Des Moines valley in 1847 under the auspices of the federal land office. In the hasty canoe voyage up the Des Moines river from Keokuk to the Lizard fork, near the present site of Ft. Dodge, numerous outcrops of coal were observed and located on a map of the stream. Although the trip was hurried this was probably the first successful attempt to bring the greatest of Iowa's mineral resources into public notice.

In 1856 A. H. Worthen, afterwards State Geologist of Illinois, made a similar reconnoissance up the Des Moines river, but added little to Owen's work. Since Owen's trip a number of small mines had been opened in various places, supplying fuel for local use. The following year the same person made an examination of several of the counties in the extreme southeastern part of the state. The presence of coal was noted in a number of places and a few small openings visited, but little definite information was given in the report of these counties.

A decade later official operations were again commenced by the State for a systematic investigation of the mineral resources of Iowa. But unfortunately for the commonwealth, the work, like the former attempt, was suddenly suspended before it had been fairly begun. Being so abruptly cut off, the field notes were necessarily scattered and of far too incomplete a character to adequately present the subject in the form it deserved. Thus, owing to circumstances largely beyond the control of those engaged in the study of the geological features of the region, accounts and expert opinions of the highest economic importance to the different communities were for the most part prevented from reaching the public.

From time to time, short, purely scientific descriptions of local geological phenomena have appeared in different periodicals; and incidental references to Iowa geology have been made in various official documents of other states and of the federal government. But they are of small popular interest; besides they are inaccessible to the majority of the people.

From the foregoing it will be gleaned that detailed information concerning Iowa's greatest source of mineral wealth is very meager and that the great industry now occupying the time and means of so many people has been allowed to develop unaided and alone. The examination now being carried on indicates plainly that the citizens of the state have not availed themselves to the extent that they might of the natural riches which Nature has bestowed. The near future will show beyond doubt a rapid advance in this industrial pursuit.

CHAPTER II.

ORIGIN OF COAL.

Common coal is one of the three forms in which free carbon exists in Nature. It is well known that the pure, well crystallized variety of carbon is the diamond; the foliated or massive form which is common in crystalline rocks, graphite; and the ordinary dull, brittle variety, along with various impurities, coal.

No one now doubts that coal is made up in large part of vegetable matter which has accumulated chiefly in swamps, though at the present day the organic nature and structure may be entirely obliterated. It would be possible to arrange a series in which the transitions are more or less complete from peat through lignite, bituminous coal, semi-bituminous coal and other grades to anthracite or even graphite.

It is not the object of the present work to give a systematic summary of the different theories that have been advanced from time to time to explain the formation of coal. Suffice it now to call attention briefly to some of the most notable opinions which have been expressed in regard to the formation of coal in general; and to describe in particular the facts bearing upon the genesis of Iowa coals and of the coals of the great interior basin.

Source of the Materials.—Although the various opinions regarding the formation of coal differ somewhat in details, the views expressed nearly all agree in ascribing a vegetable origin to the deposit. After plants are dead they rapidly decay and go to enrich the soil, when allowed to stand under ordinary atmospheric conditions. If, however, they are covered with water or prevented from having free access to the air they do not lose their stuctural characters entirely. Under these circumstances a mass of vegetation subjected to an even temperature and an increased pressure is converted into common mineral coal in a comparatively short time. This conversion is often seen in old mines where the timbers have been allowed to remain under conditions similar to those just mentioned. One of the best known instances of this kind is that alluded to by Hirschwald* in the case of the Dorothea mine near Clausthal in the upper Hartz, where the wooden supports in a deserted chamber of the mine had remained untouched for more than four hundred years. During this time the timber had been thoroughly soaked in water and shut off from the air. When brought to light after its long burial, it was found to be changed into true brown coal, having a characteristic glistening fracture.

The evidence in support of the vegetable origin of coal is derived from a variety of sources. In the layers associated with the coal seams, plant remains are of common occurrence. The white underclays and sandstones just below the coal yield abundant roots of the larger tree-like forms of plants. The overlying layers, whether black shales or soft sandstones, are often crowded with leaves and stems of many species; broad, spreading fronds of delicate ferns; bark and branches of huge lycopods. In the majority of cases the plant remains are spread out between the thin sheets of fissile shale or in the sandstone

* Zeits. d. deutsch. geol. Gesel., Band XXV, 364-366. 1873.

layers, where they are preserved in great perfection. Frequently, however, they are found inside of small concretions of clay ironstone. Sometimes, also, the plants are perfectly preserved by iron pyrite. In the underclay at Ford, in Marion county, as well as elsewhere, the roots of lepidodendrids are found with all the delicate tissues intact. Beneath the pitted bark the woody fibers are plainly visible. Under the microscope all the minute cell structures may be made out as easily as in a living plant. The fibro-vascular bundles are beautifully displayed, while the ducts and scalariform cells with all the minute markings are defined as distinctly as they existed in the original vegetable tissues.

In the coal seams themselves, the vegetable remains are often also well preserved. In nodules of pyrite embedded in the coal, fragments of plants occur in which the microscopical characters of the organisms are as plainly made out as in the cases just mentioned.

Proper preparation of thin slices of all the ordinary coals usually enables the cellular and vascular structures peculiar to plants to be made out with greater or less distinctness when examined under the microscope. The ash left after burning also frequently retains, under favorable conditions, microscopic structures of the different wood cells.

In many coal localities all the stages of bituminization may be made out, from peat or loose plant accumulations to the hard, glistening anthracite. In Iowa the different gradations cannot be traced in all their details, though peat, lignite and various grades of bituminous coal are to be found in the state. The first is abundant in the modern swamp lands of the northern part of the state. Another stage is sometimes exposed in road cuttings where the old marshes have been covered with drift. Lignite of various sorts is plentiful in the Cretaceous deposits of the Sioux river region. The range of varieties of bituminous coal in the Carboniferous is also very considerable; so that after all, the different stages of bituminization are found to be measurably complete in the state.

The formation of mineral coal artificially is very suggestive of the natural processes which may have been at work in certain phases of the metamorphism of vegetable materials on a large scale in Nature. Under high pressures ordinary peat becomes a compact substance like coal in its properties. Daubrée,* by the subjection of wood to the action of super-heated water, has succeeded in producing a substance indistinguishable from ordinary anthracite. The production of brown coal or lignite in the deserted Clausthal mine has already been mentioned. Seeland† also reports an interesting case in which the timbers supporting a steam hammer had been changed completely into lignite within a period of twenty years. Numerous other cases might be mentioned in this connection.

Conditions of Deposition.—The examination of the stratigraphical relations of the Coal Measures of the continental interior has shown that during the Carboniferous period there was a slow, though often interrupted, depression of the land surface over the entire region. This phenomenon is in accordance with the general law which appears to govern depositions of this kind.

In certain localities a prolonged subsidence of the sea bottom is known to have pushed the ancient shore line many miles inland. The movement was manifestly gradual and to some extent intermittent. The seas being

* Géologie Expérimentale, p. 464. Paris, 1879.

† Verh. Geol. Reichs., p. 193. 1883.

shallow the conditions were unusually favorable for the formation of extensive coastal swamps which were capable of supporting dense jungles of aborescent plants, together with ferns and other vascular cryptograms. The salt waters could easily and frequently invade the swamps or the tropical vegetation could spread out into the quiet bays or sheltered lagoons of the adjacent seas. This may be inferred from the fact that mingled with remains of the plants are the hard parts of numerous marine animals, which evidently swarmed in countless myriads in the more open places. The effect produced was probably not very unlike that of one of the modern mangrove swamps of southern Florida.

As the subsidence for a brief period suddenly became more rapid currents were allowed to enter bringing in sediments which quickly buried the accumulated masses of vegetation. Other swamps constantly formed landward and the same cycle of changes was repeated.

In other places along the coast, but removed from the immediate influence of the sea, there were doubtless other swamps of a nature somewhat different from that just mentioned. They more nearly resembled the present peat-bogs, that are common in northern Iowa, as well as in Minnesota and other parts of the upper Mississippi valley.

This then is briefly what appears to be the geological history of the coal formations of the continental interior; and there is but little doubt that the basins were formed almost entirely in swampy regions. In this respect they are very similar to the majority of the coal districts of the world. The relations of the coal seams to the rocks lying above and below, the character of the under-clays and the superimposed black shales, the nature of the floras embedded in the strata and the faunal features of the associated layers, all afford conclusive and independent lines of evidence pointing to the same conclusion.

If it were possible to reconstruct now the state of things that existed at the time the Carboniferous beds were forming over the area of the present upper Mississippi basin there would appear first a long, low shore bordering broad shallow bays, more or less completely sheltered from the direct and destructive influences of the sea. Over the wide marginal lowland, stretching sometimes for many miles, sometimes only for a few hundred yards, would be marshes and peat-bogs, separated from one another by short intervals of dry, elevated land or by low hills rising one after another for long distances. Thus for many hundreds of miles along the shore-line would appear innumerable swamps and marshes, of all sizes and shapes and in all stages of formation, from those just beginning an existence to those about to be silted up or buried. Numberless marsh areas, large and small, some having no connection whatever with one another and often widely separated, others barely coming in contact during their last stages, would exist contemporaneously.

The conditions just described are those which might readily exist on the sheltered coast of any low-land plain. It depends, however, entirely upon the crustal movements, upon a change of level of the land surface of the region, whether or not the accumulated vegetation is favorably situated so as eventually to form carbonaceous deposits to be preserved through the ages.

It is a well known fact that when vegetable matter is allowed to decompose freely in the atmosphere the chemical changes are very different from those taking place where the same material is kept partially or entirely shut off from ordinary air. In the first case the plant remains usually lose their identity completely, a little inorganic matter only is left behind and is soon blown about by the winds, mingled with the soil, or in rare instances, perhaps, collects in small quantities, locally forming a powdery substance like mineral charcoal. The process is the simple one of oxydation. In the second instance some of the plant fragments can nearly always be recognized, and the entire mass goes through a process of bituminization. Shut off from direct contact with the atmospheric oxygen the elements react chemically among themselves.

In Nature both kinds of changes take place on a large as well as on a small scale. They affect alike the great swamp accumulations and the delicate fern of the darkling glade. The marsh owes its preservation or destruction to the same titanic forces which raise the mountains; the frond withers on its leafy bed in the forest, or falls into a quiet pool to rest.

Oscillations of the shore-line, even though slight one way or the other, may be, then, of the greatest import to the future history of the coastal swamp lands. So long as the level of the neighboring country remains the same with respect to the sea-level and the shore-line practically stationary, the marsh growths may continue to flourish indefinitely. When, however, the land rises, or the shore-line moves seaward from its old position, the swamp begins to be drained, finally becomes dried, and the accumulated masses of vegetation brought under the influences of the open air. In a comparatively short time all traces of the once extensive marsh are lost completely. On the other hand, if the sea invades the land, the great body of decomposed and partially decayed plant remains is soon covered by sediments which, after a brief interval of time, greatly retard further dissolution of the organic matter, and finally the process of decay practically ceases.

In general, then, it may be concluded that with the same vegetable accumulations along a sheltered shore a rising of the land does not afford the proper conditions for preserving intact the plant mass; while a constant sinking of the surface previously above water is conducive to the permanent preservation of a great part at least of the organic deposit. These influences are in perfect harmony with the facts deduced from observations made on the old Carboniferous swamp lands of Iowa.

Under circumstances which are favorable to the preservation of vegetable tissues, there is a constant addition of sediments above, increasing the superincumbent weight until it frequently becomes something enormous. The temperature of the mass at the same time gradually rises. The heat and pressure, aided at times by other agencies perhaps, may continue to be operative for long periods; the vegetable mass in the meanwhile going successively through all the stages of bituminization to the hardest anthracite or even to graphite. In the process, through the loss of water and various gases, and through certain chemical reactions of the various component elements or compounds among themselves, the bulk of the vegetable mass is very greatly reduced, the amount of reduction of course depending upon the nature of the swamp materials, the degree of bituminization, and method by which the loss of carbon is effected. According to the estimates of Maclaren in one of the Scottish coal-fields it would take nearly 2,000 acres of forest to produce an acre of coal three feet in thickness. In case of the average Iowa coal bed it has probably taken upwards of thirty feet of closely compacted material of the original woody growth to produce a seam of coal having the thickness of four and one-half feet — the mean measurement of the veins mined in the state. Ordinary anthracite probably shrinks to less than one-tenth of its original bulk in the course of its formation; so that a bed twenty-five feet thick may represent between two hundred and fifty and three hundred feet of the original mass.

In the diminution of bulk in a great lenticular deposit of vegetation the change in dimensions is chiefly in a vertical direction. Providing the surface of the marsh was originally nearly horizontal, as is probably usually the case, the margins would remain stationary while the cen-

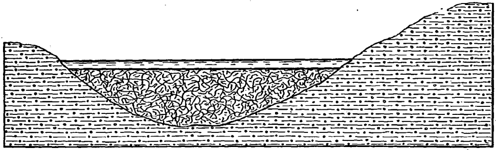

Figure 1. Section of Peat Swamp in Northern Iowa.

ter of the mass where the contraction is naturally greatest would be depressed below the level of the borders, producing, when fully compressed, a shallow saucer-shaped sheet of coal. This fact is also well exhibited in the coal deposits of Iowa, especially in the case of the smaller basins. The six-foot coal vein displayed at the top of the Redrock sandstone quarry in Marion county is a good example.

The original conditions of deposition of the Iowa coal beds appear in many respects to be not very unlike those observed at present in the peat swamps of the northern part of the state, the most noticeable difference being, perhaps, that in Carboniferous times the marshes were largely maritime. The peat bogs of northern Iowa, or "lakes," as they are often called, occupy shallow saucer-shaped depressions in the drift. A cross-section is represented in figure 1. In size the "lakes" may vary from a few hundred yards to a dozen or more miles in extent. The bottoms of the marshes are commonly covered by matted masses of vegetation in a more or less advanced state of decomposition. The waters are always shallow, for the greater part only a few feet in depth. Most of the "lakes" seem to be gradually filling up their basins with dead vegetation, each year's growth falling into the water, then, only partially decaying, contributes some increment to the accumulating mass which for centuries has been slowly augmenting season after season. The process differs considerably from that of the silting up of an open lake in that the depth of the water appears to remain the same each year, each accumulation of plant remains on the bottom merely allowing, to all appearances, the level of the water to annually rise a little in the swamp. The extent to which the vegetable matter is accumulated in the peat swamps is shown in a number of places where railway lines have attempted to cross the marshes. In the effort to secure a firm road bed piles have been driven down fifty to one hundred feet, without obtaining sufficient support. The same is true in many Minnesota localities. In several instances piling was driven down nearly two hundred feet without reaching bottom, and finally large quantities of brush and trees were cut down and placed along the line surveyed through the swamp. Upon this gravel and clay were placed and the grade established as in an ordinary filling. The matted vegetable matter below was everywhere firm enough to bear the weight of all the trains passing over the road, with no inconvenience to traffic.

As an example of what took place during the period when coal was forming a case may be assumed somewhat similar to that just mentioned. Let there be imagined a swamp one-fourth to one-half a mile in diameter and two hundred feet in depth; let the swamp be filled to within a few feet of the water level with half decayed vegetation; let the region after this stage is reached become one of slow subsidence, and let it be so situated as to allow the introduction into the swamp of currents which sweep in sediments of different kinds; and the conditions of the

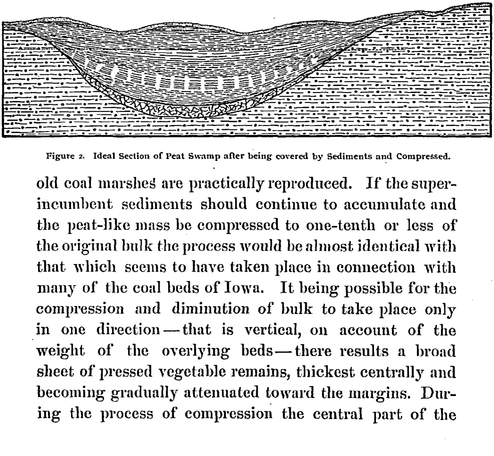

Figure 2. Ideal Section of Peat Swamp after being covered by Sediments and Compressed.

old coal marshes are practically reproduced. If the superincumbent sediments should continue to accumulate and the peat-like mass be compressed to one-tenth or less of the original bulk the process would be almost identical with that which seems to have taken place in connection with many of the coal beds of Iowa. It being possible for the compression and diminution of bulk to take place only in one direction—that is vertical, on account of the weight of the overlying beds—there results a broad sheet of pressed vegetable remains, thickest centrally and becoming gradually attenuated toward the margins. During the process of compression the central part of the upper surface, which, just prior to the influx of sediments when the swamp had reached its greatest development and expansion, was on a level with the margins, is little by little depressed or bent downward as the plant remains are more and more compacted. (Figure 2.) At the end of the process the upper surface of the vegetable mass at the center of the basin will be from one hundred and seventy-five to one hundred and eighty-five feet below its original level. In the particular case assumed this would be a slope of about one to thirteen in all directions towards the center, or a dip of five degrees nearly. Conceiving this area to be covered to a considerable depth with other beds the phenomenon becomes practically identical with what is now observed everywhere in connection with the coal beds. The areas are numerous throughout the Iowa coal field where the veins of coal have been opened in a hill-side, for instance, showing a considerable dip inward as the entry was driven forward, the coal at the same time rapidly increasing in thickness. After progressing some distance the inclination has become nearly horizontal and soon has changed in the opposite direction. With this change in dip the coal becomes thinner and thinner until mining in that particular seam is no longer profitable. Basins of this kind have been noticed in nearly every county of the Iowa area. At the Redrock quarry, in Marion county, an excellent illustration is to be seen. (Figure 3.)

Associated Beds.—So many references are made to the different layers found in connection with the coal beds that little needs to be said here. Attention may be called to the great similarity of vertical sections of Coal Measure strata taken in various parts of the world; and to the fact that the common sequence of beds observed in

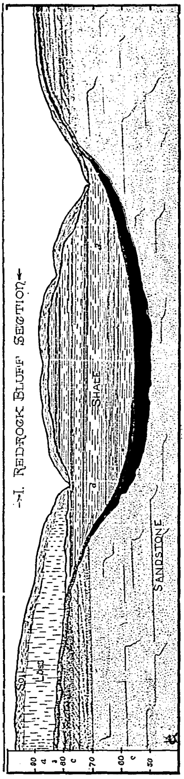

Figure 3. Section of small Coal Basin in Redrock Quarry, Marion County.

different places is indicative of the same gradual succession of physical conditions. Beginning at the bottom of the series there are: (1) fireclay; (2) coal; (3) dark, bituminous clay-shale; and (4) sandstone or shale. These beds are naturally closely related. The first named, being the soil upon which grew the coal flora, may be, in its formation, entirely independent of the underlying strata, and may even rest upon them unconformably. The third stratum mentioned may be extremely thin, owing to local conditions, but being simply mud deposited directly upon the old vegetable remains it has become more or less impregnated with bituminous matter. The fourth group of layers is dependent entirely upon chance currents of water and really is not closely related to the other beds. The strata may be shales, sandstone, or calcareous deposits, or an alternating succession of these. This sequence may be a few or many feet in thickness before another repetition of the coal series occurs.

CHAPTER III.

THE CARBONIFEROUS BASIN OF THE MISSISSIPPI VALLEY.

The broad undulatory plain which occupies the heart of the American continent, stretching out from the base of the Appalachians to the foot-hills of the Rockies, makes up the principal portion of what is known as the Continental Interior region. It spreads out in one direction for more than nine hundred, and in another over twelve hundred miles. Its superficial contents are upwards of one million square miles, or more than one-third of the entire areal mileage of the United States. This vast expanse of country, whose surface is unbroken by mountains and whose borders are untouched by the waters of the sea, has been aptly designated a great basin. The Great Mississippi Basin it is called, from the majestic river, the "Father of Waters," which flows centrally through it.

The region may be properly regarded as a wide stretch of low-land sloping gently in all directions from the margins towards the center and southward. The "Great Plains" form the western portion of the region, the rolling prairies of the "Upper Mississippi" the median part, the fertile valley of the Ohio and the Cumberland plateau the eastern section. No marked contrasts of altitude break the surface relief of the Mississippi basin. The lowest point, in the south-central part, is about four hundred feet above tide-level; the highest places are on the northern and western margins, where the mean elevation is not far from two thousand feet.

Everywhere are evidences of the topographic youth of the region, of a comparatively recent rising of a surface which has lain for ages near the level of the sea, a rising which is probably even now in progress. It is shown in the narrow gorges of the principal water-ways, with their steep-sided bluffs, channeled from hard limerock and indurated clays; in the torrential beds and falls of the minor tributaries as they near the larger streams; in the imperfectly drained uplands which are yet untrenched by clean-cut gashes and freshet runnels, which usher in each new cycle of rapid erosion.

The contrasts of relief to be considered in the interior basin are not those between different parts of the plain itself, but those between the basin as a whole and region immediately around it. Beyond the boundaries in nearly every direction a mountainous physiognomy is presented. The Appalachians on the east and southeast; the Rockies on the west; the highlands of the Great Lake region northward, all stand out sharply against the country they surround. They all tell of powerful dynamic action which has been at work elevating broad stretches of territory; of continental movements which have operated on a grand scale.

On the whole, erosive agencies have not acted very vigorously since the deposits of the Mississippi valley were originally laid down in old Carboniferous times. Through most of the long period, from the eons when the beds were first raised above the level of the waters of the great interior sea at the close of the Carboniferous age to the present date, the vast region must have been nearly the same level low-land that it is to-day; a plain whose surface has remained nearly at base-level for ages, sometimes rising slightly, sometimes sinking a little, but never oscillating far either one way or the other.

GENERAL GEOLOGICAL FEATURES.

Structure.—Great as is the difference between the broad central area of low-lying plains and its high serrated borders, there is a diversity of structural features in the geological details of each of the two districts, as distinct and as far removed from one another in character as are the two widely separated types of surface sculpture. On the one hand, throughout the marginal region of the interior basin the elevation of the land has been accompanied by violent disturbances in the strata, folding, crumpling, breaking, grinding the once horizontal beds until now they lie at high angles with upturned edges everywhere exposed to the swift ravishes of time. The bold, rugged contours of the mountain surface thus disclose the complicated structure of rocky beds beneath. On the other hand, the low-land plain presents its strata spread out in broad, nearly level sheets much in the same position as when they were first laid down. Although made up almost entirely of sediments dating back in their origin to old Paleozoic times it is indeed quite remarkable that, formed so long ago, remote even in geological units of time, the structural changes should be no greater than they are and that the region should still retain over the greater part of its extent the same simplicity of geological structure that is found to-day among the more modern depositions of the coastal plains which fringe the great land areas of the globe. The hypsometric changes over the whole region have been, therefore, of the character of continental elevation and depression.

Though composed of flat-lying beds, as a rule, the strata of the Continental Interior nevertheless present evidences of slight orographic movements, shown in a series of low folds which trend north and south in their general direction. The most prominent of these great corrugations are five in number.

In the extreme east of the region there are the most westerly anticlines of the Appalachian system of mountains with its closely appressed folds running southwestward from New England to central Alabama. Next is a broad dome-like elevation which finds expression in the uplift of central Tennessee, the Cincinnati arch and the minor elevations of the older rocks in northern Ohio and western Ontario. The axis of this fold extends from Lake Huron southward, with a little inclination to the west. Midway between the two great mountain chains of America is a third slight fold whose anticlinal axis extends approximately along the line of the Mississippi river. It is shown in the rocks of central Arkansas, in the eastern part of the Ozark uplift, in the many exposures of strata older than the Carboniferous in northeastern Missouri and eastern Iowa, in the "Isle of Wisconsin" and in some of the ancient crystallines of the Lake Superior region. The outcrops of the older Paleozoic rocks along the Mississippi river cannot be regarded as due entirely to unaided erosion. Apparently the deep gorges of the great river are due partly to the result of the ordinary action of running water; partly to the result of an accelerated erosion on account of the gradual elevation of the principal line of drainage. There is evidence at hand to show that the movement, slight as it may be, had already begun before the close of the Lower Carboniferous in the present upper Mississippi valley. The fourth fold is perhaps somewhat imperfectly defined, but it is indicated by a line of small areas of very ancient rocks trending northwesterly through central Texas and Indian Territory, and protruding through much younger strata. The last is a series of deformations on the extreme west, forming the easternmost range of the Rockies. The trend of the axis is southeastward.

It is a significant fact that the axes of all five of the great folds when prolonged strike approximately the same point in the Gulf of Mexico, a short distance from the mouth of the Mississippi river, a place where a maximum load of sediments is now being deposited; or, in other words, the axes radiate from this point.

Comparatively simple in its general geological structure, easy of subdivision into tolerably well defined minor groups according to lithological features, and abundantly supplied with characteristic fossils in all its beds, the Paleozoic series of the Interior basin still possesses stratigraphical phases highly complicated in their nature. It is an arrangement of strata such as might occur along the coast of any continental mass receiving sediments from numerous sources and forming very distinct interlocking beds each of which rapidly or gradually thins out in all directions and is replaced by others. It is an arrangement that presents great difficulties to a natural geological classification of the beds that would be applicable to all portions of the district, both on account of the vastness of the province and the multiplicity of conditions under which the depositions were made.

The geological phenomena presented by the interior Coal Measures form the final chapters in the maritime history of the region. These closing episodes of the Paleozoic in the Mississippi basin have centered around them some of the most instructive phenomena concerning continental growth that can be found anywhere on the globe. The details and correlation of the formations are not yet known with accuracy in all the different parts of the area, but much has been done of recent years toward solving the problems presented.

The geological history of the Carboniferous in the Continental interior is, in its general features, much the same throughout the entire region. The period was ushered in with conditions favorable to the formation of extensive beds of calcareous materials which are now traceable without interruption over broad stretches of country. Upon this great floor, as it were, of limestone the coal-bearing strata were laid down.

Geological Provinces.—The Carboniferous rocks of North America occur chiefly in five geographical areas which are well marked and distinct and which are separated from one another by broad strips of older strata. They are:

(1) The Eastern Border region, of Nova Scotia.

(2) The Appalachian region, stretching in a narrow belt from New York to Alabama.

(3) The Continental Interior region, occupying a broad area on each side of the Mississippi river.

(4) The Rocky Mountain region, of Montana, Wyoming and Nevada.

(5) The Arctic region, of the northern portion of America.

Each of these regions has its stratigraphical peculiarities which readily distinguish it from all others. Only those of the third, however, are of special importance here. In topographical features, in geological structure, and in the history of formation the marginal zone of the Mississippi basin stands out in strong *bas relief* against the lowland plain of the interior region. Its present boundaries form approximately the limits of an area which in Carboniferous times had a development peculiarly its own and in a great measure unaffected by events transpiring in neighboring districts. The origin and deposition of its strata, the lithological characters of its beds, the succession and evolution of its faunas were wholly independent of the surrounding areas. In short, the Carboniferous Basin of the Mississippi Valley represents, in every sense of the word, what in geology is called a "Geological Province."

It is by their contained fossils that the stratified rocks of the globe are known. It is by the organic remains also that the strata of the different districts are classified and correlated. Yet important as is the systematic study of ancient forms of life it is one of the younger of the geological sciences and the first application of the principle of recognizing strata by their fossils was made less than three-quarters of a century ago.

The study of the rocks of a particular geological formation or age in any one locality naturally leads to the extension of the investigation beyond the boundaries of the political district in which the work began. The investigation may not always be carried on with equal accuracy and with like interest in all parts of the geographical area of the deposits, but if it be exhaustive it usually limits itself finally to the lines where the particular formation disappears through the superposition of later beds, or on account of a thinning out over earlier strata. These lines commonly mark the geographical limits of the geological province.

The stratigraphical, lithological and faunal characters of a formation are so intimately related that the proper interpretation of any one of the three classes of phenomena presented would, under normal conditions, indicate the more salient features of the other two. In practice, however, there are great difficulties encountered in attempting to infer the entire geological history of a series of beds from a single group of facts. The geological record is more or less incomplete as a rule. The larger part of the preserved records is in great measure inaccessible. Those portions which are open to investigation have as yet been only partially considered. For many years to come the places which may be inspected will require constant study before the history to be made out will be even measurably complete. At the present time, therefore, it becomes absolutely necessary to carry on investigations involving the historical sequence of geological events along all three lines at once. Every fact is needed to throw light upon the general theme. If the problems were attacked in any one of the three directions alone, without due regard for the information presented by the others, very different and perhaps antagonistic conclusions would probably be reached, at least in the present state of knowledge on the subject. In the interpretation, then, of the geological history of a region, and in suggesting a geological classification of the formations in accordance with the interpretation, it is of vital importance that there should be weighed carefully the evidences set forth by the arrangement, composition and contained organic remains of the rock series as a whole and of its several parts regarded as units.

The methods and criteria employed at different times in the classification of geological formations have been various. Some of the leading ones are best known under the headings of: (1) Superposition of the strata; (2) Organic remains contained; (3) Lithological characters of the beds; and (4) Unconformities. The terms are so readily understood in their general application that they scarcely require any farther explanation here. In certain localities some one of the classes of correlative methods will be more applicable than the rest. In other places different criteria for correlation must assume prominence.

The characterization of the Carboniferous as well as the other geological systems rests at present upon far-reaching principles. These have been formulated by Lapworth* as follows:

(1) "That the great geological groups must rest on the broad zoological characters of their included faunas, and not upon local stratigraphical breaks between certain series of rocks or upon local differences in sedimentation; (2) that the most reliable chronological scale in geology is that afforded by the relative magnitude of zoological change; and (3) that the geological duration and importance of any system are in strict proportion to the comparative magnitude and distinctness of its collective fauna."

Applying these principles to the Carboniferous system of the Mississippi basin the criteria defining its limits are embraced, as recently stated by Williams,† under the heads of "geographical position," "geological delimitation," and "biological definition." These principles, with some

*Geological Magazine, new ser., Dec. II, vol. VI, p. 3. 1879.
†Bul. U. S. Geol. Sur., No. 80, p. 61. 1890.

minor modifications, are applicable also to each of the several subdivisions. In the consideration of the Carboniferous rocks of the interior of North America, the system itself, as represented in that region, may be taken up in accordance with the principles already given. The great divisions of the system and their minor formations may likewise be treated in the same way.

In any geological province, especially if it be one having a very considerable geographical extent, the clasification of the strata must always accord with the sequence of events which took place during the formation of the entire series presented. The history is a record of changes in the position of the oceanic shore-line, of continental growth and decline, of secular movements of the earth's crust. When the mountain-making forces have operated vigorously on a large scale the strata become so folded, faulted and disguised that the evolution of land growth over this part of the continent is largely obliterated. But when crustal movements have been slight or gradual and not accompanied by the sharp folding so characteristic of mountainous districts all changes of the ancient shore-line become reliable guides for a natural systematic arrangement of the various formations. In a region like the Mississippi basin made up of great flat-lying sheets of sediments the oscillation of the line separating land and water assumes special importance. The lithological character, the stratigraphical peculiarities, the faunal facies all closely follow inward and landward the advancing shore-line during periods of land subsidence; or proceed outward and seaward with the retreating waters where the coast rises. Ancient oceanic retreats are not clearly marked in the rocks except in a general way by the total absence, perhaps, of certain formations.

The extension of the seas over the land, on the other hand, are more or less well defined over at least some portion of the geological province. The details are disclosed in the unconformities of the strata, which may be either local or wide spreading in their character. Unconformities, therefore, assume important rôles in all regions like those under consideration when it comes to seeking for the most reliable criteria in systematically arranging the strata in accordance with the principles already mentioned.

The Continental Interior Previous to the Carboniferous.—The Archæan crystallines forming the nucleus of the North American continent sweep down from the far north in a broad belt to the southern shore of Lake Superior, where they bend abruptly and pass northeasterly through Ontario and Quebec, striking the Atlantic ocean just above Newfoundland. Around the borders of these old crystalline areas the Paleozoic sediments of the continental interior were laid down. The deposition of each formation carried the old shore-line farther and farther southward until at the close of the Carboniferous period the land surface had been extended to the central portion of what is now the state of Arkansas. From old Laurencian times to the beginning of the Carboniferous the great body of water of which the Gulf of Mexico is the diminutive remnant, and which covered the major part of the present area of North America, rapidly shoaled and deepened many times. A large mass of sediments derived from the secularly decayed crystallines of the ancient land surface constantly crept seaward, forming extensive sand accumulations near shore and farther outward argillaceous beds, which soon mingled with the calcareous materials of the deeper waters. At the commencement of the Carboniferous a vast sea of shallow water spread out over what was soon to be the heart of a great continent. A long period of quietude existed over the region, during which great beds of limestone were laid down in sheets more or less continuous throughout the area. Both the structural characters of the fossils and the arrangement of the beds indicate a very slow alteration of the sea bottom. The physical conditions imposed formed an especially favorable environment for a wide geographical and geological dispersion of the various forms of organisms. The remarkable uniformity of these conditions over wide areas is amply attested by the occurrence of identical species in localities widely separated geographically. Yet, notwithstanding the extensive distribution of the large majority of forms, many of the tribes were very limited in space, and especially in time. Those groups, therefore, which experienced a wide dispersion form valuable and reliable criteria for correlating horizons far removed from one another. The sequence, however, of strata of different localities can at best be only approximately determined from paleontological data. As suggested by Williams the biological sequence of any limited region does not necessarily indicate the genetic succession of the inhabitants, but merely a sequence of occupants within that particular area. The gradual oscillation of the sea bottom and the continual change of habitat to which most of the forms were subjected would have had a tendency to make their migrations extend over longer periods of time and their specific existence more prolonged than the stratigraphy of any one place would indicate. Thus, certain species would have become extinct in one region and be completely replaced by very different forms, while in distant localities, perhaps, the migratory species would continue to flourish in all their wonted vigor.

Major Members of the American Carboniferous.—In its leading features the geological and geographical limits of the Carboniferous rocks of the Mississippi province are pretty generally understood. The salient faunal characters are even more familiar; since the organic remains, entombed everywhere in great profusion throughout the extent of the later Paleozoic rocks of the region, attracted attention long before the rocks themselves were carefully studied. For more than half a century fossil collectors by the score have taken great delight in delving after new treasures, while during more than two generations students have almost daily brought to light new facts through their own researches and through the comparisons of the myriads of forms already obtained by others.

The Carboniferous rocks of the world are commonly referred to one of three periods: The Lower Carboniferous (Sub-Carboniferous), Carboniferous proper, and the Permian. In the Mississippi basin only the first two of these have heretofore been considered as well marked divisions. The third has had claims of recognition along the Missouri river, but it is doubtful whether it can be differentiated from the series of strata usually called the Upper Coal Measures. Although so important a formation in many parts of Europe, where all three members of the Carboniferous were first studied and defined, the so-called Permian of this country does not assume any great importance as a distinct and separate geological division. The beds of Kansas which have been referred to the uppermost division of the Paleozoic appear for the most part to belong more properly to the Upper Coal Measures, as shown very conclusively by Meek and others.

The Carboniferous rocks of the Mississippi basin form geologically a three-fold division. The line of demarkation between the lower and median members is the same as that which has been recognized since the region was first studied. The delimiting boundaries of the middle and upper series are as yet somewhat vague but they coincide approximately with those which usually separate the "Lower" and "Upper" Coal Measures. Recently these two series have been called the Des Moines and Missouri formations respectively. A lower portion of the latter was probably formed contemporaneously with the former but as there are doubtless few or no exposures open to view these seaward-lying beds are of small importance practically.

Broadly speaking the three divisions recognized represent marked changes in the relations of the land and water areas of the region. During the Lower Carboniferous, or Mississippian, open sea conditions prevailed widely. While the Lower Coal Measures were being laid down shallow waters continued to follow a northward retreating shore-line, as a long period of continental subsidence set in. The "Upper" Coal Measures represent another cycle when the sea again had full sweep over the region.

The Carboniferous of the Mississippi province has been divided into:

(1) Pennsylvanian Series.

(2) Mississippian Series.

It is quite probable that the first of these should be again divided into two portions having equal rank with the second, and corresponding to the Missouri and Des Moines formations, or "Upper" and "Lower" Coal Measures. The arrangement here suggested applies more particularly to the Interior basin, west of the line of the Mississippi river. It is quite likely that it is also applicable, with some minor modifications, perhaps, to the Carboniferous area east of the great river, though the geological history of the two districts began to be more or less independent of each other even before the close of the Lower Carboniferous period.

The leading historical events which transpired during the deposition of the Carboniferous sediments in central North America will receive full consideration elsewhere.

THE MISSISSIPPIAN, OR LOWER CARBONIFEROUS, SERIES.

In ascending the Mississippi river from Cairo to St. Louis and from St. Louis to Rock Island one is impressed with a remarkable series of limestones visible on one side of the river or the other nearly the entire distance. They rise in steep acclivities, high mural escarpments and overhanging cliffs miles in extent. Were the section fully exposed and unbroken by the corrading action of running water from the numberless tributaries of the great stream, the rocks in practically parallel bands would be seen rising and sinking in broad graceful undulations like the monstrous folds of some mighty fabled serpent. If the traveler be acquainted with even the rudiments of geological history his interest will be keenly awakened as he passes or tarries at certain landings; Chester, Kaskaskia, Ste. Genevieve, St. Louis, Kinderhook, Warsaw, Keokuk, Burlington. These have become classic names in American geology. Under one of these terms or another are known the vast beds of "Mountain Limestone," as represented in the broad Mississippi basin, extending with more or less regular continuity from the southern shores of Erie to the Lake Valley mining region of New Mexico, and from the "Coteau des Prairies" to the southern prolongation of the Appalachians in northern Alabama.

The maximum thickness of this great succession of Lower Carboniferous strata is probably not far from 1,200 feet; but the actual measurement in any one place is of course considerably less. Shales, sands and limestones they are chiefly, the latter greatly predominating almost to the exclusion of the other rocks, and presenting a very marked contrast to the overlying Coal Measures. The distribution, the lithological characters, the wonderful uniformity in stratification over wide areas and the inclosed faunal remains, tell of a broad open body of water that once stretched out over the interior of the western mainland; of a vast expanse of shallow water broken only here and there by a few small islets; of a long period of quietude when all changes in the depth of the great sea were exceedingly gradual and affected but slowly its host of tenants.

Derivation of the Limestones.—The Mississippian limestones have been derived for the most part from organic remains. At the time of deposition animal life of various types abounded in particular regions, where age after age the hard parts of the numberless species and countless multitudes of individuals accumulated. In other districts corals have usually supplied the bulk of the material for extensive limestone beds; but in the Lower Carboniferous series the organic débris differs from the usual order, in being chiefly composed of the remains of crinoids. In this peculiar feature the rocks as represented in the Interior basin are so distinctive that they were called "Encrinital" limestones by the earlier geologists who explored the region. A very appropriate name it is, for the disjointed skeletal remains form great beds of what has been aptly termed a "crinoidal breccia." The beds, however, are seldom uniform in physical characters; some layers are very hard and compact; others are easily crumbled. Frequently the strata are full of interstices with scarcely any finer cementing materials. Amongst the skeletal fragments, beds many feet in thickness are literally composed of nothing but broken and shattered calyces of crinoids, fragments of arms and portions of stems. In the massive compact beds the organic remains have been more or less completely comminuted by the grinding action of moving water. But often there are layers separated by clayey or sandy seams. Here lying partly enclosed by the hard limestone are sometimes myriads of stemmed feather stars, perfect as the day when they were entombed, forms of wonderous beauty and rare delicacy, gracefully and intricately intertwined like rich flowing Arabesques, and depicting clearly the condition of their environment when they waved slowly to and fro in the secluded depths of the great Carboniferous sea.

Mingled with the delicately built organisms, but in far less numbers, were forms of a closely related group of stalked echinoderms, the blastoids — very curious bud-like animals which became extinct ere the close of the Paleozoic. Occasionally also there are various species of echinoids, star-fish and ophiurans, the long serpentine rays of the latter sometimes entangled or wound around the arms of the crinoids. Other strata disclose countless shells of mollusks and brachiopods and still others multitudes of delicate retiary bryozoans perfectly preserved in a soft matrix of clay or shale. Another very characteristic feature of these rocks is the remains of fishes, principally the teeth and fin spines of hybodont sharks, and the oral plates of Cestracionts. So plentiful are these hard parts of fishes that locally the layers containing them are called "fish beds." Indeed it might be truly stated that perhaps no field has ever been more inviting to the student of ancient life than that presented by the Carboniferous rocks of the Mississippi valley. It is matchless in the multitude of forms presented; unrivaled in the continuity and succession of related faunas; unique in its simplicity and vastness. Fruitful as have already been the researches in the region, important facts are being continually brought to light, rendering more and more complete the great scheme of life as it was once, and ever revealing new episodes in the charming story as yet only hinted at in the half-read, ragged leaves of Nature's book.

Such then is the great basement upon which rests the coal deposits of the Continental Interior, by far the greatest single area of coal-bearing strata in the world. Its history is more wonderful than the stories of the East; more marvelous than the myths of antiquity. It forms one of the fairy tales of Science.

Use of Term.—For a long time the term "Subcarboniferous" has been widely used to designate the great series of "Mountain Limestone" forming at the base of the Carboniferous rocks of central North America. Of late years "Lower Carboniferous" has been substituted to a great extent. Still more recently the term "Mississippian" has been employed for the rock series under consideration. The objections to the use of "Subcarboniferous" are numerous. As originally proposed by Owen it embraced all strata below the Coal Measures down to the Hudson River beds, thus including not only the "Lower" Carboniferous but the Devonian and a great part of the Silurian as well. Since the term first came into geological use it has been restricted from time to time; and only of late years have its limits coincided with the boundaries of the Lower Carboniferous.

The most serious objection to the term "Lower" Carboniferous is that the term is not definite enough, though it may be retained as a substitute in special cases.

The title Mississippian* is a revival, with a slight terminal modification, of an old name originally suggested by Alexander Winchell†. He called the strata of the interior basin ordinarily designated as the Lower Carboniferous rocks, the Mississippi limestone, thus applying the name to the series of beds embraced within nearly the same limits as those included under the more familiar term.

Geographical Distribution.—The Lower Carboniferous rocks of the Mississippi basin are predominantly calcareous in their lithological character. As already said they are distinguished from the other great limestone formations of the region by being made up in great part of crinoid remains.

In the Continental Interior the beds of Lower Carboniferous age have a large surface exposure. They extend in a narrow strip along the northern and western borders of the Appalachian system, from western New York, through Pennsylvania, Ohio, Kentucky and Tennessee, to northern Alabama. In southern Kentucky they extend westward to the mouth of the Ohio. They sweep round the Cincinnati dome into western Indiana. The Carboniferous basin of Michigan lies immediately north of the uplift and is separated from the western Indiana and eastern Ohio strips only by narrow bands of older rocks. The Lower Carboniferous deposits do not

* Williams: Bul. U. S. Geol. Sur., No. 80, p. 135. Washington, 1891.

† Proc. Am. Philosophical Soc., vol. XI, p. 79. Philadelphia, 1879.

appear to be exposed at the surface at all in northern Illinois. From the mouth of the Ohio the strata of this age occur on both sides of the Mississippi river for a distance of more than three hundred miles, reaching northward to the mouth of the Iowa river, about twenty miles above Burlington. From this point they bend northwestward, reaching nearly, if not quite, to the Iowa-Minnesota boundary line. From the mouth of the Missouri the Lower Carboniferous limestones extend around the Ozark uplift, through central and southwestern Missouri to the eastern part of Indian Territory and the northern and central portions of Arkansas. They then continue southwestward into New Mexico.

Geological Delimitation.—Regarding the stratigraphical limits of the Lower Carboniferous rocks of the Mississippi basin little difficulty has been experienced in limiting the formation above. Wherever the superior portion is exposed the limestone gives away abruptly to shales and sandstones; the marine fauna disappears and its place is taken by brackish water and littoral forms; and a line of marked unconformity separates the calcareous and argillaceous beds. The line of demarkation between the two formations is so pronounced that it was one of the first stratigraphical features to force itself upon the attention of the earlier geologists who studied the succession of the rocks in the Mississippi valley. For many years throughout the region it was the starting point for all classifications of the Paleozoic. It was the line from which all correlations of the rocks above and below were begun. It was an horizon which was easily recognized and to which all others could be referred. Above it were the coal deposits which alone enabled a boundless, savage wilderness to blossom, in a single generation, into a modern nineteenth century civilization. Below it the magical wand was not. Important as it was as a stratigraphical datum-line, as a guide to the prospector for mineral wealth its value was even greater. In its bearing, therefore, upon the geological investigation of the country it has been one of the prime factors of progress and must ever remain one of the leading landmarks in the study of the rock strata of the American interior.

While the top of the Mississippian series over the greater part of its geographical extent is so clearly set off from the overlying formations its basal limits are rather vaguely defined.

When Owen, a third of a century ago, began his geological explorations in the Upper Mississippi valley he placed an indefinite series of strata lying below the Coal Measures in his "Sub-Carboniferous." At a somewhat later date the same author gave as the base of the "Sub-Carboniferous" the blue, fossil-bearing limestones now known as the Cincinnati beds. Half a decade later Owen and Norwood still farther restricted the formation by calling the "black slates" the uppermost member of the Devonian. Thus for the first time the term Subcarboniferous was given the meaning which has of late years been generally attached to it.

In Ohio, where shore deposits make up the Lower Carboniferous rocks for the most part, the stratigraphical considerations to be taken up are somewhat different from those in other parts of the basin. The rocks are chiefly argillaceous shales and grits with limestone at the summit. The series is now widely known as the Waverly beds, the entire sequence probably being the shore equivalent of the great Mississippian limestone of the more central portion of the basin. The black shale (Cleveland shale) is generally regarded as the base upon which rest the Lower Carboniferous beds of the state named. This thick bed is said to be quite persistent. It extends over a large part of the state and passes southward into central Kentucky. A similar black shale in Tennessee and Kentucky was the upper limiting member of the Devonian, according to Owen and Norwood, as already stated. Meek and Worthen also refer in a number of places to a "black shale" occurring in Indiana and Illinois, which they regard as identical with the Tennessee beds, and which they consider as occupying a similar stratigraphical position. In Missouri there is a thin stratum of dark colored bituminous shale, immediately beneath the Louisiana (Lithographic) limestone. If the black shales just referred to form one and the same stratum and consequently the same geological formation, it is a remarkable fact. Its wide geographical extent, persistence, and lithological uniformity would be indeed something little short of marvelous. The origin of all such shales is practically the same. The deposits are products derived from the denudation of the land, and a sifting of the fine clay particles from the coarser materials, as gravel and sand, through a mechanical separation effected by currents of water. The color, whether gray or blue as when it is originally deposited, or red, brown and black, as it may afterwards have become, is the most prominent physical character of a clay bed at first sight and is perhaps the first feature to attract attention. If, however, towards the close of the Devonian a great expanse of shallow water occupied the northeastern portion of the Continental Interior, in which were abundant growths of seaweed after the manner of the Sargasso seas of to-day, as was suggested by Newberry, the presence of such a widely distributed stratum of black, organicly colored clay or shale is easy of explanation. The accidentally tinted bed thus becomes a convenient horizon for separating the Devonian and Carboniferous within the region mentioned. But there is considerable doubt at present as to whether the "black shale" actually does form a single horizon over all the eastern area ascribed to it. It is also questionable whether the Devonian of the Upper Mississippi can be properly regarded as ending with the "black shale."

The fossils of the Bedford shale, the lowermost member, according to Newberry, of the Waverly or Lower Carboniferous in Ohio, and the formation immediately overlying the Cleveland black shale, which have lately been studied carefully by Herrick, appear to belong to a lower horizon, and to have a typical Devonian facies.

Still more recently the basal line of delimitation of the Carboniferous has been critically examined in northeastern Missouri. The preliminary results of the examination have already appeared.

The facts, however, may be briefly summarized in this connection as they are important in their bearing upon the classification of the Carboniferous rocks of the region. The subject may apparently open again the "Chemung controversy" of thirty years ago, when the Kinderhook beds of Burlington, Iowa, were regarded by some as Devonian in age. Even a casual consideration of the present question will soon indicate the very different lines and limits of the two problems.

At Louisiana, in Pike county, Missouri, the so-called base of the Carboniferous affords more favorable opportunities for examination than perhaps anywhere else.

Good exposures, however, are numerous along the great river for a distance of more than seventy miles.

The vertical section is as follows:

		Feet.
16.	Limestone, brown and white, compact, encrinital, thinly bedded, with some chert	55
15.	Limestone, white, encrinital, very heavily bedded	12
14.	Limestone, coarse-grained, encrinital, very heavily bedded	20
13.	Limestone, massive, white, encrinital, coarse-grained, with abundant white chert nodules and nodular bands	11
12.	Limestone, brown, encrinital, compact and heavily bedded, somewhat earthy in places	10
11.	Limestone, compact, fine-grained, buff, with few or no partings	8
10.	Shale, sandy, brownish, forming soft friable sandstone locally	12
9.	Shales, greenish, clayey	70
8.	Limestone, thinly bedded, compact, fine-grained, with conchoidal fracture, in layers 4 to 6 inches in thickness, like lithographic stone in texture and appearance	50
7.	Clay-shale, sandy in part, (2 to 4 inches)	
6.	Shales, dark blue or greenish, clayey	2
5.	Shales, black, fissile, clayey	4
4.	Limestone, buff, magnesian, very heavily bedded	10
3.	Oolite, compact, white	5
2.	Clay-shale, blue, with thin bands of impure limestone	60
1.	Limestone, heavily bedded, (exposed)	5

Number 1 is the Trenton limestone; 2 the Hudson River shales; numbers 3 and 4 probably represent the Niagara limestone; the first increases rapidly in thickness southward and in a distance of twenty miles reaches a vertical measurement of thirty to forty feet. Numbers 5 and 6 are probably Devonian, equivalent to the "black shale" of adjoining states. Number 7 is a thin seam two to four inches in thickness and highly fossiliferous. With few exceptions the "lithographic" fossils come from this layer. It probably belongs more properly with beds 5 and 6. Apparently the organic remains are nearly all identical with forms from the Hamilton rocks farther northward. Should the union of this thin highly fossiliferous seam to the underlying shales be more in harmony with the real relations of the faunas of the respective beds, as now seems likely, then the Devonian facies of the Lithographic (Louisana) limestone is lost entirely. Number 8 is the Louisiana limestone, a compact rather thinly bedded rock, breaking with a conchoidal fracture. It is very poor in fossils. Numbers 9 and 10 are the Hannibal shales, number 11, the Chouteau limestone, with a few fossils. Number 12 is the Burlington limestone with the characteristic basal fauna of the Lower Burlington. Number 13 is also the Lower Burlington limestone but contains a Kinderhook fauna; 14 and 15 belong to the Lower Burlington; 16 contains the typical fauna distinctive of the upper division.

Owen, who was the first to give attention to the geological details of the rocks as exposed along the "Father of Waters" above the mouth of the Missouri, used in 1852, the term "Subcarboniferous," which hitherto had long been applied to all the strata below the Coal Measures as far down as the Lower Silurian series, in a very limited sense. The Louisiana or "Lithographic" limestone was not included; for his "argillaceous marlites" seem to have been regarded as the basal member.

Swallow, Hall and White, who were all well acquainted with the sections and their fossils, correlated the beds immediately below the Burlington limestone with the Chemung (Devonian). In northeastern Missouri and adjoining portions of Iowa and Illinois, the "Chemung" included the Chouteau limestone, Vermicular shales and Lithographic limestone.

Hall, having studied more particularly in Iowa, erroneously regarded certain sandy shales, or yellow sandstones, just below the great limestone at Burlington, identical in age with a lithologically similar rock fifty miles to the northward, at the mouth of Pine creek, in Muscatine county. Consequently, having investigated the northern locality more thoroughly, perhaps, he very naturally came to the conclusion that the entire formation under consideration as he understood it was actually Devonian. But the rocks of the two places are widely separated in point of time, and it has been shown recently by Calvin* that the latter do really belong to the Devonian.

Meek and Worthen, who had considered chiefly the fossils in the upper part of the so-called "Chemung," both at Burlington, Iowa, and Kinderhook, Illinois, a few miles from Hannibal, Missouri, regarded the fauna more closely related to the Carboniferous than the Devonian. Since the publication of these views writers upon the subject have accepted them and they have been adopted in all of the later geological reports of Illinois, Missouri and Iowa.

By reference to the vertical section already given it will be seen that the commonly called Kinderhook of this region is a three-fold division, the upper and lower portions being limestones and the middle one a clayey or sandy shale. At Burlington the fossils heretofore noted have been found only in the upper part of the formation, though recently an extensive and interesting fauna has been discovered in the clayey portion much lower down. Here the lower calcareous member is not exposed. At Louisiana and vicinity the median member is practically unfossiliferous, as is also the lower, except at the very base.

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*Am. Geologist, Vol. III, p. 25. 1889.

It will be recalled that Marion and Pike counties, Missouri, at Hannibal, Louisiana and Clarksville, principally, were the leading localities for a large proportion of the "Kinderhook" fossils originally described by Shumard, White and Winchell. And it has been noted that most of these fossils have a decided Devonian aspect; that they give a peculiar tone to the fauna of these beds.

Heretofore little mention has been made concerning the exact horizon of the fossils in question, since reference to the "Lithographic" limestone or "Kinderhook" beds has been considered sufficient. Lately, however, extensive collections of fossils have been made at all three of the places just mentioned, as well as at many intervening and neighboring exposures. Everywhere the "Lithographic," or Louisiana, limestone has been found to be practically devoid of organic remains except an occasional form in the thin sand partings above the bottom layer which is less than one foot in thickness.

At the very base of the limestone is a thin seam of buff, sandy shale seldom over three or four inches in thickness (number 7 of section). This seam is highly fossiliferous. It contains the *Productella pyxidata* (Hall), *Cyrtina acutirostris* (Shumard), *Chonetes ornata* (Shumard), *Spirifera hannibalensis* (Shumard), and a host of other forms, many indistinguishable from species occurring in undoubted beds of western Hamilton—the Cedar Valley limestone of Iowa. The sandy seam is underlain by six feet of dark colored argillaceous shale which has been regarded as part of the Devonian "black shale" of the Mississippi basin. This in turn rests upon fifteen feet or more of buff magnesian limestone and oolite of "Niagara" age probably.

Lithologically the thin sandy layer is more closely related to the underlying shales than to the overlying limestones. Faunally it has very much closer affinities with the western Hamilton (Devonian) than with the Kinderhook (Lower Carboniferous).

In Iowa the "Devonian aspect" of the Kinderhook fossils has disappeared largely since Calvin's recent discovery that the "Kinderhook" sandstones of Pine creek, Muscatine county, are in reality true Devonian. In Missouri the same Devonian facies of the fauna contained in the lowest member of the Carboniferous is lost from view completely by eliminating the species found in the thin sandy seam at the base of the Louisiana, or Lithographic, limestone. Thus the faunas of the Devonian and Carboniferous of the upper Mississippi valley become more sharply contrasted than ever. The apparent mingling of faunas from the two geological systems manifestly is due to erroneous assumption rather than detailed field evidence.

Depriving the "Lithographic" limestone, which attains a thickness of more than sixty feet at Louisiana, in Pike county, Missouri, almost entirely of the extensive fauna commonly ascribed to it, and which, as has been seen, comes from a thin seam lying below the calcareous layers its geological age becomes a problem yet to be solved. The few fossil species known from the limestone itself have been heretofore rarely met with.

It is quite likely, however, that these organic remains will be found eventually scattered through the entire vertical thickness of "Lithographic" beds. But even if it should prove more advisable to place the Louisiana limestone in the Devonian it would not radically change the present classification of the Carboniferous.

The Louisiana limestone appears to thin out rapidly northward. Borings at Keokuk show that there are only ten feet of limestone which can be referred to this formation, only one-sixth of the thickness at the typical locality in Missouri. A short distance beyond it probably disappears altogether.

Until, however, sufficient evidence is adduced to show conclusively that the limestone beds are best united with the Devonian they must be regarded as forming the basal member of the Carboniferous in this region.

In Iowa little is known as yet in regard to the exact relations of the beds forming the top of the Devonian and the base of the Carboniferous.

Biological Definition.—The fauna of the Mississippian series is a strictly marine phase of animal life. It is rather sharply cut off below from the Devonian faunas by the absence of many characteristic genera and by a marked change in the structural features of numerous groups common to both horizons. Above, it abruptly terminates over the greater part of its range with the shore and brackish-water types of the Coal Measures.

Of the different zoological groups the corals, brachiopods, mollusks and crustaceans continued as in the earlier Paleozoic to flourish in large numbers, and myriads of individuals are often collected together in places. A special feature which is quite noticeable in these groups is the prominence which the gasteropods assumed among the mollusks and a great diminution in size and number of the trilobites among the crustaceans. The most important and characteristic biological feature of the Mississippian rocks, however, was the great development and expansion of the echinoderms and fishes. Among the former the crinoids and blastoids assumed such unusual prominence that Dana has called the period the Crinoidal period of geological history; while Wachsmuth has suggested the names "Crinoidal" and "Blastoidal" limestones to designate the upper and median portions of the series.

Indeed the crinoids and blastoids make up such a conspicuous part of the fauna of the Mississippian that they must ever remain the most valuable and most reliable criteria in the classification of the series in accordance with the life remains. Their existence during a long period of time and their wide geographical distribution gave unusually favorable opportunities for the recording of all the geological changes throughout the entire basin. Besides, their structural features also are particularly well adapted to giving an insight into the physical conditions of their habitat. In the general relations of the plates making up the skeletal parts, in their definite arrangement, in the surface ornamentation, in the delicately constructed arms and characteristic stalks are found admirable features for tracing the evolution of the different forms from the bottom to the top of the series. The different phases passed through in the evolution of the different groups are most noticeable among the actinocrinoids, yet they are also well marked in many other families. In almost every case the various forms beginning in the Lower Burlington were small sized, and delicately ornamented. As the different types advance upwards they rapidly increased in size, the plates becoming very much heavier, the ornamentation coarser, and many structural features greatly exaggerated in various ways.

The blastoids, though abundant in the lower part of the series, became astonishingly numerous in the upper part, where in many places they almost excluded all the other groups of echinoderms. Near the top they acquired a very large size, certain species assuming enormous proportions.

The hard parts of fishes are exceedingly abundant and in places often make up entire layers. The species are very numerous and the generic types quite varied.

Subdivisions of the Mississippian Series.—The Carboniferous rocks of the Continental Interior have been recently the subject of special investigation. The resulting systematic arrangement, as based upon the best lithological, stratigraphical and faunal evidence now at hand, is that given in the scheme below. The table indicates the relations of the geological terranes as at presence understood. It also shows the arrangement of the various minor subdivisions which have from time to time been described in different parts of the region. The tabulation applies essentially to the more strictly marine deposits which have such a wide geographical distribution. The Waverly shore sediments probably cannot be paralleled in their smaller divisions with the terranes here recognized; but as a whole may be regarded as representing approximately the entire Lower Carboniferous series of the more westerly region of the upper Mississippi.

MISSISSIPPIAN SERIES.	Kaskaskia....	"Chester shales." "Kaskaskia limestone." Aux Vases sandstone.
	St. Louis	Sainte Genevieve limestone. Saint Louis limestone. Warsaw limestone (in part not typical).
	Augusta......	Warsaw shales and limestones (typical). "Geode bed." Keokuk limestone. Upper Burlington limestone. Lower Burlington limestone.
	Kinderhook ..	Chouteau limestone. Hannibal shales. Louisiana limestone.

The basal division, the Kinderhook, is commonly regarded as a triple member of which the upper and lower portions are limestones, the median part clay and sandy shales.

The second grand division of the Lower Carboniferous is the Augusta limestone. This embraces the five divisions of southeastern Iowa called respectively, the lower and upper Burlington limestones, the Keokuk limestone, the "Geode bed," and the typical Warsaw shales and limestones. This formation has been shown to be practically one, upon both stratigraphical and paleontological grounds. Furthermore, local unconformities appear between the upper stratum, the "Warsaw," and the overlying rocks. Aside from the upper portion the Augusta formation is made up almost entirely of massive limestones everywhere highly charged with organic remains. Fossil echinoderms are especially abundant; brachiopods also form a prominent feature. As has been fully set forth in another place the faunas contained in the Augusta beds are to be regarded as perfectly continuous throughout. The limestone is essentially a crinoidal one, though in its upper part this character is not as well marked as toward the base. The section commonly known as the Burlington is everywhere the same coarse-grained, encrinital limestone, usually white and quite pure in certain layers. The basal portion — the "lower" Burlington limestone — usually contains considerable ferric oxide and consequently has a characteristic reddish hue on weathered faces. The lithological features of the Burlington are remarkably constant over broad strips of territory. They have been traced from east central Iowa to western Illinois, to southwestern Missouri and Arkansas. East of the Mississippi the typical exposures of this rock are unimportant and the sections are confined to the vicinity of the great water-course. The division lines of the two Burlington limestones and of the Keokuk are marked by silicious beds. The lowermost of these chert beds has a thickness of twenty to twenty-five feet. It is made up largely of nodular masses and irregular beds of flint with some calcareous matter. The upper chert bed — the one between the Burlington and Keokuk limestones — was reported by Hall to be upwards of one hundred feet in thickness. Recent observations go to show, however, that it probably has no greater importance than the lower chert bed. Accurate records of borings indicate that the entire thickness of the Augusta beds — from the top of the "Warsaw" to the bottom of the Burlington — is not over 225 feet. Wherever the Augusta limestone is exposed along the Mississippi north of the Missouri river, it stands out over soft Kinderhook shales in rugged, overhanging cliffs or high walls. At Burlington the basal line is marked by heavy layers of limestone which often project to a distance of twenty or thirty feet. The small streams flowing over the limestone break into cascades twenty-five to fifty feet in height.

The upper Burlington division differs from the lower, in its lithological characters chiefly by being more thinly bedded and containing layers of argillaceous shale.

The Keokuk beds are distributed chiefly on the east side of the Mississippi, covering a wide area in Illinois, Indiana, Kentucky and Tennessee. West of the river the best exposures are in southeastern Iowa and northeastern Missouri. At the typical locality the Keokuk beds consist of gray encrinital limestones with considerable chert, in layers or nodules. The lower portion is a heavily bedded, compact limerock having a bluish cast. The upper part is composed of clay shales with calcareous bands.

The Warsaw beds as originally described, consist of two massive layers of yellow limestone separated by thirty feet of blue calcareous shales with many thin limestone seams. Beyond the immediate vicinity of Warsaw the formation has not been recognized in its typical development. The "Warsaw" reported from many localities has in most cases proved to be lower St. Louis.

The light ash-colored limestones, occurring in Iowa and now known under the name of St. Louis, were first mentioned by Owen under the title of concretionary limestone. Near the mouth of the Missouri river where these rocks attain a much greater development Shumard gave them the name of the leading place in the region. Since this recognition by Shumard little difficulty has been encountered in locating the St. Louis limestone over a wide stretch of country. Its northern border is several hundred miles beyond any known exposure of Keokuk rocks. From this limit nearly to the mouth of the Missouri river the limestone is quite thin; but southward it rapidly thickens until in Ste. Genevieve county, Missouri, it attains a measurement of more than 300 feet; and still farther southeastward more than double the thickness known in the state mentioned. Everywhere over the northern area of the St. Louis a characteristic brecciated rock is observable; but south of the Missouri river evenly bedded limerocks are present with occasional extensive beds of oolite.

Frequently, near the base of the limestone is a well marked breccia made up of a very fine-grained, compact blue limestone which breaks with a conchoidal fracture. The fragments are angular and vary in size from a few inches to several feet. The interstices are filled with a clayey calcareous material which is usually much softer than the limestone and in weathering allows the limestone fragments to project far beyond the matrix. Above the brecciated portion of this limestone the strata are laid down very irregularly, but upward rapidly pass into evenly bedded layers. Capping the St. Louis limestone is often seen ten to twenty feet of white calcareous marl which is usually highly fossiliferous.

The upper member of the lower Carboniferous is the Kaskaskia. North of the Missouri river the epoch was one of denundation but south of the line mentioned deposition continued. The formation is a triple division made up of a basal portion called the Aux Vases sandstone; a median part, the Kaskaskia limestone proper; and an upper portion usually made up of argillaceous shales. The sandstone has been noted from time to time but its true significance does not appear to have been fully understood until quite recently, when the absence of the Kaskaskia rocks north of the Missouri river was also taken into consideration. This sandstone is said to be exposed above the city of St. Louis where it is a dozen feet or more in thickness. Southward it rapidly thickens until in the immediate vicinity of the typical locality it attains a maximum measurement of more than one hundred feet.

The great arenaceous deposit lying immediately below the Kaskaskia limestone has been termed ferruginous sandstone by Shumard and others. Most observers, however, have confounded it with the lithologically similar rock occurring at the base of the Coal Measures, but the latter is located upon instead of under the Kaskaskia. In northern Missouri and Iowa where the superior member of the Mississippian series is wanting the basal sand rocks of the Coal Measures occupy apparently the same stratigraphical position as the lower Kaskaskia sandstone, that is directly superimposed upon the St. Louis.

Upper Mississippi Region at the Beginning of the Coal Measure Epoch.—The latter part of the Lower Carboniferous age is noteworthy as a period of land elevation. The crustal movements over this part of the earth's surface were continental in their character. The relative change between the land and sea areas was an apparent rising of the former and a gain of vast tracts of territory from the latter along the borders of the growing continent. An entire geological formation,—the Kaskaskia—the uppermost member of the series, was not deposited over a large portion of the present upper Mississippi valley, and the evidence is ample indicating that the shore-line of the old Kaskaskia sea retreated southward during the epoch to a point beyond the present mouth of the Missouri river, a distance of more than four hundred miles from the coast of the St. Louis waters at the time of their greatest expansion. Shore deposits were laid down far beyond any point previously reached in the growth of the nascent continent.

When the oceanic waters again invaded the land the territory upon which most of the coastal sediments were laid down had become an old, water-worn surface, channelled and grooved everywhere, with hills and hillocks, ridges and swells rising up from the numberless waterways. The Kaskaskia epoch, then, was one possessing much more importance than is usually ascribed to it. Over much of the Mississippi valley it represents, between the marine platform beneath the Coal Measures and the coal bearing strata themselves, the long erosion interval during which was formed a great irregular plane of unconformity for the basal members of subsequent shallow water deposits.

As the land began to slowly sink and the seas commenced to gradually creep inland owing to wide-spread, though slight, perhaps, secular changes in the earth's crust, the physical conditions became very favorable to the formation of luxuriant vegetable growths, destined to make the thick, matted masses which were to be preserved during the ages. The shallow marshes of brackish water, choked with dense jungles of tropical plants, preceded the open seas which subsequently spread over the province, covering all like a mantle.

In the deposition of the coal-bearing strata of the interior a long period was marked out during which there was a prolonged though somewhat intermittent continental subsidence, which continued until a rapid continental movement set in, driving again the maritime border southward far beyond its former position at the close of the Kaskaskia.

PENNSYLVANIAN, OR COAL MEASURE, SERIES.

Occurrence of coal.—It is a significant fact that the Paleozöic coals of the world are all deposited in more or less limited basin-shaped areas. In England, in France, in Germany and in other European countries, in India and elsewhere the coal mining industry is developed only in those districts which geologically are more or less completely isolated. Careful investigation by many different workers in the various coal fields points to a common geological history for all. In America the same phenomena are observable. But in the interior of the western continent the vastness of the area, over which must have extended such a similarity of physical conditions during the deposition of the coal-bearing rocks, is something remarkable and finds a parallel nowhere on the globe.

When the Coal period set in through the central part of North America the conditions of deposition were practically uniform over the entire extent of the area occupied by rocks of this age. Before, however, sedimentation had progressed very far orographic movements began to change the ordinary sequence of events in different portions of the region. Though comparatively slight in themselves these changes were of continental extent in character. The geological conditions, which at the beginning of the period seem to have been similar over the whole region, ere the close of the period began to assume phases which were variously modified in different places. Two portions especially may be contrasted. These were the coal fields which are now separated by the Mississippi river. The geological history of the two districts even commences to diverge somewhat before the more strictly marine sediments had ceased to be deposited in the upper Mississippi valley region. The considerations referred to in detail hereafter regarding the upper Carboniferous of the Interior basin will be applicable more specifically to the region west of the "great river," sometimes called the "Western Interior" coal field, though in its general bearing the eastern region may be regarded as having a very similar record.

The great economic value of the coal-bearing formation of the Mississippi province has directed particular attention to its geology. Within the limits of the region it may now be said that the Coal Measures have received more careful attention than any other of the geological formations represented. But, at the same time, for this very reason, the stratigraphical importance of the formation has been very greatly overestimated. It has led to the attachment of far too much significance to really trivial characters which, though they may be quite conspicuous in themselves, are of comparatively small value. Features which in other formations would be entirely overlooked, in connection with coal seams become greatly magnified on account of their bearing upon the expense of mining. Among these factors may be mentioned the various kinds of "faults," slips and "cut-outs." Besides, the great economic value of certain coal beds has led to attempts at correlation, which have often led to very erroneous conclusions. One of the most notable instances is the claim of a number of different workers that they were able to trace single coal seams continuously over all the territory lying between western Pennsylvania and Missouri. Later and more careful investigation has shown that this generalization was entirely unsupported by facts and that it was based upon very insufficient data.

In geographical distribution, in stratigraphical arrangement, in lithological characters and in faunal features the series of beds which bear most of the workable coal seams in the upper Mississippi basin, and which are commonly called the Lower Coal Measures, has an individuality that is peculiarly its own. In all respects it stands out sharply defined from all the formations beneath it. As a whole it presents marked contrasts with all associated strata both younger and older.

Regarding the geographical position in its general relations to the upper Carboniferous rocks, the "Lower" Coal Measures form a broad zone around the areas of the "Upper" division — a zone which separates everywhere the surface exposures of the latter rocks from those of older geological age. The geological delimitation of the

Lower Coal Measures is well defined. In its entirety, as has been indicated already, the Carboniferous of the Mississippi Valley presents three well-marked groups of rocks, the lower and upper members being manifestly marine deposits, the median section clearly a shore formation. Below, therefore, the Lower Coal Measures are cut off by the strictly maritime beds of the Mississippian series; above by the open sea deposits of the "Upper" Coal Measures. The delimiting line of the Lower Coal Measures below is one of marked unconformity. It has already been fully described, in connection with the Mississippian series. There is probably no greater physical break recorded in the entire sequence of Paleozoic rocks of the interior region.

The lithological and stratigraphical characters of the Lower Coal Measures are described in detail in subsequent chapters. The remarks there made apply, with a few modifications and additions perhaps, also to the eastern basin and need no further expansion here.

Prominent among the distinctive characters are the biological features of the Lower Coal Measures. In these respects there is a characteristic littoral, brackish or freshwater fauna and a luxuriant land or swamp flora as compared with truly marine faunas in the deposits above and below.

Coal Fields of the Interior Basin.—The Carboniferous basin of the Mississippi valley presents four more or less well-defined areas in which coal is obtained. These fields are known as the Appalachian, the Michigan, the Eastern Interior or Central, and the Western Interior.

Appalachian Coal Field. In a broad belt seventy-five to eighty miles in width, it extends a distance of more than seven hundred miles, from western New York through western Pennsylvania, the eastern borders of Ohio, Kentucky and Tennessee, the western portions of Maryland and the Virginias to northern Alabama. In its general geological structure it is a greatly elongated basin, made up of many folds trending with the eastern cordilleras. In the northern part the Ohio river flows southward through the median portion for nearly one-third of its entire length. The western half has a gradual inclination to the eastward; the eastern half to the westward. In Ohio the western slope is not a uniform one, as was once supposed, for as shown by Newberry, the Coal Measures of the state "lie in a series of subordinate troughs which are in a general way parallel with the axis of the great one of which they are parts." A similar series of folds has been recognized in the eastern half of the same basin, in Pennsylvania. With the nascent Appalachians on the east and the old Cincinnati uplift on the west, the region of the upper Ohio, submerged during Carboniferous times, must have been a long narrow arm of the great interior sea. Many of the minor folds and troughs were doubtless acquired after all the deposits had been laid down.

In the Appalachian, or Alleghany field, the subdivisions of the Upper Carboniferous are as follows:

5. Upper Barren Coal Measures.
4. Upper Productive Coal Measures.
3. Lower Barren Coal Measures.
2. Lower Productive Coal Measures.
1. Conglomerate series.

In a general way this sequence coincides to a remarkable degree with an arrangement recently made out in the Western Interior basin, which will be referred to more specifically in another place.

Michigan Basin. This is a small islolated district occupying about one-third of the areal mileage of the southern peninsula. Although having such a considerable geographical area it is of relatively little importance. The maximum thickness is not over two hundred feet, half of which is occupied by the basal sandstone. Only one or two workable veins of coal are reported; and the mining of commercial supples is confined entirely to two counties.

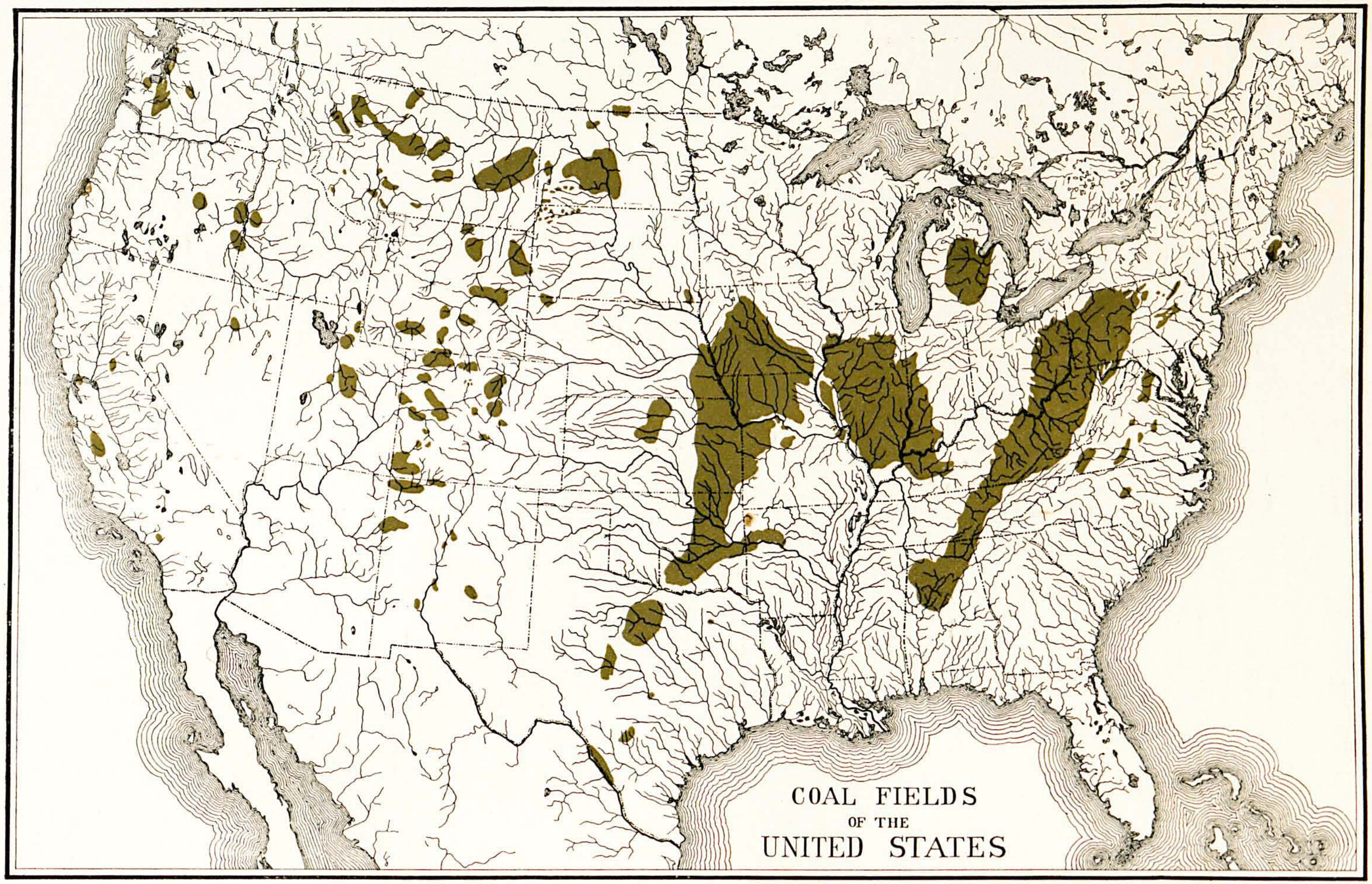
Eastern Interior Coal Field. The other two areas have been commonly regarded as essentially one, forming what has been called the great Interior coal field of North America. The Mississippi river divides the region into two parts. Along the dividing line the great watercourse has cut its channel completely through the coal strata, which probably were never very thick, exposing on each side, in a narrow strip, rocks much older. Everywhere within the limits of the area just referred to, along the borders of the stream, outliers or pockets of the coal-bearing deposits are found in ancient gorges and depressions, the beds connecting them with the chief masses having been almost completely removed through erosion, leaving only scattered remnants of their once greater extension.

The first of the two fields last mentioned comprises northwestern Kentucky, southwestern Indiana, central and southern Illinois. The basin is elliptical in general outline. It presents a wide marginal zone of coastal sediments carrying the coal of the region and a broad central area representing the more open sea deposits. The first of these formations has been usually known as the Lower Coal Measures and the second as the Upper. The number of seams are upwards of half a dozen and appear to have a much wider geographic extent than the beds west of the Mississippi river. The various beds have been numbered much after the same plan as in Ohio, but it is very doubtful whether any of them have near the range commonly ascribed to them.

Western Interior Coal Field. Occupying over two-thirds of the great coal producing area divided by the Mississippi river is a field which embraces the southern third of Iowa, the northwestern half of Missouri, the extreme eastern borders of Nebraska, Kansas, and Indian Territory and western Arkansas. It extends still farther toward the southwest in a narrow belt into central Texas. Eastward it thins out and is limited by the older formations which outcrop along the Mississippi river. Westward in the vicinity of the Missouri river it becomes covered by later deposits chiefly of Cretaceous age, so that its exact extent in this direction cannot be determined. On the whole the deposits of coal in single beds are not as extensive as in the region east of the great river, yet the total amount of accessible fuel is probably much greater.

Broadly speaking, the formations of this field correspond in their sequence in a striking manner with the arrangement commonly recognized in the coal bearing strata of Pennsylvania. It is of interest to note the areal distribution of the several formations seen in the western region. The recognition of the coincidence in general arrangement of the Pennsylvania and Iowa coal fields interferes in no way with the acceptance of the views advanced elsewhere, for the present suggestion merely gives, perhaps, undue prominence to certain minor episodes in the geological history of the district.

The geographical position and distribution of the coal bearing areas of the United States is shown in the accompanying sketch map which is modified from that published in the "Mineral Industries," one of the reports of the Eleventh Census of the United States. (Plate i).


COAL FIELDS
OF THE
UNITED STATES

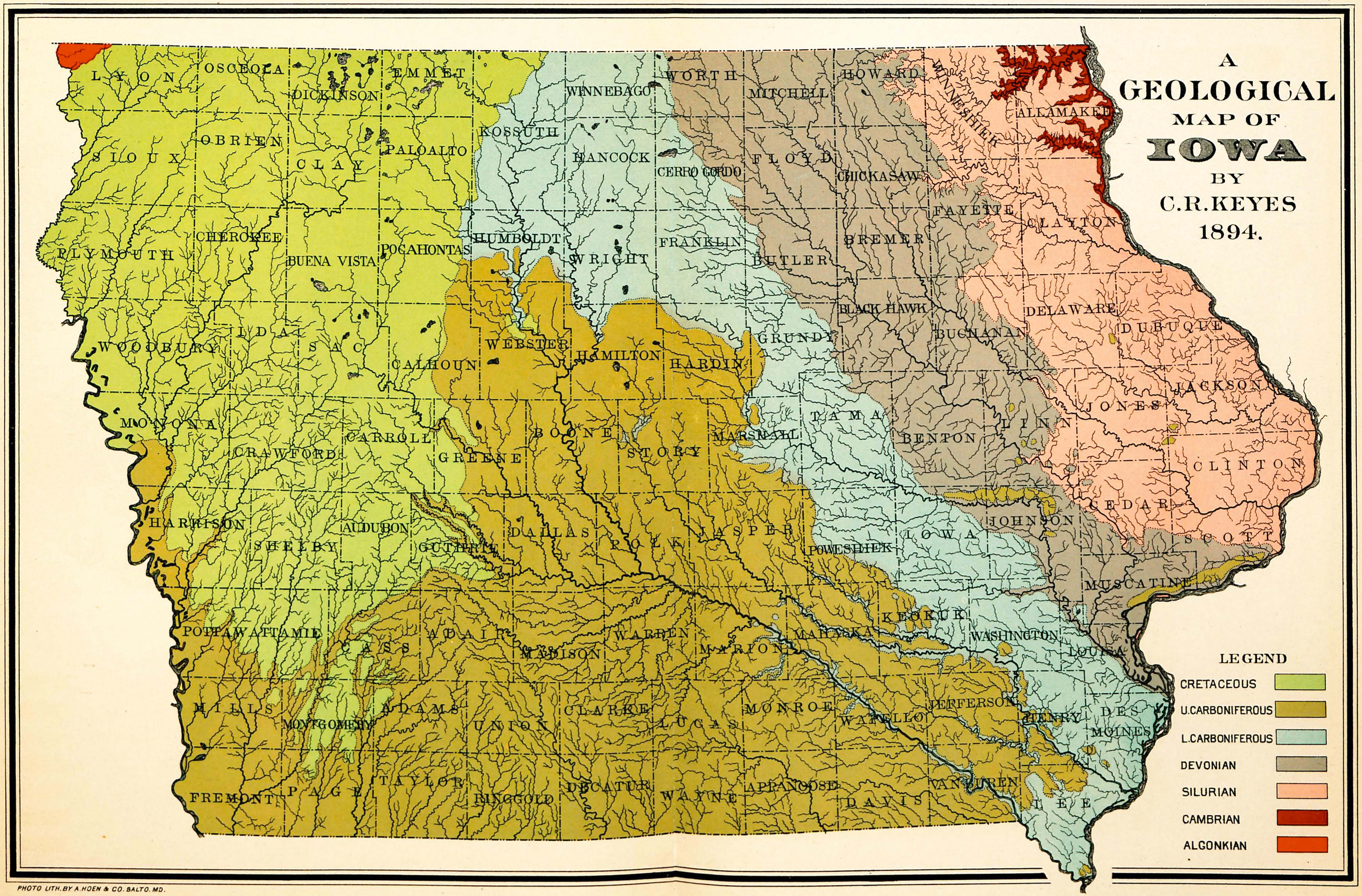


PHOTO LITH. BY A. HOEN & CO. BALTO. MD.

CHAPTER IV.

GENERAL GEOLOGY OF THE COAL REGION.

Geographical Limits of the Iowa Area.—The Iowa Coal Measures cover a little more than one-third of the entire surface of the state. Geometrically the area is a trapezoid with the entire southern boundary of the state forming one side, the Missouri river another; an irregularly curved line connecting Keokuk and Ft. Dodge a third; while the fourth, or northwesterly side, is not as yet well defined on account of the deep deposits of drift materials covering the region, but it is probably approximately along a sinuous line running from Ft. Dodge to Council Bluffs.

Beyond the boundaries mentioned, especially to the eastward, outliers of coal deposits are scattered even as far north as Jackson county on the Mississippi river. Many of these isolated basins often afford seams of coal sufficiently thick for profitable working.

The distribution of the coal-bearing rocks of the state as briefly described above is shown graphically on the accompanying geological map (plate ii). It will be noticed that the rocks having the same geological age as the coal of Iowa, and in which there is more or less likelihood of obtaining coal are distributed over half of the total number of counties in the state. The area covered by these Carboniferous strata is not far from 20,000 square miles.

It must not be inferred, however, that the coal is equally distributed over all this area; for such is not the case. The broad belt running southeast and northwest and traversed its entire length by the Des Moines river from Ft. Dodge to Keokuk has heretofore been found to be much more productive of coal than other parts of the district. Lately in places outside of this belt coal has been discovered in abundance and mines are rapidly being opened throughout the districts, often where the presence of the mineral was before unsuspected.

Topography.—The surface of the Iowa coal region is topographically a gently undulatory plane, moderately elevated and tilted slightly southward. The larger water courses traversing this district have cut their channels rather rapidly to a moderate depth. On this account in the vicinity of these streams the country is much more broken than in the interior and the slopes descend often quite abruptly.

The eastern two-thirds of the coal district is drained by waterways flowing southeasterly into the Mississippi river. In the western third the streams flow southwesterly into the Missouri. In the southeast the principal water courses are two sluggish branches of the Skunk river which meander along the extreme margin of the coal region. Immediately west of this basin the Des Moines river, flowing southeastward, drains more than one-third of the entire area. Still farther westward are the two branches of the Grand river, the Nodaway and the Nishnabotna. All of these streams belong to the types which are so characteristic of the drift. region of the upper Mississippi valley. Their drainage basins are comparatively very long and very narrow, and trend approximately parallel to one another. The observations of McGee on the streams of northeastern Iowa apply equally well to those of many other parts of the state. "The most striking characteristic of all these streams is their great length in proportion to their volume, and the striking characteristic of the basins is their length and slenderness. Moreover, there is a dearth of small tributaries, and so occasional lakes and ponds (generally too small to appear on maps), swamps, and extensive sloughs are common. Indeed the slough is a characteristic feature of the region. It stands midway between the swamp and the upland prairie. In pioneer days, when the prairie surface was heavily grassed, these tracts were thousands of square miles in extent, particularly in spring time, and were impassable to vehicles for most of the summer. Muskrats and crayfish inhabited them. They were dotted with the houses of the former and perforated with the chimneys of the latter. With the incursion of settlers some of the sloughs dried up spontaneously, others were drained, and now nearly all have been invaded by the plow, or at least converted into pasture lands."

The altitudes of the different parts of the plain already referred to are shown by the elevations of the places in the subjoined table:

Keokuk	625
Keosauqua	720
Bloomfield	860
Centerville	1,010
Fairfield	770
Ottumwa	750
Albia	950
Chariton	1,030
Washington	740
Sigourney	770

*U. S. Geol. Sur., 11th Ann. Rep., p. 359. 1893.

Oskaloosa	850
Knoxville	910
Indianola	970
Winterset	1,130
Montezuma	950
Newton	960
Des Moines	920
Adel	975
Boone	1,160
Ft. Dodge	1,175
Osceola	1,125
Council Bluffs	1,140
Red Oak	1,035

Where the largest streams cut the elevated plain the altitudes are from 150 to 200 feet lower than those of the general surface.

All of the coal region of Iowa lies within the limits of the glaciated area and the entire surface is covered consequently by a great mantle of soft, incoherent clays and sands commonly known as drift. This mass of glacial débris has a thickness from a few feet to several hundred feet. It rests on an unevenly weathered and eroded surface. The pre-glacial channels and gorges are often quite deep cutting into the Coal Measure strata often through the coal beds themselves. Frequently, at a considerable distance below the present surface of the ground, coal beds occur having practically no substantial roof. In the northern portion of the Iowa coal field soft Cretaceous sediments overlie the Coal Measures. Although known definitely only at a few points, as in the vicinity of Ft. Dodge, the Cretaceous probably covers the Coal Measure rocks to a much greater extent than has been commonly heretofore supposed. Hence on account of the character of the materials overlying the coal the topography of the Coal Measures is greatly subdued.

GEOLOGICAL FORMATIONS OF THE STATE.

The geographical distribution and the more salient features of the various geological formations represented in the state may be briefly alluded to here in order that the relations of the coal-bearing strata and older deposits may be more clearly understood. As may have been already inferred from what has been said, the strata are relatively little disturbed and lie in broad nearly level sheets, which often rise in low folds or sink in shallow synclines.

As commonly regarded, the oldest of the rocks exposed in Iowa are found in the extreme northwestern corner of the state. The next oldest are in the northeastern corner at the very base of the high bluffs along the Mississippi river. Around the latter point all the later beds are laid down with a slight inclination to the south and west.

Sioux Quartzite.—The rocks exposed within the limits of the state which are usually considered to be the most ancient geologically are those called the Sioux quartzite or Sioux "granite." They form outcrops of considerable extent in the northwestern part of Lyon county. While there is no doubt that all the stratified sediments of Iowa rest, at no very great depth, upon the great fundamental complex of crystallines which probably support all the sedimentary rocks of the globe, the Sioux quartzite and its associated masses are the only truly metamorphosed or massive crystalline rocks having a surface exposure in the state. The common phase of the rock under consideration is a completely vitreous type not unlike red jasper in general appearance and properties. Other parts of the mass are less indurated; and still others are simply loose sand. In places the formation is distinctly conglomeratic. Although the quartzite has been rendered in places so thoroughly crystalline since its original deposition as an ordinary clastic, no eruptive rocks have been noted in the vicinity until very recently. Within a few miles of the Iowa border large exposures of a black trap rock have been found in the midst of the Sioux quartzite. Microscopic examination shows that it is a coarse-grained, olivine diabase—a massive basic rock of unquestionably igneous origin. A little to the southward, in Sioux county, beds of flint-like lavas have been encountered in boring. These rocks are typical quartz-porphyries. They were first struck in the well at Hull at a depth of about 750 feet.

Saint Croix Sandstone.—This formation is a thick unconsolidated sandbed exposed in the extreme northeastern corner of the state along the Mississippi river. The greatest vertical measurement found in Iowa is about 300 feet; but borings show that it has a maximum thickness of not less than 1,000 feet. While for the most part it is a soft sandstone wearing away rapidly under atmospheric influences, there are in places clay seams and thin layers of limerock frequently developed. In the neighboring states the calcareous and argillaceous beds assume a much greater importance and form shales and shaly limestones which are charged with the remains of trilobites. This sandstone has been called by most writers on the geology of the Upper Mississippi valley the "Potsdam" and has been regarded as the western extension of the formation known by that name in New York.

Oneota Limestone.—This is the formation usually known as the lower Magnesian limestone. It is exposed only over a very small area in the northeastern portion of the state, but attains a thickness of between two and three hundred feet. Along the border of the Mississippi it rises above the soft St. Croix sandstone in bold mural escarpments and castellated walls. For the most part the rock is a rather impure dolomite with occasional thin sandstone layers in the upper part. In color it is buff to brown. It is often vesicular and cavernous. In Wisconsin and Minnesota the Lower Magnesian limestone embraces other layers than those represented in Iowa. The principal beds thus referred to are called Willow River limestone and New Richmond sandstone in Wisconsin, and the Shakopee limestone and white sandstone in Minnesota.

St. Peter Sandstone.— Overlying the Oneota limestone is a heavy bed of pure siliceous sandstone, very friable and with few lines of stratification. It is occasionally somewhat indurated, but as a rule is incoherent. In the upper Mississippi region it has long been known under the name of the "pictured rocks," best exposed perhaps in the vicinity of McGregor. Northward along the boundary of the state thin limestone layers are often intercalated. In places this sand formation graduates downward by a rapid increase of calcareous matter into the Oneota limestone.

Trenton Limestone.— This rock is of the ordinary blue variety instead of the dolomitic, as is common in the other Silurian limestones. It is very compact, highly fossiliferous, and is texturally very distinct from the associated formations.

Galena Limestone.— In northeastern Iowa the heavily bedded brown dolomite which immediately overlies the Trenton limestone is called the Galena limestone. Its maximum thickness in the state is between two and three hundred feet, being greatest, perhaps, in the immediate vicinity of Dubuque, where it forms the principal part of the high castellated bluffs along the river. Some sandy material is found in different parts of the formation, but the partings are usually clay. The limestone is traversed in all directions by vertical cracks, horizontal partings and broad cavities, which form one of its most characteristic features. In these openings are deposited the lead and zinc ores of the region.

Maquoketa Shales.—Along the entire western slope of the Turkey river, and below the mouth of that stream on the Mississippi as far as Clinton county, there is exposed between the Galena limestone and the Niagara an extensive bed of bluish or greenish shales. Disintegrating readily under the influences of weathering, these shales allow the massive overlying dolomites to form bold mural escarpments which extend the entire length of the river mentioned. The shales have not been reported north of the Iowa boundary. Beginning at a point in Winneshiek county about twenty miles from the Minnesota line the Maquoketa shales have a thickness of only a dozen feet or more. This thickness rapidly increases until at its southernmost exposure it attains a vertical measurement of more than one hundred and twenty-five feet. At Dubuque a few feet of these shales are seen in isolated patches on the summits of the bluffs. For the most part these shales form alternating bands of dark and light colored clays with occasional thin seams of impure limestone. On the upper Maquoketa where the typical locality is located, the shales are highly charged with many species of fossils.

Niagara Limestone.—The Upper Silurian limestones which form the high escarpment on the western slope of the Turkey river and continue southward along the Mississippi nearly to Davenport are chiefly massive, yellowish or brownish dolomites having a great uniformity of texture. The greatest thickness is perhaps over three hundred feet. At the southern end they are heavily bedded and in many places the beds are folded and tilted very considerably, sometimes as much as fifty or sixty degrees.

LeClaire Limestone.—This formation like the Niagara is a dolomitic limerock. It is about two hundred feet in thickness. If the Anamosa beds are included, the formation is the uppermost member of the Silurian system in Iowa. It has been united with the Niagara below, but it is believed that the two formations are sufficiently distinct in their faunal, stratigraphical and lithological characters to warrant special designations.

Independence Shale.—For a long time the Devonian beds of Iowa were regarded as made up almost entirely of limestone. Hall and others found clay beds in the northern part of the state; while still more recently Calvin has discovered important shale layers at the base of the Devonian, in Buchanan county. The latter beds are made up of dark carbonaceous clays with thin bands of impure concretionary limerock. In places the shales are so highly charged with bituminous matter that considerable excitement has been caused at different times on account of their supposed nearness to coal deposits. Remains of plants have been found scattered through these clays and they have also accumulated so abundantly locally as to form thin veins of true coal. The shales also yield a very considerable number of animal remains.

Cedar Valley Limestone.—As already remarked the greater portion of the Devonian in Iowa is made up of limestones, for which it seems desirable to revive Owen's old name of Cedar Valley. These limerocks present very considerable differences in lithological characters, although for the most part they are ordinary limestones that pass rapidly into argillaceous, dolomitic, or even bituminous phases. Many of the beds are very massive though others are somewhat shaly. Everywhere the rocks of this age are highly charged with fossils of many kinds.

Montpelier Sandstone.—This name is applied to certain arenaceous beds which are well exposed in Muscatine county, and which have been recently differentiated by Calvin from the lower Carboniferous sandrock found farther to the southward. They are Devonian in age, but were formerly regarded as being identical with the Kinderhook sandstone exposed in the vicinity of Burlington. The Montpelier sandstone lies immediately above the Devonian limestone. The chief exposures of this rock are near the mouth of Pine creek in the county mentioned.

Lime Creek Shale.—These beds have long been supposed to form the uppermost member of the Devonian in Iowa. They are well exposed in many places, in Floyd county especially; some of the most important outcrops being at Rockford and along Lime creek. At the latter place there is exposed a vertical thickness of about one hundred feet of argillaceous shales which are highly fossiliferous.

Mississippian Series.—At the base of the Carboniferous rocks as represented in Iowa and forming one of the most important geological formations exposed within the limits of the state is the great series of limestones which have commonly been termed the Subcarboniferous. These rocks form a sinuous belt twenty-five to forty or more miles in width midway between the Cedar and Des

Moines rivers. The zone mentioned thus extends from the southeastern corner of the state northwestward as far as the Minnesota line. The Mississippian series as represented in the continental interior is made up of four distinct formations. Only three of these, however, are exposed in Iowa. They are the Kinderhook, Augusta and the St. Louis formations. The subdivisions here given have already been described in detail.

Pennsylvanian Series.—Economically the most important geological formation of the state is the Coal Measures. As now recognized in Iowa the series is divided into the Missouri stage, corresponding to the Upper Coal Measures, and the Des Moines stage, corresponding to the Lower Coal Measures. The former may be regarded as forming the more strictly marine deposits of which the latter are the marginal accumulations. The lithological and stratigraphical characters of the series are fully described in subsequent chapters.

Nishnabotna Sandstone.—Lying unconformably upon all older geological formations in the northwestern part of the state is a series of shore deposits which have a thickness of probably more than three hundred feet. Although the exact boundary of the eastern extension of this deposit is not definitely known, recent borings indicate that the beds have a much wider geographical distribution than has been generally supposed.

There are four formations in Iowa which are probably referable to the Cretaceous, though the exact stratigraphical equivalents of two of these are at present somewhat doubtful. They are the Ft. Dodge beds—gypsum deposits—and the Nishnabotna sandstone. Although the latter beds have been usually referred to the Cretaceous they have never been directly traced to the outcrops of the Woodbury shales. The geographic distance between the nearest exposures of the two formations as at present known is very considerable. If the Nishnabotna is Cretaceous, it may be the equivalent either of the Woodbury shales or of the Niobrara chalk; which one it is cannot now be stated. At present time it seems best not to attempt a specific correlation of the gypsum deposits, or of the Nishnabotna sandstone, but merely regard them as Cretaceous in age. The sandstones and loose sands that have been called Nishnabotna are to be regarded as shore deposits, along with numerous other beds of similar character which occasionally are found as outliers through central and northern Iowa. The Nishnabotna as reported by White has a thickness of fifty to seventy-five feet; and is seen exposed in the southeastern part of Guthrie county; southern Montgomery county and elsewhere in the western parts of central Iowa.

Fort Dodge Beds.—This name is applied to the gypsum deposits and certain associated beds which are well exposed in the neighborhood of Fort Dodge. The gypsum attains a vertical measurement of from two to thirty feet, its average thickness being, perhaps, about fifteen or sixteen feet. It occupies an area in the central part of Webster county, of about twenty-five square miles. It is traversed north and south its entire length by the Des Moines river and is cut through by many of the smaller tributaries of this stream. Probably more than one-half of the entire deposit has been removed through erosion by the chief water course. The most extensive exposures now opened are about four miles below Ft. Dodge.

Woodbury Shales.—As already intimated the typical outcrops of this formation are to be seen in Woodbury county along the Big Sioux river. The formation corresponds essentially with the Dakota and Fort Benton groups of Hayden. The beds represent shore deposits and it seems desirable to retain the name in preference to the two proposed by Hayden. "Woodbury sandstones and shales," as defined by White, expresses more accurately than any other name yet proposed the lithological features of the rocks as represented in Iowa. The Woodbury shales are made up in certain places largely of the sandstones, which sometimes form hard concretionary masses not unlike quartzite. In some localities these masses are so near together that they may be quarried to advantage for building stone. The most important of these openings is in the vicinity of Sioux City and is now known as the Reese granite quarry.

Niobrara Chalk.—These beds in their chalky facies have been observed in Iowa in the vicinity of the Big Sioux river. They are known to occur as far east as Auburn, in Sac county, and are probably represented still farther eastward by more strictly shore deposits. They consist of fine calcareous layers appearing not unlike clay at first glance.

Surface Deposits.—In the greater part of the upper Mississippi valley all the indurated rocks are covered to a depth of from a few inches to two or three hundred feet with a mantle of glacial débris. This, in its lower portion, is a heterogeneous mass of clay, sand, gravel and boulders which is seen almost everywhere within the state, and is known by the name of drift, or is a fine homogeneous clay-like material often showing a tendency towards stratification and is known as the Loess. In addition to these surface deposits there are the fine sediments laid down in river valleys, making up what is commonly known as the flood plains, and is specifically called alluvium.

GENERAL GEOLOGICAL RELATIONS OF THE COAL MEASURES IN IOWA.

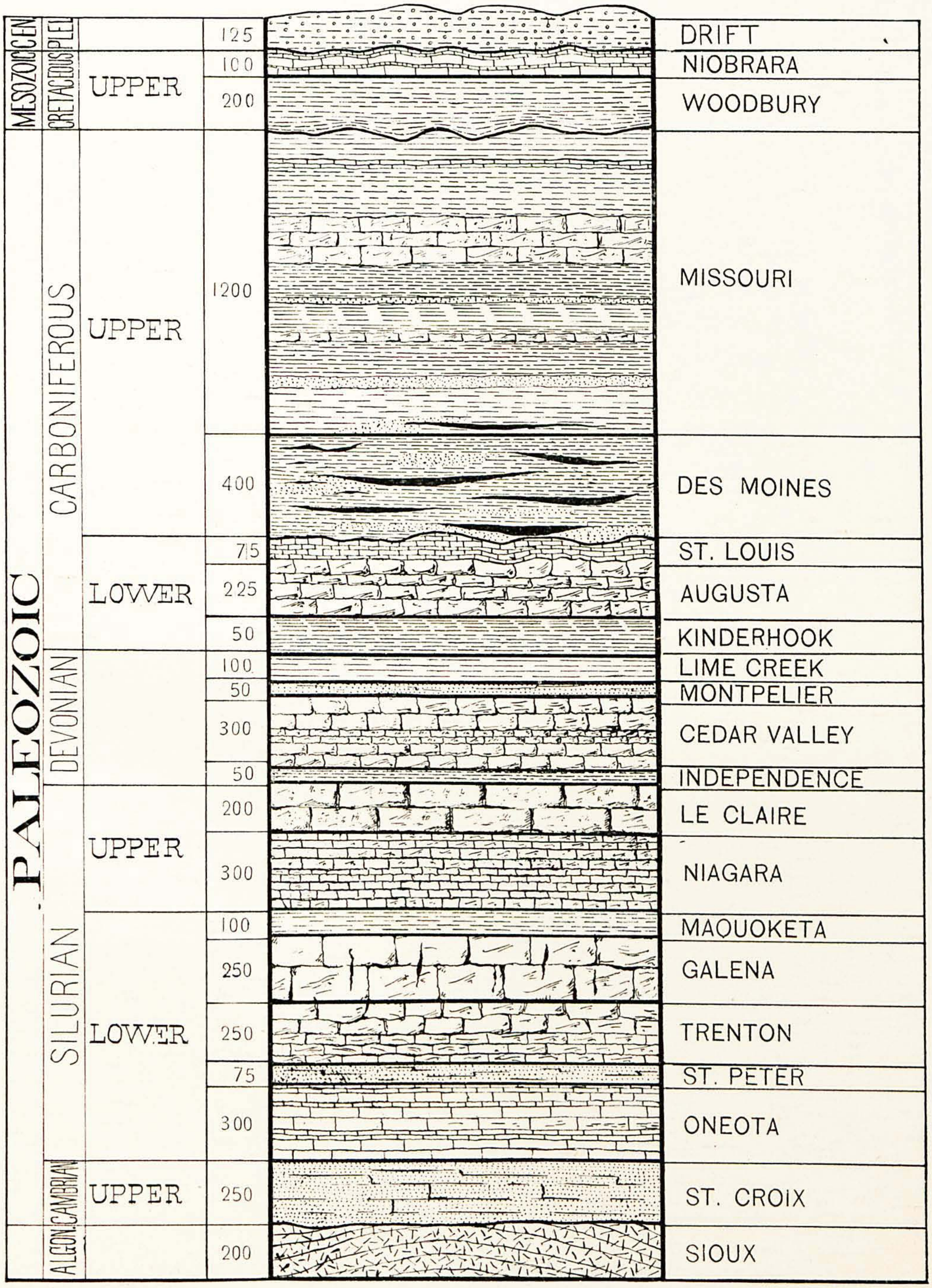
The total thickness of the rock formations in Iowa approximates 5,000 feet. Of this the Coal Measures occupy one-third or about sixteen hundred feet. The strata as a whole, although thin in comparison with the same formations in other states, form a measurably complete series. As already seen, the Paleozoic beds from the Cambrian to the Carboniferous are very fully represented. The Mesozoic deposits, of Cretaceous age chiefly, are found in considerable thickness. Over all spreads a thick mantle of drift or glacial débris.

The leading lithological characters and relative thickness of the different rock beds as represented in Iowa are shown in the accompanying general section of the state. (Plate iii.)

As early as 1857, in a paper published in the American Journal of Science, James Hall wrote: "I have ascertained in the most satisfactory manner that the coal fields of Iowa, Missouri and Illinois rest unconformably upon the strata beneath, whether these strata be Carboniferous limestones, Devonian, Upper Silurian or Lower Silurian rocks."* Although no details were given, nor any references to the evidence made, this appears to be the first notice calling attention to the existence of a physical break in the Carboniferous rocks of the Mississippi basin.

A decade later White,† calling attention to the same fact, stated that another unconformity existed between the St. Louis limestone and the underlying rocks of the Lower Carboniferous. These remarks also appeared

*Am. Jour. Sci., (2), vol. XXVII, p. 197. New Haven, 1857.
†Am. Jour. Sci., (2), vol. XLV, pp. 331-334. New Haven, 1868.



GENERAL GEOLOGICAL SECTION OF IOWA.

subsequently in the Iowa Report.* They are all very general in their character, but there is added to Hall's observation the important fact that the St. Louis limestone also overlaps in the state the older formations.

In Iowa, at least, it appears that the extension of the Coal Measures beyond the boundaries of the St. Louis limestone was much more than an overlap in the ordinary sense of the word, such as might have taken place off shore in gradually deepening waters. It was a sinking of an ancient land surface that had been more or less profoundly carved into hills and vales, affording protected nooks favorable to swamp formation, and the rapid accumulation of vegetable materials.

Since the observations recorded by Hall and White were originally published little work bearing upon the subject in hand had been done until quite recently. In Missouri, Iowa and western Illinois much valuable information has accumulated during several years past, so that now the principal changes of level during the Carboniferous over the region mentioned are tolerably well understood. The nature of the unconformities referred to by the writers named has been made out with considerable detail; while numerous minor physical breaks have been recognized.

The problem therefore centers around the oscillation of the old Carboniferous shore-line in the upper Mississippi basin. The changes are graphically shown in the accompanying diagram, representing the movements of the land margin in the direction of greatest shifting. The Devonian rocks doubtless extend northward beyond the present limits of Iowa. Toward the close of the Devonian period the seas over this region gradually contracted.

* Geology Iowa, vol. I, pp. 225-229. Des Moines, 1870.

This recession continued more rapidly as the Lower Carboniferous period was ushered in, until the water line reached nearly the present southern boundary of Iowa. The St. Louis epoch represented a period during which there was a general depression of the land allowing an overlap of the St. Louis rocks of more than two hundred miles, the seas extending nearly or quite to the present Iowa-Minnesota line. Another cycle of the great continental change then set in pushing the shore-line rapidly some five hundred miles southward to the vicinity of the present city of St. Louis. For the most part the Coal

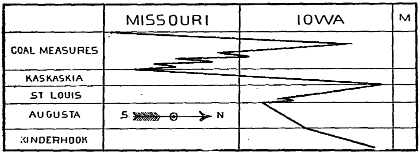


Figure 4. Changes of the Carboniferous Shore-line in the Upper Mississippi Basin.

Measures represented a period of general though not uninterrupted subsidence. During the latter part of the period the waters receded rapidly far below the Missouri and Iowa boundary. A long time intervened before the seas again occupied the Iowa territory. This incursion was recorded in the Cretaceous deposits of the north-western part of the state.

This, then, is a brief statement of the shore-line changes during and following the Carboniferous in the upper Mississippi valley. The phenomena recording these movements may now be briefly summarized. A general geological section in a north and south direction through

Figure 5. Generalized Section along the Mississippi from the Minnesota Line to the Mouth of the Ohio, showing Geological Relations of the Formations.

eastern Iowa shows that the different geological formations occupy successively smaller areas of the Iowa region until the top of the Keokuk is reached. During all this time no apparent sinking of the sea bottom took place.

Along the line of the Mississippi river shore deposits were laid down in southeastern Missouri and western Illinois, with open sea deposits farther southward and probably also west of the Missouri river. A new period of subsidence ushered in the Upper Carboniferous over this part of the American continent.

While the Kaskaskia beds were being deposited south of the mouth of the Missouri river agencies of degradation were busily at work over all the Iowa and northern Missouri areas, as will be more fully shown presently. The St. Louis limestone was deeply eroded as is plainly shown in numerous places. The depressions, channels and gorges were soon filled with clays and sands, while here and there thick beds of carbonaceous matter were deposited.

A generalized section, modified after Hall, and shown in figure 5, graphically summarizes the stratigraphical features of the region as recently made out with considerable detail. Number 1 is Cambrian; 2, Silurian; 3, Independence shales; 4, Cedar Valley limestone; 5, Kinderhook shales; 6, Augusta limestone; 7, St. Louis limestone; 8, Coal Measures.

In considering now the nature of the physical break at the base of the Coal Measures in Iowa and Missouri, attention must be directed briefly to a few of the leading sections showing the line of separation between the two formations.

One of the most important exposures bearing upon the question under consideration has been fully described in connection with the cross-section of the Lower Coal Measures of the central part of the state. It was shown that in Marion county between Harvey and Redrock, in a distance of less than ten miles, not less than seventy-five feet of shales were present between the two different horizons of the Coal Measures reposing upon the St. Louis limestone. The great part of the vertical distance just referred to appeared to be due to irregularities in the lime-rock, which were carved out through erosion prior to the laying down of the Coal Measures.

Near Fairfield in Jefferson county the Coal Measure clays, with their seams of carbonaceous matter, rest directly upon the uneven surface of the St. Louis marls which cap the limestone of the same age. The Lower Carboniferous rocks contain fossils in abundance.

At Keokuk, Coal Measure deposits are found in numerous places near the top of the bluffs. The St. Louis limestone as represented in this locality is partly a compact limerock, regularly bedded, partly a brecciated limestone. Everywhere in the vicinity the basal sandstone —a rather soft, friable rock of buff or brownish color— covers the uneven channeled surface of the St. Louis limestone. Some of these sandstones with accompanying

UNCONFORMITY OF COAL MEASURES AND ST. LOUIS LIMESTONE. KEOKUK.

dark shales, apparently rest also on the Keokuk limestone. Plate iv shows a typical section in which the sandstone is seen resting immediately upon the limestone. The latter is brecciated; the former exhibits very decided cross-bedding.

At various places in Keokuk and Mahaska county borings, as well as exposures, indicate that the irregularities in the surface of the St. Louis limestone are even greater than those in Marion county already described. The borings just referred to are quite numerous and special care had been taken for the reason that search was in progress for a "second" vein of coal—a seam thought to exist much lower than the one at present being worked. In one place where the St. Louis limestone was exposed at the surface operations with a diamond drill had begun in hopes of reaching the "lower" coal bed. The reason given for carrying on the work in this manner was that a mile away the coal at present worked was many feet lower down than the limestone outcrop and therefore the coal bed must lie beneath.

Relations similar to those above described have also been observed in connection with the St. Louis limestone and Lower Coal Measures at Fort Dodge and elsewhere in Webster county. Identical cases might be repeated again and again, if it were necessary in the present connection. They occur not only in connection with the rocks named but also with the Devonian as at Iowa City and the Silurian as at LeClaire. (Plate v.)

The unconformity of the Coal Measures is fully described in connection with the remarks on the stratigraphy of the region. The characters of the local unconformities are shown in the sections at Redrock, in Marion county, near Bellefountain, in Mahaska county, as well as in other places.

GEOLOGICAL SUBDIVISIONS.

With the exception of a few carbonaceous seams in the Cretaceous rocks in the northwestern part of the state the coal bearing strata of Iowa belong to the median portion of the Carboniferous age, or Coal Measures. The rocks of this formation are made up largely of argillaceous materials, with some sandstones and limestones, the coal beds forming an inconspicuous part of the entire series. It has been customary in Missouri and Iowa to subdivide the Coal Measures into:

(3) Upper Coal Measures.
(2) Middle Coal Measures.
(1) Lower Coal Measures.

The exact lines of demarkation have been very different in the various states within the limits of the interior region. In Iowa and Missouri for instance the "lower" Coal Measures of the former do not correspond at all with the similarly named division represented in the latter state; and the same may be said in regard to the so-called middle and upper divisions of these two provinces. White, following the idea already suggested, also divides the Coal Measures of Iowa into Lower, Middle and Upper sections, each of which he regarded about 200 feet feet in thickness. Recently it has been shown* that the respective thicknesses of the three formations already referred to are very different from the measurements ascribed to them by the author just mentioned. The vertical distance between the base and the top of the lower member is more than double the distance usually

*Keyes: Bul. Geol. Soc. America, vol. II, pp. 277-292. Rochester, 1891.

CARBONIFEROUS SANDSTONE IN OLD DEVONIAN GORGE.—IOWA CITY.

given, or over 400 feet. White's middle member is very much thinner than was at first supposed. From investigations lately made in both Iowa and Missouri the actual thickness of the "Upper" Coal Measures is found to be more than four times the vertical distance formerly estimated, that is, more than 800 feet.

In considering the Coal Measures as a whole two tolerably distinct classes of sediments are readily recognized: (1) the marginal or coastal deposits; and (2) the beds laid down in the more open sea.

These two categories are sharply contrasted lithologically, stratigraphically and faunally. The first is characterized by the rocks being predominantly clay shales and sandstones with practically no limestones. The individual beds have usually a very limited extent, and replace one another in rapid succession both laterally and vertically. The sandstones often form great lenticular masses, sometimes deeply channeled on the upper surface and the excavations filled with Coal Measure clays. These and many other phenomena attest a constantly shifting shore-line and shallow waters. The fossils contained are nearly all brackish water forms or shore species. The remains of pelagic organisms are not numerous.

On the other hand the second class above mentioned is made up largely of calcareous shales, with heavy beds of limestone, the layers are evenly bedded, and extend over very considerable distances. The faunas are chiefly composed of the more strictly open sea forms.

As the conditions of deposition were evidently those of a slowly sinking shore, the marginal deposits as a whole practically underlie the open sea formations, the former being regarded as the "lower" Coal Measures and the latter as the "upper" Coal Measures. At the same time it must be remembered that this does not necessarily imply that the "lower" Measures are to be regarded as much older than the "upper;" but rather that along the great and successive planes of sedimentation, different beds of the upper and lower divisions were laid down contemporaneously.

While the general divisions of the Coal Measures may be readily recognized it does not seem advisable to draw an exact line of demarkation between the two formations until the evidence of the faunal studies already begun has been fully taken into consideration, and a comparison of the results of the different methods of solving the problem is made.

With this idea of the Coal Measures of the Interior basin the limits of the two formations in Iowa assume somewhat different lines of separation from those that have been commonly recognized.

It has been proposed therefore to divide the "Upper" Carboniferous or Pennsylvanian series, into:

(2) The Missouri Stage.

(1) The Des Moines Stage.

The Des Moines formation corresponds essentially to the group of strata commonly called "lower" Coal Measures. It represents the marginal deposits of the Upper Carboniferous. It takes its name from the Des Moines river which flows for more than two hundred miles directly through the beds of this terrane. It extends in a broad belt into Missouri and follows around the northern and western boundaries of the Ozark uplift into Kansas and Indian Territory and continues into central Texas.

The Missouri Terrane is practically identical with the "upper" Coal Measures, and represents the more strictly marine beds. It is the formation typically developed in the northwestern part of the state of Missouri. The Missouri river also winds its way for more than 400 miles through the beds of this stage, exposing numberless excellent sections on both sides of the stream throughout the entire distance. The strata occupy the interior central portion of the great bay-like expansion of Carboniferous, of which the Des Moines beds form the marginal zone.

CHAPTER V.

LITHOLOGY OF THE COAL MEASURES.

GENERAL CONSIDERATIONS.

It is a well known fact in geology that whenever a series of sedimentary rocks are exposed there are always certain kinds of beds which are usually found intimately associated. The relations of the different members of a given series or sequence are such that when only one of them is visible in a natural outcropping or in an artificial cutting it may be inferred that the others are also represented in some way or other either above or below the layer noted. This general succession of particular beds in certain groups of strata is easily explained upon the supposition that in each case there was a similarity of physical conditions under which the different successions were laid down. Thus, whenever a particular set of conditions prevails for the formation of any one of the beds in question the circumstances leading up to this special construction, and rendering possible the accumulation of the deposit must necessarily give rise in the process to other conditions favorable to the laying down of some of the other layers related to the series. This succession may not be carried through all the stages necessary to the formation of the last in the series for other physical changes may interrupt the usual order of deposition. Hence, only a part of the entire repetition may occur at a particular time, as is quite frequently the case; while elsewhere the complete sequence is present.

This relation and association of particular kinds of beds is nowhere better exemplified than in the Coal Measures of Iowa. The succession of strata commonly observed in connection with the coal seams is quite constant, as is well shown by an examination of the various vertical sections of the beds. Immediately below the coal vein, no matter how thin it may be, there is found almost without exception, a bed of white or ash colored clay, highly plastic, homogeneous and free from pebbles. It resists the action of fire in a remarkable way and consequently is of great value in the manufacture of brick or utensils which are to be subjected to a high degree of heat. On account of this property it is commonly called fire clay. Its position and physical properties are better understood when it is remembered, as will be fully shown farther on, that this under-clay formed the old soil upon which the coal plants grew. Superimposed on the fire clay is the coal seam of greater or less thickness. Above this again is a black, highly bituminous clay-shale, usually fossiliferous, and varying in thickness from a few inches to twenty-five or thirty feet or more. Next is a layer of sandstone or shale; rarely limestone. Sometimes the dark shale overlying the coal is extremely thin and a heavy sandrock appears to lie immediately upon the coal. This sequence, then, is the one which is commonly noticed in Iowa in connection with the coal seams. Fuller appreciation of its importance economically comes with the proper recognition of the relatively small proportion of the entire mass of Coal Measures that the coal itself forms.

In order of their abundance the rocks of the Iowa Coal Measures are clay-shales, sandstones, limestones and coals. The secondary part which the calcareous beds play in the lower division of the Upper Carboniferous of the state, sharply distinguishes the formation from the older Paleozoic rocks of the same area. Below, the Coal Measures rest on a great basement of massive limestones with but few clay or sand beds of separation. Not less striking is the relative thinness, as a rule, of the individual layers which follow and replace one another upwards and laterally in rapid succession. Often within a vertical distance of a few inches or a few feet, layers of clay, sand or shale are succeeded by different strata; or they are changed both in color and chemical composition.

If the upper and lower divisions of the Coal Measures in Iowa were to be contrasted upon a single lithological character it would be found that the former is prevailingly calcareous; the latter prevailingly argillaceous. Further comparing, the Upper Measures have even their clay-shales charged with disseminated lime; the Lower Measures have their limestone beds commonly in thin bands, few in number. The sand beds in the superior portion of the Upper Carboniferous are usually shaly, mixed with much calcareous and clayey material; in the inferior part the arenaceous formations are often great sandstones, frequently of very considerable geographic and vertical extent. As regards carbonaceous materials there is a very great predominance in the "lower" Coal Measures —not only disseminated through the clays making them often highly bituminous, but concentrated in very pure seams and beds furnishing by far the greater part of the coal mined in the state. The "upper" Coal Measures, though carrying some workable coal, are, as compared with the formations immediately underlying them, meagerly supplied with bituminous matter.

The two subdivisions of the Upper Carboniferous being so well distinguished in a general way by their differences in constructional materials, as well as in other ways, it would seem desirable to treat more especially and in detail the lithological features of the lower and upper members separately.

LOWER COAL MEASURES (DES MOINES FORMATION).

Clay-Shales.—As already intimated these materials make up by far the greater part of the Carboniferous as as represented in Iowa. On exposure to atmospheric agencies they quickly disintegrate into soft clays and are easily carried away by running water. For the most part they are ashen, drab, or black in color, though red, yellow, buff and blue shades are of not uncommon occurrence. In some localities the variegated shales, blue, red, drab, yellow and ashen, indiscriminately mingled, predominate.

The shales may be (1) argillaceous, (2) arenaceous, (3) calcareous, or (4) bituminous. These all merge into one another but in places there may be sharp dividing lines between them. By the gradual addition of fine sandy material on the one hand they pass imperceptibly into sandy shales; these again into shaly sandstones and finally into hard, compact sandrock. On the other hand, through the increase of lime constituents, these deposits grade into calcareous shales and then into earthy limestones and finally to ordinary limerock. In another direction carbonaceous matter may rapidly become prominent; the shales acquire a dark color, assume a highly bituminous character and finally pass into coaly layers. These gradual transitions may take place laterally in the same horizon, or vertically from one layer to another.

TYPICAL DEVELOPMENT OF COAL MEASURE SHALES.—DES MOINES.

The light colored shales frequently form beds of considerable thickness, the prevailing color being drab or bluish. They are compact, more or less massive with the lines of stratification poorly defined. When first encountered in artificial excavations, as in railway cuttings or coal shafts, these shales are quite hard and extremely tough. During the process of removal they yield but little to the pick and require as much blasting as for ordinary limestone or sandrock. Upon exposure to the weather these shales readily go through a process of "slacking," as it is called by miners, after which they become fine, highly plastic clays. The shales under consideration form the best of material for the manufacture of brick, the bluish tinted varieties being much sought for in making "pavers," which need to be very dense, hard and partially vitrified when burnt.

The most important, economically, of the light colored shales are the fire clays, which form the under-clay of the coal seams. No matter how thin a vein of coal may be the fire clay is almost invariably found below it. This substratum has a thickness of from one foot to half a dozen or more feet, but ordinarily has a measurement of three or four feet. It is a fine, soft, homogeneous clay, white or ashen in color, highly plastic, and resists the action of heat in a remarkable manner, hence its name. The relations of the coal and its under-clay indicate clearly that the white layers are to be regarded as the soil which supported the luxuriant plant growth of the ancient marshes, just as at the present time there is found at the bottom of many modern peat bogs a fine clay of similar character. The peculiar properties of the fire clays are probably due in large part to the action of the water-loving plants which flourished on this rich submerged soil; for it is a well established fact that aquatic vegetation removes from the soil all or nearly all the alkalies, iron, sulphur and a considerable percentage of the silica, leaving finally a light colored clay rich in alumina. The abstraction of the alkalies from the clay takes out those constituents which act as fluxes when the substance is highly heated. In ordinary clays these materials allow melting when brought in contact with fire, forming a glass-like mass, which is in reality a complex system of small glassy threads binding together the impurities. In fire clays the absence of fluxing components prevent the argillaceous mass from fusing.

In many places in the light colored clays crystallized gypsum occurs abundantly. At Des Moines for instance where diamond shaped crystals of selenite are plentiful, it is not infrequent that there are found individuals greatly elongated in the direction of the vertical axis, sometimes to a length of eight to ten inches. In the latter habit twinning is quite common. Often the crystals are acicular and radiating from a center form little rosettes, which lie in great numbers on the exposed surface of the clays. Occasionally the light colored shales also afford impressions of ferns and lepidodenron roots, but for the most part they are unfossiliferous.

There occurs often in the gray shales and also, but less frequently, in the dark colored varieties, a structure which is popularly called cone-in-cone. It is found in layers or sheets from two to six or eight inches in thickness and of varying extent. Ordinarily it appears as series of small cones set one within the another, the separate piles closely pressed together, the bases being parallel with the surface of the layer. Usually it appears to be a concretionary or pressure structure caused by

ELK CLIFF, COAL MEASURE SANDSTONE, ROUSSEAU.—MARION COUNTY.

slipping of certain of the hardened clay layers. To all appearances it seems to be composed of the same clayey material as the beds in which it occurs. The explanation of the formation of cone-in-cone has always been a subject about which there has been considerable doubt. The solutions of the problem have been numerous, but so far as they have been noticed none are very satisfactory. Recently a number of occurrences of cone-in-cone from different parts of the state have been carefully examined. Certain examples from Marion and Boone counties were found to be crystallizations of gypsum, numberless small needles being set nearly parallel with one another but in reality radiating from centers. In all cases the needles were arranged perpendicular to the bedding planes of the shale just as in the deposits of massive gypsum of Webster county, Iowa, and elsewhere. From this very pure variety of cone-in-cone in which the needles are quite transparent and display clearly the gypseous character of the "cones" there are all gradations of clay impurities until so little of the hydrous sulphate of lime remains that the composition cannot be distinguished optically from the beds inclosing it. These isolated layers of cone-in-cone then may be regarded as depositions of gypsum not unlike the massive deposits seen at Fort Dodge, but with clay impurities so abundant as to obscure the real mineralogical character of the substance. Similar crystallizations of minerals having a strong crystallizing power are not uncommon. Calcite is perhaps one of the most familiar examples. Often the impurities of clay or sand are so great in amount that the calcareous solution penetrating the unconsolidated beds allows individual calcite crystals to crystallize out in characteristic forms but with so much clay or sand incorporated that they look like clay or sand models of different calcites.

The arenaceous shales differ greatly in color and character. In some varieties the sand particles are so very fine they can scarcely be detected except by the magnifying glass. From this extreme the grit may increase in quantity and size of grains until a well marked sandy shale is noticed which may, however, pass into shaly sandstone. The beds of this description are of little economic value but are often mixed with certain clays in the manufacture of brick. Shales bearing a considerable amount of sandy material are usually poor in organic remains; though impressions of plants are sometimes quite abundant.

The calcareous shales are of relatively small importance in the lower part of Coal Measures. They occur chiefly in the neighborhood of the thin limestone bands which are found in various places. They frequently form marly layers which are often crowded with fossil shells. These shales are usually full of small limestone concretions which cause considerable trouble when the shales are used in the making of brick and tile, as the calcareous nodules form quicklime in burning. This interferes seriously with the durability of the product.

The dark colored shales vary greatly in composition but they all contain more or less carbonaceous matter. Some varieties are massive with no indications of stratification while others have this feature very prominently developed and cleave in large flat leaves as thin as paper. In many of these shales oily matter is widely disseminated and in many cases could probably be obtained in commercial quantities through proper distillation. Considerable pyrite is present scattered through the black shales.

QUARTZITIC CONCRETIONS IN REDROCK SANDSTONE.-MARION COUNTY.

Sometimes it is in fine particles but usually is in small concretionary masses. Frequently crystals of this mineral with bright faces occur. The amount of bituminous matter is commonly too great to allow the beds to be used for brickmaking. These shales usually graduate into coal and consequently mark valuable coal horizons. At the same time they are often quite deceptive to many persons who drill wells or prospect for coal and they lead to the eager search for mineral fuel in places where there is no hope of finding it. For the most part the bituminous shales are highly fossiliferous. Plants, well preserved, are often abundant. Animal remains in large numbers occur, the gasteropods and lamellibranchs forming the chief groups. Plate vi shows a typical development of Coal Measure shales; it represents a portion of the clay pit at the Iowa Pipe and Tile Works at Des Moines. The section is:

		FEET.
11.	Drift	4
10.	Shale, yellowish, sandy	8
9.	Sandstone, fine grained, rather massive	6
8.	Shale, argillaceous, light colored	9
7.	Coal, impure	4
6.	Sandstone, fine grained, white	3
5.	Coal	1
4.	Fire clay	3
3.	Shale, drab, coaly below	2
2.	Shale, light colored, gritty	3
1.	Shale, dark gray	4

Sandstones.—There is a large amount of sandy material in the Coal Measures of the region under consideration so mixed with clay as actually to form sandy shales. In some cases, however, the sand constitutes a rock which is sufficiently compact to afford material for ordinary rough masonry. The hard portions of the sandstones are for the most part very limited, being only two or three feet in thickness; or are in the form of large spherical concretions in a softer matrix. The concretionary masses sometimes attain a diametric measurement of five or six feet. Within the limits of the area in question there are some notable exceptions to the general character of the arenaceous deposits; as for example the Redrock sandstone. This sandstone has long attracted popular attention. The bright vermillion cliffs rise to a height of 100 to 150 feet above the water surface of the Des Moines river. The red coloration of the rock is, however, local, merging laterally and downward into a yellow or buff color. At Redrock cliff the stone is for the most part massive; but rather soft and thin bedded above. At this place it is a very fine grained and homogeneous sandrock, some portions even affording excellent material for grindstones. But southwestward and at Elk Bluff, two miles below, the sandstone passes into a fine grained, ferrugineous conglomerate. The bluff is fully 150 feet in height and rises perpendicularly out of the river as shown in plate vii. Occasionally large spherical concretions are met with which closely resemble metamorphic quartzites. (Plate viii.) The rock is entirely massive; the horizontal lines shown in the plate are projections left by the channeling machine used in quarrying. In the upper part it becomes thinly bedded, with a considerable amount of clay intermingled. The base is rich in plant remains; lepidodendrids, sigillarids, calamites and ferns of many species. The upper surface has been subjected to sub-aerial erosive agencies, as has been fully shown in another place.* The formation is, then, an enormous consolidated sand bed having a geographic extent of more than twenty miles in

*Am. Jour. Sci., (3), vol. XLI, pp. 273-276. 1891.

CROSS BEDDING IN COAL MEASURE SANDSTONE.—REDROCK QUARRY.

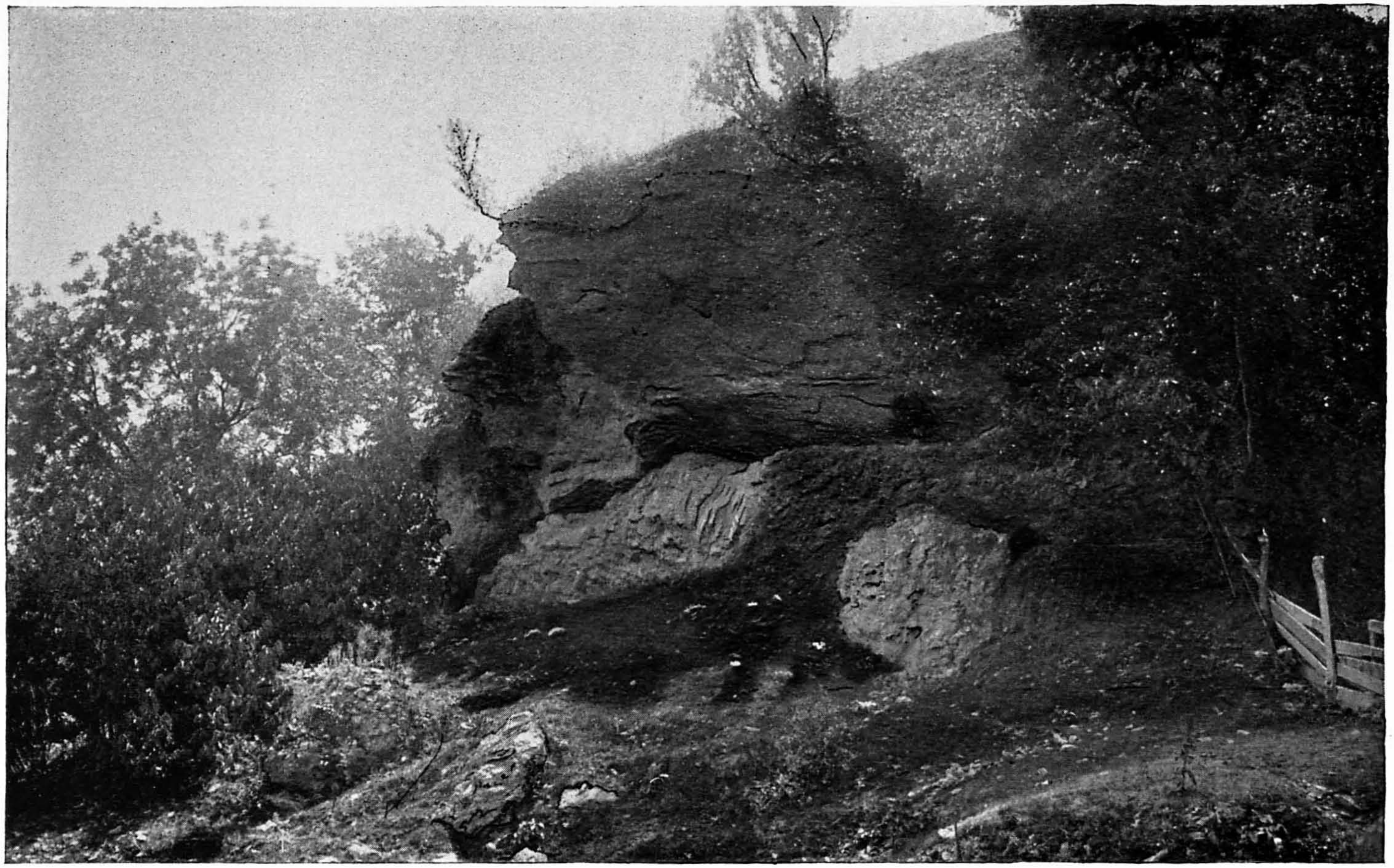
one direction and at least six or seven miles in the other, with a maximum thicknes not less than 150 feet.

The sandstone of Redrock has recently come into prominence as a building stone and is now used more or less extensively throughout the state for the better class of architectural work. Long ago this rock was utilized in various structures at Des Moines and elsewhere, but the method of obtaining it, by blasting, shattered the stone so as to render it almost worthless for building purposes. It soon fell into disrepute and for more than thirty years has not been used except for unimportant local masonry. Recently extensive steam sawing apparatus has been brought in, and the stone removed in huge blocks before reduction by further sawing to sizes required. In this way the sandstone is not injured as was the case when the quarrymen resorted to blasting. The resistence to crushing power of the better portions of the rock is now considered to be nearly equal to any sandstone of similar character in the country.

Both the conglomeratic and upper portions of the sandstone are beautifully cross bedded. At the Redrock quarry especially good examples may be noticed. Plate ix shows a portion of a ledge in which the false bedding in made quite striking through weathering.

Farther down the Des Moines river in Mahaska county are similar cliffs of Lower Coal Measure sandstones, the principal one of which is known as "The Bluffs" or Raven Cliff. Whenever these great sandstones are cut through by the water courses precipitous cliffs are formed like those just described. They are found in many places; in Wapello county near Eldon; on the Des Moines below Moingona in Boone county; in Warren county at Ford; in Dallas county; near Eldora in Hardin county; and less prominently elsewhere. Away from the streams the great consolidated sandbeds also occur but they are apt to be passed by unnoticed as they do not form prominent relief features.

Of the other compact sandrocks of the same geological age the most important, perhaps, is what is known as the "basal sandstone" of the Coal Measures. Instead of being a single bed, as might be inferred from the name, it is in fact made up of a number of isolated masses. The name, however, is still very appropriate as the rocks under consideration are usually found at the base of the Coal Measure series, having filled depressions and old gorges eroded in the underlying limestones during the laying down of the Upper Carboniferous series. The basal sandstones are more conspicuous perhaps in the outliers of Carboniferous strata where the superincumbent beds have been removed through erosion. At Keokuk, in Lee county, sandrocks of the character just described form the upper part of the bluffs along the Mississippi and Des Moines rivers. They have a thickness of twenty-five feet or more and are durable enough in places to furnish material for ordinary masonry. A bluff of this sandstone is shown in plate x. The same arenaceous beds rest directly upon the St. Louis limestone, the upper surface of which is seen in many places to be deeply eroded and uneven. The sandstone at the bottom is very unevenly cross bedded, indicating the shallowness of the waters in which it was deposited. Similar massive sandstones have long been quarried at Muscatine where certain parts of the beds have hard concretionary masses of spherical shape very much like those referred to in connection with the Redrock sandstone. Other exposures of Carboniferous sandstones are found along the Iowa



OVERHANGING LEDGE; BASAL SANDSTONE RESTING ON SAINT LOUIS LIMESTONE.—KEOKUK.

river, where they are to be seen lying in Devonian gorges as at Iowa City.

The organic remains found in the sandstones or the more compact of the sandy shales are almost entirely plants. Beautiful ferns are not uncommon. Many kinds of Lepidodendron and Sigillaria are very abundant, and huge calamites are not rare. In certain parts of the Redrock sandstone, south of Pella, Marion county, for example, it is not unusual to see tons of great plant trunks, finely marked, lying in the talus at the foot of the mural escarpments along the Des Moines river. Other localities are equally prolific of vegetable remains.

Calcareous Beds.—The limestones of the Lower Coal Measures play an unimportant part in the lithological features of the region. With a few exceptions they consist merely of a few thin bands chiefly in the upper portion of the section, above the lower Coal Measures, as commonly designated in this state. Though seldom exceeding ten or twelve inches in thickness, these calcareous bands are more persistent and are more easily recognizable over wide areas than any of the other horizons. They are fragmentary or nodular, very impure from a large admixture of clayey material, and more or less highly fossiliferous.

There are some few exceptions, however. In Appanoose county, for instance, there are two limestones which have a wide geographical extent and bear a definite relation to the coal seam most generally worked. They are known as the "seventeen-" and "fifty-foot" limestones. The one is usually three feet in thickness; the other six feet. They also extend into the neighboring counties and southward into Missouri.

At the mouth of Cedar creek in Mahaska county, a couple of miles below Bellefountaine, a six foot layer of limestone is found capping a thick massive sandrock which is apparently the southern prolongation of the Redrock sandstone. At this place it has been cut through by Carboniferous streams.

Overlying many of the coal seams is an impure, bituminous limestone usually containing considerable iron. It is commonly charged with fossils, many of them marine species. It is quite probable that some of these beds are represented in other districts by purer limestones. They often are nodular and then pass under the name of "boulders."

Coals.—Little need be said here concerning the lithological character of the coals of the state. They are all of the bituminous varieties, though a few limited deposits of tolerably good cannel coal are known. The seams vary from a few inches to seven or eight and even ten feet in thickness; the average of the veins at present worked being between four and five feet. These beds are disposed not in two or three continuous layers over the entire area as has been commonly supposed, but in numerous lenticular masses from a few hundred yards to several miles in extent. As a rule the coals of the state are rather soft. They often contain some pyrites, and not infrequently there are small flakes of lime or gypsum along the line of stratification and fracture. Thin shaly seams also occur. Almost without exception the workable coal beds are underlain by a soft white clay which is often taken out along with coal and made into fire brick. Usually roots of lepidodendrons are found abundantly in this under clay. The roof of the coal beds is usually a bituminous, fissile shale; intensely black below but commonly becoming lighter colored upwards. The thickness of the "roof" may vary from a few inches to fifteen or twenty feet.

Frequently just above the coal, in the lowermost layers of the roof, there is a black nodular band of hard calcareous material, the individual spherical masses being called locally "nigger heads." The larger of these may measure ten or twelve feet in diameter. They are sometimes charged with fossils, chiefly lamellibranchs and gasteropods in great variety. The "nigger heads" are quite distinct from the septarial masses often associated with the coal and having the same general appearance.

There are also associated with the coal layers a compact, massive rock having a somewhat metalic ring when struck with the hammer. It is one of the ores of iron and is commonly called clay iron stone. At Flagler, in Marion county, one bed ten inches thick divides a five-foot vein of coal into two parts.

UPPER COAL MEASURES (MISSOURI FORMATION).

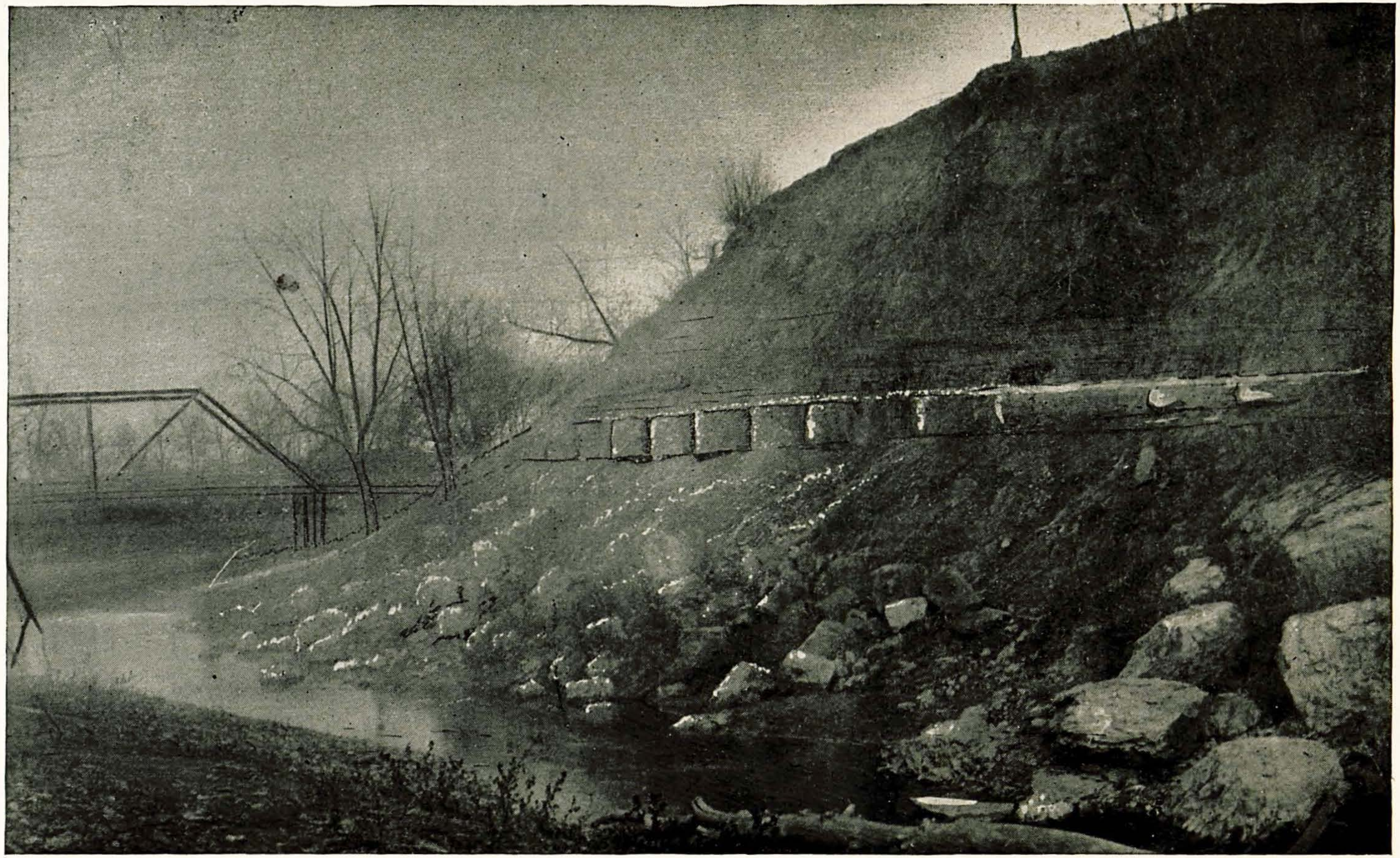
Clay-Shales.—As in the lower division of the Iowa Coal Measures the argillaceous materials of the upper part predominate over the other components. But instead of being dark colored as a rule the clays of the upper division are light colored—calcareous rather than bituminous. The transitions from one lithologically distinct bed to another are much more gradual and layers are far more presistent than in the Lower Coal Measures. A pure clay stratum acquires more and more calcareous material until through various shaly stages it eventually becomes a well marked limestone. The clays carrying a high percentage of lime are popularly termed "marlites" and commonly yield large numbers of molluscan shells in a good state of preservation. Although there are bituminous shales in the Upper Measures of the state, they are, for the most part, quite limited.

Limestones.—Next to the clays the limestones rank in importance in the making up of the Upper Coal Measures. Their presence forms the most prominent lithological difference between the upper and lower divisions. In thickness the beds vary from a few inches to twenty or thirty feet and upwards. Many of the bands are somewhat earthy, but very compact and break with a conchoidal fracture. The thicker layers may be thick- or thin-bedded, the latter being more common. Fossils abound in nearly all the limerocks, especially those inclosed in calcareous shales.

The limestones, even in thin bands, are the most persistent of all the strata of the region; single beds having a wide geographical extent. Hence in the recognition of horizons at different places the layers in question become very valuable as means of correct correlation.

The hard calcareous beds, beginning in the uppermost part of the lower Coal Measures with a few thin impure bands of very limited extent, rapidly increase in number, thickness and importance until at the top of the series, they form great beds.

Arenaceous Materials.—The sands of the Upper Coal Measures are largely disseminated through clays forming sandy shales or shaly sandstones. The massive sandstones are not common. They are chiefly confined to limited layers of a few feet in thickness. Occasionally a bed of considerable vertical measurement is met with in the lower portions of the formation, but it is always very local.



LOWER COAL MEASURE LIMESTONE.--MYSTIC.

Coal. Over a large part of the upper Measures, coal seams of economic importance are not common. The seam twenty inches thick which occurs in Page, Taylor and Adams is perhaps the most important one at present known. It is well exposed in the bluffs of the Nodaway and its branches and has a considerable geographical extent. Deep borings, however, will probably disclose a large amount of workable coal. In fact this has already been accomplished with profit at Leavenworth, Kansas, and neighboring places.

UPPER COAL MEASURE LIMESTONE.—EARLHAM.

CHAPTER VI.

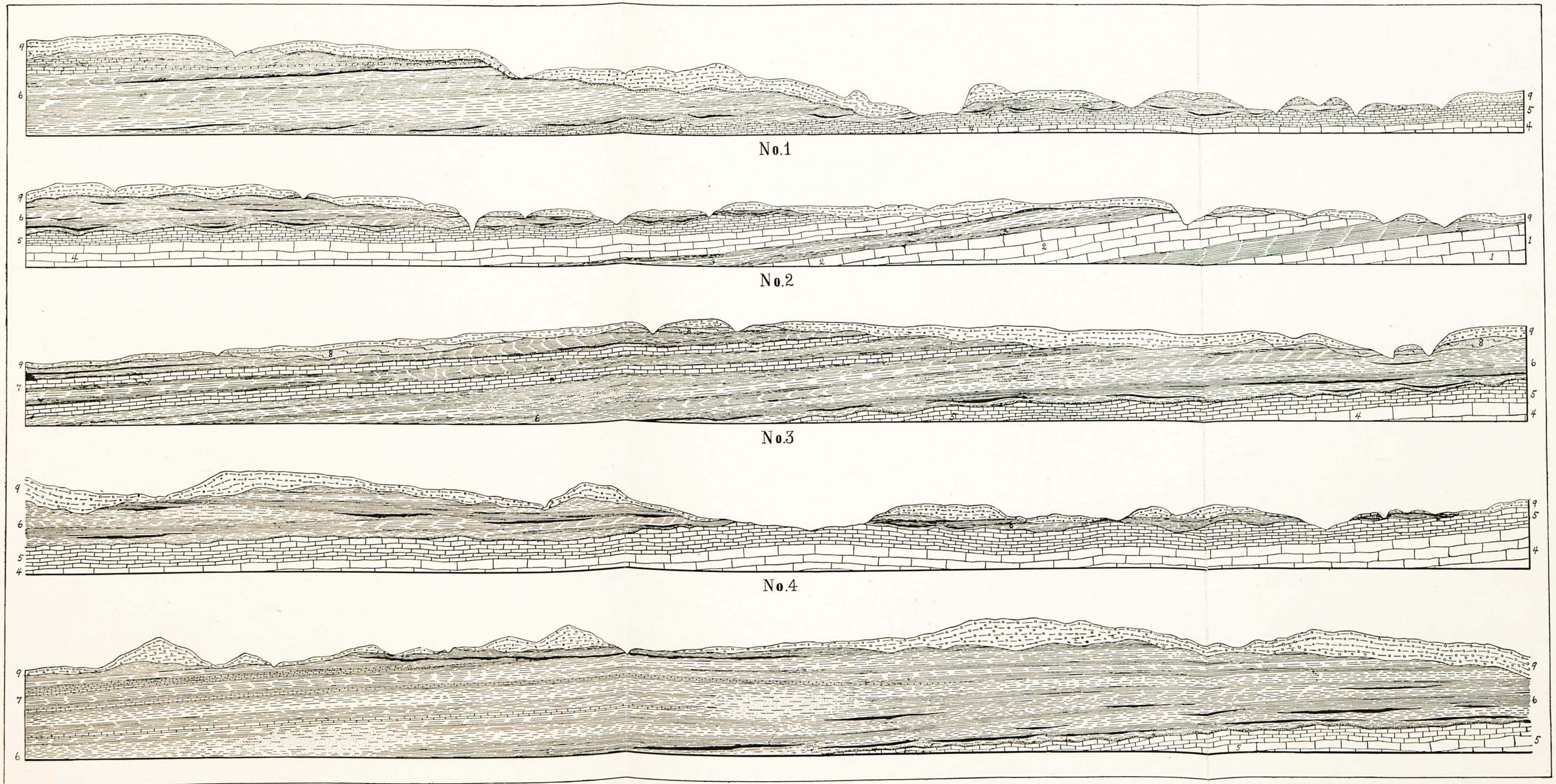
STRATIGRAPHY OF THE COAL MEASURES.

Introductory Remarks.—Iowa has been little affected by mountain-making forces. The rock strata are consequently largely undisturbed. As compared with mountainous regions, the arrangement of the successive layers of sediments is in a general way quite simple. Nevertheless when considered in detail there appears at the outset a complexity of structure in much of the coal producing area which is entirely unlooked for. Owing to particular conditions of deposition and to certain peculiarities of later erosion the relations of the different rock strata do not present the great simplicity that might be expected. According to the best information derived from a study of the rocks throughout the Coal Measure area of Iowa these beds were laid down along the coastal incline of an old Paleozoic continent. The various layers were formed on a low plain which, though remaining near sea-level most of the time, was sometimes elevated above the water and subjected to erosive agencies or depressed below the surface of the sea to be covered by new accumulations of sediments. With the erosion of the land and the action of ever varying currents the final disposition of the beds became more or less highly complicated.

The Iowa-Missouri coal basin represents a broad bay-like expansion opening toward the west, and in this direction, during later Paleozoic times, into the great interior sea which occupied all the western half of the present continent of North America. The Iowa coal field may have been at one time connected with the Illinois area but the evidence now seems to indicate that if this was ever the case the belt now traversed by the Mississippi river was not far below sea-level and that the waters at all times were very shallow.

Regarding, then, the Iowa Coal basin as once forming a part of a large sheltered bay in which were deposited shore sediments along the marginal zone, and open sea beds in the interior or central portion, lines drawn perpendicular to the old shore-line would be directed westward in the southern portion of the state and southwestward and southward in the north-central and northwestern portions. Geological sections along the lines mentioned show that everywhere within the marginal zone of shore deposits there is a characteristic want of continuity of the different layers, while, as the interior district is approached, particular strata assume a wide geographical extent. As in lithological features, therefore, the stratigraphical characters of the Iowa Coal Measures exhibit in a general way two well marked phases, the one distinctive of the marginal belt which has heretofore been commonly known as the "Lower" division and the other of the central area or "Upper" portion of the coal-bearing series.

General Sections.—Several generalized sections crossing the central portion of the state are shown in the accompanying plate. In all of the sections the different geological formations are numbered like: 1 is Silurian; 2, Devonian; 3, Kinderhook; 4, Augusta; 5, Saint Louis; 6, Lower Coal Measures; 7, Upper Coal Measures; 8, Cretaceous; 9, Drift. Section number 1 is approximately



GENERAL CROSS SECTIONS OF COAL MEASURE BASIN IN IOWA.

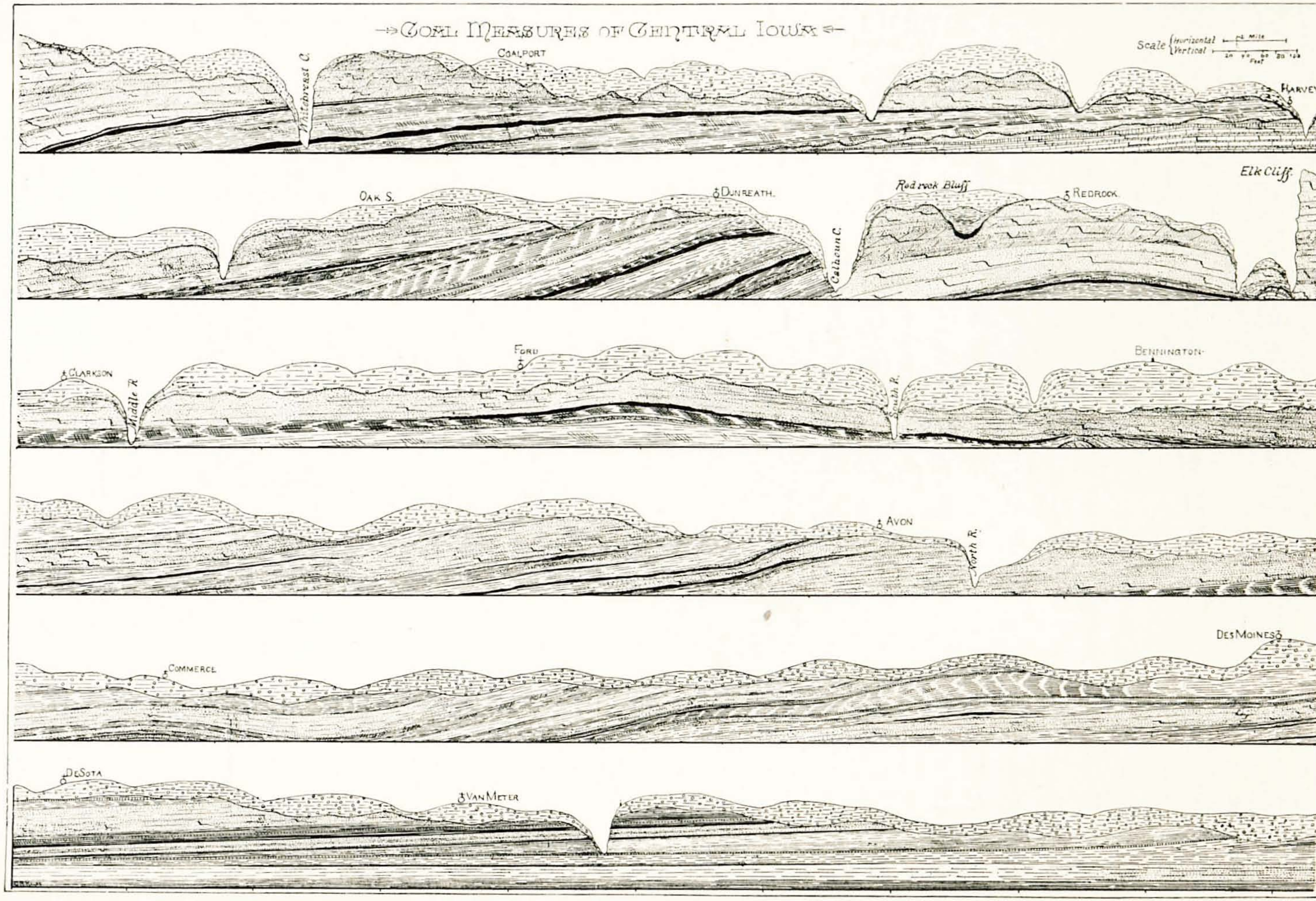
along the line of the southwestern branch of the Chicago, Rock Island and Pacific railroad, from Washington to the south state line. At its northeastern limit only the St. Louis limestone is shown at the surface. For some distance the Coal Measures are quite thin and the Lower Carboniferous limestone appears in the beds of the streams. Section number 2 is in a northeast and southwest direction from Cedar Rapids to Chariton. The older formations are represented as having a general dip to the southwest and the Coal Measures as resting unconformably upon them. Section number 3 is from the southwestern corner of Webster county to the northeastern corner of Page and has nearly a north and south direction. The Cretaceous beds are seen lying unconformably upon both the upper and lower Coal Measures. Section number 4 is constructed in an east and west direction along the line of the Chicago, Burlington and Quincy railroad.

The sequence of strata, the succession of fire clay, coal, bituminous shale or slate, sandstone, or sandy shales is so frequently repeated everywhere throughout the coal region of Iowa that it often becomes a matter of extreme difficulty to detect the fact that workable coal beds operated only a short distance apart may be very distinct from one another and that each is a separate horizon. Thus, failure to recognize the details of the proper arrangement of the coal-carrying strata had led prospectors and miners to claim that the different coal seams worked in a given locality have a much wider distribution than they really possess.

Form of the Coal Basin.—The northward extension of the great Interior coal basin of Iowa and Missouri occupies a broad, shallow depression deepening to the westward. Its thickest portion is centrally about at the present Iowa-Missouri boundary line, on the Missouri river. The vertical measurement at this place is variously estimated from 1,200 to 2,000 feet; but from that point it becomes attenuated toward the east and north, and thins out completely before reaching the Mississippi river in the one direction, or the northern boundary of Iowa in the other. The general relations of the Iowa Coal Measures to the underlying strata are those of a coal-bearing series of rocks reclining unconformably upon its limestone floor and therefore presenting some stratigraphical peculiarities not commonly met with among the other geological formations of the state; for the deeply eroded surface of the basement renders the disposition of the beds much more irregular than if it was an ordinary overlap of strata on a level area.

LOWER COAL MEASURES (DES MOINES BEDS).

Of all the Iowa Coal Measure districts that part in the central portion of the state in Marion, Polk and Dallas counties is perhaps better understood geologically than any other. Both the phenomena of structure and arrangement of the coal-bearing strata presented by this region may be taken as typical of a greater part of the Iowa Coal field. The leading facts are shown in a very detailed section from Harvey, in the southwestern part of Marion county, along the line of the Des Móines river to the Capital City, and thence up the Raccoon river to DeSoto in Dallas county, a distance of about sixty miles. The construction of the section has been greatly facilitated by the numerous excellent exposures afforded by railway lines that have been built nearly the entire distance on each side of the two streams. These railway cuts taken



GEOLOGICAL SECTION ALONG DES MOINES AND RACCOON RIVERS IN CENTRAL IOWA.

together with the natural outcrops on the rivers, permit the stratigraphy of the district to be very satisfactorily traced in all the minor particulars.

Along the line just specified, several hundred exposures were examined and measured, the different beds being carefully correlated in the field by direct passage from point to point. Out of the entire number of measurements made, ten of the most instructive and typical sections were recently selected and fully described. Accompanying the notes was a general section, the base of which was the low-water limit in the Des Moines river and on which was marked each of the localities considered. The Pleistocene deposits were not differentiated with sufficient care to warrant the separation, on the general section, of the drift sheets and loess.

Detailed Section in Central Iowa.—Passing westward from Harvey, at the southern extremity of the section, the St. Louis limestone, overlain at frequent intervals by white, fossiliferous marls from a few inches to fifteen or twenty feet in thickness, disappears below the water level in the Des Moines river at the bridge spanning the stream on the Pella and Knoxville road. This limestone appears again at Elk Cliff just below the town of Redrock in a low anticline exposed for a few hundred yards. At various places this limestone shows its upper surface channeled and unevenly eroded, the soft white clays which form the superior member of the formation in the district being completely removed. Coal Measure clays or sands fill these ancient ravines. The extent of the erosive action that took place prior to the deposition of the Coal Measures has not as yet been accurately made out. In a distance of ten miles, between Harvey and Elk Cliff where careful and satisfactory measurements have been taken, it is known that not less than seventy-five feet of shales intervene between the two horizons of the Lower Coal Measure sediments in contact with the Saint Louis limestone of the two places.

The exposure at Elk Cliff is very instructive for other reasons than those here mentioned. A small but deep ravine divides the section. On the left is the concretionary limestone, the last outcrop of the Saint Louis in Central Iowa to be noted in the ascent of the Des Moines river. At this place it rises in a low arch about fifteen feet above low-water. Overlying it are marly and somewhat sandy shales which have a vertical exposure of sixteen feet. The Redrock sandstone rises in vertical cliffs to a height of 150 feet. The inclination is 5° to the westward; but the dip is perhaps even greater to the southeast. The strata are visible down to the water's edge. The direct line of contact between the arenaceous and calcareous beds is not shown, as the detritus brought down by the streamlet, and the alluvial material deposited at its mouth by the Des Moines river during high water, completely conceal the stratified rocks for several yards on each side of the entrance. In his ascent of the Des Moines river in 1852, Owen observed the same exposure and thought that it indicated a fault of 150 feet or more. It is probable, however, that the case is one similar to that exhibited at the Redrock quarry; and that the limestone area at the time of deposition of the sandy material was a slowly sinking island or low promontory, which was eventually completely covered by the arenaceous deposit.

At Redrock cliff the stone is for the most part massive, with a dip everywhere to the south and west; and a short distance above the quarry just alluded to, the inclination is very considerable. A mile beyond, the sandstone has disappeared completely and the section shows only shales and clays. The space between the latter exposure and the last known outcrop of the sandstone is, perhaps, half a mile, the interval being largely hidden by Pleistocene deposits down to the water-level. The abrupt change in the lithological characters of the rocks in so short a distance has been mentioned by Owen and by Worthen but the explanation is entirely different from that offered by these writers.

The upper limit of the Redrock sandstone as disclosed in the quarry is very uneven and paved everywhere with rounded waterworn boulders and pebbles, derived from the sandstone itself. A fire clay covers this pavement and upon it rests a coal bed having a thickness of six feet centrally, but rapidly thinning out laterally in both directions to an unimportant, scarcely recognizable bituminous seam. Northward, or at right angles to the face of the section, the coal is thicker. Superimposed upon the coal are drab and ash colored clayey shales having an exposed thickness of thirty feet but which are manifestly much more extensive. From a consideration of this section, then, it is clear that before the superimposing coal seam was formed the vast sand bed had been raised above the surface of the waters, consolidated, and was then subjected to considerable denudation. In a small trough or ravine, excavated in the sandstone, the Carboniferous material was deposited as the land was again being submerged. Immediately to the north of the section represented in the figure (which faces the south) the corrasion acted much more vigorously, as is shown by the rapid inclination of the axis of the trough in that direction; so that the section is actually across a tributary ravine opening into a large basin in which the coal is now mined in large quantities. The inference is, then, that the abrupt disappearance of the great bed of sandstone in such a short distance as half a mile above the quarry where it has an exposure of more than one hundred feet, is not due wholly to inclination of the stratum, but it is the result of great erosion in that direction, previous to the deposition of the shales and clays; and that the massive sandstone really formed a bare hill of considerable height against which the subsequent deposits were laid, when the conditions for such a change occurred.

Here, to all appearances is an extensive sandstone formation with a maximum thickness of more than one hundred and fifty feet, lying unconformably upon the St. Louis limestone and with coal bearing strata imposed unconformably upon it. At one time it was thought the sandy member represented shore or estuary deposits of the Kaskaskia sea. Such, however, was found not to be the case. A few miles below Elk Cliff, as already remarked, exposures were observed showing fully seventy-five feet of dark sandy, clayey and bituminous shales between the sandstone and the concretionary limestone. The shales carry at least two workable seams of good coal, one of which attains a thickness of five to seven feet and has a very considerable geographical extent.

The recent observations therefore have cleared up many of the hitherto doubtful points concerning the geological history of the Redrock sandstone. It is not the basal member of the Coal Measures as was regarded by Worthen; nor is it a shore extension of the Kaskaskia limestone; neither is its geographical extent as limited as has been supposed. Twenty miles to the southeast of Redrock a sandstone of great thickness, having identical lithological characters and with a similar stratigraphical position, is believed to be its extension southward. And it may also rise a few feet above low-water in the north-west corner of Marion county. The most interesting consideration in regard to this Redrock sandstone is the fact of its considerable elevation above the surface of the sea and its subjection to subaerial erosive agencies for a long period of time before the submergence again took place. During the interval the great thickness of sandstone probably was almost entirely removed in places.

A short distance above the Redrock cliff where the great sandstone completely disappears the sandstones,

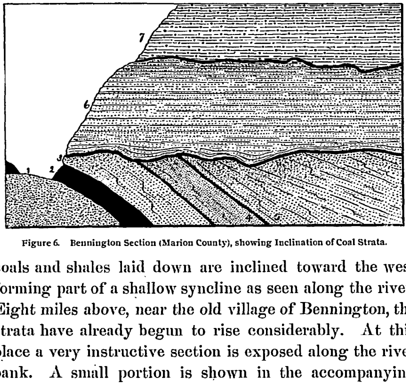


Figure 6. Bennington Section (Marion County), showing Inclination of Coal Strata.

coals and shales laid down are inclined toward the west forming part of a shallow syncline as seen along the river. Eight miles above, near the old village of Bennington, the strata have already begun to rise considerably. At this place a very instructive section is exposed along the river bank. A small portion is shown in the accompanying figure 6.

In this section number 1 is a massive, compact sandstone somewhat concretionary in places. It appears to be a small knoll, rising scarcely ten feet above the water level of the river and exposed horizontally only about a dozen yards. Its rounded surface is considerably hardened and more or less ferruginous. In lithological characters this rock is identical in all respects with the Redrock sandstone and may represent the summit of an eroded elevation of that great sand stratum. Immediately overlying the sandstone and inclined at a considerable angle is a bed of coal two feet in thickness (number 2). Above the coal is a heavily bedded yellow sandstone (number 3) having a measurement of four feet. This is followed by a soft blue sandrock about three feet in thickness. Next comes a buff, rather soft sandstone, heavily bedded at first, but gradually becoming more and more thinly bedded eastward. This formation is at first inclined about the same as the coal bed, but in passing down the stream the dip acquires a lower and lower angle, until a quarter of a mile away the planes of stratification are nearly horizontal. Number 6 is a thin ferruginous band about two inches in thickness, very irregular and cutting across the underlying beds obliquely. It is manifestly an old eroded surface. Above it are ten feet of thin clayey sandstone layers and sandy shales, the bedding planes following the sinuosities of the irregular band at first but quickly assuming a straight horizontal position. The sandy shales were evidently more extensive but were probably removed largely through glacial action. More than forty feet of drift cover them.

From Bennington to Des Moines the strata are very undulatory, sometimes rising, sometimes sinking. Beyond Des Moines westward, the layers become nearly horizontal with little or no change in the dip. This very noticeable difference in the laying down of the beds marks the

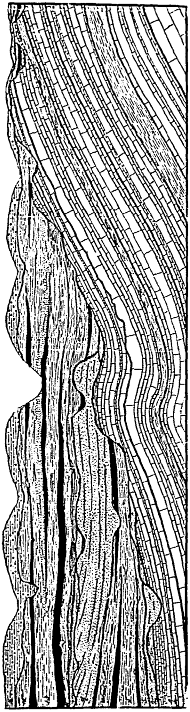


Figure 7. Composite Section showing Structure of Lower Coal Measures of Iowa.

passage from the "Lower" to the "Upper" Coal Measures — a transition from the marginal or coastal sediments to the more open sea deposits.

The geological cross section of the Carboniferous in central Iowa may be taken as representative of the Lower Coal Measures of the state. A summary of the facts brought out may be graphically given in a generalized, or rather composite, section, as shown in figure 7.

There is in the Lower Coal Measures one notable exception to the general arrangement of the coal seams and associated strata in limited interlocking beds. This is the Mystic coal vein which simulates the even character of the Upper Division. While properly belonging to the marginal deposits it is quite probable that it was formed in a more open part of the coastal zone under conditions much like those prevailing in the formation of the Upper Coal Series. The coal seam and two beds of heavy limestone, thirty feet apart and some distance above the coal, are found to extend with little or no change of relations for a distance of fifty miles in one direction and forty in another. Wherever the strata in this area are penetrated the same succession of layers is passed through. The strata are very regular and dip slightly to the south and west, so that in crossing the county of Appanoose there is a fall of about one hundred and twenty-five feet.

Variability of Strata.—In considering the stratigraphical features of the Lower Coal Measures the conclusion will probably have been reached that the beds present great variability. Such indeed is found to be the case. In fact it is one of the most striking characteristics of the formation represented in Iowa. The rapid passage from one bed to another lithologically very distinct is everywhere apparent, the transition taking place vertically in different layers or laterally in the same horizon. The stages and manner of gradation of the various beds from one to another have already been described sufficiently.

Unconformities in the Coal Measures.—Local unconformities in the Iowa Coal Measures are well shown in a number of places. Those noticed in connection with the Redrock sandstone, already described in the geological cross section of the Coal Measures in central Iowa, is perhaps the most prominent now known. It is fully 200 feet above the Lower Carboniferous limestone, and sections show the entire thickness of more than 100 feet of the Redrock sandstone to be removed through erosion. In some places coal beds fill old gorges. Other physical breaks in the Coal Measures are indicated elsewhere along the same stream but at present they are more or less completely obscured by débris. These phenomena go to show that during the deposition of the coal bearing strata numerous minor oscillations of the shore-line occurred allowing the waters to recede slightly and then again advance inland.

Thickness of the Lower Coal Measures.—In connection with the brief account of the leading geological features of central Iowa as brought out by an examination of some of the natural exposures, allusion should be made to the information pertaining to the Carboniferous rocks below the datum line of the general section. All attempts to secure reliable accounts of the strata passed through in the borings and the sinking of mine shafts have availed but little, since such information is almost invariably withheld by the parties in charge of the operations. For this reason the difficulties of working out the structural details of this part of the Carboniferous group were somewhat greater than they otherwise would have been; and the final results are thus considerably delayed.

As already stated the general dip of the strata along the principal line of investigation is southwestward. The mean thickness of the Lower Coal Measures, as shown by careful measurement of the various members, must originally have been considerably more than seven hundred feet. This determination was arrived at in the following way. At the most easterly exposure of the section, the distance from the St. Louis limestone to an easily recognizable bed near the top of the bluff was perhaps fifty feet in a direction normal to the dip and strike. This particular layer was then traced to the point where it disappeared below the datum line and the measurement was repeated in the same manner as before. Of course it is not to be supposed that the present thickness of the Lower Coal Measures in central Iowa is nearly so great as the figures above given would suggest; for in reality the maximum vertical measurement of the beds is probably a little over one-half that estimate or not far from four hundred feet as is fully attested by borings. Erosion has largely removed the coal bearing strata of the district, and therefore the original thickness of these rocks is not preserved in any one place.

Summary.—Briefly stated the leading stratigraphical features of the Lower Coal Measures may be summarized as follows:

(1) The Coal Measures of Iowa were laid down over an ancient surface with hills and vales, ridges and gorges, the line of overlap passing over Lower Carboniferous, Devonian or even Silurian rocks.

(2) The unconformity of the Lower Coal Measures of Iowa upon limestones of the Lower Carboniferous is much more pronounced than has been generally suspected. The confirmation of this statement is found in observations recently made at Elk Cliff, Harvey, and Maryville, in Marion county, at Fairfield, in Jefferson county, at What Cheer, in Keokuk county, and at many other points.

(3) The striking unconformities in the Lower Coal Measures have never been so apparent as at present. The most remarkable instance of this sort is the case of the Redrock sandstone. The thick sand bed was manifestly consolidated and elevated above the surface of the sea for a considerable distance, then it was subjected to long denudation as is shown in the deep gorges and ravines which are still preserved in the hard sandstone. So wide spread was the action of the erosive agencies that the great sandstone more than one hundred and fifty feet in thickness, was largely removed, so that at present only a

few isolated outliers tell of its former great extent. When regional submergence again set in, the old gorges and shore depressions were occupied by small swamps.

(4) With a few exceptions the earliest formed coal seams are far more extensive both geographically and vertically than later ones.

(5) The coal of Iowa may be regarded as distributed in innumerable lenticular basins, sometimes several miles in diameter and six or seven feet in thickness centrally, sometimes only a few hundred yards in extent. These occur at many different horizons and interlock with one another, so that a boring may pass through a score or more coal horizons without meeting more than one or two veins of sufficient thickness for profitable working.

UPPER COAL MEASURES (MISSOURI FORMATION).

In contradistinction with the stratigraphy of the Lower Coal Measures that of the Upper Division is remarkably regular, in this respect closely resembling the Lower Carboniferous. The stratigraphical continuity is therefore very much more pronounced than in the case of the marginal zone. This fact is due chiefly to the different conditions under which the two formations were laid down, the Upper Coal Measures being essentially open sea deposits for the most part. As already seen the lithological characters are also less changeable than they are in the Lower productive measures. The greater prevalence of limestones, which are among the most persistent of strata, gives a continuity of horizons not met elsewhere in the Coal Measures. The different layers are capable of being traced long distances.

Typical Section.—Perhaps the best sections of the Upper Coal Measure rocks are exposed along the Nodaway river in Page, Montgomery, Adams and Adair counties, along the Nishnabotna in Page and Montgomery counties and along the Missouri from Council Bluffs to the southern boundary of the state. On the two former streams the horizons appear very even and seem to dip with the stream and at about the same angle. The principal coal vein is exposed in many places and always at nearly the same distance above the water level. In the northern part of Adams county the seam apparently passes beneath the bed of the water course. The remarkable uniformity in the low inclination of the strata in the Nodaway river section may be due to the fact that this river flows approximately parallel to a shallow synclinal axis; for there are known to be well defined folds in the Carboniferous strata of southwestern Iowa.

Deformations.— Along the Missouri river very considerable dips in the beds are noticeable at various places. The most conspicuous inclination is near Jones Point where a thickness of more than one hundred feet of strata is carried below the water level within the distance of a mile. Certain of the thick limestone beds are easily recognizable for miles along the stream. Todd, who has given careful attention to the section, has recently shown that there are a number of these corrugations whose axes trend north 60 degrees east or approximately parallel to the northwestern boundary of the Iowa coal field. Measurements show that the crest of one of the anticlines is nearly five hundred feet above the trough of an adjoining syncline. The recognition of regular folds in the Carboniferous strata of the state has a very important bearing upon the explanation of certain geological phenomena in different parts of the coal field which are not easy to understand otherwise. In the Lower Coal Measures the entire absence of persistent horizons over wide areas has prevented deformations of this kind from being studied satisfactorily. A number of well marked anticlines and synclines in the strata older than the Carboniferous has been known for some time, though their exact boundaries and amplitude are not as yet definitely known. With the presence of these folds in the formations above and below the coal bearing rocks it is to be inferred with but little doubt that the bending has been also imparted to these border layers in which it has not heretofore been recognized. The bearing of this observation upon the possible occurrence of natural oil and gas in commercial quantities in Iowa is very important. It is known now that all of the conditions for a successful flow are present in the state, but the exact extent to which each of these conditions are satisfied yet remains to be determined. The crest of the anticlines must be penetrated in order to obtain a proper flowing. It therefore is of prime importance to have the different folds located accurately, but this requires time and careful study of the geological structure before outlays of money should be made in prospecting. When this work is accomplished a few tests will soon disclose whether or not Iowa is to become a gas and oil center.

Rock oil is an almost universally distributed substance ; but for the successful production in commercial quantities four conditions must be fulfilled. The absence of any one of these must result in the failure of any enterprise of this kind undertaken. There must be :

(1) A suitable receptacle or reservoir in which the oil or gas may accumulate.

(2) A non-porous cover to retain these substances.

(3) A particular geological structure or arrangement of strata.

(4) A pressure sufficient to force the oil or gas to the surface.

The first of these conditions is commonly fulfilled by a coarse sandstone, conglomerate or porous limestone. The rocks allow the ready transmission of liquids or gases from one part of a stratum to another. The second condition is satisfied by some close-grained rock overlying the porous stratum. This impermeable layer is usually found in a shale. Both of these requirements are found almost everywhere on the globe to a greater or less extent wherever stratified rocks are laid down.

The third requirement is that the rocks must be tilted. In the porous layer this permits of a movement of the water, oil and gas particles—a free mechanical rearrangement. The accumulation is in order of the respective specific gravities, the water at the bottom, then the oil and finally the gas at the top. The particular geological structure requisite is ordinarily the arch, fold or anticline. It is readily understood that having arranged themselves according to their respective specific gravities the gas occupies the central portion of the arch, the water the bottom and the oil a space between. When the top of the dome is pierced gas escapes; when the arch a little farther down is drilled into oil flows out, while if the strata near the base of the bow are penetrated only salt water appears. The formation of the arch is due to the same causes which elevate the mountains. Consequently in mountainous regions the folding is more pronounced than in districts little affected by the forces named. In those portions of the continent that are remote from mountain ranges the bending of the strata is not so striking and the determination of the extent of the folding is much more difficult than in regions that have suffered greater disturbance. The folds when they appear are not so extensive, but in many cases they are still sufficiently great to satisfy one of the most important conditions for a successful flow of oil or gas. The fourth or last condition to be considered is the presence of rock pressure which is essentially artesian or hydrostatic and is measured by the height of a column of salt water which would rise in any well were water struck instead of gas.

Thickness of the Upper Coal Measures.—The thickness of the Carboniferous strata of southwestern Iowa and the adjoining parts of Missouri has been variously estimated. Broadhead was of the opinion that the Upper Coal Measures were between 1,300 and 1,400 feet in thickness. White regards them as only 200 feet thick. Todd, who has made some careful measurements along the Missouri river, has shown that no less than 350 feet are represented. Winslow recently making an investigation of deep drillings in northwestern Missouri is led to believe that the thickness of the beds is even greater than any of the figures here given. Deep borings at Red Oak, in Montgomery county, seem to indicate that the thickness of the Upper Coal Measures strata at that point is more than 500 feet. Putting together all the data upon which these various estimates have been made, and taking into consideration recent observations in the southwestern part of the state, it is probable that the greatest thickness of the Coal Measures is in the neighborhood of 800 feet. This latter estimate includes also most of the so-called Middle Coal Measures of White, which were regarded by him as having a thickness of 200 feet, but which later were shown to be considerably less.

GENERAL CONCLUSIONS CONCERNING THE LOCAL STRATIGRAPHY OF THE IOWA COAL MEASURES.

Heretofore the general impression has been that the "Lower" Coal Measures of the state were deposited prior to the laying down of the rocks of the Upper Division. Recent investigation seems to show that the two were formed contemporaneously; and that the former is to be regarded as a marginal or shore formation while the latter is the more open sea deposit.

It has already been shown that, just previous to the deposition of the Coal Measures in Iowa, Missouri and Kansas, continental movements caused the shore-line of this region to recede several hundred miles to the southward. For a considerable period—during the Kaskaskia epoch—erosive agencies were actively at work on the land surface which extended southward about as far as the present city of Saint Louis. Shore deposits—sands and clays—were laid down immediately beyond the place just mentioned, while farther southward marine beds continued to be formed one above another conformably.

When a new period of depression set in, coal marshes were formed along the landward creeping shore-line. The more strictly marine deposits began to slowly extend farther and farther northward resting on the older calcareous beds as well as the earlier formed marginal areas of sands, clays and accumulated vegetation. This process with many brief interruptions continued until the old shore-line had again gained its former place near the present Iowa-Minnesota boundary. As represented in the accompanying figure 8 it will be seen that the coal or marginal beds were formed at the same time as certain limy layers farther outward; and that all formations along any given horizontal line (nearly horizontal but having a slight inclination to the southwest) were deposited contemporaneously. On a sinking coast the marginal sediments would have continually the later open sea deposits laid down upon them. The covering of the coal bearing strata by the calcareous beds would constantly take place as long as the depression of the shore continued.

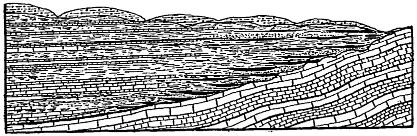


Figure 8. Ideal Cross-section of the Iowa Carboniferous Rocks.

The "Lower" Coal Measures are not then a series of beds laid down previous to the deposition of the "Upper" Coal Measures. Each particular part of the former was deposited at the same time as portions of the latter farther seaward; the lines of contemporaneous deposition being nearly horizontal, yet having a common though slight seaward tilt. As a whole the "Lower" Coal Measures do actually lie beneath the "Upper" Coal Measures; but the line of separation is not a line drawn parallel, but obliquely to the planes of sedimentation.

The essential difference between the two ideas is graphically shown in the following diagrams. (Figures 9 and 10.)

Beyond the point of the southernmost extension of the ancient shore line (a little beyond the left hand terminus of the cut perhaps, figure 10) the limestones of the Upper Carboniferous would lie upon the Lower with practically no evidence of any physical break. The fauna of the latter would continue into the former with little or no change or inconvenience.

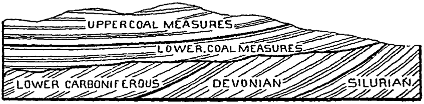


Figure 9. Popular Idea of the Relations of the Lower and Upper Coal Measures.

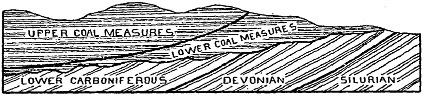


Figure 10. Actual Relations of Lower and Upper Coal Measures as now Understood.

COAL HORIZONS.

From what has been said it will be readily inferred that the Western Interior coal field at the time of its deposition was for the most part a broad shallow bay opening to the westward into the great continental sea, which then occupied most of what is now western North America. That the Coal Measures of the region were laid down during a period of gradual, prolonged, though often checked, subsidence is evidenced by all stratigraphical and lithological details, as well as by the characteristic faunal peculiarities. That the coal beds originated largely in coastal swamps of limited breadth but, with some interruptions, of very considerable length, stretching out near sea level for long distances and sending out minor extensions into the old rivers and estuaries is fully warranted by the facts disclosed everywhere. On the low slowly sinking shores there prevailed at certain times a similarity of physical conditions especially favorable to coal formation.

During these intervals unusual amounts of coaly material were allowed to accumulate and to be preserved in places, the period being pre-eminently one of coal growth, at least for a given province. The great stratigraphic plane marking the record may be appropriately termed a "Coal Horizon."

In stratigraphy, a geological horizon is a level recognizable over a considerable geographical extent, having a more or less well defined stratigraphical position, distinctive as to lithological features and characterized by a particular set of fossils. The term in a broad sense is almost equivalent to formation and has been used as indefinitely. In its more limited meaning it is applied properly to a minor part or zone of the smallest stratigraphical unit having a commonly accepted specific name. Understood in the same way, a coal horizon represents an even more limited expansion, where coal forming materials have accumulated. Practically it is one of the greater planes of sedimentation, marking a distinct episode in the deposition of a series of strata. Theoretically it represents not a phenomenon but rather a set of conditions, a period during which the physical circumstances were similar over a considerable marginal portion of a geological province. From an economic standpoint it stands not for a continuous bed of mineral fuel but a stratigraphical level where workable beds are more likely to occur than elsewhere and where the coal is to be especially sought for in a wide belt fringing a great coal basin. It is not to be inferred, then, that the mineral is equally developed on a given horizon in all portions of this marginal border. In some places the accumulations of plant remains are much greater than in others; limited basins and troughs of unusual thickness are there found.

Elsewhere the old vegetable materials are meagerly represented; only thin seams of coaly matter are preserved. Wide intervals of sandstone and shale often separate adjoining basins, or ancient land elevations may cut off one area from another. (See figure 1.) Yet through all of the many irregularities of deposition and subsequent deformation there are, nevertheless, discernible certain levels quite well defined at which coal beds are very much better developed than at others; clearly marked coal horizons they are, broad in extent and capable, in the case of the greater ones under favorable circumstances, of being traced over a large part of a given coal province. The coal may not be present in a continuous seam over the whole border district and probably never is; but along much of the margin of the coal horizon which at one time must have stood near the sea level for a considerable period, are innumerable basins separated from one another perhaps, yet to all appearances formed contemporaneously. Now they may thicken into sharply defined lenticular beds; now thin out to mere films, or disappear altogether; and again farther on they assume the form of extensive lens-shaped sheets. During deposition, as subsidence became too rapid or the sea too deep for the proper accumulation of vegetable material sediments were carried in, covering the plant beds. Or, if elevation took place, the old swamps, already shut off from free access to the sea, were subject to the agencies of denudation and were partially or entirely removed. As favorable physical conditions again set in the same course of events might be repeated.

In considering the relations of the different coal horizons to one another an approximate parallelism may be made out; not a strict parallelism of the nature which

Andrews* claimed to be true in Ohio, and which Newberry† subsequently stated to be entirely unsubstantiated by facts, but an approximate parallelism in a broad way.

There was apparently the germ of the truth in the idea of the first named author, though he was probably unfortunate in the choice of a name for his theory. Moreover, none of his writings indicate that he understood the problem in the way that recent investigations reveal it. His statements all seem to show that, while he was manifestly on the right path only one side of the subject had been presented to him, just as, quite recently, the question has been discussed from the opposite extreme. Andrews' views are perhaps best expressed in the following paragraph taken from his paper‡ on the subject:

"I have never found the slightest proof of the formation of a seam of coal over hills or high grounds. The parallelism of the seams, of which further mention will be made forbids it. * * * So far as my observations go, I have never found an instance where two distinct seams of coal came together, or conversely, where a seam became divided and its parts continued to diverge for a long or indefinite distance. It is not uncommon to find, in a seam of coal, proof that the coal marsh had in it local depressions, which were filled with sediments, making a soil on which new vegetation grew, and thus the seam shows two parts, separated by fire clay sometimes several feet thick; but in every instance when traced, I have found the parts to re-unite. The two parts never diverge indefinitely. From these statements we may infer a general law of parallelism. Such law is in harmony with

*Geol. Sur. Ohio, vol. I, p. 348. Columbus, 1873.
†Geol. Sur. Ohio, vol. II, p. 169. Columbus, 1874.
‡Geol. Sur. Ohio, vol. I, pp. 348–350. Columbus, 1873.

the belief of the most careful observers, that our productive Coal Period was characterized by great quietness and freedom from violent local disturbances."

This describes the apparent condition of things in Ohio, the same, with minor modifications and explanations, may be regarded as according fairly well with the facts observed in the Iowa-Missouri coal field.

On the other hand there are many who, with Newberry, have directly opposed any approach to the recognition of the parallelism of coal seams. Among the latest to express an opinion on this side of the discussion is Winslow* who in considering the stratigraphy of Missouri

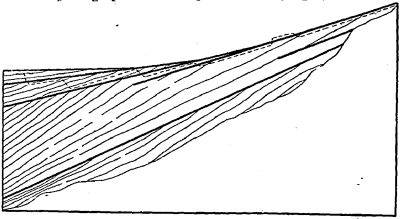


Figure 11. Stratigraphy of Coal Beds.

coal seams is lead to believe that the different veins diverge from one another in a manner best explained by the diagram given above, the dotted line representing Post-Carboniferous erosion. (Figure 11.)

These conditions also accord in the main with the facts observed in all the Western Interior coal field.

An attempt to harmonize the two seemingly very divergent and even contradictory theories is apparently fruitless. But a more careful examination of the subject

* Geol. Sur. Missouri, Prelim. Rep. Coal, pp. 28–30. Jefferson City, 1891.

shows that the two theories are manifestly not based upon facts taken from the same point of view, but from quite different positions. Andrews' idea may be regarded as representing cross sections of the coal bearing strata taken parallel to the general course of the shore; Winslow's a section at right angles.

In districts where mountains are being elevated orographic movements in the earth's crust continue to be felt for long distances from the line of maximum disturbance. If a great sea or an ocean occupies a region affected to a moderate extent by the oscillations, an extended shore-line trends approximately with the axis of the mountain system, for the more important minor corrugations commonly run in similar parallel lines. The direction of maximum change in the inclination of the strata is therefore at right angles to the axis of the folds and hence in a broad way perpendicular to the shore-line. The direction of minimum change in tilting is under ordinary conditions the same as the axes or parallel to the shore. Bearing these suggestions in mind geological cross sections, under favorable circumstances of examination, would show a general parallelism of coal beds when made in one way; a decided tendency to non-parallelism when constructed in the other.

Granting, then, an old uneven land surface such as is known to have existed in Carboniferous times in the upper Mississippi, with the waters of the sea and the marginal maritime flats gradually creeping inland, it would naturally be expected that in any one of the marshy plains skirting the shores for any great distance there would be a very tortuous boundary on the land side and a somewhat less sinuous line of the seaward side; on the one hand were probably low hills and uplands sending out spurs here and there which cut off one marsh from another and often allowed long open stretches of low upland to reach out even to the waters of the sea itself (figure 12); on the other hand were often narrow

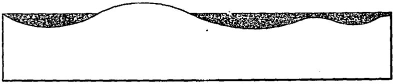


Figure 12. Coal Horizon at Time of Formation; Parallel to Shore-line.

coastal plains rising scarcely above sea level, but shutting off to a great extent very effectually the saline waters from the swamps. Viewed areally the productive part of a great coal horizon is a wide irregular zone running in a tortuous course around a more or less extensive portion of the margin of a coal bearing basin included within the limits of a geological province. Examined at the present time coal horizons present, with all the irregularities of original deposition, subsequent change and deformation, a quite different aspect from the ideally perfect level of the ancient surface, or zone, during the process of formation.

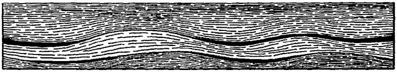


Figure 13. Coal Horizon as it Now Exists; Parallel to Shore-line.

In one direction parallel to the shore, there would be a series of minor saucer-shaped basins strung along on about the same great stratigraphical plane. (Figure 13.) They may rise or fall according as the other strata change in inclination. They may be separated by wide stretches of sandstones or shale or may come together in places. In the different basins the original vegetable materials in becoming compact shrink most in bulk in the middle, thus allowing the margins to remain considerably higher than the center. This is more noticeable in small basins than in large ones. Then too the fact that the direction of minimum movement in the changes of level was, as has been shown, parallel to the prevailing trend of the shore does not preclude even in this direction a certain amount of tilting of the strata either by the rising or the sinking of one portion of the shore more rapidly than another; or by the passage of minor folds in directions not strictly harmonious with the general rising.

When a new cycle of vegetable accumulation took place the coastal swamps would again spread out at sea level, but not on plains exactly parallel to the horizon previously formed. Horizons which were separated to very considerable distances by shales or other strata probably are rarely exactly parallel to one another, or if so the parallelism is purely coincidental. There are other causes which also lead to the non-parallelism of the coal horizons. The original bottom of the shore may have been very uneven, as it is well shown in the very irregular surface of the Saint Louis limestone on which the Coal Measures of Iowa were laid down. Or, in two different areas the inequalities may be very great, the extremes often occurring in the same locality and thus presenting a much greater apparent unevenness than really exists. Erosion or currents may alter the position of the seams or parts of them. The top of the seams which were originally level become subsequently depressed in the center more than at the margins. There are also other causes tending to widen the seeming discrepancies.

In another direction, at right angles to the old shore, the minor basins along the different horizons may appear to show no tendency to parallelism at all. The approach to the parallel condition is inversely proportional to the amount of deformation occurring in the region at the time of the formation of the coal beds. Instead also of the seam being continuous for a considerable distance across the coal basins, as may be inferred from Winslow's graphic representation the productive coal strata should be confined to a limited marginal area and the coal horizon would only extend into the interior as a great stratigraph-

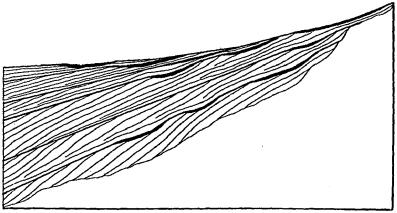


Figure 14. Coal Horizon Viewed at Right Angles to Shore-line.

ical plane, not easily recognizable perhaps, nor with any of the mineral itself to mark it. (Figure 14.)

The conditions described apply particularly to coal fields of Iowa and Missouri, where comparatively few disturbances of the strata have taken place. The relations are relatively simple. But in Ohio and Pennsylvania as the mountains are approached the structure increases rapidly in complexity, until in the highly folded and faulted districts attempts to follow out the original state of things may become utterly hopeless.

The majority of the larger coal deposits of the Western Interior field may be considered then as having been formed in swamps skirting a great shallow gulf, the extent of the productive portions of the different horizons being in a measure dependent upon the length of time the physical conditions were favorable to coal formation. Many short minor episodes doubtless existed between the larger ones during which comparatively small accumulations of vegetable material took place.

Another fact to be taken into consideration is that all the coal of the region was not formed in marine swamps, but that some of the minor basins were doubtless originally a very considerable distance from the sea, while certain others were formed with open sea conditions prevailing largely. A few seams also appear to have been formed as drift materials in estuaries at the mouths of streams.

CHAPTER VII.

THE COAL BEDS.

Important as coal is in its relations to the industrial prosperity of a community, and as extensively as mining is carried on in some localities, the proportion which the seam bears to the entire thickness and mass of Carboniferous strata is surprisingly small. On the whole the coal layers probably do not compose more than one-sixtieth of the entire thickness of the productive measures and in the majority of cases one one-hundredth, would be nearer the actual ratio. In thickness Iowa veins vary from a small fraction of an inch, a mere film, to ten or twelve feet; and at least one place is known where the vertical measurement is fully fifteen feet. The number of seams in different localities is not the same; in some places only one bed being present, in others upwards of a dozen.

Extent of Individual Coal Beds.—The geographical extent of single coal strata has long been the subject of much discussion, both at home and abroad. In the Appalachian region individual veins, like the Pittsburg seam, are recognizable over large stretches of territory. But in Iowa there is no such wide reaching continuity of coal layers. The workable beds, though numerous are more or less distinctly lenticular and are more limited geographically than in the eastern field. The arrangement in the western area of the bituminous deposits in numberless basins, at many different horizons in the Carboniferous series, is such as to give to each county a very much larger amount of coal than could possibly be disposed in one or two continuous sheets of the thickness of any one of the basins, and spread out over the whole district equally.

The great similarity of the different coal seams and their associated beds enables almost identical vertical sections to be seen in widely different localities and at very different horizons. Hence, unless extreme care is taken, and a given layer traced from point to point, great confusion is apt to occur in regard to correct identifications. This similarity of carbonaceous beds has given rise to the opinion that coal layers in general are very presistent, extending continuously over broad stretches of country. Among the extremists defending this theory may be mentioned Lesquereux, who states* in summing up his conclusions in regard to the fossil plants of Illinois:

"I think we can readily admit that the contemporaneousness of formation is recognizable over the whole extent of our coal fields, not only on a general point of view but even considering each separate bed of coal." This assertion was not made concerning the Pennsylvanian coal seams alone but was applied to beds which were thought to spread out continuously from the Appalachian coal fields as far as the Mississippi river or even into regions still farther west.

Newberry† has shown conclusively that the writer just mentioned was in error in regard to the coal beds, at least so far as Ohio is concerned. It is also now generally conceded that in Indiana and Illinois the individual coal beds

* Geol. Sur. Illinois, vol. II, p. 467. 1866.

† Geol. Sur. Ohio, vol. II, pp. 166–167. 1874.

do not have near the extent that they were once supposed to possess. The same has been more recently found true of both the Iowa and Missouri areas.

Character and Number of the Coal Beds.—There is an opinion among the miners of the state that there are three workable coal veins. These are usually designated as the "first," "second" and "third" seams. Should subordinate beds be encountered in the sinking of a shaft they are not taken into consideration. As a matter of fact the occurrence of several seams in a locality is purely accidental. The "three" veins are not continuous over areas of any great extent, and may have widely different stratigraphical values, even within very short distances. The "first," "second," and "third," seams of one shaft may be entirely distinct from the similarly called beds of another mine but a short distance away. A noteworthy instance for citation in this connection is a boring made near the city of Des Moines. It was two hundred feet in depth. Twelve distinct coal horizons were passed through, giving a total thickness of coal of thirteen and one-half feet; yet none of the beds were thick enough for profitable working. Only one-third of a mile away was a mine removing coal from two seams, one of which was four to five feet thick. It thus happens that in counties where the Coal Measures are 200 or 300 feet in thickness below the "third" vein, and could be easily penetrated with every probability of reaching workable beds, it is impossible to induce operators to search for coal below the lowest of the three beds known, and as soon as the coal has been recovered from the three veins the mines are abandoned. Yet, on the other hand, so widely spread are the ideas of the great extent of workable coal veins that it is not unusual to find persons engaged in mining, claiming to be operating the identical beds which are worked in distant parts of the state. Some operators in Dallas county, and even Guthrie county, have expressed great confidence in finding the "Des Moines vein" in all its thickness and properties by boring deeper than the shafts at present operated. The "first," "second," and "third" veins are sometimes thought to extend over nearly the entire state. This conception is often firmly believed to be the exact arrangement of the coal beds. In the western part of Keokuk county, where the Coal Measures are quite thin, and where only one seam of coal has been opened, borings for the "second" vein were commenced not long ago in a knoll of Saint Louis limestone and put down more than 200 feet. This is only an isolated case taken from many which shows the fallacy regarding the wide areal distribution of single seams.

The stratigraphical importance of the coal seams is not so great as has generally been supposed, since as already shown, the bituminous beds are, with very few exceptions, quite limited. Few cases are at present known in which the geographical extent of a workable coal stratum is more than four or five miles. It follows that the coal seams of this region are not nearly so extensive as commonly regarded and that until the more important coal horizons are carefully made out they possess little value in general correlations.

The basal coal seams in the Lower Coal Measures of Iowa appear to be much more extensive than those toward the top, where they may be only a few inches in vertical measurement and perhaps a few hundred yards in extent. The coal may, therefore, be considered, as stated already, as disposed in numerous basins of greater or less area, thickened centrally, but gradually becoming attenuated toward the margins. This arrangement is seen in the Des Moines river section of the Lower Coal Measures. (Plate xiv.) It may be more clearly represented by the following (figure 15).

The disposition of the coal in numerous limited lenticular basins instead of a few layers extending over broad areas is of the utmost importance from a purely economic standpoint. In all mining operations and in all prospecting it is very essential that this fact be kept constantly in mind. With methods of boring more modern than those commonly employed throughout the western states, there is every reason to believe that, in the Lower Coal Measures especially, the large majority of good coal

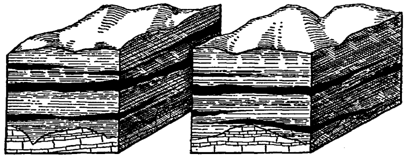


Figure 15. Stratigraphical Arrangement of Iowa Coal Beds.

seams twelve inches in thickness and over, encountered in prospecting, can be traced readily and easily to localities where they are thick enough for profitable working.

INTERRUPTED CONTINUITY OF THE COAL BEDS.

In Iowa the restrictions upon the distribution of the individual seams are not numerous as compared with other regions. Yet there are disturbances of various kinds which break the continuity of the coal strata, locally interfering somewhat but seldom severely with mining operations. They are referable to the three general agencies of deposition, erosion and dislocation.

Irregularities of Deposition.—These are due (1) to unequal subsidence or elevation; (2) to the unevenness of the Coal Measure floor; (3) to the former presence of varying currents. The effect of greater movements, upwards or downwards, in one part of an area than in another is to cause various beds to thin out in some directions or to increase in thickness in others. Old currents are directed out of their original courses or they bring in a different class of sediments.

The unevenness of the floor upon which the coal is deposited is due to a number of different causes. Before deposition there may have been gentle folds or undulations in the strata beneath whereby the coal was allowed

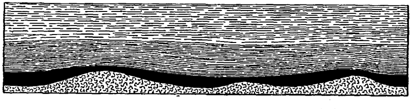


Figure 16. Uneven Character of Surface upon which Coal was Deposited. Markham Mine, Marion County.

to accumulate in synclinal troughs of the subjacent limestones. These folds, however, are commonly so broad that they affect but little single coal basins. Usually they limit the seam on one side, but unless the basin be very large there is little interference in the interior. Another cause for the unevenness of the coal seam is the undulatory character of the original swamp bottom. (Figure 16.) The same effect is produced also by the unequal density of the strata beneath the coal. When the pressure increases over the more open textured portions of the beds, the coal strata above form small anticlines and synclines. Or, when a part of the underlying strata is very hard and

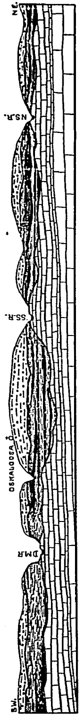


Figure 17. Ideal Section across Mahaska County, showing Unevenness of Coal Measure Floor.

unyielding, as when sandstone is formed, the beds are unequally depressed.

Another cause for the unevenness in the coal seam is the presence of unconformities below. When the unconformity is wide spread and partakes of the character of an old eroded land surface upon which the coal deposits are laid down the unequal distribution of the layers is very noticeable. This is the case of the Coal Measures in Iowa. Where the Coal Measures are comparatively thin the recognition of the exact conditions is of the greatest import. The coal laid down in one of the old valleys is often of very limited extent, the separate seams terminating abruptly against old hillsides of the limestone. In some places several veins one above the other are known to end in the manner described. (Figure 17.)

There are minor unconformities in the Coal Measures themselves which though far less extensive produce the same results locally. The section at the Redrock quarry in Marion county already described may be taken as a good illustration.

On account of the inequalities of the bottom on which the coal rests the seam is apt to terminate abruptly; to gradually thin out or entirely disappear over a low elevation or swell; to subdivide in the basin into several minor areas. Or, the converse of these results is obtained in all cases where depressions are present instead of elevations, causing local increases in the thickness of the coal.

Varying currents may also have influenced the accumulation of carbonaceous material, previous to or during the deposition of the coal. Currents of water may throw up small ridges which take the place of the coaly matter

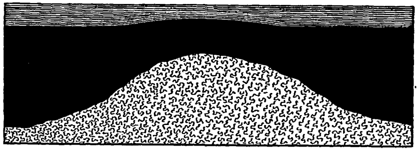


Figure 18. "Horseback" in Craig Slope. Kalo, Webster County.

so that locally the coal seam is very much thinner or often entirely pinched out over the elevations. (Figure 18.) The existence of former currents in an area where coal was formed may on the other hand cause an uncommon collection of bituminous material to take place. Thus

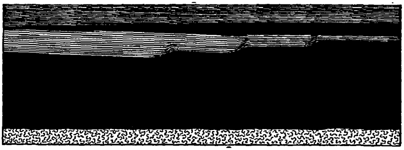


Figure 19. Extraneous Sediments in Coal Seam. Garfield Mine, Oskaloosa.

at some points an unusual thickness of coaly material will be laid down while in others it is almost entirely absent. Occasional currents may also bring in sediments during the deposition of the coal thereby dividing the vein in one or more parts. (Figure 19; also in figure 21).

Good examples of this are seen in the seams just north of the milldam at Des Moines and in the Garfield mine at Beacon, in Mahaska county.

Erosion.—The effects of the corrading action of water are to cut out the coal seams partially or entirely in some places, and to destroy or weaken the roof in others. Of all the "troubles" encountered in mining in Iowa those rising from erosion are the most serious. The old erosive troughs are caused by the same action which is now in process at the surface through means of modern streams. The water courses constantly wear away the strata over which they run cutting out channels for themselves. As on the present surface, the size of the channel encountered is directly proportional to the volume and velocity of the stream and the length of time it has been at work and inversely proportional to the hardness of the strata. The excavations made through erosive action may vary greatly from the course of the smallest rill to valleys of almost any magnitude.

In point of time erosive channels may be divided into three classes: first, those which were formed during Carboniferous time, while the Coal Measures were yet being deposited; second, those which were made after the laying down of the Coal Measures previous to the glacial period; and third, those which have been formed since glacial times. The erosive effects of later geological or postglacial times are easily inferred from the present topography of the region. They cause but little embarrassment in mining operations for they are seen in the valleys of the modern water courses. The work of preglacial degradation cannot be read from existing surface relief. Consequently the old channels, now filled with sand and clay, are often unexpectedly encountered in mining. As they abruptly cut out thick coal veins it is necessary before continuing the work of mining to prospect from the surface of the ground by means of boring in order to find out the extent of these "cutouts."

(1) Carboniferous Troughs. There is now abundant evidence to show that during the deposition of the coal bearing rocks of Iowa there were numerous minor periods of subsidence and elevation. During the latter the coal marshes were often above sea level and subjected to the action of running water. Coal beds which had been previously formed were often cut out in places by currents of water and subsequently filled with sand or clay which eventually became hardened into sandstone and shale. Carboniferous troughs of the kind described have been

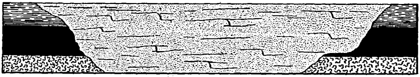


Figure 20. Carboniferous Erosion: Sandstone Occupying "Cutout" in Coal Seam. Smoky Hollow Mine, Avery, Monroe County.

observed in a number of localities. In What Cheer mine No. 5, at What Cheer, in Keokuk county, and in the Smoky Hollow mine at Avery, in Monroe county, channels filled with sand have been encountered. (Figure 20.) In the first named mine the margin of the coal now lying next to the sandstone shows all evidence of weathering to the depth of several inches. At the second place the channel is more than 100 feet across and cuts out not only the coal but the underlying strata to a considerable depth. Carboniferous "cutouts" filled with shale have been noticed in the Dalby mine, at Angus, in Boone county, in the Smoky Hollow mine already mentioned, and the Frey mine at Confidence, in Wayne county, as well as elsewhere.

(2) Preglacial Channels. Probably no other class of "cutouts" interfere with mining to such an extent as those of this description. The material filling them being usually an incoherent sand or gravel through which water readily percolates and flows, forming underground streams. When suddenly broken into, a mine may be quickly flooded; or, if not, the entry must be walled up securely with solid masonry. At other times deposits of drift or plastic clay, boulders and logs of wood are encountered and if the entry be driven through, it must be well timbered or walled the entire distance by masonry. The preglacial channels are more apt to interfere with mining in those seams which are near the surface, while the deeper veins are rarely affected. Interferences of this character are found in almost every county of the state. At Fort Dodge several of the mines have been compelled to close on account of encountering channels filled with glacial débris. In the vicinity of Des Moines a number of preglacial "cutouts" are known. On the east side the "third" vein has been extensively mined. It lies from 90 to 125 feet below the surface. The roof is ordinarily very good, being composed of a thick black shale. The shafts first sunk in this neighborhood chanced to be on the west margin of an extensive coal basin. As the entries were driven eastward the coal became thicker which fact led to the sinking of other shafts in this direction. In six or eight of these the entries had been driven but a short distance when the roof caved in filling the mines completely with water and making it necessary to abandon them. It was found that running north and south through the middle of the coal basin was a broad valley filled with sand and gravel, along with logs of wood and other glacial material. Although the channel had not reached the coal bed it had cut almost

through the roof. When the coal was removed below the roof was unable to support the great weight of superincumbent water and gravel and so gave away. Since the mines were abandoned prospecting has been carried some distance to the eastward beyond the old channel which has been found to be nearly a mile wide. On its eastern border several shafts have recently been put down and are now working the coal in the opposite direction from this channel. In the consideration of the present position of the old stream it seems quite probable that this valley is a deserted channel of the Des Moines river which in later times has been directed along a new course

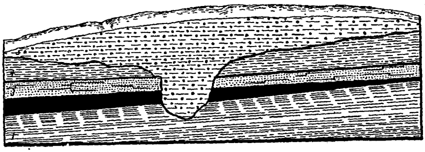


Figure 21. Preglacial Erosion: Drift Occupying Small Gorge. Old Polk County Mine, Des Moines.

a mile and a half to the westward. There is now a valley opening to the southward and connecting with the Raccoon river bottom which comes in from the west and forms part of the wide valley of the present Des Moines. At the north the valley mentioned unites with that of the Des Moines several miles above the Capital city. The fact also that the Des Moines river at the present time runs through a narrow gorge-like excavation seems to substantiate this view.

In south Des Moines narrow gorges filled with glacial débris have been met with in the Polk county mine when it was operating in one of the upper seams, and in several other openings which were working near the surface. (Figure 21.) At the Runnells slope, sixteen miles southeast of Des Moines, a channel filled with boulders and drift has been traced for more than half a mile. Several branches open into it. At the Carbonado mine No. 4, south of Oskaloosa, in Mahaska county, a well marked channel of preglacial origin was recently encountered, and it has been traced a considerable distance. In that part of the mine where it first begins to be noticed it is found gradually cutting through the roof in a short V-shape runnel only five or six feet wide and about the

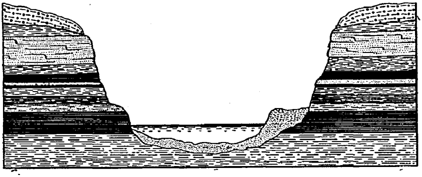


Figure 22. Postglacial Erosion: Gorge of Des Moines River at City of Des Moines.

same depth. In the course of a quarter of a mile it has a width of more than 150 feet cutting out all the coal and extending some distance below the seam. At Mystic, in Appanoose county, east of the Lodwick mine a channel over 1,200 feet in width has been found. Smaller and narrower channels are not infrequent in neighboring places.

(3) Postglacial Valleys. Modern rivers often cut out much valuable coal. But they have been the means of forming numerous outcrops through the discovery of which the western coal field was first opened. They afford easy access to the coal which may be obtained by drifts or by shallow slopes. The narrow gorge of the

Des Moines river at the capital city is an excellent illustration of coal bearing strata cut through by modern erosive agencies. (Figure 22.) During the early settlement of the state for many years the districts presenting natural outcrops were the ones in which the coal industry was first established and carried on most extensively.

Dislocations.—The ruptures and slippings of the beds in the Iowa Coal Measures are comparatively unimportant. Geological "faults" are seldom more than a few feet in extent. The majority of these are of the normal variety with a hade of from 15 to 45 degrees. (Figure 23.) It would be impossible to recognize these slippings ordinarily except when fortunate artificial excavations would disclose them. It is only through the extensive working of a comparatively thin bed that they are capable of being made out. The two faces of the fracture which have been rubbed together are commonly very dense and highly polished and pass under the name of "slickensides." From an examination of the number and location of these small faults, and of others of similiar character in distant regions, it would appear that the adjustment of the tension in the earth's crust here as in more mountainous regions is carried on largely by means of many small slips rather than a few large ones. Similar facts have been brought out in the mountain districts of

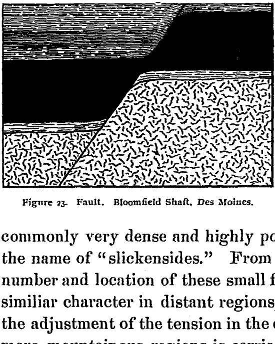


Figure 23. Fault. Bloomfield Shaft, Des Moines.

California, where recently Becker has made some interesting observations in this direction.

In a number of places step-faults have been observed. In the Davidson mine near Newton, in Jasper county, quite a number of slips of from six inches to four feet were noticed, the inclination being about 45 degrees. (Figure 24.) In the Deep Vein mine at Foster, in Monroe county, a similar series of step-faults has been made out. Instances of this kind are quite numerous in many parts of the state and in nearly all cases the different faults in any given series are practically parallel to one another. It has been noticed in some instances that when the line of

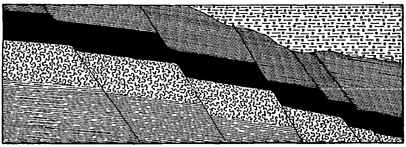


Figure 24. Step-fault. Davidson Mine, Newton, Jasper County.

slip passes from a hard to a soft layer or vice versa that it is changed in direction. In the first case the line of fracture is bent away from the perpendicular while in the latter it is bent toward the perpendicular in the same way as when light passes from a denser to a rarer medium. This is sometimes shown where a series of iron-stone nodules or a layer of iron-stone is enclosed in a coal seam.

Another phase of normal faults is shown where, in the crest of a small anticline, a wedge shaped piece is allowed to drop. A good illustration is found in the Appanoose mine at Cincinnati, in southern Appanoose county. (Figure 25.)

The term roll is applied to any part of the coal vein where the roof occupies a portion of the seam. In most cases it seems to be due to the pressure of the overlying rocks which squeeze out some or all of the softer bitu-

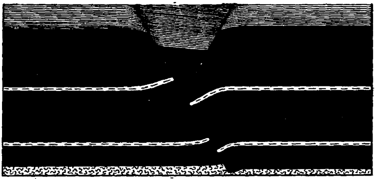


Figure 25. "Wedge" Fault. Appanoose Shaft, Cincinnati, Appanoose County.

minous layers. The rolls may be mere indentations of a few inches of the roof into the coal seam, as is seen in the Thistle mine, at Cincinnati, in Appanoose county; (figure 26) or, they may be found in connection with a slip fault as in Appanoose mine at the same place; or, it may

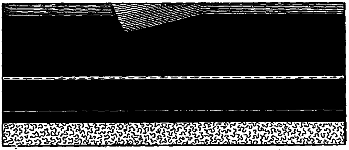


Figure 26. "Roll," Thistle Mine, Cincinnati.

occur at a fracture in a coal seam and accompanying beds where the coal vein has apparently parted a few inches allowing the roof to come down and the floor up; or, finally, the coal may be nearly or completely displaced, in which case it is commonly called by the miners a "pinch-out." (Figure 27.)

Clay Seams.—Simple fissures or ruptures are not of unfrequent occurrence in coal veins. They are merely a separation of different parts of the coal seams without

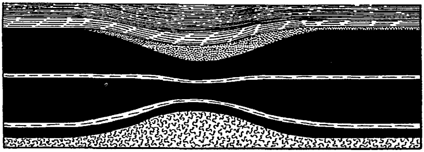


Figure 27. "Pinch." Mendota Mine, near south Line of Appanoose County.

displacement. They are usually more or less vertical with often very irregular borders; or they may be inclined at very considerable angles. Examples of the former are seen in the Reese mine at Panora, in Guthrie county, at the Christy mine near Des Moines, in Polk county (figure

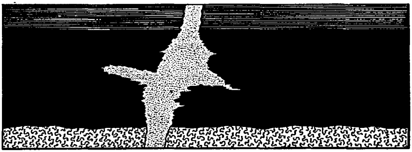


Figure 28. Fissure filled with Clay. Christy Mine, east of Des Moines.

28), at the Thistle mine at Cincinnati, Appanoose county, and elsewhere. The latter are met with in several places at the Keeler mine near Linden, in Dallas county. In the majority of cases clay fills the fissure which may be from an inch to a foot or more in width; or sand may occupy the space forming a compact sandstone wall.

There is another class of fractures which appear in the coal seams which are partly due to the forces producing faulting and partly to other causes, the most prominent of which, perhaps, is contraction. These are commonly called "joints". They are usually more or less vertical and form two sets running at right angles to one another. On account of their presence the coal is easily gotten in more or less cuboidal pieces. The adjoining parts are often separated by calcite, gypsum, iron pyrite or in some cases clay.

AVAILABILITY.

Profitable mining of coal has a number of restrictions imposed upon it in addition to those embraced under distribution. By far the most important of these natural obstacles to the economic working of a coal bed relates to the thickness of the seams.

Insufficient Thickness.—The limitation due to this factor varies greatly in different localities, not only in the country at large but within the boundaries of a single state; and is dependent also on the presence of other limiting conditions even in the same county. In some districts, where veins of coal attain a vertical measurement of five to seven feet or more, a seam is rarely touched which has a thickness much below three feet. On the other hand, in districts where coal deposits are not very extensive a vein of two or even one and one-half feet is utilized. With the proper development of the industries connected with the manufacture of clay products it is very probable that the under clays and the overlying shales of coal beds will before long be taken out on a large scale along with the coal. Brick especially, of all kinds, for which there is a constant and ever growing demand, comes prominently under this head. The shales above and below the seam are admirably adapted for making vitrified blocks of high grade for paving purposes, of unrivaled ornamental materials and the best of fire brick. Plants have already been erected in a number of places for the utilization of the refuse shales as they come from the mines, with good results. At Grand Junction, in Greene county, one brick company has sunk a shaft 150 feet for the clay found in connection with an eighteen inch vein of coal, the output of the latter being almost entirely used in the kilns. At Van Meter, in Dallas county, at Des Moines, Fort Dodge and elsewhere, large and well equipped works are in active operation the year round, manufacturing brick and tile from the shales near the coal seams. By removing the associated clays for the purposes named it is believed that the minimum thickness of a workable coal bed may be greatly reduced, perhaps as low as one foot in some cases. Veins which have long been allowed to pass unnoticed may thus be mined with profit. The combining of the two industries will doubtless lead in the near future to a very great development of both, for the uses to which clay is being put are many and are even increasing with astonishing rapidity. It may, therefore, be confidently expected that the minimum of adequate thickness of workable coal seams will become very greatly reduced and that the available amount of coal in the state will be doubled or trebled beyond what it is commonly thought to be at present. From the known form of the coal beds, disposed as they are in lenticular masses, it is not always safe to conclude after drilling a single hole through a "thin" seam that it is unavailable on account of inadequate thickness. The bed may probably be thicker a shorter distance away in the direction of the center of the original basin; and yet it is quite possible that, on the other hand, it may rapidly thin out, and disappear.

Depth.—The second great factor in limiting the removal of coal with profit is that of excessive depth. In many mining localities this is a very serious restriction, but in Iowa it is relatively unimportant. The very large majority of the mines in the state have a depth of less than 150 feet; a number are from 200 to 250 feet deep; while in a very few instances the shafts go down as far as 300 feet. The mines in Missouri are very similiar to the Iowa pits in being comparatively shallow and according to Winslow the shafts rarely are deeper than 200 feet. The peculiarities in the structure of the Coal Measures necessarily prevents deep mining along the eastern margin of the Iowa coal fields as far as, and even beyond the line of the Des Moines river. Westward from this limit, the best veins opened, gradually come to lie deeper and deeper. It is very probable that judicious deep drilling from 500 to 1,000 feet or more would reveal good coal in nearly all sections of the southwestern part of the state. For some reason or other deep prospecting for coal has as yet been undertaken only on a small scale. The significance of the suggestion is quite pertinent and has an important industrial bearing, especially in those southwestern counties which now mine little or no fuel. At Leavenworth, Kansas, a short distance from the boundary of Iowa, coal less than two feet in thickness is now being mined successfully in large quantities at a depth of nearly 800 feet. On the whole it is not at all probable that the factor of excessive depth will ever interfere seriously with the mining of Iowa coals.

In considering the depth at which coal may be profitably worked, it is interesting to refer to the facts as presented in other coal fields. In England veins little more than a foot in thickness have been mined at a depth of over 800 feet. It is not an uncommon thing in certain parts of the Lancashire district to find shafts from 1,200 to 2,000 feet deep, some even reaching a depth of 2,800 feet. In Belgium one of the Charlroi mines has been worked to a depth of over 2,400 feet. Nor is this regarded as the limit to which it is practicable to operate.

CHAPTER VIII.

DESCRIPTION OF THE COAL BEDS NOW OPERATED IN NORTHCENTRAL IOWA.

In areal distribution the Coal Measures of the district constitute the apical portion of the great triangle which the Carboniferous of Iowa forms, the base being the southern state boundary. To the northeastward the surface rocks are Lower Carboniferous in age and the coal bearing strata thin out in this direction. To the northwestward the Cretaceous beds soon cover the Coal Measures, the attenuated margin of the former extending nearly if not quite to the Des Moines river. The workable coal is therefore limited on the east by rocks older than the Coal Measures; but on the west the Carboniferous is known to extend beneath the Cretaceous for a considerable distance beyond the surface boundary of the two formations. Along the attenuated edge of the coal field the strata containing mineral fuel are found only in the hills, the underlying rocks extending along the larger streams in long estuary-like arms, often a distance of twenty-five miles or more into the extreme margin of the Coal Measure area.

The details of the different geological formations and their relations to one another are referred to more specifically farther on. The counties included in northcentral Iowa are Humboldt, Webster, Hamilton, Hardin, Carroll, Greene, Boone, Story and Marshall.

HUMBOLDT COUNTY.

Although almost beyond the productive area it is not improbable that workable coal will yet be found within the limits of this county. Having a rather level surface and covered by heavy deposits of drift, natural outcrops of the indurated rocks are comparatively few in number except along the two branches of the Des Moines river. In the beds of these water-courses the Lower Carboniferous limestones are exposed from the south county line up to Rutland and beyond on the west fork of the Des Moines, and for several miles above Dakota on the east fork of the same stream. Coal Measure sandstones and shales are known to occur at several points; part of them doubtless constituting the northern extension of the Iowa coal field and part, in all probability, forming outliers. On the west fork of the Des Moines half way between Rutland and Humboldt the Lower Carboniferous limestone disappears beneath the water level, and the bluffs show light colored shales and sandstones, to all appearances of Coal Measure age. Little prospecting for coal has yet been done in the county. Recently, however, some desultory searching for mineral fuel has been carried on a mile below the town of Humboldt. At this point one seam of coal was found about twenty-five feet above the water level but is apparently not thick enough for profitable working. The occurrence of this bed of coal and its associated strata at the place mentioned clearly indicates that coal bearing strata have a much wider geographical distribution in Humboldt county than has been generally regarded heretofore, and that it is not at all unlikely that workable seams of coal will yet be found within the limits of the district. This is especially true of the southwestern quarter of the county and may be applicable also to the southeastern portion.

WEBSTER COUNTY.

This district contains the most northerly coal mines in the state. It has long been known as one of the leading coal counties and is probably more favorably situated than any other coal county for shipping its production northward to the large areas which have no fuel supplies of their own.

The surface of the county is everywhere quite level except in the immediate vicinity of the chief water course where short deep ravines appear sloping steeply toward the river which is from 130 to 150 feet below the general level of the surrounding country. In Webster the Des Moines river valley which cuts centrally through the entire county from north to south is very narrow with scarcely any alluvial flood-plains. The sides of the valley are very steep and even precipitous. All the minor tributaries of the chief water-course likewise flow in narrow steep sided valleys very deep toward their lower extremities, but in opposite directions passing into broad shallow drainage basins. The ravines are very numerous, close together, and very tortuous, and they are separated from one another by sharp ridges. The steep sides of the streams afford numerous outcrops showing the geological characters of the stratified rocks. The entire surface of the county is deeply covered with drift material so that at a short distance from the principal stream the underlying rocks are rarely exposed. The geological formations represented in the county are the Lower Carboniferous limestone (Saint Louis), the Upper Carboniferous shales (Coal Measures), the Cretaceous deposits (gypsum beds) and the Pleistocene (glacial accumulations). In the order mentioned they lie unconformably upon one another.

The Saint Louis member of the Lower Carboniferous has a surface distribution only in the immediate vicinity of the Des Moines river from Fort Dodge to the north county line, and in some of the smaller tributaries near their mouths. This formation is the blue or ash colored, fine grained limestone which presents a very uneven upper surface and on which rests the friable sandstones and shales of the Coal Measures. Above the Coal Measures and resting unconformably upon them are the gypsum beds which, with but little doubt, are of Cretaceous age. The gypsum itself is a massive layer two to thirty feet in thickness with an average measurement of about sixteen feet. It is overlain in many places by sands and clays with thin corrugated seams of gypsum intercalated. The gypsum beds are located chiefly in the vicinity of Fort Dodge and directly to the southward. (Figure 29.) Just north of Fort Dodge they probably rest directly upon the Saint Louis limestone while five or six miles to the southward they are from 50 to 100 feet or more above the limestone basement. It is quite probable that in the western and northwestern parts of the county still more extensive Cretaceous deposits exist at no great depth beneath the drift. Outliers of the same layers probably also are present in other parts of the district.

Figure 29. Section across Des Moines River Valley, showing Arrangement of Geological Formations. Fort Dodge.

The relations of the formations are well shown in the vicinity of the mouth of Lizard creek on both sides of the Des Moines river and in the north part of the city of Fort Dodge. The Saint Louis limestone occupies the base of the section and is exposed in the bed of the creeks. Immediately overlying it, on the west side of the river especially, are clays and shales of the Coal Measures with a few thin coal seams. Resting unconformably upon both members of the Carboniferous are the gypsum and associated beds. The former comes down to the water level in Soldier creek at Kohl's brewery north of Fort Dodge and elsewhere farther up the stream. On the west side of the river the gypsum is over 100 feet higher than on the east side.

Although the coal bearing strata become greatly attenuated just north of Fort Dodge along the Des Moines river where the Lower Carboniferous limestone appears, they probably have a considerable thickness in the upland away from the river on both sides. Southward, the Coal Measures rapidly thicken until at the southern border of the county they doubtless have a maximum thickness of not less than 150 or 200 feet. In a distance of only five miles from Fort Dodge to the southward the Coal Measures increase in thickness from nothing to more than 200 feet. The coal bearing strata of Webster county are largely argillaceous shales with comparatively little sandstone. In these shales are intercalated numerous lenticular layers of coal which vary from three to five feet in thickness, in some places attaining a measurement of even eight or nine feet. Thus instead of one continuous seam there are a number of horizons yielding coal. At the present time the mines of the county are clustered around a few places; near Coalville and Kalo on opposite sides of the Des Moines river seven miles below Fort Dodge; at Lehigh, about fifteen miles below the same town; and at points on Lizard creek near Tara four miles west of Fort Dodge. Considerable coal has also been mined at and around the latter town. For a number of miles below the place, in the bluffs of the Des Moines river and its tributaries, there are numerous outcrops of coal at various heights above the water level. They all show at first glance a remarkable uniformity of thickness, but upon closer examination it is found that the seams are really made up of many limited pockets which exhibit but little regularity. The easy accessibility of the coal in the hillsides has had a tendency to cause its development by drift mining and many of these openings are located along the river, and its larger branches. In the sides of the bluffs the coal seams are often found to dip away from the mouth of the drifts and to increase in thickness from three or four feet to six or seven in a distance of less than seventy-five or eighty yards. Then the seams may rise, at the same time gradually getting thinner and thinner until they become too attenuated for profitable working, or they run out entirely away from the bluff and consequently little prospecting has been done in those parts of the county remote from the river. When the great thickness of the drift deposits and the Cretaceous beds are taken into consideration it will be seen that deeper drillings than have heretofore been made will probably lead to the development of more or less extensive coal seams in different parts of the region.

Formerly considerable coal was mined in the vicinity of Fort Dodge, but of late years comparatively little has been taken out. Abandoned shafts and drifts are to be seen at many points in the bluffs along the river. North of Fort Dodge on both sides of the Des Moines river a number of country banks have been opened (Tp. 89 N., R. XXVIII W., Sec. 7). At present only two of these openings are operated. One is the Smith shaft and the other is the Johnson slope. The coal averages twenty-eight inches in thickness and is considered to be of very good quality. A section of the bluff at this place gives the following measurements:

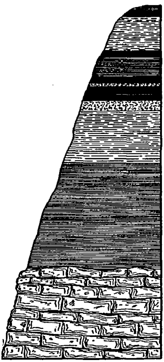
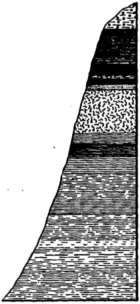


Figure 30. Coal Beds near Johnson Mine, north of Fort Dodge.

		FEET.	INCHES.
15.	Drift	40	
14.	Shale, black	1	
13.	Coal	1	6
12.	Shale, light colored, becoming darker below	10	
11.	Coal, cannel	1	8
10.	Shale, drab	6	
9.	Coal	1	10
8.	Clay, light colored	1	
7.	Coal	1	6
6.	Clay, dark colored	1	2
5.	Coal	1	4
4.	Fire clay	3	
3.	Shale, light colored	15	
2.	Shales, dark colored, resting uncomformably on next	30	
1.	Limestone, compact, with marly partings, Saint Louis formation, (exposed)	25	

Between this point and the mouth of Soldier creek which flows through the corporate limits of Fort Dodge numerous openings have been made in the coal seams and a considerable amount of fuel extracted. The most extensive of the mines near the town were known as the Rees. Thin coal bands are shown in the clay pit of the Fort Dodge Pressed Brick Company, the section exposed being as follows:



		FEET.	INCHES.
12.	Drift and soil...............	3	
11.	Shale, black, bituminous fissile	4	
10.	Coal..........................	1	2
9.	Clay...		3
8.	Coal............		5
7.	Sandstone, soft, yellow and white in color...............		8
6.	Shale, light colored argillaceous "fire clay"..................	5	
5.	Shale, dark colored, bituminous	1	4
4.	Shale, bituminous, fissile......	1	2
3.	Shale, dark colored...........	2	
2.	Shale, light colored...........	4	6
1.	Shale, dark colored (exposed).	10	

Figure 31. Section at Clay Pit of Fort Dodge Pressed Brick Works. Fort Dodge.

Tara.—Four miles west of Fort Dodge and about a mile east of Tara several shafts have been put down in the valley of Lizard creek. They vary in depth from forty to one hundred feet. The Martin shaft (Tp. 89 N., R. XXIX W., Sec. 23, SE. qr., SE. ¼) is one hundred feet in depth and operates a vein of coal five feet in thickness. The coal is underlain by good fire clay and is covered by blue shale, which, however, in some places forms such a poor roof that some of the coal is left to protect it. The section at the bottom of the shaft gives:

Figure 32. Coal Bed at the Martin Shaft. Tara.

Near the Martin mine was the old shaft of Collins and Myers which was sixty feet deep with coal four feet in thickness. It was operated only in the winter. The Scally mine was also located in the same vicinity but has been abandoned some time. Other mines opened in this vicinity also worked coal averaging four feet in thickness.

Coalville.—This place is on the east side of the Des Moines river opposite Kalo. The veins of coal vary in thickness from three to eight feet. There is also a variety of cannel coal which outcrops at the water level. It has a thickness of about six feet, though on account of the inferior quality of the upper part the lower two feet only are mined. It is said to lie from fifty to sixty feet below the principal seam worked.

For many years mining has been carried on extensively in the neighborhood of Coalville and the openings are innumerable. Among the chief mines operated at the present time may be mentioned the Collins mine No. 4, which is located near the river south of the village. The coal worked is from four to five feet in thickness. The seam is somewhat uneven but quite free from faults. Forty feet below this seam is a vein of cannel coal. The sequence of the strata is shown in figure 33 on the following page.

Some distance east of this mine is the Collins No. 16. A short distance northeast of the latter is the McClure shaft which has been recently sunk. North of the Collins mine half a mile are the Lichfield, Davis, Dupleas, and Fort Dodge No. 1, all of which are operated on a small scale. For many years the Fort Dodge Coal Company mined extensively in this vicinity, putting down a number of shafts. The company failed and since that time the mines have been worked chiefly for local use.

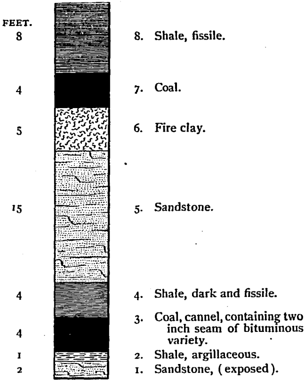


Figure 33. Portion of Shaft at Collins Mine, No. 4. Coalville.

Along the river bluffs are several drifts where the coal outcrops some distance above the bed of the stream. The seam of cannel just mentioned occurs a few feet above the water level.

Kalo.—This place is situated on the west side of the Des Moines river directly opposite Coalville. The coal seam crops out in the bluffs where innumerable drifts have been opened during the last twenty-five or thirty years. Six miles below Fort Dodge and within a mile of Kalo the first mine encountered is the Johnson drift (Tp. 88 N., R. XXVIII W., Sec. 8, NW. qr., NW. $\frac{1}{4}$) situated not far from the river on the Kalo switch. Both cannel and ordinary 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 34. Cannel and Bituminous Veins at the Johnson Mine., Kalo.

A quarter of a mile south of the Johnson mine is the Irvine drift which works in a thirty inch seam of cannel. Measurements of the different beds at this place give:

FEET.	INCHES.	
2	6	4. Shale, dark argillaceous.
2	6	3. Coal.
1		2. Shale, black, containing plant remains.
2		1. Sandstone.

Figure 35. Bed of Cannel Coal at Irvine Drift. Kalo.

In the eastern part of section 17 and in the northeastern portion of section 18 (Tp. 88 N., R. XXVIII W.), the Craig Coal Company has operated quite extensively for a number of years, though at present only two of the openings are worked. The first of the Craig mines is a quarter of a mile south of the Irvine drift and is known as No. 6. It was abandoned on account of the coal becoming too thin for profitable working in extending the entries westward. A short distance still farther to the southward of these mines are two others which were operated by the same company, Nos. 1 and 5. They were also abandoned for the same reason. Between the last two mines is located the Craig Cannel Shaft. It is situated at the foot of the hill below the Minneapolis and Saint Louis railway station. The shaft is forty-two feet in depth and works the same vein of coal as is found in the Irvine mine. The seam is much more even than the bituminous vein and shows no signs of thinning out in any direction. Half a mile to the southward of the latter in a ravine leading down to Craig Hollow is the Craig slope. The seam averages two feet in thickness, but its mining is somewhat interfered with by the presence of large iron-stone concretions. The strata shown in connection with the coal seam are:

	FEET.	INCHES.
3. Shale, hard, fissile	1	
2. Coal	2	6
1. Fire clay	1	

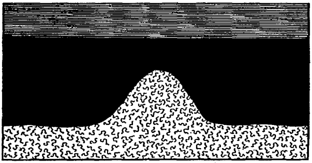


Figure 36. "Horseback" in Craig Slope. Kalo.

In several places in this mine "horsebacks" have been encountered one of which, represented in the cut, is remarkably abrupt. Northeast of the last named opening is the Nichols and Todd drift which has been opened quite recently and is apparently in the same vein of coal as is worked in the Craig slope. The deep ravine in this vicinity is called the Craig Hollow and along its sides many openings of coal have been made during the past twenty years. South of the Craig cannel shaft about half a mile are the two McGovern mines. One of these work the bituminous seam; while the other opening is in the cannel seam forty feet below. A short distance down the river from the latter named place is the Craig No. 4; and still farther to the southward on the hillside is the Harbach and Bunck mines and the Craig bituminous shaft. A short distance from the Craig slope the Carlston mine has been opened in a vein of coal three feet six inches in thickness. In addition to the mines mentioned a large number of smaller banks have been operated from time to time west of Kalo.

In the town and just south of it are several openings known as the Mills mines. Southeast of the village mines have also been opened. Down the river a distance of one and a half miles (Tp. 88 N., R. XXVIII W., Sec. 16, SW. qr., SW. $\frac{1}{4}$.) two openings have been made; one the Johnson and the other the Cheleen, both of which operate in a vein containing cannel and bituminous coal the former resting directly upon the latter. Both seams are removed and the production sold chiefly to local trade. Among the other mines operated in the vicinity are the Lamb, Bennett, Craig No. 2, Craig No. 3, and the Webster, besides a large number of small country banks.

Lehigh.— There are several veins of coal known to exist in the vicinity of this place. They vary from one and a half to five feet in thickness. The record of a drill hole put down in Tp. 87 N., R. XXVII W., Sec. 7, NE.

qr., NE. ¼, beginning in the top of the bluffs is as follows:

		FEET.	INCHES.
55.	Blue clay	50	
54.	Sand and gravel	10	
53.	Yellow clay	20	
52.	Red sand and gravel	10	
51.	Blue clay	20	
50.	Sand and gravel	8	
49.	Blue clay	5	
48.	Light shale	3	
47.	Sandstone	5	8
46.	Sandstone indurated	3	6
45.	Sandstone	5	2
44.	Light "slate"	4	
43.	Light shale	5	8
42.	Sandy shale	5	
41.	Light "slate"	12	7
40.	Coal and sandstone	1	
39.	Light shale	7	9
38.	Dark shale	2	3
37.	Sandstone	2	9
36.	Dark shale	11	
35.	White sand	16	
34.	Dark gray sandstone	4	
33.	Coal		23
32.	Light sandstone	7	
31.	Red sandstone	2	
30.	Sandstone boulder	4	
29.	Light sandstone	5	9
28.	Light shale	5	
27.	Hard sandstone	12	
26.	Light shale	9	
25.	Light shale	1	
24.	Light hard shale	2	6
23.	Coal	1	6
22.	Dark shale	3	4
21.	Coal	1	
20.	Light shale	2	
19.	Coal		6
18.	Light shale	1	
17.	Light hard shale	3	10
16.	Coal		1
15.	Dark sandstone	1	

		FEET.	INCHES.
14.	Light sandy shale	4	
13.	Dark shale	1	
12.	Coal	1	
11.	Light shale	1	
10.	Dark hard shale	8	
9.	Coal and pyrite	1	
8.	Coal (pure)	2	4
7.	Fire clay		6
6.	Dark hard shale	1	
5.	Coal		6
4.	Light shale	4	8
3.	Hard dark shale	2	
2.	Hard sandstone	5	9
1.	Conglomerate		3

No less than seven coal horizons were passed through in sinking the hole. Mining has been carried on in the neighborhood of the town for a number of years past and the openings are quite numerous along the Des Moines river and its tributaries. Just north of Lehigh numerous drifts are seen in the bluffs. To the west the principal mine is the Harper. Immediately south of the town Crooked creek enters from the west. Along this stream a large number of openings have been made, the principal one being operated by the Crooked Creek Coal Company. The section at Mine No. 3, is as follows:

FEET.	INCHES.		
2		3	Shale, hard, fissile.
2	6	2.	Coal.
2		1.	Fire clay.

Figure 37. Coal Bed at Crooked Creek Mine. No. 3. Lehigh.

The output is shipped over a long switch from the Illinois Central railroad. A slope belonging to the company is operated on the south side of the creek in coal two feet six inches thick and of very good quality. The roof is a hard bituminous shale and the floor of fire clay.

A short distance west of this mine is the Corey, the coal in which is from two to four and a half feet in thickness. This roof is also a hard black shale with some concretions of clay iron-stone. The coal is mined on the long wall system. South of this point a quarter of a mile the same company has sunk a shaft to the depth of eighty-one feet into the same bed of coal.

On the west side of the Des Moines river extensive mining has also been done by the Crooked Creek Coal Company which has put down several shafts. The one at present operated is forty feet deep, with coal about four feet in thickness. The bottom of the shaft exhibits:

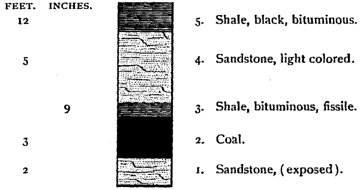


Figure 38. Section of Coal at Crooked Creek Mine, No. 1. Lehigh.

The general dip of the seam is slightly to the southeastward. The same vein of coal outcrops in a ravine about three hundred yards to the south where numerous country banks have been opened and worked for many years. South of the Crooked Creek Mine No. 1 is the Smith mine and immediately north of it the Hiller.

Below Lehigh coal is exposed in the river bluffs at short intervals as far as the south county line. On the south side of the river three miles below the town coal has been mined in the valley of a small stream. The section shown on the river bank half a mile farther down (Tp. 87 N., R. XXVII W., Sec. 21, SW. qr., SW. ¼) is:

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

Coal and the accompanying shales crop out in the river bank between the last named point and the south county line but no mining has been done except in the valley of a small stream five miles east of Dayton on the Chicago and Northwestern railroad. Here near the mouth of the creek in the center of section 16 (Tp. 86 N., R. XXVII W.) small country banks are in active operation during winter months. They are the Gruber and Baker, Gruber and McGovern and the Timmons. The shaft is thirty-five feet in depth. The section at the bottom shows:

	FEET.
3. Shale, gray, bituminous below	7
2. Coal 16 to 30 inches	2
1. Fire clay	4

Prospecting has indicated that there is a second seam of coal about twenty feet beneath the one now worked. The larger part of the output of these mines is hauled by wagons to Dayton.

A short distance beyond the south county line in Boone is the extensive field of the Pilot Mound district in which recently extensive preparations have been made for mining large quantities of coal.

HAMILTON COUNTY.

Hamilton county lies on the northern margin of the Iowa coal field. The southwestern half, at least, and probably nearly all of the county is made up of Coal Measure strata while a small portion of the northern or northeastern region is composed of Lower Carboniferous limestones. Over most of the county the Saint Louis limestone probably exists at no very great depth. It is exposed at various places along the different streams traversing the county and extends in the bed of the Boone river as far southward as five miles below Webster City. The upper surface of the Saint Louis presents the same uneven character as is seen in other parts of the state, and the irregularities of the Coal Measures are consequently very marked.

The Coal Measures of the southwestern part of Hamilton belong to the main body of the Iowa field. Toward the northeast other cases of similar strata are reported but they are doubtless outliers of greater or less magnitude. In the formations of this age the clay shales predominate, affording inexhaustible supplies of the best of material for the manufacture of all kinds of clay products. Although doubtless well furnished with coal, in the southern and southwestern portion of the county the only locality where mining has been carried on to any extent is along the Boone river a few miles below Webster City. Passing down the Boone river, from Webster City, the first opening met with is the Brockshink mine on the west side of the stream (Tp. 88 N., R. XXVI W., Sec. 25, SW. qr., SW. ¼). This is a local mine working coal three feet in thickness. The seam is overlain by a thick roof of sandstone. A mile east, on the opposite side of the river, are two openings, the Morrow and the Claffin (Tp. 88 N., R. XXV W., Sec. 31, NW. qr., SW. ¼). The coal is two feet six inches in thickness and is obtained chiefly by mining along the outcrop. A mile southeast of the Brockshink on the same side of the river (Tp. 88 N., R.

XXVI W., Sec. 36, SE. qr., SE. ¼) is the Silver mine. The coal outcrops in a small ravine and was first obtained by stripping along the line of exposure. During the past few years coal taken out has been sold chiefly to local trade. During one season 2,000 tons are said to have been removed. The section of the bluff near the opening shows:

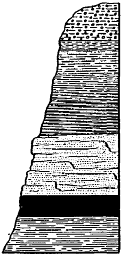


Figure 39. Section of Bluff near the Silver Mine. Below Webster City, Hamilton County.

		FEET.	INCHES.
6.	Drift	2	
5.	Shale		6
4.	Shale, light and dark colored, somewhat sandy in places	4	8
3.	Sandstone, massive, with occasional bands of bituminous shale	3	4
2.	Coal	1	2
1.	Shale, drab, and fire clay, (exposed)	2	

The roof is quite variable sometimes being sandstone, often slaty coal or bituminous shale. A thin seam of cannel coal is also found in connection with the vein, but is not thick enough for profitable working.

A short distance southeast of the Silver drift is the Martin mine. The coal crops out in the sides of the stream and is obtained in part by working along the line of the exposure. The seam is from two to two and a half feet in thickness. Near by is the Louis mine where the coal is three feet in thickness in some places.

Two miles south of the last mentioned bank on the east side of the river is the Maxwell shaft, fourteen feet in depth. The coal is about two and a half feet in thickness. This is a new mine recently opened. A mile to the southwest, near the river bank, is the Shaw and Wilson mine. It is a shaft seventy-five feet in depth, with coal four feet in thickness. Two miles to the westward on the north side of the river is the Stockdale mine (Tp. 87 N., R. XXVI W., Sec. 10, SE. qr., SW. ¼). The seam of coal is quite regular and from three to four feet in thickness; the roof is a bituminous shale and sandstone and the floor a fire clay. The vein dips to the north and west. This is one of the oldest mines in the vicinity, having been worked for more than thirty years, though until lately not very systematically. Several small rolls have been encountered but none of sufficient importance to interfere with mining. The section is as follows:

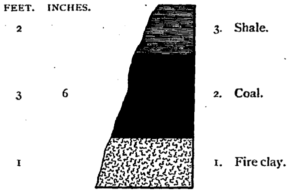


Figure 40. Coal Bed at Stockdale Opening. Ten miles below Webster City.

Farther down the stream openings have been made at various times, the most important of which perhaps is the Prim, which has been operated more or less continuously for upwards of fifteen years.

HARDIN COUNTY.

This may be regarded as one of the border counties of the coal field. Fully two-thirds of the entire area of the county is probably underlain, immediately beneath the drift, by Coal Measure strata. The coal bearing rocks in all likelihood are continuous with the coal field proper; though it is quite possible that they represent large outliers. In that part of the county north of the Iowa river the rocks are of Lower Carboniferous age and consist chiefly of limestones. These strata are well exposed at numerous points along the river from the north county line down to the neighborhood of Steamboat Rock where they suddenly disappear beneath the water level. Beyond the latter place the Coal Measure sandstones rise abruptly along the river in high perpendicular cliffs. From this point to the southern county line the Coal Measures are exposed at short intervals, a considerable portion of the distance being occupied by bluffs eighty to one hundred feet in height and capped by massive sandstones. A few miles below the county line in Marshall coal has been mined successfully for a number of years. Drill holes show the thickness of the Carboniferous strata to be not less than one hundred and fifty feet. In places a massive brown sandstone occupies over half of the entire thickness. It is to this indurated formation principally, which is everywhere underlain by softer beds, that the rugged topography of eastern Hardin county is due. Below the sandstone the shales have a very considerable thickness and carry several seams of coal. A drill hole put down in the vicinity of Gifford in the southeastern part of the area revealed a small seam of coal at a depth of more than one hundred feet.

The workable coal in the county is at present known only in the immediate vicinity of Eldora. The mines are mostly on the east side of the river, commencing at a point a mile below Steamboat Rock and extending to within a short distance of the first named place. Almost the entire distance the Iowa river flows through a deep gorge which has been cut entirely through the massive yellow sandstone, the bed of the river now being some feet below in the softer shales.

The most northerly point where coal has been mined in the district is the opening known as the Gilman mine situated two miles below Steamboat Rock on the east side of the river (Tp. 88 N., R. XIX W., Sec. 32, NW. qr., NE. ¼). In this vicinity coal has been mined for nearly forty years. The section is as follows:

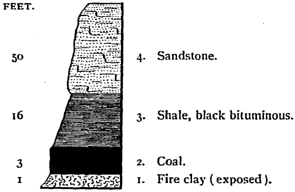


Figure 41. Bluff at Gilman Drift. Steamboat Rock, Hardin County.

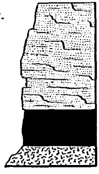
A short distance above the latter named mine just below the bridge (Tp. 87 N., R. XIX W., Sec. 5, NW. qr., NE. ¼) is situated the Langworthy drift which, however, has been abandoned recently. The coal here was four feet thick and was mined on the long wall system. Not far from the Langworthy opening is the Hall mine where the coal is also four feet thick. A drill hole put down near this place, beginning below the sandstone, is said to have passed through the following strata:

		FEET.	INCHES.
12.	Surface deposits	5	
11.	Limestone brown impure, somewhat fossiliferous	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	

About a mile from this place Robert Smith, in sinking a well, is said to have passed through practically the same layers.

By far the greater number of openings are situated near the line between townships 87 and 88, range nineteen, in the bend of the river. Toward the eastern limit of these openings they are called collectively the Chaffin mines. Most of them have been abandoned for a considerable time, only one being operated at present. The coal at this opening is four feet thick with a hard shale roof four feet in thickness, above which is the thick stratum of sandstone already referred to. In an old opening twenty-five yards directly south of this the roof shale has disappeared and the sandstone rests directly upon the coal. The section here is:

FEET.



50 — 3. Sandstone, massive, yellow.

4 — 2. Coal.

2 — 1. Fire clay, (exposed).

Figure 42. Coal Bed at Chaffin Mine. Eldora.

The banks of the river in this vicinity for a quarter of a mile are covered with refuse coal and bituminous shale taken from the numerous openings showing that large quantities of coal have been taken out. There are also a number of small mines which are worked to some extent in the winter. A decade ago very considerable quantities of coal were shipped from the mines of this district the Chaffin alone producing annually over 4000 tons. At present, however, the mining is carried on in a very desultory manner and probably not more than 100 tons a year are taken from any of the openings. They are worked only in the winter and in the summer the roof is allowed to cave in, a new entry being made the following season. Near the old Chaffin mine (Tp. 88 N., R. XIX W., Sec. 32, SW. qr., NE. $\frac{1}{4}$) is the Madden drift which operates in the winter an 18-inch seam of coal. On the opposite side of the river the arrangement of the coal and its associated beds is essentially the same and a number of drifts have been opened under the sandstone. Very little is now being done to develop the coal at this place.

Twenty years ago Eldora was quite a coal district; the chief mines being operated by the Eldora Coal Company which worked quite extensively, shipping coal northward to many points in Iowa.

CARROLL COUNTY.

No coal is known to have been mined within the limits of this county. The surface beneath the drift is made up largely of Cretaceous and Coal Measure strata, the latter probably extending over the entire county and containing workable seams of coal. Like in Audubon and some of the neighboring counties no systematic prospecting for coal has ever been undertaken. That coal seams of workable thickness do exist within the borders of Carroll seems to be fully indicated by the presence of good veins a few miles from the county line in Guthrie. As in other counties along the eastern margin of the Cretaceous area the coal must be sought for at somewhat greater depths than in the counties immediately to the eastward.

GREENE COUNTY.

Like Webster and Guthrie, the adjoining counties north and south, Greene lies on the eastern margin of the Cretaceous. Although at the present time the exact limits of this formation are not definitely known it is quite probable that the beds of Cretaceous strata present are largely a part of the main body which occupies much of the northwestern portion of the state. Beds which correspond in all particulars to the well known Cretaceous deposits of Guthrie county outcrop at a number of places in the central part of Greene, near Jefferson, and also in the western part of the district. These strata are chiefly incoherent sands or friable sandstones, more or less ferruginous, and alternated with clays. The deposits of this age farther westward are found to contain layers of lignite, or brown coal, some of the beds having a thickness of four feet and upwards and it is not improbable that similar depositions may yet be found within the limits of the county under consideration. The extensive mantle of drift greatly obscures the underlying stratified rocks over most of the county so that there are comparatively few natural outcrops except in the immediate neighborhood of the larger streams.

The Coal Measures probably underlie all of Greene county. In the eastern part they are near the surface, immediately beneath the drift, and are exposed in the beds of many of the streams. In the western portion they are some little distance below the glacial deposits.

Up to the present time workable seams of coal have only been opened in the extreme eastern part of the county; yet doubtless they extend, through a greater depth perhaps, much farther to the westward. On account of the heavy drift and Cretaceous deposits very little systematic prospecting for coal has been done except along the eastern border of the county. The natural outcrops of coal are few and are confined to thin seams along the Raccoon river chiefly in the southeastern part of the region. The veins range from a few to eighteen inches in thickness and while they are not as important as a more extensive seam which exists at a great depth they have served to draw attention and to develop the coal industry of the region.

At Grand Junction a seam of coal averaging one and one-half feet in thickness is known to exist at a depth of from 140 to 160 feet. Just west of the town (Tp. 83 N., R. XXIX W., Sec. 4, NW. qr., NW. ¼) the Dale and Goodwin mine has been opened for some years. The shaft is 150 feet deep, with eighteen inches of coal covered by twenty inches of black shale having thin layers of good coal intercalated. Beneath the coal is an excellent bed of fire clay having a very considerable thickness. It is used for the manufacture of brick and tile. In fact the mining of the clay forms the principal output of the mine the coal taken out in connection with it being used largely for fuel in the kilns.

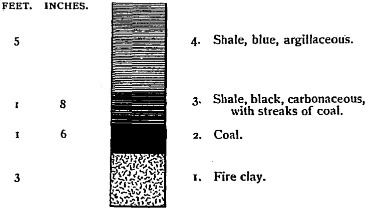


Figure 43. Coal Bed in Dale and Goodwin Mine. Grand Junction.

Eight miles south of Grand Junction, at Rippey, coal has been mined for some years. A short distance east of the railroad station (Tp. 82 N., R. XXIX W., Sec. 11, NW. qr., NW. $\frac{1}{4}$) is the Kennedy mine. This is a well equipped shaft working a seam at a depth of 125 feet. The following sequence of beds at this place is:

FEET.	INCHES.		
40		12	Drift, sand and clay.
60		11.	Clay, soft, black, "sea-mud."
5		10.	Shale, bituminous, fissile.
4		9.	Sandstone, fine grained.
3		8.	Shale, light colored.
9		7.	Shale, hard, carbonaceous.
4	6	6.	Coal.
8		5.	Fire clay.
4		4.	Shale, bituminous, compact.
1	6	3.	Coal.
26		2.	Shale, blue, argillaceous.
10		1.	Sandstone (exposed).

Figure 44. Section at Kennedy Shaft. Rippey.

The coal is from four to five feet in thickness and exhibits three well marked benches: the upper eleven inches is rather soft and contains considerable mineral charcoal; the middle twenty-four inches is quite hard, pure, lustrous and contains some pyrite; while the lower portion, thirteen inches, is a hard, lustrous variety. Below this is a six-inch bed of impure coal or "black-jack" resting upon fire clay. The details of the principal coal bed are:

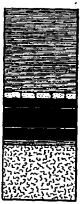
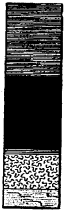


Figure 45. Tripartite Seam at Kennedy Mine. Rippey.

There are no clay seams in the vein, the differences in the three divisions being based entirely upon the physical properties. Immediately over the coal seam is a thin band of gray clay above which comes the nine feet of black shale forming an excellent roof. The main entry near the shaft is fifteen feet wide and has stood nine years without timbering. The seam is rather undulatory and has a general dip to the northeast of about two feet in a hundred. It is quite free from faults though occasionally small slips occur. In a few places the roof has been disturbed through erosion.

In the southeastern corner of the county coal has been extensively mined around Angus both in the adjoining portion of Boone and Dallas counties as well as in Greene. The mines in Greene have worked in two veins. A few of these have mined a seam near the surface which is thought to be the same as that outcropping along the Raccoon river a few miles to the westward. The greatest amount of coal, however, has been taken from the lower vein 100 to 120 feet beneath the surface. It is three and a half to four feet in thickness, hard and of good quality. The roof is a good black shale, which is covered by a considerable thickness of gray clay shale. Beneath the seam of coal the fire clay is said to be eight feet thick in places. The vein is more or less undulatory and has been disturbed but little. The faults are small and of quite local extent. There were at one time twelve mines working in this part of Greene county. The bed of coal, as shown in the Angus mine in Boone county, near the eastern limits of Greene, has the following association of strata:



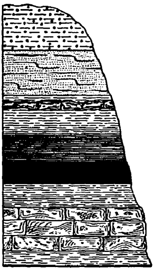
FEET.	INCHES.	
4		5. Shale, black, bituminous.
4		4. Coal.
	2	3. Shale, carbonaceous, black.
2		2. Fire clay.
1		1. Sandstone, (thickness not known).

Figure 46. Bed in Angus Mine. Near southeast Corner of Greene County.

The principal mines of this neighborhood were the Keystone, Craig, Moingona, Standard, Hager, Buckeye, Armstrong and Morris. These have all been abandoned though the Buckeye slope was in full operation until quite recently.

An interesting example of the method often employed in opening a coal district is shown by the Angus region. Within an area of seven or eight square miles including portions of Greene, Boone and Dallas counties eighteen or twenty mines were opened in the vein known to exist. In the course of time the coal was entirely removed throughout the available territory. A few desultory attempts were made to discover a lower seam though no systematic search was carried out and the Coal Measures were not penetrated very far at any point. These attempts not meeting with immediate success the mines with the exception of two or three were successively closed up and abandoned, the tracks taken up and the machinery and top works moved away. Subsequently a boring was made near the deserted shaft of the Keystone mine and carried to a depth of ninety feet beneath the level of the old workings and a vein of coal four feet four inches in thickness located.

Five or six miles southwest of Rippey and about the same distance west of Angus near the Raccoon river coal has been mined for a long time. The principal openings are the Dicholm and Bussey mines. The coal is about one foot and a half in thickness. In the bluffs the coal seam is exposed about twenty-five feet above the river bed. The section is as follows:



	FEET.	INCHES.
8. Drift........................	3	
7. Sandstone, yellowish, shaly and somewhat argillaceous.	3	
6. Shale, clayey, blue, containing irregular bands of impure, fossiliferous limerock.	1	6
5. Shale, bituminous, fossiliferous........................	3	
4. Coal...........	1	6
3. Shale, clayey, blue	1	6
2. Limestone, bluish, compact, fossiliferous..............	3	
1. Shale, yellowish.............	1	

Figure 47. Section of Bluff near Bussey Drift. Southwest of Rippey.

In Guthrie county three miles from the southwestern corner of Greene county coal has been mined to a considerable extent the vein being twenty-two inches thick. It is mined at a depth of from sixty to one hundred feet. It probably extends northward into Greene county but to what extent is not at present known. The section found in the Hughes mine in Guthrie near the southwest corner of Greene is:

FEET.	INCHES.	
2		4. Shale, light colored.
5	6	3. Shale, dark, bituminous, somewhat fissile.
1	6	2. Coal, a two-inch clay parting four inches from the bottom.
4		1. Fire clay, (exposed).

Figure 48. Coal Seam in Hughes Mine. Near southwest Corner of Greene County.

BOONE COUNTY.

Boone is surrounded on all sides by coal counties and has long been known among the leading producing districts of the state. The drift deposits have a very considerable thickness over the greater part of the region yet they have been completely cut away along the Des Moines river which flows southward through the center of the county in a deep, gorge-like valley. Both on the main stream and all its principal tributaries the stratified rocks are well exposed at short intervals.

The Lower Carboniferous limestones while present at no very great distance below the surface are nowhere exposed within the limits of the district; but a few miles beyond the east county line the Saint Louis limestone crops out in the valley of the Skunk river. The county may, therefore, be regarded as entirely underlain by coal bearing strata.

Boone was one of the first counties in the state to assume prominence in the coal industry and mining has gone on steadily for upwards of a third of a century. In the central part of the county where coal has been taken out for the greatest length of time two principal seams have been opened up. In the southwestern portion of the region, around Angus, several veins are known to exist. It is also quite probable that other beds than those at present generally known occur lower down. In fact some of the deeper borings in different parts of the county clearly indicate the presence of other coal horizons at greater depths than have yet been reached by shafts.

At the present time preparations are being actively carried on for more extensive mining than ever before, especially in those localities along the Des Moines river in the central part of the county.

Angus District.—In the extreme southwestern portion of Boone county is a region which a few years ago was one of the most important mining localities in the state.

It forms a part of the district which lies in portions of three counties: Boone, Dallas and Greene. The leading mines, however, were located in Boone. Altogether upwards of a score of shafts have been operated here. At the present time only a few are working; the principal ones running being the Angus and Dalby mines. Among the operators of the district considerable confusion exists as to the exact arrangement of the coal seams. There is one which is worked in the Angus mine and was formerly also in the Craig, Ramsey and Panic shafts. Above this is a thinner seam which has also been worked to some extent in the Craig and the Hagger mines. This is the same vein which is said to crop out in the bluffs of the Raccoon river a few miles to the westward, but there is considerable doubt as to the correctness of the correlation. Lower down than the chief bed worked at the Angus mine is another seam which has been opened in the Dalby shaft. Beneath the first mentioned seam there has been reported a third coal bed which, though not yet worked, has been encountered in borings. Other veins are also known to exist but none have yet been found thick enough for profitable working. The "third" seam is five and one-half feet in thickness according to the best information obtainable, and is located at a depth of ninety feet below the bed opened in the Keystone mine. All the mines are situated southwest of the Angus station. Drillings show that the seams extend beneath the town, but they are somewhat thinner and the roof is poor. A shaft put down east of the place was flooded after working but a short time.

The Angus mine, one of the largest now in operation, is located a short distance from Angus station (Tp. 82 N., R. XXVII W., Sec. 31, NW. qr., NW. ¼). It is a shaft fifty feet in depth, and is thought to be working in the "middle" seam. The coal is from three and one-half to five feet in thickness, with an average of about four feet. The section shows:

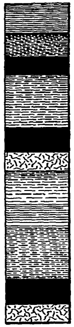


Figure 49. Part of Shaft in Angus Mine. Angus.

The seam is quite undulatory. A few faults have been met with and also several "horsebacks." The mine is worked on the room and pillar plan. As the coal is worked out over all the available territory in anyone direction the pillars are "robbed" and the roof finally allowed to fall in.

Half a mile south of the Angus mine is the Dalby. This mine is a shaft 120 feet deep and works in the "lower" vein. The seam is from three to four and one-half feet in thickness; the roof a hard black shale and sandstone but in some places rather poor. The bed is somewhat undulatory; faults are rare. The bottom of the shaft shows:

Figure 50. Bed in Dalby Shaft. Angus.

In several places a soft fire clay is found pressing up into the entry forming "creeps" one of which is represented in the accompanying figure 51.

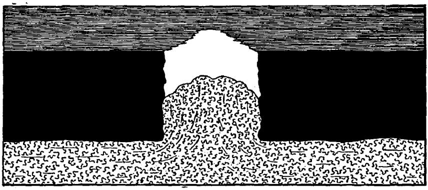


Figure 51. "Creep" in Dalby Mine. Angus.

Des Moines Valley.—Local mines have been opened from time to time along the river west of Madrid, but most of these are operated only to supply the immediate neighborhood with fuel during the winter season. The more important mines are in the central portion of the county. About eight miles from the south boundary line is the Potter slope (Tp. 82 N., R. XXVI W., Sec. 15, SW. qr., NW. ¼). The section near the coal bed is as follows:

FEET.	INCHES.	
1		5. Limerock, impure, compact, bituminous, "cap-rock."
	7	4. Shale, bituminous.
2	6	3. Coal.
4		2. Fire clay.
7		1. Shale, black, bituminous.

Figure 52. Coal Seam at Potter Slope on the Des Moines River. Below Moingona.

The so-called "cap-rock" is a black, very compact and brittle calcareous shale separated from the coal by a few inches of dark fissile shale which is quite fossiliferous. The vein of coal is about fifty feet above low water in the Des Moines river. A mile farther up the stream in the southeast quarter of section 9, is the Knox slope. The seam operated appears to be the same as that worked farther down the river but here it is fully seventy feet above the water level. It varies from two and one-half to three and one-half feet in thickness. Two miles beyond near a sharp bend in the river, in section 5, is the Blyth slope. Two veins of coal are exposed, the lower one being about three feet above low water in the Des Moines and the other about forty feet higher up. The lower seam ends abruptly towards the southward, being cut out, through Carboniferous erosion, and the channel filled in with clay. This vein is three feet in thickness; while the "upper" one is two and one-half feet to three feet thick, with a good roof. Between this point and Moingona the bluffs form high mural escarpments of sandstone through which deep labyrinthine ravines have been gouged out by numberless small tributaries as they approach the larger water course. A mile below the town on the west river bank (Tp. 83 N., R. XXVI W., Sec. 18, NE. qr., SW. ¼) is the Highland Chief mine which has been in operation for many years. It is a shaft sixty feet in depth and working the "upper" vein, which is here from two to three feet in thickness. A half a mile directly west is the Moingona shaft No. 6, the last mine opened by the company in the neighborhood. In the vicinity of the town coal crops out in many places in the sides of the Des Moines valley and along the minor streams flowing into the river. Directly opposite the railroad station at Moingona is the White Smoke mine. This is a shaft recently put down. It is about fifty feet in depth and reaches the "upper" vein which has a thickness of two and one-half feet. The section is:

FEET.	INCHES.		
4		5.	Shale, bituminous.
	4	4.	Limerock, impure, very compact, bituminous, ferruginous.
2	6	3.	Coal.
	7	2.	Fire clay.
1		1.	Sandstone, (exposed).

Figure 53. Vein at White Smoke Mine. Moingona.

There are several country banks in the neighborhood which furnish considerable fuel for local use. This locality was formerly an important mining region, but at the present time comparatively little coal is being taken out. North of Moingona about a mile and a half is the old Clyde Mine No. 2, which is now deserted; and farther northward is the Ogden (Tp. 84 N., R. XXVII W., Sec. 27, SE. qr., NE. ¼). The coal mined at the latter place is the "lower" vein which, however, seems to be distinct from the similarly named bed of the Milford district a few miles to the northward. A mile north of the Ogden is the Clyde No. 1, now abandoned. This is the southernmost of the more important mines which are comprised in the Milford area. Near by is the Rogers and Crow shaft (Tp. 84 N., R. XXVII W., Sec. 14, SW. qr., SW. $\frac{1}{4}$). It is located on the summit of the bluff and is 206 feet in depth. The drift deposits at this point are 100 feet in thickness. There are two veins of coal the "upper" being about ten feet above the "lower". The latter is three and one-half feet in thickness on an average. It is somewhat irregular, becoming considerably thicker and thinner in places than the average measurement given. The upper vein is somewhat thinner than the other but more uniform. There is also a third vein said to be present about forty feet below the "lower" vein. About two hundred yards to the northeastward is the Milford shaft which is located at the base of the bluff. It is 100 feet in depth and also works in the "lower" vein which here has a thickness of four feet. At the bottom of the shaft there are:

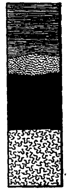


Figure 54. Bottom of Shaft, Milford Mine. Boonsborough.

The upper seam is ten to twelve feet above this and three feet in thickness. Several thin veins were passed through in sinking a shaft before reaching the upper seam. Half a mile southeast of the Milford is the Boone Valley shaft which is seventy feet in depth. The coal is three and one half feet in thickness. A second vein is eight feet higher but only the lower one is mined at the present time. The same company also operates two mines three miles to the northward. Directly to the east are several shafts known as the Marshall mines. They are all located on the river bottom and work coal from two and a half to four feet in thickness.

On the opposite side of the Des Moines river a number of mines are in active operation, the most important of which is the Hunt (Tp. 84 N., R. XXVII W., Sec. 13, NE. qr., SE. $\frac{1}{4}$). Half a mile to the southward is the Marshall slope and about the same distance beyond this, the Johnson mine. The latter is the oldest and largest mine in the county. It is still in operation though opened more than thirty years ago. For about a quarter of a century it has been under the present management. Two workable seams of coal are found, both being worked by the long wall method. The section of the shaft which was prepared from small samples obtained by the foreman at the time of sinking is as follows:

	FEET.	INCHES.
29. Soil	5	
28. Clay, yellowish	20	
27. Clay, bluish	40	
26. Clay, yellowish	40	
25. Shale, bluish, massive, dark below	9	
24. Sandstone, light colored, shaly	9	
23. Shale, dark	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, fossiliferous, hard, compact	7	
17. Shale, light colored	5	
16. Sandstone, whitish, argillaceous	13	
15. Sandstone, compact, somewhat course in texture	8	
14. Shale, black, bituminous, fissile below	3	
13. Fire clay, light colored shale	9	
12. Shale, hard	5	
11. Fire clay,	1	

		FEET.	INCHES.
10.	Shale, dark, highly bituminous	3	
9.	Coal		6
8.	Limerock, impure clay, iron-stone, highly fossiliferous	2	
7.	Coal, "upper vein"	4	
6.	Fire clay	3	
5.	Shale, with irregular iron-stone concretions	4	
4.	Coal, "lower vein"	4	6
3.	Fire clay	3	
2.	Shale, light colored	3	
1.	Shale, dark, bituminous	2	

The "lower" vein is quite variable in thickness but reaches a maximum measurement of five feet. A mile to the southeastward is the Heap mine which is a shaft 208 feet in depth. Only the "lower" vein is mined at present; it appears to be the same as the similiarly called seam in the Johnson mine. The coal is from two to four feet in thickness. About a mile to the southward is the McBrinie shaft 175 feet deep. The coal seam is from three to four feet in thickness, with an excellent roof. The strata shown in connection with the coal at this point are as follows:

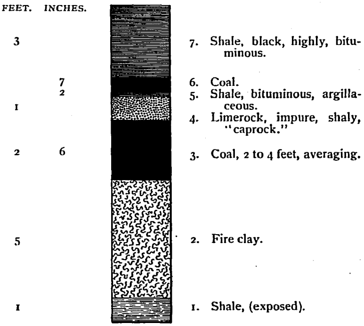


Figure 55. Section in McBrinie Shaft. Boonsborough.

Opened in the same vein are a number of other mines; though at the present time they are not in operation. Among these may be mentioned the Flock and Clarke mines, and the McBrinie and Nelson shaft.

About five miles to the northward from the Milford district and a couple of miles from Pilot Mound station several large mines have recently been opened. They are shafts sixty to one hundred feet in depth. Preparations are actively going on for extensive mining in this vicinity. The openings are known as the Boone Valley mines. Considerable land on both sides of the river is controlled by the company and a railroad is being built from the Pilot Mound to the mines. On the opposite side of the river country banks have been opened from time to time. With better railroad facilities than those now existing in this district they will doubtless soon form mines of commercial importance.

Squaw Creek Valley.—Considerable mining has been carried on in the vicinity of Zenorsville in the eastern part of the county. The principal mines are three in number. The Hutchinson, No. 1 (Tp. 84 N., R. XXV. W., Sec. 12, SW. qr., SE. ¼), is a shaft 125 feet deep with coal twenty-eight inches in thickness. The section of the shaft is as follows:

		FEET.	INCHES.
11.	Soil, gray and sandy	1	
10.	Clay, joint	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	1	6

Hutchinson shaft No. 2 is located about 300 yards to the northward. It is 105 feet in depth with coal nearly four feet in thickness. There is an upper vein present at this point about six feet above the lower, the latter only being mined at this point. The section at the base of the shaft is:

Figure 56. Coal Bed in Hutchinson Mine near Squaw Creek. Zenorsville.

Northeast of the Hutchinson mine about a quarter of a mile are the York and the Clemens mine, which at the present time are not in operation.

STORY COUNTY.

Probably more than one-half of Story county is underlain by Coal Measure strata. These, however, do not form a very great thickness over most of the district since the Lower Carboniferous limestones outcrop along the Skunk river and its tributaries for a distance of several miles to the north of Ames. On Squaw creek a short distance north of Ontario station coal is now being mined (Tp. 84 N., R. XXIV W., Sec. 21, SE. qr., SE. $\frac{1}{4}$) at a place known as the Johnson shaft. The coal is said to be four and a half feet in thickness, with two thinner veins some distance above. Considerable coal has already been taken out. The following is the section of the strata exposed near the coal seam:

Figure 57. Section of Coal in Johnson Shaft.
Gilbert.

Only four miles to the eastward the Saint Louis limestone crops out at the surface. The coal area seems to be an eastern portion of the Squaw creek region which has been operated more extensively in Boone county.

MARSHALL COUNTY.

This is one of the marginal counties of the Iowa coal field. About one-half of the district is probably underlain immediately under the drift by Lower Carboniferous rocks. These are well exposed along the Iowa river east of Marshalltown. At the extreme eastern edge of the county in the neighborhood of LeGrand quarry and vicinity, thick limestone beds are exposed on both sides of the river showing a thickness above the water-level of seventy-five or eighty feet. The greater part of the rocks exposed belong to the lowermost member of the Lower Carboniferous — the Kinderhook. At the top of the bluff certain strata appear to form a part of the Burlington limestone so well represented in the southeastern part of the state. It is quite likely also that the Saint Louis limestone crops out at different places within the limits of the county. Away from the immediate vicinity of the Iowa river, which flows across the northeastern corner of the county, the drift has such a great thickness that few outcrops of the stratified rocks are visible.

The Coal Measures occupy fully one-third to one-half of the district underlying the western and southwestern portions especially. Coal pockets also doubtless occur in different parts of the area. Four miles southwest of Marshalltown is the easternmost exposure at present known of the Coal Measure rocks in this county. At this place, on Linn creek, the section is chiefly shale and sandstone the latter being compact enough to be used as a building stone and has been quarried for a number of years. Other large outlyers of Coal Measure are known twenty to twenty-five miles to the eastward, in Benton and Iowa counties.

The principal locality where coal has been mined in Marshall county is on the Iowa river at a place called Mormon Ridge three miles from Albion, a short distance northwest of Marshalltown (Tp. 85 N., R. XIX W., Sec. 34, SW. qr., SE. $\frac{1}{4}$). A shaft forty feet deep was sunk a few years ago and was known as the Mormon Ridge mine. The coal was three feet in thickness.

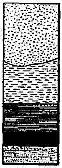


Figure 58. Bed at Mormon Ridge Mine. near Albion.

At one time fourteen men were employed. The shaft was operated only a short time for the reason that only three or four feet of shale intervened in the roof between the coal and a thick stratum of sand and water. The water gave so much trouble that the mine was abandoned after being operated about a year. Not more than one hundred tons of coal were taken out. A few years later another company leased the property and attempted to work the coal, but owing to defective pumps made little progress.

A quarter of a mile directly north of this shaft on the north side of Mormon Ridge in an old bed of the Iowa river a considerable quantity of coal is reported to have been taken out some years ago; but at present the bed is not exposed.

In a drill hole, put down one mile northwest of the Mormon Ridge shaft, on the farm of W. C. Radduck (Tp. 85 N., R. XIX W., Sec. 28, SW. qr., SW. $\frac{1}{4}$), a bed of black shale with some coal was encountered, at a depth of 118 feet. The layer was several feet thick and immediately underlain by a thin seam of fire clay.

Some years ago a shaft was sunk on the farm of A. R. Pierce on Minerva creek five miles north of Bangor (Tp. 85 N., R. XX W., Sec. 9, SE. qr., SE. $\frac{1}{4}$). Coal was found here, but to what extent it is not now definitely known.

Like some of the other bordering counties of the coal field systematic prospecting in Marshall will doubtless enable it to rank, at no very distant date, among the districts of the state producing coal in commercial quantities.

CHAPTER IX.

DESCRIPTION OF THE COAL BEDS OF CENTRAL IOWA.

The coal deposits of the counties embraced within this area are by far the most important in the state. The production of coal in this region is much greater than in any of the others. The limits of the district are of course perfectly arbitrary and are merely selected for convenience in the treatment of the subject. Forming the median portion of the region traversed by the Des Moines river it is surrounded on all sides by counties whose surfaces are occupied largely by Coal Measure strata. The maximum thickness of the coal bearing beds of the area is probably between four hundred and five hundred feet. Although the Coal Measures become attenuated to the eastward the Lower Carboniferous limestones are nowhere exposed at the surface except in the southeastern corner of the district where in Marion and Mahaska counties the Saint Louis limestone outcrops in some of the beds of the principal streams. Thus over much of the central region considerable depths may be penetrated before reaching the Coal Measure basement. Towards the east the heavy drift deposits prevent the exact boundaries of the coal field from being determined with accuracy over a part of the region. The numerous well borings, however, have enabled the leading features to be made out and the actual limits eastward are probably not far from those assigned them on the accompanying map. Toward the west the Upper Coal Measures come in, covering the more productive deposits, which come to lie deeper and deeper in that direction. Outliers of Cretaceous also occur in some of the more western counties but in no case are these very extensive.

The counties embraced in the central district are: Guthrie, Dallas, Polk, Jasper, Poweshiek, Madison, Warren, Marion and Mahaska.

GUTHRIE COUNTY.

This county lies in that part of the coal field where the Coal Measure strata begin to pass beneath rocks much younger. The entire surface of the county being mantled by drift to a considerable depth the natural outcrops of the underlying stratified rocks are seldom found well exposed.

The eastern margin of the Iowa Cretaceous stretches out into the western and central portions of the county, occupying fully one-third of the entire district. As this formation here presents only its attenuated edge it is not very well marked. In the extreme western portion of the county Cretaceous rocks are exposed along the various streams showing a thickness sometimes of eighty or ninety feet. The beds consist chiefly of ferruginous grits and conglomerates with a development of argillaceous shales. In a few places brown coal has been found in thin seams two or three inches in thickness. While probably not of any economic value at present these lignites are of interest in showing the presence in the county of Cretaceous as well as Carboniferous coals. Indeed these two coals have been noticed in the same section, within thirty feet of one another, a few miles west of Guthrie Center.

Besides the rather extensive development, in the western and northwestern parts of the county, of the Cretaceous which seems to resemble portions of the main body there are doubtless outliers of greater or less extent. That these deposits were much more extensive at one time than at present is shown by the occurrence in the drift of large fragments and boulders of Cretaceous sandstone charged with fossils. These blocks have been found scattered eastward through Dallas and Polk counties. Some of the fragments contain fossils in a good state of preservation, among which have been recognized specifically a number of species of sharks and gasteropods of undoubted Cretaceous types. The good preservation of fragile mollusks and the comparative softness of the masses indicate clearly that the fragments are not far removed from the locality of original deposition. Outliers which are found capping the hills along the rivers may therefore be regarded as portions of the main mass, the larger streams having cut their channels completely through into the Coal Measures below.

With the exception of the comparatively thin covering of Cretaceous beds and the mantle of drift the county may be regarded as entirely made up of Coal Measure strata. Like in most other counties situated in this part of the state the coal beds have been sought for principally only in the hillsides along the streams. Like also in the neighboring counties prospecting to a depth of three to four hundred feet would doubtless disclose much more extensive seams than are now known anywhere within the limits of the district, for coal in workable beds probably exists over much of the county. At the present time, however, it has been developed almost entirely along the streams, most of the product being taken out of small local drifts. The coal obtained in this manner is all taken from thin seams and is in some instances poor in quality. At present there are a score or more of mines operated in the region but with one or two exceptions they are country banks furnishing supplies for local trade only. A number of shafts have been put down but they rarely reach a depth greater than seventy-five or eighty feet. No systematic search has yet been made for a deeper coal horizon.

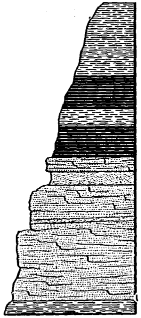
The principal places where coal is mined are situated along the Middle Raccoon river where the majority of the natural exposures are located. Linden, just over the line in Dallas county, Panora, Fansler and Bayard are the leading points. Coal is also mined to a considerable extent on the South Raccoon, and in the northeastern part of Guthrie. North of Stuart mines have also been opened in the extreme southeastern part of the district.

Jamaica District.—This is in the extreme northeastern corner of Guthrie, near where coal has been mined in Dallas county in the valley of the Raccoon river not far from the boundary line. It forms a part of the region which in Dallas has been called the valley of the North Raccoon river. This stream does not enter Guthrie; but on a small creek known as the Greenbrier which flows across the northeastern corner of Guthrie into the Raccoon near Dawson and about a mile northeast of Jamaica (Tp. 81 N., R. XXX W., Sec. 1, NE. qr., SW. $\frac{1}{4}$) there is located the Simons or Greenbrier mine. It is a shaft thirty feet in depth, with coal two feet in thickness. The vein thickens toward the east and becomes better in quality. It rests upon a bed of fire clay several feet in thickness and is covered by a hard black shale, as shown in the following section:

Figure 59. Coal Bed at Greenbrier Mine. Jamaica.

The mine is worked chiefly during the winter; and an important local trade is supplied. A short distance east of here at Dawson, in Dallas county, considerable mining is carried on. At least six seams of coal are known to occur, though with two exceptions they are too thin for profitable working. On the Raccoon near here important mining operations have been carried on; while six or seven miles east, at Angus, deeper veins are known to exist and one of these has been quite extensively mined. It seems quite probable that this coal horizon extends westward under a portion, at least, of Guthrie county.

Middle Raccoon Valley.—The largest coal mines in Guthrie are situated along the Middle Raccoon river. The exposures showing coal above the river level are quite numerous from the southeast corner where the stream leaves the county to the northwest corner where it enters. Several veins of coal outcrop in the bluffs and are reached at a number of places by drifts and shallow shafts. At the southeast corner the coal basin is a continuation of the Redfield district of Dallas county. Half a mile east of the Guthrie county line at Linden is the Dale mine where considerable coal has been mined. Two miles southwest of this place, on the south side of the river, is the Stapes coal mine (Tp. 79 N., R. XXX W., Sec. 36, NE. qr., NE. $\frac{1}{4}$). The vein worked is seventeen inches in thickness. As at the opening half a mile to the eastward, known as the Keeler mine, there are numerous clay seams running through the coal and the clay partings so characteristic of this vein also occur here. The coal bed is comparatively free from faults or "troubles." In the neighborhood of the mine mentioned there are also a number of small drifts operated from time to time, but as yet they have not been systematically worked. Just beyond the mine mentioned coal and bituminous shale are frequently seen outcropping in the hillsides on the south side of the river. On the opposite side of the Raccoon, directly across from the Stapes mine, are also several good exposures, one of which may be described as:



FEET.	INCHES.	
5		8. Shale, light colored.
2	3	7. Shale, bituminous.
1	1	6. Shale, light colored.
2	2	5. Shale, bituminous.
1		4. Sandstone, hard, yellow, ferruginous.
	10	3. Sandstone, friable.
8		2. Sandstone, hard, massive, with thin shale partings.
10		1. Shale, light colored, arenaceous.

Figure 60. Bluff on Middle Raccoon. Near East County Line of Guthrie.

About two miles to the northwestward is the Tann mine (Tp. 79 N., R. XXX W., Sec. 22, SE. qr., NE. ¼). It was a small drift and is said to have worked a seam of cannel coal twenty-two inches in thickness. A mile to the northwest and about three miles directly south of Panora on the south side of the river several openings have been made a short distance from the stream. The principal mine is the Burgess. It has only been recently opened and is a shaft fifty-four feet in depth, working twenty inches of coal. A second vein a short distance below has been located but has not been opened up yet. A quarter of a mile to the northward are the Fisher and Dygart mines, the former working the same vein as the Burgess mine. The Fisher shaft is thirty-six feet in depth. Near the Dygart the section shown is:

FEET.	INCHES.	
3		5. Shale (exposed).
	5	4. Coal.
	4	3. Clay shale.
	4	2. Coal.
2		1. Fire clay (exposed).

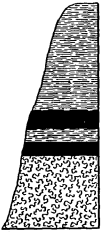


Figure 61. Bluff at Dygart Drift. Panora.

Near the river, on the east side, a mile and a half below Panora, a number of openings have been made, though none of them are in active operation. In this vicinity the coal is exposed in the bluffs, the principal vein here, which is one foot thick, being known as the Panora coal. The section is:

		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

Directly opposite Panora on the river bank St. John gives the following section at Wasson's coal mine, near the old Panora woolen factory:

		FEET.
11.	Shale, blue and reddish	2
10.	Limestone, rather impure, in three layers with shaly partings, lower one fragmentary and fossiliferous	4
9.	Shale, dark blue	6
8.	Limestone, impure, compact, bluish, containing fossils	⅔
7.	Shale, dark, bituminous	1½
6.	Coal	1
5.	Shale, light colored	10
4.	Shale, variegated	6
3.	Shale, bluish	3
2.	Shale, variegated	7
1.	Sandstone, micaceous (exposed)	12

A short distance to the westward of the last mentioned point is the Reese mine, (Tp. 79 N., R. XXX W., Sec. 6, NE. qr., SE. ¼). It is a shaft ninety feet deep working coal eighteen inches in thickness. No "horsebacks" or faults are encountered and the seam is quite regular. Clay seams are sometimes met with. The beds associated with the coal vein are:

		FEET.	INCHES.
5.	Shale, bituminous		6
4.	Limestone, dark, impure, bituminous, concretionary, "niggerhead"		6
3.	Shale, bituminous		4
2.	Coal	1	6
1.	Fire clay		6

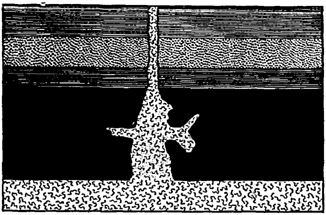
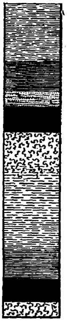


Figure 62. "Clay Seam" in Reese Mine. Panora.

The portion of the coal bed represented shows one of the clay fissures commonly met with.

Three miles northwest of Panora is the Harris mine (Tp. 80 N., R. XXXI W., Sec. 25, SW. qr., NE. ¼), situated about half a mile from the river. It has but recently been opened and is a shaft twenty feet deep, with coal eighteen to twenty inches in thickness. A mile directly north of the mine on south bank of the river a short distance above the wagon bridge there is a good exposure more than 200 feet long showing chiefly sandstones and shales.

In the neighborhood of Fanslers considerable mining has been carried on during the past few years. A mile below the mill is the old shaft of the Jones mine, forty feet deep. The coal is eighteen inches in thickness. At the present time the mine is not in operation. Directly north of the mill site numerous openings have been made, among which is the Scott mine (Tp. 80 N., R. XXXI W., Sec. 9, SE. qr., NW. ¼). It is a new shaft, seventy-six feet deep, with coal thirty-two inches in thickness. Half a mile northwest on the river bank is the Renslow mine, eighty-seven feet in depth. On the opposite side of the river are several mines which were opened a few years ago. These were the Marshman, the Decker and the Oleson. They were all shafts working the same vein of coal at a depth of from sixty to ninety feet. East of the mill a short distance is the Hughes mine a shaft seventy feet deep. The seam is quite regular and from twenty to twenty-two inches in thickness. The coal is worked on the long wall plan and a considerable local demand is supplied. Above the mill a short distance, near the river bank, is another mine, the Marchant, which is a shaft 126 feet deep, with coal two feet in thickness. It has been operated for a dozen years or more and is supplying an important local trade. Further up the stream are the Eclipse and Scott mines and on the opposite side the Thomas shaft. The latter is 142 feet deep with coal twenty-six to twenty-eight inches in thickness. At the Scott two seams of coal are present:



FEET.	INCHES.	
4		7. Shale, light colored, argillaceous, sandy in places (exposed).
2		6. Clay shale, dark, fissile.
1		5. Sandstone, "caprock."
1	10	4. Coal, containing heart shaped pericarps in pyrite, four inches of shaly material at the bottom.
10		3. Fire clay and clay shales.
1	6	2. Coal.
1		1. Fire clay.

Figure 63. Section of Scott Shaft. Fauslers.

The bed at the Eclipse shows:

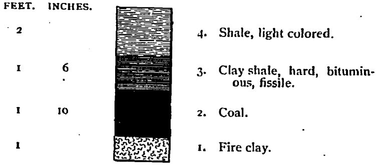


Figure 64. Bed at Eclipse Mine. Fanslers.

About five miles west of Fanslers a number of openings were formerly worked on both sides of the river. The principal mine now in operation is the Eureka (Tp. 81 N., R. XXXII W., Sec. 33, NE. qr., NW. ¼) which is on the south side of the river and opened in the same vein as the old Mount mine. It has been operated for about twenty years, new drifts being made each winter. The relation of the coal seam and its associated beds are:

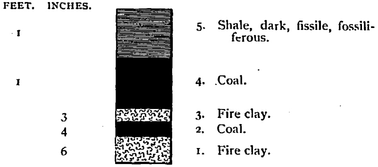


Figure 65. Coal Seam at Eureka Mine. Bayard.

There are a number of country banks in the neighborhood all working the same coal which is from twelve to eighteen inches in thickness. A distinguishing feature of this seam is a three-inch parting of clay, separating the upper twelve inches of the bed from rest of the seam.

A few miles to the northwestward and about five miles southwest of Bayard another group of mines is located along the river bank. The principal one of these is the

Hughes (Tp. 81 N., R. XXXIII W., Sec. 24, SE. qr., NE. ¼). This is a shaft thirty-nine feet deep. A rather important local trade is supplied. For several miles along the river drifts are found some of which have produced considerable coal. The seam exposed varies from one to one and a half feet in thickness. In this part of the county the Cretaceous rocks are found overlying the Coal Measures.

Stuart District.—In the southeastern corner of the county, in Penn township, coal has been mined at a number of places the principal locality being on Deer creek, a small tributary of the South Raccoon. Most of the mines are drifts which have been worked in a very unsystematic way, but yet have taken out considerable coal. Two miles north of Stuart is the Lamb mine (Tp. 78 N., R. XXX W., Sec. 20, SW. qr., NW. ¼). It is a shaft thirty-five feet deep, with coal two feet in thickness. On the opposite side of the creek the following section is shown:

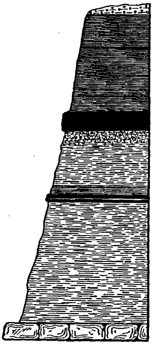


Figure 66. Section of Bluff on Deer Creek. Stuart.

A short distance farther north is the Suggert and Saint mine. It has been opened only recently. The shaft is forty feet deep; the coal twenty-two inches thick.

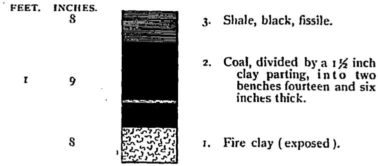


Figure 67. Coal with Clay Parting, in Suggart Mine. Stuart.

Coal has also been mined to some extent near Glendon and Menlo but the workings have been abandoned for several years.

DALLAS COUNTY.

Dallas is underlain everywhere by Upper Carboniferous strata. The workable coal exposed in the natural outcrops along the water courses, probably makes up only a comparatively small portion of the total amount existing in the county. The entire northeastern third of the district is occupied immediately beneath the drift by Lower Coal Measure beds. The rest of the county has the Upper Measures overlying the lower division, which becomes more and more deeply buried towards the southwestern corner. Over this portion of the region the stratified formations near the surface exhibit limestones and calcareous shales in great prominence as compared with the strata of the Lower Coal Measures and they have relatively few coal bearing horizons. Borings in the county from 250 to 400 feet would doubtless reveal a number of coal veins sufficiently thick for profitable working. Heretofore with one or two exceptions the coal of Dallas has been mined by means of drifts or slopes in the hillsides, along the streams above the water level. Most of the veins are between one and a half and three feet in thickness. The popular impression therefore has been that this county does not possess any greater coal supplies than is visible in the various natural outcrops and its annual production would seem to indicate the same thing. A more careful examination of the strata indicates beyond question that the amount of mineral fuel in the county is very much greater than has commonly been supposed, but that it lies somewhat deeper than in the country immediately to the eastward. Therefore, if instead of confining coal prospecting to the surface veins, attention be directed to deeper boring, Dallas would soon greatly increase its annual production over that now credited to it.

The Lower Coal Measures are well exposed in the northeastern corner of the county. Along the Raccoon river which flows entirely across the county from the northwest to southeast corner numerous outcrops of coal are found. There are also many exposures along the South Raccoon, which with the lower portion of the main stream just mentioned traverses the southern tier of townships from west to east.

Des Moines River Valley.—Along this stream the bluffs are usually quite high, often quite precipitous, on both sides of the water course. Numerous good sections of the strata are presented in the deep, narrow ravines opening into the river valley. There are now known to be at least two seams of coal above the water level in this part of the county; and probably more important seams exist below the river bed. The coal has been mined at short intervals along the bluffs on both sides of the stream, the openings being country banks which are operated for local use during the colder months of the year. On the east side of the river there are a number of old drifts a short distance above High Bridge. On the west side of the stream near the point just mentioned the Pritchard mine was worked for a long term of years but has recently been given up. The seam of coal is rather thin and is broken through by many clay seams. Although not easily worked there was a good local demand for the output and during the period of its activity a considerable amount of coal was taken out. A section of the bluff shows:

FEET.	INCHES.	
4		5. Drift.
3		4. Sandstone, thinly bedded.
18		3. Shale, light colored, with sandy concretions, grading downward into bituminous.
1	8	2. Coal.
	4	1. Fire clay (exposed).

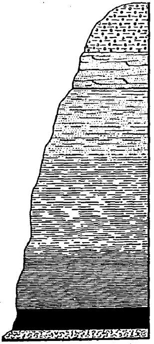
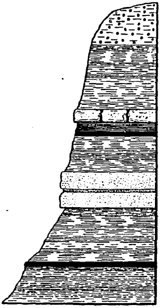


Figure 68. Bluff near Pritchard Drift. High Bridge.

The principal mines at present in operation in the northeastern corner of Dallas are the Tabor shafts. They are situated southeast of Woodward near the wagon bridge crossing the river (Tp. 81 N., R. XXVIW., Sec. 14, SW. qr., NE. ¼). They are at present owned by Strange and Son. There are three openings all in the same seam of coal and only a short distance apart. They are all shafts, No. 1, the most easterly, being thirty-two feet deep, No. 2 forty-two feet deep and No. 3 seventy-four feet deep. The coal is two feet in thickness and is worked on the long wall method. There is a good roof. No partings are observed in the coal, but occasionally clay seams cut across the vein in certain places. There are a number of openings in this part of the county which are not now operated. Among the leading ones is the Snider slope located a mile west of High Bridge on the west side of the Des Moines river. The coal is two feet thick with a hard shale roof. In mining clay seams were encountered which cut the coal veins in various directions. Half a mile west of the Snider was the Miller shaft thirty feet deep. Still farther to the northward was the Chestnut Ford mine formerly operated by J. R. Strange. It was a shaft thirty-two feet deep with coal two and a half feet in thickness. In the same vein also is the West shaft which is forty-three feet deep and working in the same vein as the Tabor mine. Coal has been reported in workable seams at a number of points along Beaver creek, which runs nearly parallel to the Des Moines river five or six miles to the westward.

Raccoon Valley.— At Commerce, just over the line, in Polk county, small drifts have been operated in the hills just east of the town. In one place a shaft has been sunk to the depth of 100 feet where a three foot vein of coal has been worked for a number of years. Between this point and Van Meter no openings are now worked though abandoned drifts and prospecting pits are noticed in various localities. About a mile east of the latter place several thin seams of coal are exposed in the river bluffs at various heights above the water level; but none of them appear to have a thickness of more than six or eight inches at this point. The upper part of the section is shown below:



		FEET.	INCHES.
9.	Drift	10	
8.	Shale, light colored	7	
7.	Limestone, compact, fossiliferous	1	6
6.	Shale, bituminous, fissile, coaly below	1	6
5.	Clay shale, light colored	4	
4.	Sandstone, brown, in two heavy beds separated by clay parting, both containing much carbonaceous matter	4	
3.	Shale, sandy above, argillaceous below	6	
2.	Coal		6
1.	Shales, and clays variegated (exposed)	5	

Figure 69. Bluff near Raccoon River. One Mile East of Van Meter.

In the bluffs around Van Meter small drifts have been started at a number of places, but apparently very little coal in commercial quantities has been taken out. The Chicago and Van Meter Coal Company have a shaft in the western part of town. Two veins of coal are worked. They are about twenty feet apart and each averages three feet in thickness. The upper vein is 285 feet from the surface or about 350 feet below the massive limestone in the top of Van Meter bluff. The coal seams are quite even and regular. The coal is worked partly on the long wall plan, partly on the room and pillar method. The layers and their relations to the coal beds are represented in the following section:

FEET.

5 — 3. Shale, dark, argillaceous, somewhat fissile.

3 — 2. Coal.

2 — 1. Fire clay.

Figure 70. Bed of Van Meter and Chicago Mine. Van Meter.

The company have also an extensive brick plant which is operated in connection with the mining of the coal. Paving, ornamental and fire bricks are manufactured. The clay used in making the brick is obtained partly from the shaft where it is mined in connection with the coal and partly from layers some distance above the coal seam.

Above Van Meter on the main or north branch of the Raccoon the outcrops of coal bearing strata are not well exposed until the vicinity of Adel is reached. Here several thin seams of coal and highly carbonaceous shales are seen in the bluffs along the river. North of town one-half or three-quarters of a mile several openings have been made in the banks of small branches flowing into the river. Four miles above Adel (Tp. 79 N., R. XXVIII W., Sec. 12) two seams of coal have been recognized. They are about thirty feet apart. The upper one is only from twelve to sixteen inches in thickness; while the lower varies from two to three feet. In this vicinity coal has been worked for many years. Among the earlier openings may be mentioned the Chaney mine and Pittman bank. Along a small creek passing through the Chaney farm coal and bituminous shales crop out in the banks for a considerable distance. The Chaney is a drift working coal eighteen inches in thickness. The output is local. Several openings were made but none are at the present time in operation. In the bluff of a ravine there are exposed:

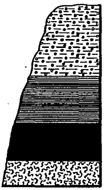
FEET.	INCHES.		
3			4. Drift.
2			3. Shale, bituminous.
1	6		2. Coal.
1			1. Fire clay (exposed).

Figure 71. Section at Chaney Drift. Four Miles North of Adel.

The coal does not appear to thin out in any direction, and is of very good quality. Between this point and Perry, near the north county line, but few good exposures are found along the river.

Just west of the town last mentioned a vein of coal one foot in thickness is exposed on the river a few feet above the water level. Three miles northwest of the station several shafts have been put down. They reach the same vein that is worked in the Angus district, a few miles over the line in Boone county. One of the principal mines, called the Belle, was abandoned only a short time ago.

Five miles west of Perry, at Dawson, several mines have been in operation for a number of years past, the leading one being the Dawson shaft, which is located in the eastern part of the village (Tp. 81 N., R. XXIX W., Sec. 10, NW. qr., SE. ¼). On the Raccoon bluff an outcrop gives:

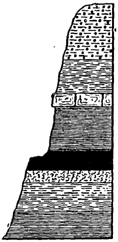


Figure 72. Bluff on Raccoon River. Near Dawson.

There are two shafts one about seventy-five feet deep and the other 160 feet in depth in the sidehill on the top of the bluffs. The Carboniferous strata at this place are covered with drift to the depth of eighty or ninety feet. No less than six different coal seams are exposed at different levels in the two shafts. At mine No. 1, nearest the river, there are three seams; one, one and a half, and four feet in thickness. Part of the coal in the lower seam is taken out through shaft No. 2, some distance away. The two shafts are connected by a drop shaft extending from the vein worked in No. 1 to the bottom of No. 2. The coal is lowered by means of two cages governed by drum and brakes, the loaded cars bringing the empty ones up. In this drop shaft three veins of coal are exhibited below the third or lower vein in shaft No. 1. The lower three are also shown in shaft No. 2. They are one and one-half, two, and three and one-half feet in thickness. Near the bottom of shaft No. 2 a drill hole was put down to a depth of eighty feet without encountering additional coal veins.

A short distance north of Dawson, near the river, is the Tudor mine which is operated by means of a shaft sixty feet deep. The vein worked varies considerably from one and one-half to three and one-half feet and thins out towards the west. The section shown is:

Figure 73. Coal Seam at Tudor Shaft. Dawson.

A short distance down the stream the same vein crops out in a river bank. Farther down, a distance of perhaps 150 yards, is an old drift called the Sarginson mine which at present is not being worked.

South Raccoon Valley.—Between Van Meter and De Soto bituminous shales and thin coaly layers are exposed at a number of points in the bluffs along the railroad. For a large part of the distance between the two places the south side of the stream is bordered by steep-sided hills which often form almost mural escarpments, especially where the hard limestone layers are allowed to project out over the softer underlying shales. Between the two points mentioned and for several miles beyond in each direction, the strata are almost on a perfect level, the inclination in eight miles being only a few feet. Several drifts have been opened, but at present there are none in operation. Opposite De Soto station, on Bulger creek, the following section is shown:

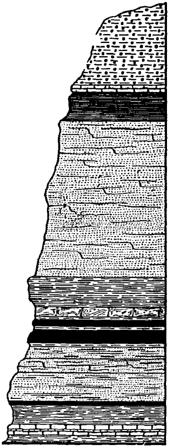


Figure 74. Section on Bulger Creek. De Soto.

		FEET.	INCHES.
14.	Drift	15	
13.	Limestone, gray, fossiliferous	1	
12.	Clay shales, variegated	8	
11.	Sandstone, buff, soft, thinly bedded, and shaly	30	
10.	Shales, blue, clayey	5	
9.	Limestone, compact, fossiliferous	2	
8.	Shales, highly bituminous, coaly below, with several clay partings	4	
7.	Sandstone, with highly ferruginous band above	2	6
6.	Sandstone, compact	3	
5.	Sandstone, shaly and clayey	6	
4.	Coal	1	6
3.	Fire clay	4	
2.	Limestone, fragmentary, fossiliferous	2	
1.	Clays, light colored (exposed)	1	

Farther up the Bulger to the county line no good exposures are to be seen. Occasional diggings or prospecting pits are noticed at various points, but evidently no coal of commercial value has been found.

North of De Soto a couple of miles on the Raccoon river, at Van Meter's mill and at various points between that place and Redfield, thin seams of coal are exposed in the bluffs. Mines have been opened on both sides of the river. Just above the mouth of the South Raccoon and within a mile of Redfield a number of slopes have been made in the sidehill where a three foot vein of coal is exposed. Ten or a dozen feet above the coal is a thick bed of massive sandstone which a few hundred yards up the stream forms a precipitous cliff which rises out of the water and is known as "Hanging Rock." At the south end of this place the section is as follows:

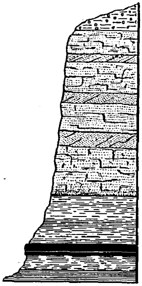


Figure 75. "Hanging Rock" Section. Redfield.

		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	

Redfield has long been known as one of the chief mining localities of the county. The earliest mines in the district were opened in this vicinity. In the valley of the South Raccoon coal has been mined quite extensively and a number of slopes and drifts have been opened from time to time. At the present time most of these mines have been abandoned or are not being worked. One of the principal openings is the Leeper shaft which was operated more than twenty years and was but recently abandoned. It was sixty-five feet deep and worked coal two to four feet in thickness with an average of about three feet. It was located in Tp. 78 N., R. XXIX, W., Sec. 4, NW. qr., NW. $\frac{1}{4}$. At this place the section is:

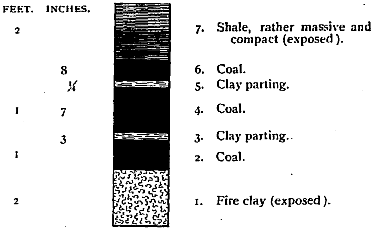


Figure 76. Bed of Old Leeper Mine. Redfield.

Not far from this place is the old Redfield mine a small drift that has been operated for a long time chiefly for local trade during the winter. Near the opening the following strata are shown:

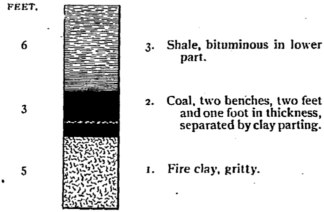
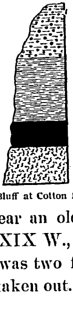


Figure 77. Coal Vein at Redfield Mine. Redfield.

South of the latter a short distance is the location of the Clood and the Peppard mines from both of which considerable coal for local use has been taken out

East of Redfield a couple of miles several local mines have been opened. The principal ones are the Davis (Tp. 78 N., R. XXIX W., Sec. 1, SW. qr., SW. $\frac{1}{4}$), the Caves, the Thompson and the Hartman, all of which work in the same seam. The seam is two feet in thickness with a thin shale parting near the top. Numerous other mines were formerly worked in this vein, but those at present operated are worked chiefly during the winter.

Between Redfield and the west county line there are frequent exposures of Coal Measure deposits and also numerous openings from which coal has been taken out at various times. Coal is exposed at several places on Mosquito creek northwest of Redfield. Among the older mines which were operated here were the Parks and the Piatt mines, the former being 200 yards directly west of the latter. Both mines have only been worked to a small extent. On both sides of a small creek which empties into the Raccoon about one mile and a half above Mosquito several drifts have been opened, among which may be mentioned the Cotton and the Booth mines. The coal is about eighteen inches thick with good roof and appears to form quite an extensive layer. At the former mine the section is:



FEET.	INCHES.	
3		4. Drift.
3	6	3. Clay shale, somewhat indurated.
1	6	2. Coal.
1	10	1. Fire clay.

Figure 78. Bluff at Cotton Drift. Linden.

On the Raccoon, near an old mill site, is the Duck mine (Tp. 79 N., R. XXIX W., Sec. 32, N.E. qr., SE. $\frac{1}{4}$) where the coal worked was two feet in thickness. Considerable coal has been taken out. At the present time the exposure is greatly obscured but the following is the section of the bluff as given by St. John:

		FEET.	INCHES.
21.	Shales, dark, buff	2	
20.	Coal	1	6
19.	Clay, ash color	10	
18.	Limestone, heavily bedded in places, fossiliferous	10	
17.	Shale, argillaceous, variegated	20	
16.	Limestone, compact, bluish gray	1	6
15.	Shale, black, bituminous, fissile, fossiliferous	2	6
14.	Clay, ash color	3	
13.	Sandstone, reddish, heavily bedded with shaly partings	10	
12.	Shale, yellow, arenaceous, with plant remains	30	
11.	Coal	10	
10.	Shale, bluish	7	
9.	Limestone, impure, buff, fragmentary	3	
8.	Shale, blue, marly, fossiliferous	1	
7.	Limestone, impure, yellow, fossiliferous	1	
6.	Shale, variegated	7	
5.	Limestone, fragmentary, buff in color	3	
4.	Shale, variegated, chocolate color	5	
3.	Sandstone, gray, rather compact, somewhat shaly above	5	
2.	Shale, variegated	14	
1.	Shale, bluish, sandy, forming a somewhat compact sandrock in places exposed	9	

Two miles south of Linden, near the west county line, on the south side of the river is the Keeler mine (Tp. 79 N., R. XXIX W., Sec. 31, NE. qr., NW. $\frac{1}{4}$). The coal is eighteen inches thick with two shaly partings. The section of the coal bed is:

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

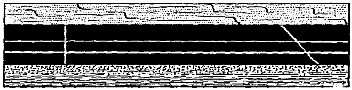


Figure 79. Clay Seams in Keeler Mine Linden.

At this place two clay seams are exposed, one cutting the vein nearly vertically and the other at an angle of about forty-five degrees.

There are other mines in the vicinity of Linden but most of these are situated just over the line in Guthrie county.

POLK COUNTY.

This county has long been one of the most important coal producing districts in the state. The beds worked have an average thickness of about four and a half feet, though the workable seams vary in different places from two to seven feet. The more important mines of the county are located in the immediate vicinity of Des Moines where a large part of the product is used. The consumption of coal, however, at this place is considerably larger than the amount mined would indicate for much is shipped in from neighboring counties. Other groups of openings are situated in the southeastern corner of the county near Runnells. Mines have also been opened along the eastern border of the district near Mitchelville and Altoona; in the southwestern part at Commerce; and in the vicinity of Polk City. A number of country banks are in operation in the extreme northwestern corner in the bluffs of the Des Moines river.

The first extensive mining in the county was begun near Fort Des Moines on the west side of the Des Moines river, where the coal crops out in the river bank about a mile above the Raccoon fork. Here as early as 1850 there was operated an opening known as Hall's coal bank. About the same time small drifts were also worked in the same vein at a number of points along the river. In the immediate vicinity of Hall's the Redhead mines were operated for a long time. Not far away, on the corner of what is now known as Sixth avenue and School street, the Rawson mine was worked for a number of years. Other mines were opened three miles northwest of the Forks in ravines leading down to the river.

On the south side of the Raccoon the existence of coal has been known ever since the time when Des Moines was a military post. A number of openings were made years ago. The best known of the earlier mines is the Van pit. The Sypher and Redhead shafts were also in the same neighborhood. These two pits developed into the Polk County and the Pioneer mines, which after being operated for more than twenty years were finally abandoned. At the present time the mining industry around Des Moines is carried on chiefly on the South side.

On the east side of the Des Moines river, coal mining was begun soon after the Hall bank was opened. At the south end of Capitol hill were a number of small drifts at the base of the bluff. They were known as the Reese mines. The coal vein is still to be seen in the cutting of the railroad a few feet above the track level. A shaft about forty feet deep and known as the Watson mine was subsequently put down in the same vicinity. For many years this mine supplied the railroads of the district with fuel. Another of these earlier mines was the Dahl, located a mile and a half north of the Watson shaft on the bank of the Des Moines river at Thompson's bend. East of the Capitol building a short distance is the location of another of the older mines, the Giant No. 1, recently abandoned. It was the most southerly of a number of shafts put down in this neighborhood. The section of rocks passed through is shown in the accompanying figure. (See figure 91.) The arrangement of the coal seams is typical of the East side mining district. Until lately mining operations were carried on more extensively in this vicinity than anywhere else in the county. No less than a dozen large shafts have been opened from time to time.

It is commonly regarded by those living outside of the state that the coal deposits of Polk county are arranged in three separate beds which come so close together at Des Moines that they are readily mined as a single seam, no one of the three being thick enough for profitable working alone. This opinion has been widely quoted and has given the impression that the tripartite seam is the only one worked in the vicinity of Des Moines. In reality the vein is one of small importance, poor quality and seldom mined. All the coal now obtained at Des Moines comes from horizons from 60 to 130 feet below that of the seam in question. In the earlier days of the settlement of the region this "first" or "upper" vein was worked to some extent as it was easily accessible in the sides of the bluffs along the Des Moines river. The best exposures of the coal seam mentioned are now on the west side of the Des Moines river a hundred yards or more north of the mill dam at the foot of Center street. The section recently disclosed by road cuttings along the bluff is shown in the accompanying figure (figure 80). It may be described as follows:

		FEET.	INCHES.
12.	Drift	6	
11.	Sandstone, soft, micaceous, buff in color, massive in places	10	
10.	Clay shales, light colored	5	
9.	Coal	2	6
8.	Sand, loose		6
7.	Coal	1	6
6.	Sandstone, massive, fine grained	2	
5.	Coal	1	
4.	Clay shale, yellow and blue in color	10	

		FEET.	INCHES.
3.	Clay shale, dark drab in color	4	
2.	Shale, somewhat sandy	5	
1.	Shale, black, bituminous (exposed)	8	

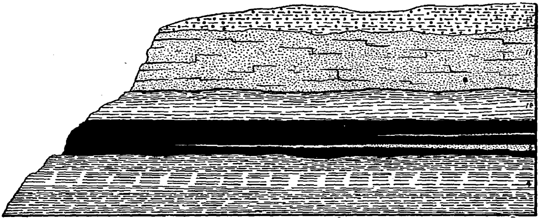


Figure 80. Bluff on Des Moines River above Milldam, at City of Des Moines. Shows Coal Seam separated by Sand Bands.

The arenaceous layers, numbers 6 and 8, thin out completely toward the south as shown in a ravine immediately north of the mill dam. Both beds, however, rapidly thicken in the opposite direction and in a distance of 150 yards the lower one of these has attained a thickness of more than three feet. Both seams of sandy material appear to be lenticular sheets intercalated in the coal vein which has a maximum thickness of over five feet.

In the immediate vicinity of Des Moines the strata exposed above the level of the river and open to view in mine shafts may be indicated in the following section:

		FEET.	INCHES.
26.	Variegated clay shales	13	
25.	Blue limestone, nodular, impure, weathering brown, fossiliferous		8
24.	Variegated shales	8	
23.	Bituminous shale, with concretionary calcareous masses below, fossil bearing	3	
22.	Coal	2	
21.	Light yellow and drab shales	7	

		FEET.	INCHES.
20.	Variegated clay shale	4	
19.	Nodular limestone, earthy, passing in places into marl, highly fossiliferous		6
18.	Light colored and variegated clay shales	5	
17.	Limestone, impure, like No. 19, but not so fossiliferous		10
16.	Light colored clay shale	5	
15.	Sandstone, soft, micaceous, concretionary in places, and passing into sandy shale elsewhere	25	
14.	Light colored shale	4	
13.	Impure coal	2	
12.	Light and dark colored clay shales	20	
11.	Bituminous shale, highly fossiliferous		8
10.	Coal	2	
9.	Fire clay	1	
8.	Variegated and sandy shales	15	
7.	Sandstone, massive	6	
6.	Coal	4	
5.	Fire clay	2	
4.	Variegated shales, sandy in places	30	
3.	Bituminous shale	5	
2.	Coal	5	
1.	Fire clay	6	

Numbers one to twelve are usually passed through in sinking shafts in south Des Moines. All numbers above ten are exposed above low water level in the Des Moines river. Numbers sixteen to eighteen are well shown in the river bed and in the adjoining bluffs on the south side of the railroad bridge on the Des Moines and Winterset branch of the C., R. I. & P. railroad (Tp. 78 N., R. 24 W., Sec. 11, SE. qr., SW. ¼). Numbers thirteen to twenty are to be seen at several places in the south end of Capitol hill. Numbers thirteen to twenty-six have recently been well disclosed in the road cuts of Prospect Park in north Des Moines.

In Polk county it is customary to recognize three seams of coal. They are commonly called "first," "second" and "third" veins. These are the workable seams. Associated with them are others which in most cases thicken sufficiently in other places to be profitably mined. On the South side number ten of the general Des Moines section just given is the coal which is usually called the "first" vein, number six the "second" and number two the "third." On the east side number thirteen is probably the "first" vein. In neighboring localities the "first," "second" and "third" veins have still different stratigraphical positions as compared with those just given. It will be readily seen therefore that the naming of the different seams is in reality quite local in its application applying only to the shafts or borings which have been put down at particular places and that the same term does not necessarily refer to the same horizon. Besides the three veins usually encountered in boring it is not infrequent to meet with half a dozen or more minor veins.

In no case at present known is coal worked at a greater depth than 100 feet below the river level. The Coal Measures at this place are probably not less than three to four hundred feet in thickness and there appears to be but little doubt that prospecting to the depth mentioned would reveal the presence of coal in quantities even greater than the known supplies at present mined.

The same remarks also apply to other portions of the county especially in the southeast where mining is almost wholly confined to the bluffs above the river level.

The special development of the coal industry in the vicinity of Des Moines is probably due, in a great measure, to the excellent railroad facilities and the large local market afforded for the product. The coal is, probably, equally well developed in nearly, if not all, portions of the county.

The shipping facilities of Polk county are, perhaps, nowhere else in the state equaled. Seventeen lines of railway enter the district enabling the coal product to be loaded at the mines directly on the cars and shipped to all parts of the state, especially to the northwest. The local consumption is also much greater than anywhere else in the state and will continue to increase.

The consideration of the outcrops of coal and the various phenomena disclosed by the mines and borings may best be taken up by districts, the various drainage basins forming the most natural limits for the several areas.

Raccoon Valley.—There are a number of exposures of coal in the bluffs of the river but the mining of coal is now carried on entirely in horizons below water level. The general arrangement of the strata above the river are shown in the section on plate xiv.

On the north side of the river there are a number of natural exposures showing coal seams to good advantage. At Commerce near the west county line small openings have been made in various places in a thin seam in the hills, but so far as known no mining has yet been carried on in these places. The coal now mined in this vicinity is chiefly at the Hulme mine which is about half a mile east of the town. The shaft is 100 feet deep; the vein from two to three feet in thickness. The dip is slightly to the northwest, somewhat undulatory. The seam is occasionally interrupted by "squeezes," sometimes from below, sometimes from above, but in no case are they of a serious nature. With the establishment of the rapidly growing town of Valley Junction, a couple of miles to the eastward, the development of the coal seams of this region will soon assume much greater importance than it has heretofore.

East of Commerce for several miles there are no outcrops; though along Walnut creek there are a few exposures. Coal has been prospected for at different places but to no very great depth. On the Valley Junction road (Tp. 78 N., R. XXV W., Sec. 11) there is a vein of coal about two feet in thickness exposed half way up the hill. It is somewhat shaly above, and probably thickens northward.

A mile to the southeast, at the mouth of the Walnut, was formerly located the Walnut Creek mine. It was just four miles west of Des Moines, on the C., R. I. & P. railroad. The shaft was about 140 feet deep; the vein from two to four feet in thickness, too thin for profitable working with the extensive top works which were erected. It thinned out rapidly northward but thickened southward. The room and pillar plan was adopted for the south side of the mine where the coal was thickest; but on the north side the long wall system was in use.

A mile east of the latter place the shaft of the Two Rivers Coal Company was formerly located. From this mine considerable coal was taken out for the city trade and for shipment over the C., R. I. & P. railroad. The ground is now occupied by the Des Moines Brick Works.

Still farther to the eastward at the south end of Terrace Hill a small coal pocket is shown in a railroad cutting (figure 81). The section is as follows:

	FEET.	INCHES.
9. Shale, light colored, (exposed)	2	6
8. Limestone, impure, nodular, weathering brown and containing fossils		8
7. Shale, argillaceous, white and drab	5	
6. Limestone, nodular, like No. 8, but containing fewer fossils		8
5. Shale, dark drab below, light colored above.	4	
4. Shale, bituminous, fissile, with coaly streaks.	2	6
3. Coal	3	
2. Shale, light colored, somewhat sandy	6	
1. Sandstone, somewhat shaly, concretionary in places, exposed above track level	6	

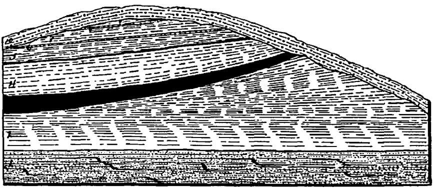


Figure 81. Terrace Hill Section. Des Moines.

On the south side of the river below Commerce there are few exposures, until within about four miles of Des Moines. The first opening met with is a small drift a few hundred yards west of the Rose Hill shaft. Apparently not much coal has yet been taken out. A short distance east of the drift is a recent railroad cutting. At this place (Tp. 78 N., R. XXIV W., Sec. 18, NE. qr., SW. ¼) the following section is exposed:

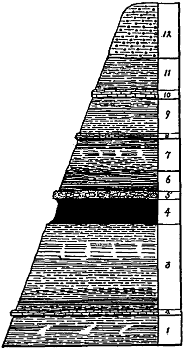


Figure 82. Railroad Cutting near Rose Hill Mine. Four Miles West of Des Moines.

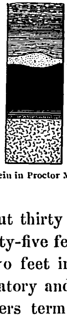
		FEET.
12.	Drift	10
11.	Clay shales, red and drab, variegated	6
10.	Limestone, earthy, nodular	½
9.	Shales, variegated	5
8.	Limestone, impure, nodular	½
7.	Clay, yellow and drab, variegated	4
6.	Clay shale, dark drab, somewhat bituminous	2
5.	Ironstone, black, nodular	1
4.	Coal, impure	3
3.	Clay shale, hard, drab, somewhat sandy in places	15
2.	Limestone, nodular	1
1.	Clay shale, blue (exposed to track level)	6

Rose Hill mine is situated on the Des Moines and Kansas City railroad. It is at the foot of the bluff and ninety feet deep. The vein is from two to four feet in thickness.

For a couple of miles east of Rose Hill coal has been prospected for along the bluff. The first place of importance is the Coon Valley mine which is located on the South side about half a mile west of the Seventh street bridge over the Raccoon river. It is on the Des Moines and Kansas City narrow gauge railroad; formerly also loading coal on the C. G. W. tracks. The shaft is 120 feet deep and is situated on the river bottom near the foot of the bluffs. The coal is four to seven feet thick. The seam is somewhat undulatory and is the "third" vein. Thirty-five to forty feet above is the second vein about four feet in thickness. Fifty feet farther up is still another seam from three to four feet thick.

A short distance to the eastward is the location of the old Pioneer mine on the south bank of the Raccoon river at the end of Seventh street bridge. The Pioneer mine was recently abandoned, after having been worked for twenty years, being one of the oldest coal pits in the county and for a long time the largest operated. It was first opened as a drift in a seam just above the water level. After working some time a shaft 150 feet deep was sunk at the same place into the "third" vein, the "second" seam at this point being too thin to be operated. The coal was from four to seven feet in thickness, somewhat undulatory or rolling. Some of the entries were driven southward more than a mile from the bottom of the shaft. The mine was operated by the room and pillar method, but the coal being rather soft many of the pillars were crushed under the great superincumbent weight and from time to time allowed the roof to settle down to the floor. Considerable coal was taken out on the north side of the shaft under the river but the coal in this direction soon became too thin for profitable working.

Just west of the shaft last mentioned a deep ravine opens out to the southward. In its sides a number of openings for coal have been made at various points, but at present most of these diggings have been abandoned. A mile to the southward of the old Pioneer shaft is the Proctor mine. The shaft is 197 feet deep. Four seams are shown in the section, only the lower two, however, being operated at present. The coal of the lower vein, the "third," is from three to five feet in thickness. The details of arrangement of the various layers are:



FEET.	INCHES.	
6		6. Shale, highly bituminous, fissile.
1		5. Ironstone, irregular, nodular and often shaly in places.
5		4. Coal.
	6	3. Coal, impure, slaty, "black-jack."
	2	2. Pyrite band.
5		1. Fire clay.

Figure 83. Coal Vein in Proctor Mine. Des Moines.

The next vein is about thirty feet above and is three to four feet thick. Thirty-five feet higher is still another seam which is about two feet in thickness. The lower vein is somewhat undulatory and presents good illustrations of what the miners term "troubles" or "horse-backs." A section of one of these is shown in the accompanying figure (84). The coal rises in a low fold to a height of fifteen or twenty feet above the rest of the seam on either side. The greatest inclination of the seam is from fifteen to twenty degrees. Near the top of the fold on one side the seam which is five feet in thickness is suddenly reduced to one-half that measurement through

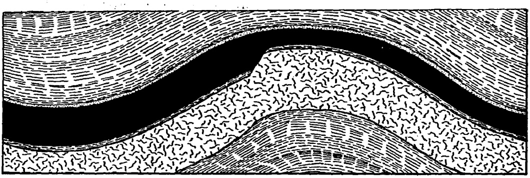


Figure 84. "Horseback" in Proctor Mine. Des Moines.

an abrupt rise in the floor forming a small fault. Over the top of the fold the coal continues to be quite thin but on the opposite side becomes slightly thicker.

Half a mile east of the Proctor and directly south of the Pioneer is located the Bloomfield mine (Tp. 78 N., R. XXIV W., Sec. 16, SW. qr., NE. ¼). When first opened it was a small shaft known as the Carlston and Lund mine. The "first" vein only was worked. The coal seam was so badly cut up by old preglacial channels that the opening was finally abandoned. When the Bloomfield company took up work the shaft was sunk to the "third" vein, which has a thickness of from four to six feet. The section of layers above and below the coal is:

		FEET.
4.	Shale, black, highly carbonaceous (exposed)	10
3.	Coal	5
2.	Fire clay	6
1.	Shale, light colored (exposed)	4

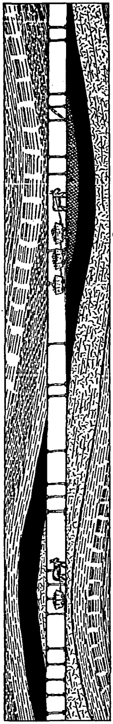


Figure 85. Section Showing Undulatory Character of the Coal Seam in Bloomfield Mine. Des Moines.

The coal is mined on the room and pillar plan. The seam is quite undulatory in character the difference in level being often as much as twenty to twenty-five feet in fifty or seventy-five yards. As the grade in the entries has to be kept as low as possible in order that the loaded cars may be drawn easily considerable expense is incurred in "leveling up" the passage ways, "shooting" down the roof in some places and filling up below or cutting out the floor. The entrances into the old rooms along an entry are thus scattered at various distances above or below the present track grade. In some cases the entries have a height of ten to fifteen feet. The undulatory nature of the coal bed enables the layers both above and below to be examined often for a dozen or more feet.

A number of small faults occur in the mine but the throw is seldom more than three or four feet. The hade varies from 30° to 60°. None of these, however, are great enough to seriously interfere with the working of the vein.

Associated with the coal bed are numerous lenticular masses of ironstone. They vary in size from a few inches to ten or twelve feet horizontally, and up to six feet vertically. The smaller ones are commonly called

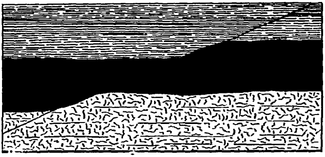


Figure 86. Fault in Bloomfield Mine. Des Moines.

"nigger heads." These segregations occur in all parts of the coal seams, but they are most abundant in the roof

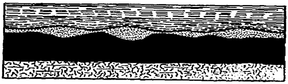


Figure 87. Ironstone Band and Roof of Coal Seam, Bloomfield Mine. Des Moines.

and upper surface of the coal, where they are often so close together as to form an almost continuous layer. It

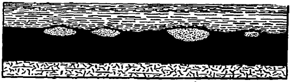


Figure 88. Ironstone Nodules in Roof of Coal Bed. Bloomfield Mine. Des Moines.

is common for the nodules in the upper part of the coal to project upwards above the top of the seam, often two to

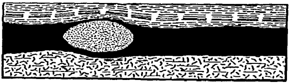


Figure 89. Ironstone Mass, in Coal Bed of Bloomfield Mine. Des Moines.

three feet in case of the large masses. They are covered usually by a few inches of carbonaceous material. Both above and below each nodule the coal is strongly laminated, indicating that the bed of coal had diminished considerably in bulk since its original burial by the overlying sediments. These various phases are illustrated by the accompanying diagrams. (Figures 87 to 89.)

The Eureka mine is situated about a mile east of the Bloomfield on a switch of the C., R. I. & P. railroad. The shaft is at the foot of the bluff and is about 160 feet deep. The thickness of the coal is from four to six feet. The coal is mined on the room and pillar plan.

The Des Moines mine in Sevastapol is half a mile east of the Eureka. It is a shaft 105 feet in depth, with coal four to six feet in thickness. Just south of the last is the Union mine, a shaft 150 feet deep. Two veins have been worked. The coal from the "second" being long since removed the "third" seam was reached by sinking the shaft deeper. The coal has an average thickness of four feet, and is now worked entirely upon the room and pillar plan.

The old Polk County mine recently worked out was situated on the South side about one mile east of the Pioneer. When first opened it was known as the "Sypher" mine. The shaft was 120 feet deep and located on the bluff about half a mile from the river. This mine was in operation for more than twenty years. In common with several other mines in the vicinity the output was loaded directly on the cars which ran over a switch from the Des Moines and Winterset branch of the C., R. I. & P. railroad. For a long time the coal was taken out from the "second" vein until finally, the territory owned by the company having been worked out, the shaft was extended downward to the "third" seam. The "second" vein was said to have a thick sandstone roof. In places the coal was cut through by some ancient water course, the channels of which were filled with logs and other driftlike material as shown in figure 21 (page 184). These cuttings appear to be preglacial and the deposits filling them glacial débris. The lower seam called the "third" is the same as in all seven of the mines just mentioned, and with the exception of the Proctor they are all connected underground.

The Pleasant Hill mine was a small shaft in the bluff, a short distance south of the Union. The shaft was eighteen feet in depth, with four feet of coal.

Just east of the Union is the Van Ginkle mine. The shaft is about seventy-five feet deep. The coal is the "second" vein and has an average thickness of four feet, the maximum measurement often being over five feet. The room and pillar plan is in use. The roof is a heavy sandstone having a thickness in places of upwards of fifteen feet. Many of the rooms are fully 200 feet long and twenty-five to thirty-five feet wide without timber supports.

A fault of considerable throw is said to trend southeast between the Des Moines and the Van Ginkle. The entry in the former mine where the slip occurs was not open at the time of writing and the extent of the throw could not be determined.

The Co-operative mine is situated on the top of the bluff a short distance south of the Van Ginkle mine. The shaft is 125 feet in depth. The Pittsburg mine was also in the same vicinity. It was a small shaft which was abandoned some seven or eight years ago. Half a mile east of the Polk County pit the Eclipse mine was located at the base of the very steep bluff and a short distance west of the present bridge of the Des Moines and Winterset branch of the C., R. I. & P. railroad. It was worked by the room and pillar method and was at one time one of the most extensive mines in the district.

Des Moines Valley above the Raccoon Fork.—In the extreme northwestern corner of the county numerous small drifts have been made for several miles along the river. There appear to be at least two seams of coal above the water level in this part of the county and there are probably other veins lower down. The principal mine now operated in this vicinity is the Strong shaft, just over the line in Dallas county. It is forty-five feet deep and works a vein of coal two to two and a half feet in thickness. The bluff just beyond the west county line shows:

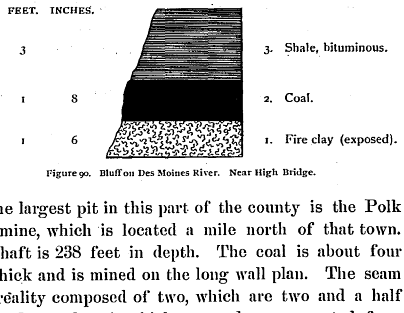


Figure 90. Bluff on Des Moines River. Near High Bridge.

The largest pit in this part of the county is the Polk City mine, which is located a mile north of that town. The shaft is 238 feet in depth. The coal is about four feet thick and is mined on the long wall plan. The seam is in reality composed of two, which are two and a half feet and one foot in thickness and are separated from each other by an eight-inch layer of black shale, which has to be taken out in working the coal. The roof is bituminous shale and is very good. The vein is slightly undulatory. The coal is used largely for local use and could be shipped over the C. & N. W. railroad.

Between Polk City and Des Moines there are no mines of any consequence until the immediate vicinity of the capital is reached, though small country openings and drifts have been operated in the bluffs at numerous places. Prospecting has been done in the valley of Beaver creek. Four miles north of Des Moines on the west side of the river, and about a mile below the mouth of Beaver creek there has recently been sunk a new shaft—the West Riverside. This mine is located at the foot of the bluff. It is 145 feet deep and operates a vein of coal six feet in thickness. Six feet above the coal worked is a thinner vein about two feet in thickness which will probably be operated after the coal below is worked out. A short distance directly south, on the farm of Judge Nourse, another shaft has been put down lately. This is the Keystone mine. It is situated on the top of the bluff and is 142 feet in depth. The coal averages five and a half feet in thickness and has a good roof of bituminous shale twelve feet thick. A mile nearer the city are several old openings in the ravines leading down to the river. Some years ago a shaft and several drifts were operated here. At the shaft which was in the creek just south of the Close place, a seam of coal of rather inferior quality is exposed in the hillside. It is about two feet thick.

Directly across the river on the east side and directly west of Highland Park is the plant of the Flint Brick Works. A shaft has been put down by the company to the depth of 122 feet. The mouth of the shaft is only a few feet above the water level of the river. The coal is five feet in thickness. Above the seam now worked are three other veins which though somewhat thinner will probably be developed after the lower vein is worked out. A quarter of a mile directly west of the Flint shaft is the Oak Park mine which is 130 feet deep with coal three and a half feet in thickness. There are three veins above the one worked, as in the mine last mentioned, the uppermost of which is four feet in thickness and is about on a level with the low water mark in the Des Moines river. This seam has been reached by means of a slope at a number of places in the vicinity, but as yet comparatively little coal has been removed.

In the top of the hills east of the brick plant a three-foot seam of coal is often struck in sinking wells. The vein lies at a depth of forty feet below the surface. Between this point and the dam two miles below coal is exposed at a number of places along the river bluff and as already said was mined years ago.

In east Des Moines considerable coal occurs east and northeast of the Capitol building. At the south end of Capitol hill the old Watson shaft forty feet in depth was operated some years ago. Immediately east of the Capitol is located the abandoned shaft of the Giant No. 1. From the section it will be seen that there are three veins of workable coal. The "first" is usually, however, rather poor in quality and seldom worked to any great extent. At this place the "second" seam was mined for a long time but finally this was abandoned and the shaft sunk forty feet deeper to a third and thicker vein. The section of strata passed through in sinking the shaft is as follows:

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.
		6. Shale, bituminous.
5	6	5. Coal.
4	6	4. Fire clay.
4		
30		3. Shale, light colored above, bituminous below.
6		2. Coal.
1		1. Fire clay.

Figure 91. Shaft of Giant No. 1. East Des Moines.

In running eastward a short distance from the shaft there is encountered a weak thin roof which is immediately overlaid by gravels and sands through which appears to flow an underground current of water of considerable extent. A number of mines in the neighborhood have been flooded and abandoned on account of the falling of the roof; but the operators of this pit removed only half the thickness of the coal leaving the other half to protect the shaly covering.

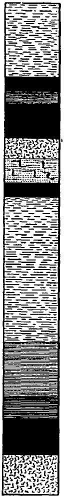
Half a mile northwest of the latter mine was located the shaft of the Giant No. 2, which was also operated for many years and produced a large amount of coal. A short distance directly north of the Giant No. 2, is the Garver, a shaft 118 feet deep. Both the upper seam and the "third" vein are worked. As in the Giant No. 1, the heavy water vein is immediately over the coal so that great care is taken to prevent the roof from becoming defective. The coal varies from four to seven feet in thickness. The mine has very recently been abandoned but the operators expect to soon put down another shaft a short distance away which will still enable them to finish working out the old mine and at the same time give them a large amount of new territory.

The Atlas shaft was located a quarter of a mile directly east of the Garver. It is 100 feet in depth. Two veins were worked. There is a considerable dip to the seams in places making the haulage from the entries somewhat difficult. Directly north of the Garver mine were situated the shafts of five other mines, the Watson, Miller, Extra, Standard No. 1, and Diamond. They were all operating veins with a slight dip to the eastward and with a gradual increase in thickness in the same direction. These mines had worked only a short distance from the bottom of the shaft when water bearing sands and gravels which overlie the coal were encountered. Owing to carelessness the roof gave way, the pits were flooded and finally abandoned. The mines just mentioned shipped the greater part of their product over the Northwestern railroad which ran long switches down from its Des Moines and Ames branch.

Another mine which deserves mention in the present connection is within three miles north of the Garver on the C. & N. W. railroad, a mile south of Saylorville station. It is the new Des Moines mine recently opened and is now operated quite extensively. A mile and a half northeast of the Garver are two other mines, the Maple Grove shaft on the C. G. W. railroad, 105 feet in depth with coal three to four feet in thickness, and the new Union shaft which is taking out considerable coal.

Des Moines Valley below the Fork.—On the south side of the river at Sevastapol there is a group of mines, of which the Eclipse is the largest. A number of prospecting holes have been put down for coal with more or less success. Several seams are also exposed in the river bluffs. Directly north of Avon a number of country banks have been operated for many years past. Lately coal has been mined at the Coal Hill shaft, known also formerly as the Coon Valley No. 2, and the Manbeck. It is located on the Des Moines and Winterset branch of the C., R. I. & P. railroad. It is near an old channel of the Des Moines river, and was formerly operated by a shaft but at present a slope has been opened through which the coal is now brought to the surface. There are two veins being worked besides which a number of thin seams are known. The distance between the two workable seams varies from twenty to thirty feet. The greatest thickness of the lower seam is about five and one-half feet, the average thickness nearly three. While somewhat undulatory the vein nevertheless has a slight southerly dip, approximately three to four feet in a hundred. The floor of the lower seam worked is a fire clay said to have a thickness of twenty feet. The roof is a hard clay shale containing much clay ironstone in the form of nodules, lenticular masses and sheets. Small irregular clay seams and faults cut the veins in many places.

The following is a detailed section showing the relations of the various coal seams at the Coal Hill mine:



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.
3		1.	Fire clay.

Figure 92. Part of Shaft of Coal Hill Mine. North of Avon.

A short distance farther to the southeastward the railroad has cut into the sidehill exposing an almost continuous section for a quarter of a mile or more. Two coal seams are shown and ledges of brown sandstone are conspicuous. The vertical section is shown in figure 93.

Directly east of Des Moines near Four Mile the first mine met with is the Gibson mine which is located on the main line of the C., R. I. & P. railroad. It is a shaft 105 feet deep with coal four and one-half to five feet in thickness and quite regular. A half a mile or more east of the Gibson on the same railroad is the Christy mine in

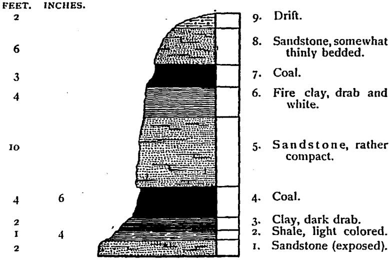


Figure 93. Railroad Cutting. One mile north of Avon.

the valley of little Four Mile creek. It is a shaft 115 feet deep with coal three to five feet in thickness.

A mile to the southeast of the latter is the Carbondale shaft, which is 108 feet deep with coal four feet in thickness. The roof is very hard and compact. The product is shipped over a long switch of the C., R. I. & P. railroad. Northeast of the Carbondale at a number of places near Rising Sun country banks have been operated for many years.

The Wabash mine is situated at Hastie, five miles southeast of Des Moines, on the Wabash railroad. The shaft is 100 feet in depth; thickness of coal four feet. Two other shaft mines, one 100 feet to the west and the other a short distance to the east, were operated until quite recently in the vicinity. A shaft was also formerly worked in the hill near by.

A mile east of the latter is a new mine of the Iowa Coal Company which has recently been opened in the valley of a small creek. The shaft is sixty-five feet deep; the coal three to three and one-half feet in thickness. A railroad cutting at this place, which is about on a level with the mouth of the shaft, shows the following section:

		FEET.	INCHES.
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		6
3.	Shale, yellow and white	4	
2.	Coal, impure		8
1.	Shale, dark drab (exposed)	6	

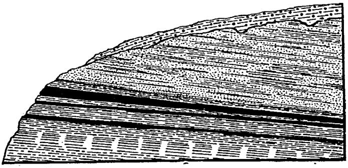


Figure 94. Railroad Cutting. One Mile East of Hastie.

Between the last point mentioned and Runnells very little mining has been done although coal is well exposed in a number of places in the bed and bluffs along the river. Country banks have been operated at various places.

About half a mile west of Runnells in the bluffs of Mud creek a short distance from the Wabash railroad is situated the Logan mine. It is a shaft forty feet deep; the coal averages four feet in thickness. At the north side of the town is the Runnells mine. The shaft is forty-five feet deep with coal four feet in thickness. Near by is the Stoughtenberg drift. The coal is about four feet in thickness and is shipped over the Wabash railroad. Five hundred yards east of Runnells postoffice is the Camp mine a small slope also shipping its output over the Wabash.

The Acme mine, formerly called the Runnells slope, is located about half a mile east of the town of Runnells, sixteen miles southeast of Des Moines on the Wabash railroad. It is a slope in the river bluff. The seam is four feet thick, and slightly undulatory. The roof is black shale and as a rule very good. The section of the coal bed is:

		FEET.
3.	Shale, bituminous, fossiliferous	6
2.	Coal	4
1.	Fire clay (exposed)	3

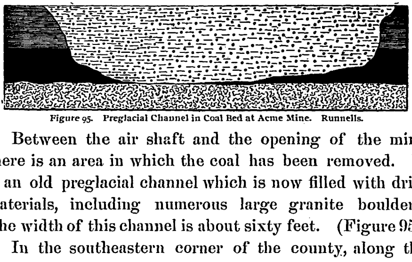


Figure 95. Preglacial Channel in Coal Bed at Acme Mine. Runnells.

Between the air shaft and the opening of the mine there is an area in which the coal has been removed. It is an old preglacial channel which is now filled with drift materials, including numerous large granite boulders. The width of this channel is about sixty feet. (Figure 95.)

In the southeastern corner of the county, along the line of the Wabash railroad, there are numerous exposures for several miles from the east county line. About a mile east of Runnells station one of the railroad cuttings shows:

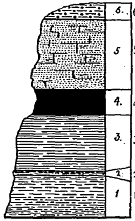


Figure 96. Railroad Cutting near east County Line, below Runnells.

The Altoona mine was located on the C., R. I. & P. railroad, just west of Altoona station, eleven miles east of Des Moines. The shaft is 215 feet deep. There are two seams of coal which are about fifteen feet apart. The upper one is about eighteen inches and the lower four feet thick. The first of these is overlain by fifteen feet of massive sandstone, which forms an excellent roof. The coal was of very good quality and much harder than the average mined in the county. The strata passed through in the sinking of the shaft are shown in the following figure:

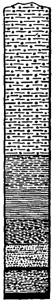


Figure 97. Shaft of Mine, at Altoona.

The vein was slightly undulatory, but had a general dip to the southward. Both east and west of the shaft the coal became thinner, but to the south the coal thickened. The shale forming the roof was twelve feet in thickness, but cracked readily as soon as the coal was removed thus requiring close propping. It was finally allowed to fall in places and the water came in, rising in the shaft to a height of 150 feet.

JASPER COUNTY.

With the exception, perhaps, of several small areas in the northeastern part, Jasper county is entirely underlain by Coal Measure strata. The county lies on the eastern edge of the Iowa coal field, the Lower Carboniferous rocks being exposed at various places near the surface immediately to the east and north. The Saint Louis limestone, the upper member of the Lower Carboniferous, crops out in the beds of the Skunk and the Des Moines rivers in Mahaska and Marion counties, within five miles of the Jasper county line. In a number of places in the central part of the county at depths of 125 to 150 feet limestone has been reported to have been encountered in drill holes in prospecting for coal. The Coal Measures in the eastern part of Jasper are comparatively thin and probably nowhere over 150 feet in thickness. Along the extreme western border of the county in the vicinity of Mitchellville this formation may be fifty or seventy-five feet greater in thickness. The northern and eastern portions of the county are deeply covered by drift deposits which greatly obscure the general character of the stratified rocks. In the Coal Measures of Jasper sandstone beds are exposed at many places, and in the southern part of the county appear to be continuous with the great Redrock sandstone so well exposed on the Des Moines river six miles south of Monroe.

Until recently Jasper county has not produced much coal and the product mined has been only for local use. Within the past few years, however, extensive operations have been carried on near Newton and Colfax which are now the most important mining points in the county.

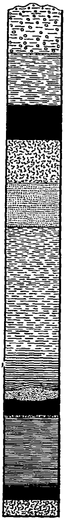
Jasper county now enjoys good railroad facilities, two lines and branches of the Chicago, Rock Island & Pacific pass almost entirely across the county, besides branches of the Iowa Central and the main line of the Chicago Great Western. From these railroads short branches have been built to some of the leading mining districts and considerable coal is now shipped.

In the extreme eastern part of the county along the North Skunk river a couple of miles above Lynnville a number of mines have been operated for some years. The largest mine in this vicinity is called the Black Oak shaft. There are three veins of coal at this place the upper being from two to four feet, the second twenty-two inches and the third sixteen inches thick. The mine is located in Tp. 79 N., R. XVII W., Sec. 34, SE. qr., NE. $\frac{1}{4}$. The section of the shaft is shown in figure 98.

Other mines in this vicinity are the Meredith, Spark, and Martin openings, besides several smaller ones.

The mining at Newton is done chiefly three miles southwest of the town on a branch of the C., R. I. & P. railroad. There are two veins of coal, the upper one about one foot in thickness and the lower from four to six feet.

The Conn and Murdock Coal Company (Tp. 79 N., R, XIX, W., Sec. 8, NE. qr., NW. $\frac{1}{4}$) has a mine which is a shaft thirty-eight feet deep, worked on the room and pillar plan. The vein dips slightly to the southeast. The Snooks Mine (Tp. 79 N., R. XIX W., Sec. 16, SE. qr., SW. $\frac{1}{4}$) is a shaft sixty feet deep with a vein of coal four to six



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 98. Shaft of Black Oak Mine, Lynnville.

feet in thickness. The roof is rather poor in places often rendering it necessary to leave a thin layer of coal to protect it from exposure to the air. The coal bed is quite undulatory but has a slight general dip to the southwestward.

The Lister mine is near the Conn and Murdock shaft (Tp. 79 N., R. XIX W., Sec. 8, NW. qr., NW. $\frac{1}{4}$). It is a country bank, though shipping some coal. The vein dips to the southwestward.

The Carson mine is a slope immediately northwest of Coal Siding (Tp. 79 N., R. XIX W., Sec. 9, SW. qr., NW. $\frac{1}{4}$). The shaft is forty feet deep and passes through three veins of coal, the lower varying from three to five feet in thickness. There is no noticable dip.

The Welch mine is situated 200 yards directly north of the Carson mine. The coal worked is the same vein as that mentioned as occurring in the other mine and is from four to four and a half feet in thickness. The Riley mine is located a short distance south of Coal Siding. The coal is three and a half feet thick with good shale roof; ten feet above this vein is another layer of coal, too thin for profitable working.

Just east of the Welch mine is another small bank operated by Thomas Snooks. The greatest thickness of the coal at this place is twenty-eight inches. Davidson No. 1 is a half a mile southeast of Coal Siding (Tp. 79 N., R. XIX W., Sec. 16, NE. qr., SE. $\frac{1}{4}$). It has been worked for twenty years, usually, however, only in the winter. Twelve or fifteen men are commonly employed. The shaft is about forty feet deep, the coal seam mined being from four and a half to five feet in thickness. The vein is somewhat undulatory with quite a number of small slips and faults. In the main east entry an interesting series of faults were encountered. In traversing a distance of 300 yards six parallel faults running from north to south were crossed. The coal in each case drops on the east a distance varying all the way from six inches to three and one-half feet. The lines of slip have an angle of about forty-five degrees. The total displacement was probably in the neighborhood of ten feet.

The Davidson No. 2 is a half a mile north of No. 1. The strata passed through in sinking the shaft are practically the same as in No. 1, except that two veins of coal appear about eighteen feet below the first. The first vein is only ten inches thick and appears to be the same as that mined in No. 1. The lower vein varies from a few inches to four and a half feet in thickness. The section is:

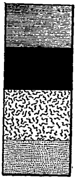


Figure 99. Bed at Davidson Shaft. Newton.

The Conn mine (Tp. 79 N., R. XIX W., Sec. 3, SE. qr., NW. $\frac{1}{4}$) is located a mile and a half directly south of Newton. The coal worked is four feet in thickness. There is also a thin vein nine feet above.

Near the southern border of the county, three or four miles east of Monroe, is a mining camp called Draper. At this place considerable coal has been mined, near the center of section 26 (Tp. 78 N., R. XIX W.), in the Barnes and Mitchell slopes. Half a mile directly west (Sec. 27, NE. qr., SE. $\frac{1}{4}$) is the Danks mine. There are two veins of coal in this neighborhood, the lower one being worked almost altogether. It is three to five feet in thickness and has a slight dip to the southwest. A mile and a half to the southwest and about two miles and a half directly east of Monroe is another group of mines. The Edward slope (Tp. 78 N., R. XIX W., Sec. 33, NE. qr., NE. $\frac{1}{4}$) is, perhaps, the most important. There are two seams of coal about ten feet apart. A short distance south of this mine is the Shaw slope. The Jasper Coal and Railway Company have several mines in this vicinity, two of which are shafts about thirty-five feet deep. The coal averages four feet in thickness, and is mined on the long wall system.

West of Monroe four or five miles on Calhoun creek a number of drifts are seen in the hillsides. There are also a half dozen or more country banks a few miles west of the last named place and three to four miles south and southwest of Prairie City.

Northwest of Prairie City and about one mile east of Mitchellville is the Cooke shaft which is ninety feet deep. There are three veins of coal, one foot, eight inches, and four and one-half feet thick. The beds are somewhat undulatory and dip slightly to the northeast. The roof is dark colored shale which has a thickness of fifteen feet. The strata at the bottom of the shaft shows:

Figure 100. Coal at the Cooke Mine. East of Mitchellville.

Along the C., R. I. & P. railroad a couple of miles northeast of Colfax several small mines have been opened along the Skunk river. The principal mining in the Colfax district is a mile and a half northwest of the town. Here the Jasper County Coal Company have sunk a number of shafts and opened up an area of considerable size. Three veins of coal are present. Shaft No. 3, which has recently been opened, is about 100 feet deep with the coal from four to five feet in thickness. This is the first vein, the two others below being too thin for profitable working as long as the thicker coal above holds out. The coal seam shows the following:

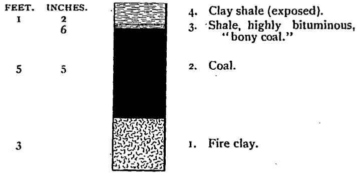


Figure 101. Coal Seam at Jasper County Mine. Colfax.

Four miles northwest of Colfax at a mining camp called Oswalt a number of shafts have been put down. The Diagonal Coal Company had four mines, the Jasper Coal and Mining Company three, Black Heath, Pittsburg Star, and Little Diamond one each. All of these have been worked out and abandoned.

POWESHIEK COUNTY.

Poweshiek county lies at the extreme eastern edge of the Iowa coal field, yet at least one-third of its area is underlain by Coal Measure strata. There are probably also numerous small basins or pockets scattered over the county which will eventually yield workable coal. The entire county, however, is so deeply covered with drift materials that exposures of stratified rocks are very few in number and are confined almost entirely to the southwestern corner of the county. It is owing chiefly to the great thickness of glacial débris that prospecting for coal has not been carried on to such an extent as it ordinarily would be in other districts.

Along the Skunk river in the extreme southwestern corner of the county the Lower Carboniferous limestone is exposed at a number of places in the river banks above the bridge of the Iowa Central railroad. Outcrops of black shales and ferruginous sandstone of Coal Measure age are also seen at many places along the same stream as far as the west county line and also in some of the small creeks in the same region. The only mining yet known to have been undertaken has been along Buck creek in Union township. In the bluffs and bed of this creek there are frequent outcrops of Coal Measure strata. It is reported that exposures occur at short intervals along the stream for a distance of six or eight miles. As long ago as 1868 Smith and Barrowman opened a mine on this creek about six miles southeast of Searsboro. Although the outcrop of coal was only eight inches in thickness, a drift was carried into the hill for a distance of 150 feet. The coal instead of becoming thicker became thinner. The black shale above the coal is really much thicker than might be inferred at the mouth of the drift. Fifteen yards away this shale is exposed by recent landslides and has a thickness of a dozen or more feet. The section at the opening is shown in figure 102.

Prospecting for coal has begun recently at various points in the southwestern part of the county. At Searsboro in the hill just west of the village two drill holes have

Figure 102. Coal at Smith and Barrowman Mine. Searsboro.

been sunk to a depth of 100 feet revealing thin seams of coal. A number of wells sunk a few miles to the southward have also encountered small layers of the same material. About a mile east of the Central Iowa railroad bridge over the Skunk river a boring has shown a coal vein one foot in thickness about fifty feet below the surface.

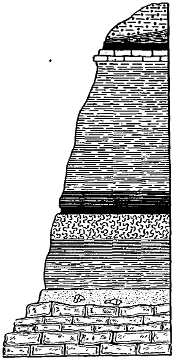
On the south side of Skunk river about a mile above the bridge of the Central Iowa railroad is the location of the old Petit mine (Tp. 78 N., R. XVI W., Sec. 36, SW. qr. NW. $\frac{1}{4}$). This was a drift opening worked some years ago and supplied a considerable amount of fuel to the neighborhood. The vein was sixteen inches in thickness and quite regular. The section of the bluff is shown in figure 103.

A short distance below this opening was the Watson drift which was worked for a short time. Other small drifts are also reported to have been opened in the ravine a short distance back from the river.

Traces of coal have been reported from points a short distance south of Montezuma, in the vicinity of Deep river in the southeastern part of the county.

In Keokuk county, at Thornburgh, coal has been mined for a number of years within two or three miles of the Poweshiek county line. This is only a half a dozen miles from the What Cheer district, which includes some of the largest and most important mines in the state.

Five miles directly west of Searsboro, in Jasper county, a number of mines have been operated in a vein of coal having a thickness of from two to four feet. The chief mine in this vicinity is the Black Oak shaft, the coal

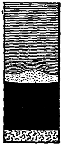


		FEET.	INCHES.
12.	Drift	5	
11.	Shale, argillaceous		6
10.	Coal		10
9.	Limestone, impure	1	6
8.	Shale, light colored above, getting darker below	18	
7.	Shale, dark, bituminous, somewhat fissile	2	
6.	Coal	1	
5.	Fire clay	3	4
4.	Shale, variegated	3	
3.	Shale, light colored, calcareous	4	
2.	Sandstone, brown and yellow, with limestone nodules	2	
1.	Limestone, compact, brittle (Saint Louis exposed)	7	

Figure 103. Section near Old Petit Mine.

worked in it having a thickness of four feet, with two thinner seams beneath. Southeast of Searsboro, in Mahaska county, a couple of miles from the Poweshiek county line, coal mines are also operated in veins three to four feet in thickness.

A number of mines have been opened here and considerable quantities of coal taken out. The nearest of these mines to Poweshiek county is the Evans, where the layers seen in connection with the coal are as follows:



FEET.	INCHES.	
6		4. Shale, bituminous.
	8	3. Limerock, impure, compact, ferruginous.
4		2. Coal.
1		1. Fire clay, from 0 to 5 feet in thickness and said to rest on sandstone (exposed).

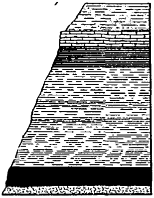
Figure 104. Seam in Evans Shaft. Near South County Line of Poweshiek.

Being located so near the edge of the coal field judicious prospecting in Poweshiek will doubtless reveal the presence of coal in a number of places, and this county may yet be numbered, in the near future, among those yielding commercial supplies of mineral fuel.

MADISON COUNTY.

The surface rocks of Madison county are largely the limestones and calcareous shales forming the lower portion of the Upper Coal Measures. The drift deposits being thinner than to the westward, outcrops of the stratified rocks are relatively more numerous than in the adjoining regions. In the northeastern part of the county the Lower Coal Measures are exposed over a considerable area.

Although coal has been mined very little in Madison county several workable seams are known to exist near the surface, and, probably, others occur at depths of from 100 to 200 feet. In the northern part of the district, six or seven miles southeast of Earlham, coal is known to outcrop in the valley of North river and some attempts have been made to mine it. On the land formerly owned by G. Clarke (Tp. 77 N., R. XXVIII W., Sec. 25, NW. qr.) a seam two feet six inches in thickness occurs. It has not been opened to any extent, though small quantities of coal are taken out at times for local use. The exposures are near the places where White gave the following section:

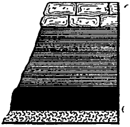


	FEET.
6. Shale, sandy	32
5. Limestone, impure, bluish	2
4. Shale, black, bituminous	3
3. Shale, argillaceous, bluish	14
2. Coal	2
1. Fire clay	1

Figure 105. Coal at Clocks Stripping. Southeast of Earlham.

Coal is also seen in thin bands in other places along North river between the one last mentioned and the east county line.

On Middle river east of Winterset several small coal seams are exposed above the water level. A mile southeast of Patterson station (Tp. 76 N., R. XXVI W., Sec. 32, NE. qr., SW. $\frac{1}{4}$) the following section is shown:



FEET.	INCHES.	
1		4. Limestone, gray, compact, fossiliferous.
2	6	3. Shale.
2		2. Coal.
	6	1. Fire clay, (exposed).

Figure 106. Bluff on Middle River. Near Patterson Station.

Considerable coal is taken out here for local use during the colder months of the year. Three miles directly east of the last mentioned exposure (Sec. 36, SW. qr., SW. ¼) a five inch seam of coal is exposed at the same horizon. A similar small seam is also shown two miles farther to the southeastward on Clanton creek. There are numerous other outcrops of thin veins in the eastern part of the county and some of them have afforded supplies for the different neighborhoods during the winter.

Coal may, and in all probability does, exist at considerable depths in the northeastern portion of the county and perhaps in most of the district. At Van Meter, one and a half miles north of the county line of Madison, there are two seams of coal three feet in thickness which have been mined extensively at depths of 350 feet below the massive limestone layer, so well exposed near the summit of the bluffs. At Commerce, two miles from the northeast corner of Madison, coal has been mined for years at a depth of 150 feet below the top of the bluffs. There are also openings a few miles east of Madison in Warren county, where the mining industry has been carried on for years.

WARREN COUNTY.

Coal has been found for many years in this region, but until quite recently it has not been produced in commercial quantities for shipment. Consequently the county has never been ranked among the leading coal counties of the state although having on the north, east and south some of the principal producing areas of the state. The neglect to develop the coal industry in the earlier days of the settlement of the county was probably due in a great measure to the absence in the region of large streams with deeply cut channels. There is probably in the northwestern half of the county at least, as rich a field of coal as in any of the neighboring districts. The particular need of deeper prospecting in the coal field is nowhere more apparent than in Warren and would without question lead to the development of extensive mining.

Like neighboring counties, Warren is covered with a tolerably thick deposit of drift which covers most of the exposures. There are no outcrops of Lower Carboniferous strata within the limits of the county, the nearest natural surface exposure of that formation being fully a dozen miles away. The older rocks are therefore probably at a considerable depth below the present surface and in all likelihood borings of 200 feet in depth would fail to reach the basal limestone. The entire county is occupied by Lower Coal Measure strata. Along the western border, however, the beds begin to approach, in lithological character, the Upper Coal Measures. The best natural sections in the region are along the valley of the Des Moines river in the northeastern part. The strata are tolerably level and regular, though a low anticlinal fold has its crest just east of Ford. Connected sections along the three principal streams of the county also indicate that the strata are all very even.

North River Valley.—In ascending North river from the mouth, the first section met with is just north of Carlisle, a short distance above the railroad bridge of the C., R. I. & P. railroad. Here sandstones and sandy shales rise on the south side of the stream to the height of fifty feet or more. These arenaceous beds immediately overlie important coal horizons which are well exposed a few miles to the eastward. Three miles west of Carlisle is the Lumsdon mine (Tp. 77 N., R. XXIV W., Sec. 7, SE. qr., SW. ¼). The coal worked lies five or six feet below the level of the small stream on which the mine is located.

The coal bed is very regular, with no faults or rolls. The section shows:

FEET.	INCHES.	
6		4. Shale, argillaceous.
1		3. Shale, black, somewhat fissile.
2	6	2. Coal.
2		1. Fire clay (exposed).

Figure 107. Coal Bed at Lumsdon Slope. Carlisle.

The strata dip to the southeast. The top of the seam is said to be affected by the weather much less easily than the bottom portion. This is also true of other mines in the vicinity. The coal is mined on what is called the "semi-long-wall" plan. A couple of miles above the last named point, just above the wagon bridge over North river on the Indianola and Des Moines road, the existence of coal has been reported. Two and a half miles north of Spring Hill, in the central part of Greenfield township, a three foot vein of coal was formerly worked by several small country banks. At the present time two openings are in operation here (Tp. 77 N., R. XXIV W., Sec. 21, SW. qr.). In the Fourst the seam is twenty-six to thirty inches in thickness. It lies only a few feet above low water level in the river. This coal crops out in several places in a ravine just south of the mine. It is also exposed near the river, about a mile to the west, and is found some little distance beyond in the bed of the stream where it has been quarried for local use. A few rods west of Fourst opening is the Ferry and Graves mine, where the seam is somewhat thicker than at the first mentioned place. These two mines furnish most of the coal used in the neighborhood and for some distance to the southward. Five miles farther up the river (Tp. 77 N., R. XXV W., Sec. 34, NE. qr.) is the Chiles shaft, which is about forty feet deep. The coal is said to be three feet in thickness. A mile from the west county line in the river there are several outcrops showing coal three feet six inches in vertical measurement. West of Spring Hill a couple of miles some stripping has been done in the bed of a ravine for a thin seam of coal. Evidence of former strippings in this vein are found about a quarter of a mile to the northeast in a tributary ravine.

Middle River Valley.—Just west of the county line, in Madison, near Bevington station, a thin seam of coal is exposed near the top of the bluff, but it is probably not thick enough for profitable working. Near Spring Hill, seven miles east of the west county line of Warren, there are two thin seams of coal above the water level in the the river. The lower of these two veins is thirteen inches in thickness and dips to the southeastward. South of Spring Hill is the Earle shaft, 126 feet in depth (Tp. 76 N., R. XXIV W., Sec. 8, NE. qr., NE. $\frac{1}{4}$). The seam worked is three feet ten inches in thickness, and dips to the southeast. East of town a couple of miles, at Glascock Mills, the vein of coal is at the water level, and is from fourteen to sixteen inches in thickness. Still farther to the southeastward in section 3, (same township and rangė) the coal is mined at the Bemis drift. A seam of coal is also exposed three miles northwest of Indianola, on both sides of the wagon road, near a small ravine.

The chief mines in the county affording coal in commercial quantities are located in the neighborhood of

Summerset. A few years ago there were three companies mining coal at this place. They were operating in the so-called "third" vein which is locally known as the Lumsdon seam. The average thickness of the bed is about four feet. It is reached by shafts varying from sixty to a hundred feet in depth. The mines working this seam at present are the Cassidy (Tp. 77 N., R. XXIII

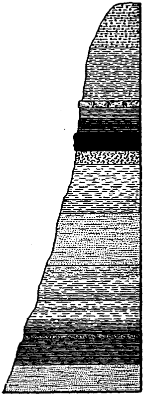


Figure 108. Bluff on Middle River. Summerset.

		FEET.	INCHES.
16.	Drift, yellow clay, soil..........	5	
15.	Shale, gray, fissile...............	6	
14.	Limestone, blue, weathering yellow or brown, with few fossils..		9
13.	Shale, sandy....................	1	2
12.	Shale, variegated and bituminous	1	8
11.	Coal, rather impure and slaty...	1	10
10.	Fire clay.......................	1	6
9.	Shale, gray, with crystals of gypsum, grading into next above..	4	
8.	Shale, sandy, yellow, containing gypsum......................	1	4
7.	Sandstone, gray, thin bedded...	6	
6.	Shale, gray, sandy in upper portion..........................	4	
5.	Shale, red, gray and blue.......	4	
4.	Shale, sandy, bituminous......		1
3.	Shale, hard, sandy.............		3
2.	Shale, dark blue, argillaceous...	3	
1.	Sandstone, yellow, thin bedded (exposed to bed of the river)..	3	

W., Sec. 31, NW. qr., NE. $\frac{1}{4}$), and the Frisbee, the latter being located about a quarter of a mile northeast of the railroad station, on the south side of Middle river. The Caldwell mine is also in the same neighborhood. Prospecting recently carried on south of town indicates that the "third" vein varies considerably in thickness.

At and near the station of Summerset two thin seams of coal are exposed in the bluffs. They are eighteen and

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

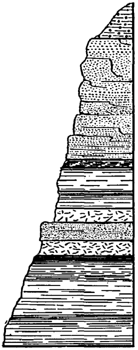
Figure 109. Section of Shaft at Bennum Mine. Summerset.

sixteen inches in thickness respectively, and the upper and thinner of the two has been mined by means of drifts at several places in the neighboring hillsides. One of the veins is exhibited on the river as shown in figure 108.

A couple of miles directly east of Summerset at the Bennum mine (Tp. 77 N., R. XXIII W., Sec. 33, NW. qr., NW. ¼) the coal is nearly three feet in thickness. To the north is the Jones opening, one of the oldest in the vicinity. At both of these pits the long wall plan of mining is adopted. A section of the shaft of the former is shown in the preceding figure 109.

Toward the mouth of Middle river little systematic mining has been done, though there are a number of small drifts observed at various places. Directly south of Clarkson station in the bed of the river is a fifteen foot bed of bituminous shale. It rests upon a thick layer of clay ironstone which is sometimes exposed at low water. There is, probably, coal immediately underneath. The bituminous shale is overlain by a heavy bed of sandstone, the same layer which is exposed to the westward near Carlisle and a couple of miles to the east at Ford.

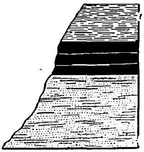
Ford was formerly the most important mining district in the county and large amounts of coal were shipped over the C., B. & Q. railroad. The principal mine worked was the Howell, which was a drift and which operated in a vein three and one-half feet in thickness. This mine has recently been reopened and arrangements are being made for extensive mining. This coal is exposed at the foot of a high bluff and is overlain by a thick stratum of massive sandstone. The strata rise rather rapidly east of the station and within a mile and a half the coal seam has risen thirty or forty feet and at the same time has thinned out to a very few inches. This is shown in the Ford bluff:



		FEET.	INCHES.
9.	Drift and loess	10	
8.	Sandstone, yellow, soft, heavily bedded above, thinly bedded below, with much clay	35	
7.	Shale, dark, highly bituminous in places, with hard concretionary layers	2	
6.	Fire clay, with sigillarid roots		3
5.	Shale, drab, somewhat sandy above	12	
4.	Clay, white	3	
3.	Sandstone, friable, buff, heavily bedded	4	
2.	Clay, white	4	
1.	Shale, sandy and clayey (exposed to water level)	25	

Figure 110. Bluff on Des Moines River. East of Ford.

South River Valley.—At the present time no coal is known to be mined in commercial quantities in the southwestern portion of Warren. Five miles southwest of Indianola, on the river, a bed of coal one and one-half to two and one-half feet in thickness is known to exist. It was formerly worked to a considerable extent for local use at an opening called the Randolph mine. Here the exposure gives:



		FEET.	INCHES.
3.	Shale, yellow, arenaceous (exposed)	5	
2.	Coal, divided by thin clay partings into three benches	4	6
1.	Sandstone, blue and yellow, soft, shaly below (exposed)	10	

Figure 111. Tripartite Seam at Randolph Mine. Five miles southwest of Indianola.

The Demory mine (Tp. 75 N., R. XXIV W., Sec. 9) is a shaft twenty-six feet deep, but is not now in operation. Three miles to the east and about the same distance south of Indianola in the bluffs, is located the Helm mine, where the seam is about two feet in thickness. Coal has also been mined to the eastward on Otter creek. Four miles directly east of Indianola are also located mines near Ackworth station. Five or six miles farther down the stream another vein has been opened and some coal taken out for local use. Between this place and the mouth of the river are other exposures, showing coal, but no mining is known to be carried on at present.

Lacona District.—In the south-central part of the county, along Otter creek, coal is exposed at a number of places. The seam is rather thin, ranging only from twelve to twenty-two inches. West of Liberty Center the vein, on account of a slight southerly dip, is only a few feet above the water level in the creek. A couple of miles farther down the stream are other exposures in which coal has been somewhat irregularly developed. Five miles below and a short distance west of Milo mining has been carried on to some extent. The Bales mine (Tp. 75 N., R. XXIII W., Sec. 26, NW. qr., NW. $\frac{1}{4}$) is located two miles southeast of Milo station. A short distance to the northwest, on the creek, exposures of sandstone and shale are shown but no coal crops out in connection with these strata. A mile directly north of the Bales is the Mitchell mine (Tp. 75 N., R. XXIII W., Sec. 23, NW. qr., SW. $\frac{1}{4}$). The coal varies from sixteen to twenty inches in thickness and dips north and northwest about two and one-half feet in a hundred. A few slight faults have been encountered, though the throw in no case observed is over six inches. The beds exhibit:

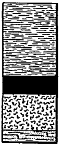


Figure 112. Seam at Mitchell Mine. Milo.

On the same quarter section are located the Morgan and the Connors mines, while a mile to the eastward is the Brown. The coal here is eighteen inches thick. A mile south of the latter and about the same distance southwest of Milo is the Richmond mine.

Southeast of the town a distance of about three miles (Tp. 75 N., R. XXII W., Sec. 28, SE. qr., SW. ¼) is the Heinan mine. Near by are other local pits, the Motherhead,

Figure 113. Coal Bed at Miller Pit. Lacona.

Sneider, and Alexander. Coal has been mined in this vicinity for many years. Among the other openings in the neighborhood are the old Dunkin and the Hudson, long since deserted. Both worked in about two feet of coal.

In the valley of Whitebreast creek coal has been mined continuously for thirty years or more. Half a mile southeast of Lacona, on Cotton creek, is the Miller slope (Tp. 74 N., R. XXII W., Sec. 28, SW. qr., NE. ¼). The coal is of good quality in a seam from sixteen to twenty-two inches in thickness. A portion of the strata visible is indicated in figure 113.

In the immediate vicinity are several openings which were formerly operated for local use. Three-fourths of a mile farther up the creek are several other country banks which are worked only during the winter. Directly south of Lacona the coal seam crops out in the bank of the stream, with this section:

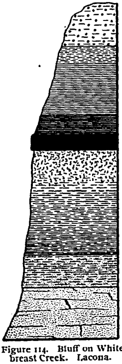


Figure 114. Bluff on Whitebreast Creek. Lacona.

		FEET.	INCHES.
8.	Drift, yellow clay, and soil	5	
7.	Shale, gray, clayey, sandy in the lower part	2	6
6.	Shale, blue, fissile, argillaceous	6	
5.	Shale, bituminous, clayey, with gypsum crystals	2	4
4.	Coal	1	10
3.	Fire clay and light colored shale	12	
2.	Shale, soft, sandy, with calcareous concretions	3	8
1.	Sandstone, massive, compact (exposed)	6	

It is also shown at short intervals for several miles down the creek to the east county line. A mile and a half directly southeast of the station just mentioned, on the east side of the creek (Tp. 74 N., R. XXII, W., Sec. 26, SW. qr., SW. ¼), are the Odell and the Fogel banks. The coal mined at this place, and also farther eastward, is about eighteen inches in thickness. Three shafts have been opened in the vicinity. Considerable coal is also removed for local use by stripping along the line of outcrop. A half a mile farther down the creek are the Howe and the Hickman mines besides several smaller banks. In the Hickman mine the coal is from two to four feet in thickness with a good shale roof. The layers are:

FEET.	
4	5. Sandstone, massive.
2	4. Shale, light colored.
2	3. Shale, black, fissile.
3	2. Coal.
2	1. Fire clay, (exposed).

Figure 115. Section at Hickman Slope. Lacona.

Besides the openings mentioned there are other exposures in the various streams east and northeast of Milo. Thicker seams outcrop farther down the creek and at a lower horizon in Marion county, indicating the presence of workable coal below the thin vein now mined in the southeastern corner of Warren.

MARION COUNTY.

Marion county for a number of years has been one of the leading coal producing districts of the state. At present it contains many mines which are in operation for the greater part of the year; besides a large number of country banks. The county is almost entirely occupied by Coal Measure strata. In the southeastern part the Lower Carboniferous limestone outcrops in a number of places. There are at least half a dozen well defined coal seams in the county. These are nearly all well exposed in the bluffs of the Des Moines river. Other veins, though not represented along the chief water course, probably exist in other parts of the district. In the neighborhood of the southwestern corner the mining of coal has assumed considerable importance just beyond the boundary line in Warren county. The coal beds of Marion are among the most extensive in central Iowa.

The eastern third of the county is underlain, at no very great depth, by the Saint Louis limestone — the uppermost member of the Lower Carboniferous in Iowa. It forms the floor of the Coal Measures over a greater part of the Iowa coal field. It is exposed in the bed of the Des Moines river for a distance of eight or nine miles from the eastern border of the county to the immediate vicinity of Coalport, four miles southwest of Pella. A small area of the same rock is exposed at low water level six miles farther up the stream near the mouth of Teeter creek, below Redrock. Here the limestone rises in a low anticlinal fold to a height of about fifteen feet above low water level. This is the last outcrop of Lower Carboniferous rocks noticed in ascending the Des Moines river in central Iowa until Fort Dodge is reached. The Saint Louis limestone is also exposed in the bed of English creek as far as Flagler, five miles above its mouth. It also forms steep bluffs thirty to fifty feet high along Cedar creek, extending probably to the southern county line. The limestone also comes to the surface in a number of places in the immediate vicinity of Pella. The exposures of Saint Louis in Marion county show tolerably well its uneven upper surface on which the coal bearing rocks have been laid down. If the latter deposits were entirely removed from the Saint Louis beds the surface relief would probably be not very unlike existing topography. There would be hills and valleys as extensive as those now existing. There is abundant evidence to show that during the closing epoch of the Lower Carboniferous the Saint Louis rocks actually did form a land surface which was subjected to erosion just as it would be to-day. The extent of this denudation has not been accurately made out in all parts of the region, but carefully made measurements along the Des Moines river indicate that in some places channels have been cut to the depth of fully 100 feet. Between the outcrop of the Saint Louis limestone a couple of miles below Redrock and the exposures at Harvey ten miles to the southeastward no less than seventy-five feet of Coal Measure deposits are known to exist between two horizons where the Saint Louis crops out, showing that after the old Lower Carboniferous hills at Harvey were covered by Coal Measure sediments it required a deposition of between seventy-five and a hundred feet more before the prominence below Redrock was completely submerged.

The greater part of the strata exposed in Marion county above the Saint Louis limestone is comparatively soft and under the influences of the weather pass into incoherent materials upon which vegetation rapidly springs up and hides from view the stratified beds. There are, nevertheless, a few beds which are quite indurated and form marked topographical features. One of the most conspicuous of them is a thick bed which has been called the Redrock sandstone. It is well exposed in the river bluffs from the vicinity of Dunreath down the river to Harvey. It probably extends westward and southward beyond Knoxville, at which point it is some distance below the surface. Perhaps it is the same stratum which is exposed in the neighborhood of Tracy, extending along the Des Moines river into Mahaska county to the locality known as the "Bluffs" or Raven cliff. The sandstone has a maximum thickness of not less than 150 feet. At Redrock bluff and Elk cliff, two miles below, the sandstone rises in perpendicular walls to a height of more than 100 feet. For several miles the Des Moines river flows through a comparatively deep gorge. The bright red color of the stone at Redrock attracted popular attention long ago, the village and township taking their names from it. Immediately below the sandstone is a four-foot vein of coal which has been worked at a number of points. In some places the coal of this seam is not of very good quality, but above the mouth of Whitebreast creek it could probably be mined with profit, as it appears to become better in quality and greater in thickness as it passes northwestward. At least two other seams occur below the vein just mentioned. Both are exposed in the river bluffs at Coalport, where they are from twelve to fifteen feet apart. The lower seam is two to three feet in thickness; the upper five to seven. The details of the geological section of this vein are given in connection with the remarks on the mines at Coalport. The upper vein forms a rather conspicuous black band, extending for several miles along the river, near the top of an almost perpendicular bluff, with a heavy talus at the base, and occurring for some distance above and below Coalport. Three or four miles below Coalport, and from one-half to three-quarters of a mile below the Pella and Knoxville wagon bridge crossing the Des Moines river, the coal seam appears a short distance below the great sandstone stratum already referred to. At the place just mentioned are numerous remains of large, finely marked lepidodendrids, sigillarids, calamites and other types of coal plants in an unusually fine state of preservation. Large slabs from one to three feet wide and several feet long, together with great numbers of smaller fragments of these plant remains lie in the utmost profusion in the talus slope of the river bluffs.

Between the Lower Carboniferous limestone and the lower surface of the great Redrock formation which extends so widely over this region, there are at least seventy-five feet of shales intervening. As has just been said there are now known to be three extensive coal seams inclosed by the shales, and it is quite likely that there are still others of commercial importance.

The upper surface of the Redrock sandstone shows abundant evidence of having been a great land surface, at one time during the Carboniferous, exposed to the denuding action of running water. The upper limit of the great sandstone is shown to the best advantage in the Redrock quarry, about three-fourths of a mile above the village of the same name. At this place the full thickness of the sandstone is not represented, as part of it is beneath the water level of the Des Moines river. The upper surface is deeply gorged and channelled, and paved everywhere with rounded waterworn boulders and pebbles, derived from the sandstone itself. A gray fire clay covers this pavement and upon it rests a coal bed having a thickness of six feet centrally, but rapidly thinning out laterally in both directions to a very unimportant, scarcely recognizable bituminous seam. Northward, or at right angles to the face of the section, the coal is thicker. Superimposed upon the coal are drab and ash colored, clayey shales, having an exposed thickness of thirty feet, but which are manifestly more extensive. From a consideration of this section, then, it is clear that before the superimposing coal vein was formed the vast sandstone had been raised above the surface of the waters, consolidated, and was then subjected to considerable denudation. In a small gorge or ravine excavated in the sandstone the Carbonaceous material was deposited as the land was again being submerged. Immediately to the north the corrasion was much more extensive, as is shown by the rapid inclination of the axis of the gorge in that direction; so that the section is actually across a tributary ravine opening into a large basin, in which the coal is now mined in great quantities. The inference is then that the abrupt disappearance of the great bed of sandstone in the short distance of half a mile above the quarry, where it has an exposure of more than one hundred feet, is not due wholly to the dip of the stratum, but that it is the result of great erosion in that direction, previous to the deposition of the shales and clays; and that the massive sandstone really formed a bare hill of considerable height against which the subsequent deposits were laid, when the conditions for such a change occurred. A short distance above the quarry and about half a mile below Dunreath, at the mouth of Calhoun creek, the Redrock sandstone abruptly disappears and the bluffs on the opposite side of the creek are made up entirely of shales. The absence of the sandstone above water level is not due entirely to dipping, which is really imperceptible here; but chiefly to vigorous subaerial erosion during Coal Measure times.

In the immediate vicinity of Dunreath there are two or three rather well defined coal seams, one of which has been quite extensively operated for a number of years. Workable coal seams are exposed in a number of places along the river between Dunreath and the northwest corner of the county. At Bennington, near a switch on the Wabash railroad called Morgan Valley, a coal vein is exposed a few feet above the river level. It is the same bed which appears on the opposite side of the stream above Swan, at Ford and on Middle river at Clarkson.

In the southwestern part of the county, along Whitebreast creek, there are several coal seams which outcrop at various points. The best known of these is called sometimes the Lacona coal, from a village of the same name a few miles over the line in Warren county. It is exposed at intervals along the banks of the stream and has been mined at a number of places.

On English and Cedar creeks other veins are exposed, one at Marysville measuring in places eleven feet in thickness.

Marion county has tolerably good railroad facilities, three lines, the C., R. I. & P., the Wabash and the C., B. & Q. entering the district. A railroad in the south and western part of the county would doubtless open up large fields of coal.

As already suggested the best natural exposures of Coal Measure strata are along the Des Moines river. Beginning in the northwestern corner of the county, coal outcrops are noticeable along the Wabash railroad and along the river for a distance of a couple of miles. Two coal seams are visible above the railroad track. The upper is about four feet in thickness, the lower about one foot. The seams are separated by ten feet of drab clay shales.

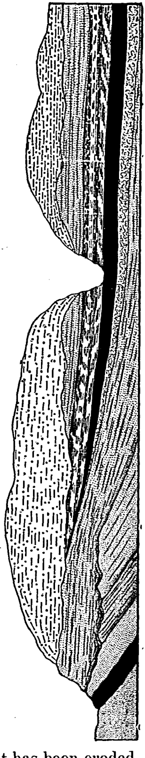


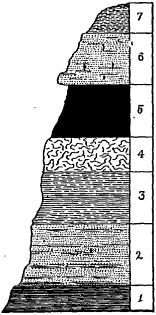
Figure 116. Section along Des Moines River, near Bennington.

The upper one is overlain by a heavily bedded, buff sandstone, which is the same as that exposed for some distance on both sides of the river and which overlies the coal seam now mined at Ford, in Warren county, a few miles west of the Marion county line. At a distance of about two miles from the western county line, in a ravine opening northward, the upper coal seam has been worked by means of a slope, the mouth of which is about half a mile north of the railroad and a few feet above the creek bed. At this place the coal dips westward, about six feet in a hundred.

On the opposite side of the creek, about thirty yards from the mouth of the slope, a shaft has been sunk by the Morgan Valley Coal Company to a depth of forty feet. This seam is four feet in thickness. But one coal bed occurs at the shaft, though it is said that two seams are present a short distance up the valley. The roof of the coal is a rather compact sandrock, and shows a thickness in the shaft of eighteen feet. It is doubtless much thicker than it appears in the valley of the creek, for here it has been eroded, clays filling part of the depressions.

A hundred yards east of the Morgan Valley shaft, the rocks are well exposed along the Des Moines river. (See figure 116.) At the west end of the exposure in a small ravine there is seen a two foot vein of coal inclosed in the sandstone. All the beds are inclined at a very considerable angle. The elevation of the different layers is shown in the accompanying section. A few rods farther down the stream a coal seam is exposed for more than a quarter of a mile just above the water level. It is underlain by several feet of fire clay which rests upon shaly sandstone. The coal seam is overlain by six feet of dark bituminous shales, part of which become coaly downward. The beds dip very perceptibly eastward, passing below the water level at the east end of the section.

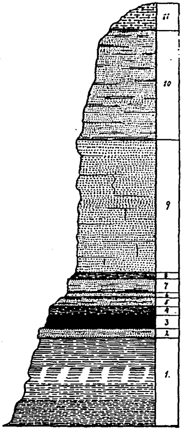
Continuing down the river along the railroad, indications of coal are seen in the hills at a number of points. In several places drifts have been made. Two miles beyond Percy station the strata gradually rise. In the steep bluffs along the railroad track coal is noticed at several elevations. At Dunreath mining has been carried on quite extensively, though with one exception the mines have been abandoned. Half a mile east of Dunreath the Black Diamond slope has been opened on the lands of the Redrock Mining Company. The coal vein is not very regular, but in places has a maximum thickness of seven feet. The coal is brought up the slope and hauled several hundred yards to the railroad, where it is loaded for shipment. A short distance south of Dunreath, on the river bank, there is a long exposure of the rocks in which two coal seams are shown, one of which is five feet in thickness. This is the vein which has been extensively mined in the slope at Dunreath station. A three-foot vein of cannel coal is said to exist at this point, specimens of which show it to be of very good quality. The vertical section:



		FEET.
7	Shale, dark colored, poorly exposed	3
6	Sandstone, heavily bedded, containing many coal plants, calamites, etc.	6
5	Coal	6
4	Fire clay	4
3	Shale, dark, with thin sandy layers	6
2	Sandstone, shaly, large lens shaped septarial masses at the bottom	7
1	Shale, black, bituminous, coaly below, (exposed to water level)	3

Figure 117. Bluff, South of Dunreath.

On the river a mile southeast of Dunreath the Redrock quarry is situated. Here a six foot vein of coal overlain by some thirty feet of shale, rests directly upon the sandstone. It has been mined but at present is not being worked. This bed of coal was well exposed a few years ago when the quarry was in full operation. At this time the quarry face was immediately beneath the vein, and this and the overlying shales were freshly cut every few months in order to get at the rock below. Smaller drifts are found in the hills for several miles below this place. Opposite the town of Redrock the high cliff affords:



	FEET.	INCHES.
11. Drift	10	
10. Sandstone, yellow, clayey	25	
9. Sandstone, heavily bedded, buff	35	
8. Shale, bituminous, coaly	1	6
7. Sandstone, soft, buff	1	
6. Sandstone, white, very compact and fine grained		10
5. Sandstone, soft, white	2	
4. Shale, bituminous, coaly below	1	
3. Coal, somewhat impure	4	
2. Sandstone, fine, massive, white, with lepidodendrid rootlets	2	
1. Shale, light colored, (exposed)	20	

Figure 118. Cliff, Opposite Redrock.

Two miles east of Fifield station, and one mile north of Coalport, the following section is seen in a railroad cutting near the river:

	FEET.
7. Drift	5
6. Sandstone, shaly, with carbonaceous seam at base	10
5. Coal	1
4. Fire clay	1
3. Shale, sandy, irregularly bedded	4
2. Sandstone, buff, massive	6
1. Shale, light colored, argillaceous	8

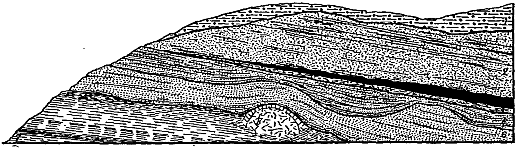


Figure 119. Railroad Cutting. North of Coalport.

The coal dips and thickens to the east. It is overlain by shaly sandstone which often has thin coal seams from a quarter of an inch to two or three inches in thickness in the bottom portion. Coal and thin bituminous shales are exposed in the creek about a mile east of the last section. A short distance below, the Saint Louis limestone appears above the river level and soon occupies forty or fifty feet of the hill. Of course, all coal found along the river from this point southeastward to the county line must be looked for above the limestone.

North of the Des Moines river, in Marion county, a number of small mines are located along the creeks flowing into that stream. Two miles and a half directly south of Monroe, in the valley of a small tributary of Brush creek (Tp. 77 N., R. XX W., Sec. 12, SE. qr., SW. ¼) several country banks have been operated; while along the creek itself at several places coal outcrops in the banks.

A mile southwest of Otley station the Crawford and Miller mine has been opened (Tp. 77 N., R. XIX W., Sec. 28, NE. qr.). The coal is from five and one-half to seven feet in thickness. The seam is somewhat undulatory, often falling or rising as much as six feet in a hundred. About half of the amount of coal mined is used locally, the other half being shipped. Several other country banks are located in the immediate vicinity.

A short distance to the southeastward and about two miles from Pella is the Markham mine. The coal averages four feet, four inches in thickness. The bed has a con-

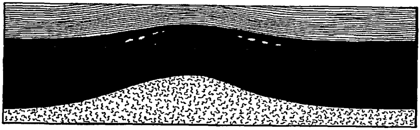


Figure 120. "Rise" in Markham Mine. Pella.

siderable extent and has been opened at several other points, though only one mine is at present in active operation. Here the section shows:

		FEET.
3.	Shale, gray, forming good roof (exposed)	2
2.	Coal, numerous concretions in the upper part of the seam, more frequent on top of the rolls	4
1.	Fire clay (exposed)	1

Three miles south of Pella, John Smith, W. Franklin, and Louis Woodyard have opened country mines. The coal is from four to six feet in thickness and of fairly good quality. Several other mines were formerly operated in the immediate neighborhood but are now abandoned. A mile and a half farther southward coal has been mined for local use. The seam is very near the base of the Coal Measures, as the Lower Carboniferous limestone crops out in the river bluffs but a short distance away.

On the south side of the Des Moines river, within a distance of four or five miles of the stream, numerous indications of coal are noticeable.

At Swan coal mining has been carried on quite extensively, several slopes having been driven into the hillsides and a number of shafts sunk. There are three veins of coal; the first is about twenty-five feet below the level of the railroad track and is a little less than three feet in thickness; the second, which is about fifteen feet lower, is three and one-half feet in thickness; the third is thirty feet below the second, and is four to six feet thick. The Kennedy Coal Company has two shafts not far from the station at Swan. They are about eighty feet deep. Three veins of coal were passed through in sinking the openings. In No. 1, which is just west of the depot, several small rolls have been encountered, but they are not of a serious nature. A short distance farther west the Black Swan Coal Company has recently put down a shaft to the depth of seventy-five feet, reaching the third seam of coal, which is five and one-half feet in thickness. This is a new mine with extensive top works and is reached by a switch from the C., B. & Q. railroad. Arrangements have been made to handle and ship a considerable output. In former years several other mines were opened directly west of the present shaft of the Black Swan, but these have worked out all their available territory. East of Swan, near the Kennedy No. 2, is the location of the Whitebreast No. 11 (Tp. 77 N., R. XXI W., Sec. 20, NW. qr., NW. $\frac{1}{4}$) which is now abandoned. It was a shallow shaft and opened up a seam six feet thick. In working north towards the river the roof became poor, owing to the nearness to the river bed. Several smaller mines have been operated from time to time immediately to the south on Coal creek.

Coal is also exposed in the bluffs of the Des Moines river at several points east of Swan for a distance of three or four miles. Southeast of Swan about three miles there is exposed (Tp. 77 N., R. 21 W., Sec. 33, SE. qr., SW. $\frac{1}{4}$) in the small ravine not far from the wagon road a fourteen inch seam of coal. Coal also outcrops in several of the deep ravines a couple of miles east of the latter locality. Four miles west of Redrock, drifts have been made in a number of places in the hillsides near an old channel of

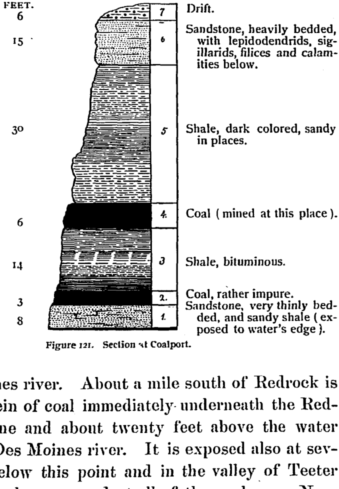


Figure 121. Section at Coalport.

the Des Moines river. About a mile south of Redrock is a four foot vein of coal immediately underneath the Redrock sandstone and about twenty feet above the water level in the Des Moines river. It is exposed also at several places below this point and in the valley of Teeter creek, and has been opened at all of these places. Near the ferry, at Rouseau post office, the same vein of coal is exposed under the great sandstone. At the mouth of

Whitebreast creek and for some distance above, dark bituminous shales crop out in the valley sides and at places prospecting for coal has been carried on with some success.

At Coalport, five miles southwest of Pella, on the west side of the river, coal has been mined for more than forty years. There are two veins; one three feet thick, eight feet above low water level in the Des Moines river, and the other vein six feet thick, fifteen feet higher up. The coal is loaded on wagons and hauled to Flagler or Pella for transportation. The section of rocks at this place is shown in the preceding figure 121.

For several miles below Coalport the upper seam is exposed high in the bluffs, forming a conspicuous black

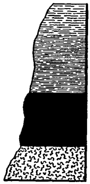


Figure 122. McElrea Drift. Near Star P. O.

band immediately beneath the sandstone. Drifts have been driven at various places and coal taken out for local use.

In the vicinity of Pleasantville along Coal creek, three miles south of the town, coal has been found in a number of localities.

In the valley of Whitebreast creek coal is found at intervals in the bank throughout its entire length from the southwestern corner of the county to where it empties into the Des Moines river. There are two small mines on the creek near Star post office, one in Tp. 75 N., R. XXI W., Sec. 24, NE. qr., SE. ¼, and the other in Tp. 75 N., R. XX W., Sec. 30, NW. qr., NW. ¼. The former is the McElrea drift, a section of which is indicated in figure 122.

The vein is about three feet in thickness and quite regular. The roof is a hard shale, and said to be about sixteen feet in thickness. There is another seam said to be exposed above this one, and which is thought to be the same vein as that mined at Lacona, in Warren county. About two miles north of Dallas village, in a deep ravine opening into the Whitebreast, there are two country banks operating in a three foot vein of coal. Coal is found in the southwestern part of Dallas township near the county line. Six miles southwest of Knoxville, and at short intervals for several miles down the stream there are numerous outcrops of coal. It has been mined in the neighborhood of Donaldson station, three miles northwest of the same town. Near Knoxville are several shafts, the coal being forty to fifty feet from the surface. The section of the bed at Knoxville is shown in the following figure 123.

A number of openings have been located immediately north of Knoxville (Tp. 75 N., R. XIX W., Sec. 6, SE. qr.) among the older of which the Collins mine was, perhaps, best known. This mine, which at different times was called the Collins, James and Knoxville City mine, was a shaft eighty feet deep and worked in a seam which averaged about four feet in thickness. The vein had a shale roof and was slightly undulatory. The coal seemed to lie in a trough about one-fourth of a mile wide and running from northwest to southeast. Immediately east of it (Tp. 75 N., R. XIX W., Sec. 6, SE. qr., SE. ½) considerable coal has been taken out by W. Gamble. He has opened three mines altogether, the one now being operated being a shaft forty feet deep. The coal is four feet thick, with a slight southerly dip. In a small ravine just north of town (Tp. 75 N., R. XIX W., Sec. 6, SE. qr., NW. ¼) two small slopes, the Anderson and the Miller, have been opened. The coal is from two and a half to four feet in thickness, with a dip to the southward of

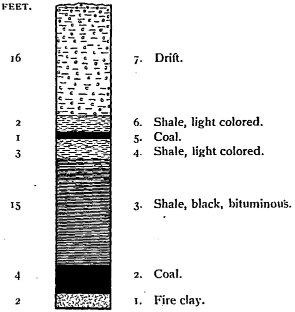


Figure 123. Shaft at Gamble Mine. Knoxville.

nearly ten feet in a hundred. A number of small slips or faults have been found, but none of a serious character.

In the valley of English creek a large number of shafts and country banks have been operated. In Washington township, in the southern part of the county, several mines have been worked in the vicinity of Gosport. Two miles west of this place, on Long branch, the Lackey drift has recently been opened in a seam three feet in thickness. The bed is somewhat undulatory, but has a general dip towards the southeast. The roof is drab shale and rather poor. A mile east of the latter locality, at the mouth of Long branch, the Bingham slope was formerly operated. The coal is apparently the same as at the Lackey mine but is somewhat thicker. Coal crops out in the banks of the stream and its tributaries at short intervals for a distance of eleven or twelve miles. Three miles southeast of Knoxville a number of openings have been made; while two miles directly south is the Robinson slope (Tp. 75 N., R. XIX W., Sec. 19, SW. qr., NE. ¼). The air shaft is twenty-five feet deep. The coal is five feet in thickness and dips quite perceptibly southwestward. Half a mile directly east is the Buckman drift. Two veins of coal, which are separated by about twenty feet of shale, are present. There is probably a third seam below. The second vein is from three and a half to four feet in thickness. Some "horse-backs" have been encountered in the mine, but none cause much trouble. A mile still farther eastward in section 21 of the same township and range is the Martin mine. In sections 15 and 16 respectively are the Griffith and Hayes banks. At the latter place the average thickness of the coal is five and one-half feet. Immediately southeast of Flagler there are a number of coal exposures along the creek.

At Flagler the Saint Louis limestone is exposed southward in the bed of English creek, as well as in a small tributary of a stream running through the town and along which the railroad has been built. Between these two streams, rising to a height of 50 to 100 feet, is a long narrow strip of land which is made up of Coal Measure strata. It consists mainly of two sandstone layers, the lower one of which is a white, shaly sandrock said to have a thickness varying from fifteen to fifty feet; the upper sandbed is usually thicker; it is a massive, soft, yellow sandrock closely resembling certain parts of that quarried at Redrock, six miles to the north. Two seams of coal are known, both of which have been worked. The one occurs between the two sandstone beds and the other at the base of the lower. The coal which was first opened in this vicinity belonged to the upper seam; but later the lower bed was discovered and worked. As elsewhere the coal has been found to lie in beds which are quite variable in thickness. In the Whitebreast No. 11, now worked out, the coal formed a lenticular basin which was fourteen feet thick centrally. From this point the bed thinned out in all directions until too thin for profitable working. The Iuka slope is now operated at this place in a vein six feet thick. The coal is somewhat variable in thickness, running from four to six feet and upwards. It has a dip towards the southwest of five to six feet per hundred.

At the Rollins mine near by the following is seen:

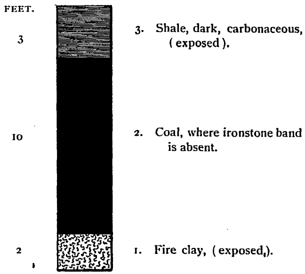
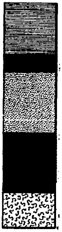


Figure 124. Coal Bed in Rollins Mine. Flagler.

In another place a thick band of clay ironstone comes in, giving:



FEET.	INCHES.	
3		5. Shale, bituminous, (exposed).
1		4. Coal.
3	6	3. Clay, ironstone.
3	6	2. Coal.
2		1. Fire clay, (exposed).

Figure 125. Bed in Rollins Mine. Flagler.

About one mile east of here the Oak Hill Coal Company has a slope working in apparently the same vein.

In the valley of Cedar creek coal is well exposed and a number of mines have been opened. Most of them are four or five miles away from the railroad and hence very little of the product is shipped. A mile and a half southwest of Marysville (Tp. 74 N., R. XVIII W., Sec. 31, NE. qr., SW. ¼) is the Whitelatch slope. A few hundred yards east of this is the Staats opening, in which the coal is from ten to eleven feet in thickness. At this point the bluff shows a section as indicated in figure 126. The same vein is also exposed along the creek a short distance west of Marysville. South of this place (in section 32) are the Yenser, the Leivy and the Walters mines, which are operated chiefly for local use. From the Yenser mine, however, coal is sent to Hamilton and loaded on railroad cars. The seam is from four to five feet in thickness. A mile west of Hamilton mines have been opened in the northwest quarter of section 34, among which may be mentioned the Davis. The coal from this place is also hauled to the railroad for shipment. Within a distance of a mile north and northwest of Hamilton half a dozen mines have been opened. In the vein at Tracy several small mines have been open for a long time.

The Boudinot slope, in the northwest quarter of section 27 (Tp. 74 N., R. XVIII W.) also sends much of its

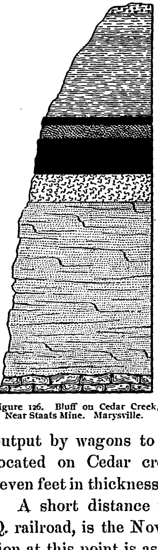


Figure 126. Bluff on Cedar Creek, Near Staats Mine. Marysville.

		FEET.
8.	Soil	1
7.	Clay shale, light colored above, dark below	30
6.	Coal	1
5.	Clay ironstone	2
4.	Coal	5
3.	Fire clay, white	4
2.	Shale, hard and gritty, followed by thinly bedded sandstone and sandy shales to the water level	50
1.	Limestone, Saint Louis (exposed at low water)	1

output by wagons to the railroad station. This mine is located on Cedar creek; the coal runs from five to seven feet in thickness and is firm, hard and of good quality.

A short distance north of Hamilton, on the C., B. & Q. railroad, is the Novelty mine, a small shaft. The section at this point is as follows:

		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.	Rock	3	
1.	Coal		1

The rock (No. 2) between the two parts of the coal is clay ironstone. It disappears farther westward and the

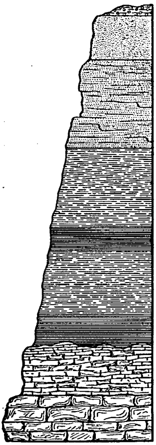


Figure 127. Bluff on Cedar Creek. Showing Coal Measures Resting on Saint Louis Limestone. Near Bussey.

		Feet.
4.	Soil	2
3.	Sandstone, light colored, more or less shaly	15
2.	Shale, light colored above, bituminous below, resting unconformably upon the next	35
1.	Limestone, decomposed and weathered above, solid and massive at base, (exposed to water level)	16

two seams run together. Another coal vein is known to exist below that now worked, since a prospect shaft about 500 feet to the westward shows one vein to be five feet in thickness; and beneath this one six feet of black shale and six feet of coal. This intervening shale is in one place nineteen feet thick.

At Bussey the Powers shafts, two in number, operate in a four foot vein of coal. The coal product is hauled on a tramway from the mines (Tp. 74 N., R. XVII W., Sec. 14, NW. qr.) to the railway where the tipple is located. The greater part of the coal from this mine is shipped out of the state. On Cedar creek, near Bussey, the Coal Measures are seen resting on the Saint Louis limestone, as shown in figure 127.

MAHASKA COUNTY.

From the earliest days of the settlement of the Des Moines valley Mahaska county has ranked among the leading coal producing districts of the region. Owen, in his celebrated exploration of the northwest in the later forties, found coal within the limits of Mahaska, and in a few years announced to the world the existence of rich deposits of mineral fuel in central Iowa. Mining, therefore, early became an important industry in this section of the state. The first localities where important mines were opened were in the immediate vicinity of Oskaloosa on Spring creek, south of that town on the Muchakinock and on the Des Moines river.

Although natural outcrops are numerous in nearly all parts of the county, little has been done until quite recently towards acquiring exact knowledge regarding the geological structure of the district. In the beds of the principal streams traversing the county the Lower

Carboniferous limestones are well exposed. These calcareous strata, though forming almost continuous belts bordering the streams, are quite irregular, both in areal distribution and vertical extent. Usually the beds rise from a few to thirty or more feet, occasionally dropping below the level of the water courses. Lithologically the formation is a white or ash colored, compact, brittle limerock, rather thinly bedded, and often somewhat brecciated. Frequently the upper portion is covered by a few feet of white, highly fossiliferous, marly clay. Both the limestone and the clay belong to the Saint Louis formation, which is even better developed farther southward. · In this part of the state it forms the basement upon which the coal bearing strata rest. As in all other parts of the state in which the rocks of the same age are exposed, the upper surface of the Saint Louis limestone is very uneven, the difference in level of neighboring inequalities being often from fifty to one hundred feet. These peculiarities of the Coal Measure platform have an important bearing upon the structure, distribution, and arrangement of the coal beds. What doubtless is the case over the entire county is disclosed plainly along the different water courses. On the North Skunk, in the eastern part of the county, it is not uncommon to find an exposed ledge of the limestone abruptly replaced by Coal Measure shales and sandstones, while a short distance beyond the limerock again comes up suddenly. It is quite manifest, after a careful consideration of the stratigraphical relations of the two formations, that the sandstone fills old gorges or eroded depressions in the limestone. Similiar outcrops are seen on the South Skunk, in the eastern part of the district, and on the Des Moines river at "The Bluffs" or Raven Cliff, where a massive sandrock forms a bold mural escarpment 100 feet in height, extending more than two miles between two old limestone hills.

The country being comparatively free from marked differences of elevation, and the drift not very deep over the greater part of Mahaska, the major part of the strata above the Saint Louis limestone may be regarded as made up of Coal Measure deposits, so that the formation spreads over the entire county with a maximum thickness of perhaps 150 feet. From this extreme limit it varies down to nothing. This variability in the vertical measurement of the Coal Measures is not the result of post-Carboniferous erosion entirely, and the consequent irregularities of the present surface relief; but is due largely to unevenness of the basement upon which the formation rests. Thus Coal Measure strata may exist at lower levels than certain outcrops of Saint Louis limestone and yet everywhere overlie the latter.

The coal seams of Mahaska are disposed in rather large basins. There are several coal horizons in the county, but the exact extent of each has not as yet been made out.

North Skunk Valley.— Although the Lower Carboniferous limestones are exposed in the bed of the river for the greater part of the distance which the stream traverses in the county, coal seams have been opened at short intervals. In the northern part of the county, northeast of New Sharon, along Buck creek, mines have been in operation for a long time and considerable coal removed. The beds are near the surface and are reached by drifts, slopes or shallow shafts. There have been many openings in the district, but few of them have been operated for more than two or three years, as it is more economical to make new entries as the coal is removed from the immediate vicinity of the mouth of the mines. In thickness the coal varies from two and one-half to six feet. A good shale roof is usually present. Occasionally small slips are met with, but rarely any serious "troubles." The most northerly mines of the district are the Evans openings (Tp. 77 N., R. XV W., Sec. 5, SE. qr., SW. ¼), one of which is within one mile of the Poweshiek county line. The coal is from three to four feet in thickness, with an average of perhaps three and one-half feet. Near by is the Smith mine, which also operates in coal from three to four feet in thickness. Half a mile southward are the Williams mines, only one of which is running at the present time. Here the section is:

FEET.	INCHES.	
14		4. Shale, bituminous, fissile below, with one-foot lime-rock band.
4	6	3. Coal.
2	6	2. Fire clay, drab, variable in thickness from 0 to 5 feet.
2		1. Sandstone, massive, (exposed).

Figure 128. Coal Bed in Williams Mine, near New Sharon.

In the southeastern part of the same section are several openings known as the Fisher mines.

Although the Coal Measures are well exposed at short intervals and exist in the bluffs on both sides of the stream from the last mentioned point to the east county line near its central part, little or no mining is now being done until the eastern margin of the county is reached. On the north side of the river, three miles from Rose Hill station, is located the Columbia mine (Tp. 76 N., R.

XVI W., Sec. 36, NW. qr., NE. $\frac{1}{4}$). At this place the following section is observed:

FEET.	
4	5. Shale, dark gray, poorly bedded, often very much broked (exposed).
2	4. Shale, dark colored, variable thickness.
6	3. Coal, containing some clay ironstone.
1	2. Fire clay, thickness not known (exposed).
15	1. Sandstone, light colored, rather massive (exposed, in road near by).

Figure 129. Seam of Coal in Columbia Shaft, Rose Hill.

The coal is from five to seven and one-half feet in thickness. Here, as elsewhere in the county to some extent, the coal seam is very undulatory the seam rising and falling at very short intervals and at high angles. The low parts of the vein are very appropriately called "swamps" by the miners, and it is only in these places that the coal can be mined, because of the poor roof over the higher portions, the coal itself remaining unimpaired. In no part of the county, perhaps, is there so great a variation in the charater of the roof. In places there is a sandy rock; at other points a good hard shale; elsewhere a poor roof of soft, blue clay.

South Skunk Valley.— Comparatively little mining has been done in the immediate vicinity of the stream. The principal openings are in the neighborhood of Oskaloosa and will be considered in connection with that district. In the northwestern part of the county a few country banks have been opened a few miles south of Peoria (Tp. 79 N., R. XVII W., Sec. 12, NW. qr., NE. $\frac{1}{4}$). On the lower portion of the river the chief mines are located near Rose Hill. Several mines have been running three miles west of the station, but at the present time only one is in active operation, the Carey (Tp. 75 N., R. XIV W., Sec. 6, NE. qr., NW. $\frac{1}{4}$). The seam here worked is from five and one-half to seven and one-half feet in thickness. The coal is near the surface. The roof is a dark shale, good throughout. The coal is mined by cutting out the bottom of the bed. By this method of working the upper coal may be wedged down or by a horizontal blast may be removed in large masses which prevents the formation of very much fine coal and slack. The lower and upper coals separate easily though there is no true parting. They show a slight difference in quality, the upper part of the seam appearing brighter and heavier. A mile to the west is the White bank where coal has been mined for several years. Other country banks are situated in this vicinity and also south of Rose Hill a couple of miles, near White Oak post office.

Oskaloosa District.—Around the county seat of Mahaska centers the leading mining activities of the region; and from this point radiate no less than nine lines of railroad. The mines embraced in this district are those located in the immediate vicinity of the town.

Northeast of town on Spring creek, coal has been mined for a long period of years. The coal crops out in the banks of the creek and has been opened by means of drifts for local use. A number of important shafts have recently been sunk, the leading ones being controlled by the Central Iowa railroad. The most northwesterly mine is the Hoover (Tp. 75 N., R. XV W., Sec. 8, NE. qr., SW. $\frac{1}{4}$). The present shaft is the second put down on a ten-acre tract. The output is chiefly for local use.

Southeast of the Hoover a short distance are the Carbonado mines, two in number. There is shown here:

		FEET.	INCHES.
4	Shale, gray, micaceous, (exposed)	10	
3.	Shale, bituminous, fissile	1	6
2.	Coal	6	
1.	Fire clay, white, free from grit	3	

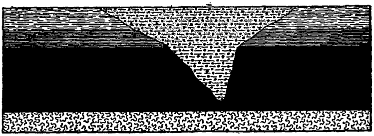


Figure 130. Coal Bed, having Erosive Channel filled with Drift Material. Carbonado Mine. Oskaloosa.

The mines have been in operation about three years, and nearly 300 acres of coal have mined, but the area worked over is considerable more than this. Much coal yet remains untouched, because of its softness or the weakness of the overlying material which consists largely of drift. The roof is a bituminous fissile shale containing many coal plants, and is overlain by from ten to forty feet of peculiar gray shale. The shafts of the Carbonado mines are ninety and ninety-four feet deep. The seam is from four and a half to seven feet in thickness, averaging perhaps six feet. It is quite undulatory, so much so that two mules are sometimes required to haul out one mine car from the side entries to the tail rope in the main entry. In parts of the mine a hard bituminous limerock is found near the top of the seam. A troublesome fault has been encountered near the north boundary line of section 8. This "trouble" is probably a preglacial channel, though the quality of the coal remains unchanged to the sharp line dividing it from the drift material, which takes its place. The old channel has been traced over a quarter of a mile to the northwestward, widening out rapidly in that direction. Within the corporate limits of Oskaloosa (Tp. 75 N., R. XV W., Sec. 18, SE. qr., SW. ¼), the Economy mine has lately been opened in a five foot seam of coal, lying at a depth of eighty feet. The roof is said to be similiar to that at the Carbonado.

At the works of the Oskaloosa Paving Brick Company a thin seam of coal was formerly mined for use in the plant, but no coal is now taken out. There were several other mines on a branch of Spring creek near the Oskaloosa and Spring Hill road, but these are now deserted.

West of Oskaloosa extensive mining has been carried on though many of the openings are now worked out. Within the city limits is the Long mine (Tp. 75 N., R. XVI W., Sec. 23, NE. qr., NE. ¼). The shaft is ninety feet deep, with coal from three and one-half to seven feet in thickness. An eroded channel cutting out the coal has been found about a quarter of a mile northwest of the shaft. The output is shipped over the C., R. I. & P. and the B. & N.W. railroads. The Reigel mine is a local opening situated just south of Oskaloosa College. In the same neighborhood there are a number of abandoned mines on the south side of the Rock Island railroad. Among these are the Acme and Standard mines, both of which have been deserted for several years. The mines now in operation in this vicinity are five in number, of which the Oskaloosa No. 1 is the largest. It is situated southwest of the Reigel (Tp. 75 N., R. XVI W., Sec. 23, SE. qr., NW. ¼). The shaft is eighty feet deep, with coal from six to seven feet in thickness. The mines of the Standard Coal Company were situated in the southwest quarter of the same section. On the north side of the road near this place is the McFay and Cook slope which has recently been opened. The coal is four feet, four inches in thickness. In the extreme northwestern corner of the same section is located the Guthrie shaft, on the Oskaloosa and Bellefountaine road, half a mile west of the city limits. The shaft is sixty feet deep, with an average of six feet of coal. Three feet of coal are also exposed in a brick yard at this point. The following is the association of strata:

	FEET.
6. Soil	2
5. Fine gravel	2
4. Clay, yellow, joint	12
3. Clay, blue	10
2. Coal	3
1. Clay, drab (exposed)	1

In the exposure the coal shows a marked dip to the southwest, but this is merely a local inclination of the seam. A short distance west of the Guthrie opening is an abandoned mine called the Logue, and in the same vicinity several others. Recently, a short distance west of the Guthrie place, a new slope has been opened in four and one-half feet of coal; and a short distance still farther northward the Andrews mine, which is a shallow shaft working three and one-half to five feet of coal. At this place the seam is about thirty feet above the railroad track and appears to have a general inclination northwestward.

Muchackinock Valley.— This has long been known as one of the most important mining districts of the county. The development of the coal industry along this particular line is probably due largely to the building of the Des Moines Valley railroad along this creek, leaving the Des

Moines river at the southern border of the county. Toward the northern edge of the district extensive mines were formerly in operation near Leighton, but at the present time little coal is taken out in the immediate neighborhood of the station. The openings are nearer Fishville than Leighton, and properly belong to this district. The old Leighton mines are located just northwest of Fishville station (Tp. 75 N., R. XVII W., Sec. 1, SE. qr., NW. $\frac{1}{4}$). The principal one is a shaft thirty feet in depth and is now known as the Davis mine. The coal is

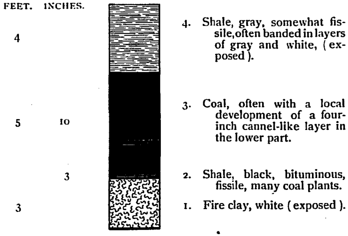


Figure 131. Coal Bed with Clay Partings, in American Slope. Evans.

five feet in thickness. The roof of the seam is a hard shale and forms a good covering. In the same vicinity were several drifts known as the Hoover mines. A short distance to the southwest is the Patterson shaft, which is seventy-six feet deep and working four and one-half to five and one-half feet of coal. Near the station is Fishville No. 2 (Tp. 75 N., R. XVII W., Sec. 12, NE. qr., NE. $\frac{1}{4}$). It is a shaft fifty feet deep. Fishville No. 1 is a drift now abandoned.

A mile farther down the creek, and a half a mile west of Evans, is the American mine, one of the largest in the state (Tp. 75 N., R. XVI W., Sec. 18, NW. qr., NW. ¼). The mine has been in operation for nearly fifteen years, and coal is taken out for more than a mile from the mouth of the slope. Electric haulage is used throughout the mine. There is a double entry, the loaded cars going out one and the empty ones returning through the other. The two entries are separated by a wall of coal. The seam is quite regular and averages about six feet in thickness. Faults are few, but several rolls occur. The section shown in the mine is indicated in figure 131.

In some places a thin seam of cannel and slaty coal occurs near the middle of the seam. These boney layers

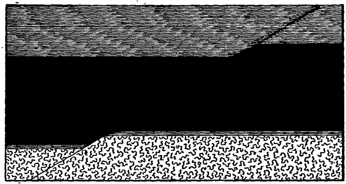


Figure 132. Fault in American Mine. Evans.

vary from two to six inches in thickness. Ironstone nodules also occur, usually near the top of the seam. In one place these concretionary masses are upwards of twelve feet in length and two feet in thickness. A few small faults have been observed in different parts of the mine, one being represented in the accompanying figure (132). Another slip is shown in the following figure (133), the line of movement passing through an irregular band of hard ironstone and showing a change of direction in passing from the softer to the harder layer. There is an old abandoned shaft near the American mine from which coal was formerly taken out in considerable quantities. A mile and a half directly south of Evans is the Hull mine.

In the vicinity of Beacon mining has been carried on quite extensively. North and northwest are a number of abandoned mines. A short distance west of the station is located the Garfield mine, which is a drift. The coal is from four to six and a half feet in thickness with an average of about five feet. In places there is an impure

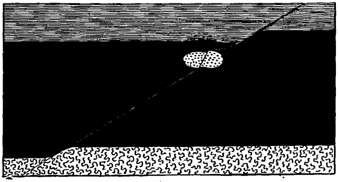


Figure 133. Fault in American Mine, Evans. Line of Slip Passing Through Irregular Ironstone Band.

limerock from one to three feet in thickness separated from the coal by six inches to one foot of drab shale. At one point the upper portion of the coal is separated from the lower part by several inches of black shale. A short distance to the southwest is the Greene mine, where the coal seam is sometimes seven and one-half feet in thickness. The roof is charged with the remains of coal plants. A fourth of a mile west of the Greene mine is the Oskaloosa No. 2. In the same vicinity is the American mine, which is not in operation yet, and the Mahaska mine, which has been abandoned. South of

Beacon there are two important mines. The Northwestern or Consolidation No. 8 (Tp. 75 N., R. XVI W., Sec. 34, SW. qr., SW. ¼) is a shaft 108 feet deep. The Oskaloosa No. 3 is a short distance to the northeast. It is sixty feet deep with coal five and one-half to six feet in thickness, and covered by a dark bituminous limerock.

East of Beacon are a number of abandoned mines which are said to have operated in coal six feet in thickness. Two miles southeast of the station is the Consolidation No. 7 (Tp. 76 N., R. XVI W., Sec. 36, NE. qr., NE. ¼). It is 150 feet deep. The strata at the bottom of the shaft show:

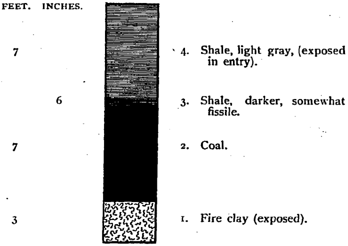
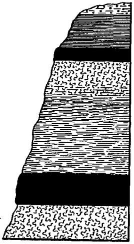


Figure 134. Coal Bed at Consolidation No. 7. Muchachinock.

Three-fourths of a mile to the southeastward is the Consolidation No. 6. A short distance beyond is the Smith, a shaft 150 feet deep with coal four and one-half to seven feet in thickness. The roof is bituminous limestone and is commonly called "hydraulic rock."

West and southwest of Given station are a number of deserted mines. The Griffith shaft is a country bank of considerable importance. The bluff near the mine shows the following sequence of layers:



		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 135. Bluff at Griffith Drift. Given.

The old Ellis bank was near here and also the Thompson and Eureka mines.

Three miles to the southeastward is an important mine — the Pekay (Tp. 74 N., R. XV W., Sec. 20, NW. qr., NW. ¼). The coal is from four and one-half to five and one-half feet in thickness. The section is shown by the following:

		FEET.
3.	Shale, dark colored, greatest thickness observed	8
2.	Coal, normal thickness	6
1.	Fire clay and light colored shale (exposed in entry below fault)	9

A few hundred feet south of the shaft in the main entry the coal rises and is faulted as shown in the following figure 136.

Figure 136. Fold and Step-Fault at Pekay Mine. Muchachinock.

In a distance of twenty-five yards the strata rise nine feet. There is a fault having a throw of about two feet. Five yards farther on there is another drop of five feet. From this point the strata gradually fall, reaching to the level of the track in a distance of forty feet. There are also in this distance three sharp bends or jogs in the coal bed. These are slight, for the coal seam has not been fractured. Mining has also been carried on along Lost creek and in the vicinity of Eddyville, but little operating is being done at the present time at these localities.

In the southeastern corner of the county, at Fremont, is an exposure showing indications of coal. The section is shown in figure 137.

Southwest Mahaska.—Along the Des Moines river coal has been taken out at a number of points. Near the mouth of Cedar creek, half a mile south of Bellefountaine, there is an exposure showing the upper eroded surface of a thick sand formation, which may be the southern extension of the Redrock sandstone. The representation is shown in cut 138.

The measurements represented are about 200 feet for the horizontal and seventy-five feet for the vertical. The sandstone is capped by about eight feet of compact, somewhat earthy limestone. Both have been deeply eroded by

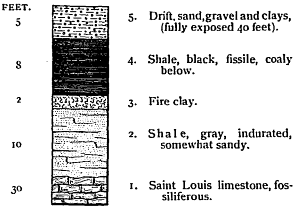


Figure 137. Part of Quarton Prospect Shaft. Fremont.

an ancient water course having a channel in an east and west trend. This channel has been filled with dark clay and shale from twenty to thirty feet in thickness. Then there is a bed of coaly shale, somewhat irregular, and rising rapidly towards the east, where it is four feet in thickness. Towards the west it thins out to about eigh-

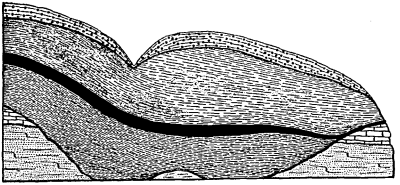
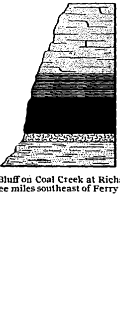


Figure 138. Section at Mouth of Cedar Creek. Below Bellefountaine.

teen inches, rising over the limestone. This coaly layer is covered by thirty to forty feet of argillaceous and sandy shale. A short distance south of the section named, which is at the iron bridge over Cedar creek, is the Hollowell mine, and a mile east of the bridge is the Ream. A short distance below the latter is a high cliff known locally as "The Bluffs," which extends for a distance of nearly two miles along an old channel of the Des Moines river. It forms a mural escarpment of massive sandstone seventy-five to 100 feet in height. A few miles down the river, near Ferry post office, coal has been mined for local use in a number of places. Three miles to the southwestward are several openings which are known as the Richardson mines. The principal one is now called the Day opening (Tp. 74 N., R. XVII W., Sec. 15, NW. qr., SW. $\frac{1}{4}$). The section is shown by the following:



FEET.	
2	5. Sandstone, massive, somewhat ferruginous, with many coal plants.
4	4. Shale, black, carbonaceous, with numerous coaly layers.
6	3. Coal, rather slaty.
2	2. Fire clay, dark gray.
4	1. Sandstone, thinly bedded, somewhat shaly, (exposed to water level).

Figure 139 Bluff on Coal Creek at Richardson Mine. Three miles southeast of Ferry P. O.

CHAPTER X.

COAL BEDS OF SOUTHEASTERN IOWA.

The counties of this district which produce coal lie partly along the eastern margin of the Iowa coal field, partly within the most productive area of the region, and partly on the border of the Upper Coal Measures. In the eastern half of the district the Lower Carboniferous limestones are exposed in the beds of all the principal streams and occasionally even in the uplands. In the extreme southeastern portion still lower members of the Lower Carboniferous are shown — the upper portion of the Augusta beds as far down as the upper part of the Burlington limestone. Eastward the Coal Measure strata thin out and pass into isolated outliers. To the westward the most productive part of the Coal Measures come to lie deeper and deeper until in the westernmost counties they are at depths of three to four hundred feet below the present surface of the ground.

The counties included in the district of southeastern Iowa are: Keokuk, Lucas, Monroe, Wapello, Jefferson, Wayne, Appanoose, Davis, and Van Buren.

KEOKUK COUNTY.

This county lies along the eastern margin of the coal field, and the Coal Measure strata are consequently comparatively thin. Nevertheless, this region ranks among the more important coal producing districts of the state. Fully one-half of the county is underlain by coal bearing layers which have been proven to contain a relatively large amount of workable coal.

The northeastern half of the county is occupied almost entirely by the Lower Carboniferous limestones. These are also well exposed at short intervals along the larger streams from the east to the west county lines. These limestones form the basement upon which the Coal Measures rest, and they manifestly lie at no very great depth from the surface even in the western part of the county. The principal portion of the limestone found is the uppermost member of the Lower Carboniferous, the Saint Louis formation. The Augusta limestone, including both the Burlington and Keokuk formations, appears to be well represented in the eastern part of the region.

The Saint Louis rocks, however, are by far the most important of the beds making up the Coal Measure basement. The surface is very uneven, having a relief not unlike the present topography of the county even where it underlies the Coal Measures. The character of the irregular surface of the Saint Louis limestone has been fully described in connection with remarks on the adjoining counties. Yet there are some particular features shown in Keokuk county which deserve special attention. Like in the neighboring counties there are wide ridges and valleys, many of considerable extent, with minor ones opening into them in all directions. With the broken relief of the surface when the Coal Measures were laid down the latter were allowed to accumulate in unusual thickness in places. Were it not for this fact no coal would now be preserved within the limits of the county. Under other conditions the limestones would be too near the surface and the drift would be too deep to allow the preservation of much of the Coal Measures. Under the existing circumstances there are numerous basins which, though limited in many cases, are in a few quite extensive, affording good deposits of coal. One of the most notable seams is in the What Cheer district. There are probably also outliers of Coal Measure strata in different parts of the county, but only in a few cases have they been definitely located.

The principal mines of the county are situated in the neighborhood of What Cheer, in the northwestern corner. At this point an important mining industry has been developed during the past few years, and some of the largest and best equipped mines in the state have here been

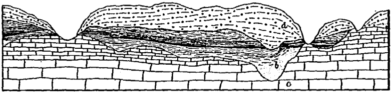


Figure 140. Ideal Cross Section through the What Cheer District from Rock Creek to the North Skunk River.

opened. The character of the formations at this point would at first glance not seem to warrant the great mining activity which at present exists. Eastward within two miles of the town the Saint Louis limestone outcrops on Rock creek, where it has been quarried. It is also known to occur at the surface within six miles to the west and the same distance to the south. The known outcrops of the neighborhood and the borings which have been made in the district show very clearly that the Coal Measures at this point occupy a considerable depression in the limestone, the basin having approximately an area of forty to fifty square miles. The relations between the two formations are graphically represented in figure 140, an ideal section through the Coal Measures in a southwesterly direction from the old quarry on Rock creek to the North Skunk river. Between Rock creek and Coal creek is a small basin in which lies the coal worked in the Armstrong mine. In the bed of Coal creek the limestone was formerly exposed and is shown in the section. It probably represents a hummock protruding through the coal rather than a ridge entirely separating two basins. West of this is the coal worked in the What Cheer No. 1, which is cut out farther west by a sandstone "fault." South and west of here the limestone is known to lie much deeper, probably on account of more profound erosion. Beyond, the conditions seem to have been favorable for coal deposition, though the limestone is again exposed at the surface in the valley of the North Skunk. To the south and west there appears to have been a large bay or series of basins in which most of the Mahaska county coal was laid down. While coal in the What Cheer area may not be found over all of the basin, and while in places it may not be at present available, owing to the drift lying immediately over it, the seams are sufficiently thick for profitable working over a considerable portion of the area. The vein worked lies about thirty-five feet above the limestone, and from twenty to one hundred and twenty-five feet below the surface, according to the surface relief. It is underlain by fire clay, five or six feet thick, and is covered by a thick band of black, fissile shale which is said to reach in places a measurement of several feet.

The phenomena observed in regard to the lithological characters and the arrangement of the beds seem to indicate that the conditions under which they were formed were manifestly quite favorable to the accumulation of the coal forming material; yet not sufficiently uniform and undisturbed to allow the formation of a perfectly continuous layer. In one place local disturbances allowed an influx of clay sediments during the deposition of the coal. This is well shown in a ridge of bony coal in the What Cheer No. 4. Again ridges and spurs of clay or sand material run out into the coal basin as noted just west of the Black Diamond mine. Low hummocks or ridges of underlying limestone protrude through the coal in several places. Thus, in driving an entry in the Armstrong mine a bench of the Saint Louis limestone was encountered.

Since the formation of the coal in Keokuk the strata of the district have been subjected to considerable erosion. Agencies of this character have also co-operated in interrupting the continuity of the seams. Channels of greater or less extent are found cut directly out of the coal beds, carrying also portions of the underlying layers. One of these ancient gullies, now filled with sand and shale, has been noted in the What Cheer No. 5. It is represented in figure 141, in which the coal is cut off abruptly, and the space occupied by sand. The face of the coal in contact with the sand is badly weathered for a distance of several inches. The following is the section of the coal seam:

	FEET.	INCHES.
3. Shale, black, fine grained, fissile	2	
2. Coal, fine, even textured	6	6
1. Fire clay, fine, gray		6

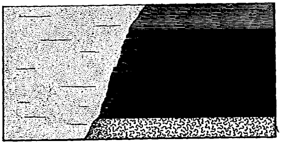


Figure 141. Seam at What Cheer Mine No. 5. Coal cut out through Erosion. What Cheer.

Despite of all the modifying conditions mentioned and the inherent improbability of any very extensive coal deposits so near the margin of the coal field, a very considerable amount of the mineral has been already found and large quantities mined.

The principal operations in this district have been carried on by the What Cheer Coal Company. Five large and important mines have been opened, two of which (Nos. 2 and 3) have been entirely worked out. No. 1 is located a mile south of the town of What Cheer (Tp. 76 N., R. XIII W., Sec. 15, SW. qr., NW. ¼); Nos. 2 and 3 are about two miles northwest of town; No. 4 about two miles directly north (Tp. 76 N., R. XIII W., Sec. 3, NW. qr., NW. ¼); and No. 5 half a mile still farther to the west. For several years past all of these mines have been worked on a large scale, and they may be regarded as among the most important in the state. A quarter of a mile northeast of the What Cheer No. 1, on Coal creek, is the Armstrong mine. The coal is of about the usual thickness and in places is within twenty or twenty-five feet of the surface. Between the two mines the Saint Louis limestone lies in a narrow ridge and was formerly exposed and quarried near by on Coal creek. A mile east of the What Cheer No. 3 is the Black Diamond, a small mine which is about forty feet in depth. In the same vicinity is the old Smith and Rowley mine. The Crescent Coal Company has opened important mines in this district; the Vulcan (No. 2) is a mile northwest of the What Cheer No. 5 (Tp. 77 N., R. XIII W., Sec. 33, SW. qr., SW. ¼); and No. 3 half a mile west of the What Cheer No. 4. The company has recently located a body of coal a short distance west and are making preparations to open it. Half a mile northeast of the What Cheer No. 5 is the shaft called the North Star, which supplies considerable coal for local trade. Two miles directly north of the latter is the Pioneer mine, opened by a company at Thornburgh. This company formerly operated a small local mine but recently sunk a new shaft a short distance north of the other one, and are now getting out considerable coal. The section shows:

Figure 142. Coal Bed at Pioneer Mine. Thornburgh.

Many other mines have been opened in the vicinity of What Cheer, or have been opened from time to time between What Cheer and Thornburgh, but most of these are now deserted. Among the principal ones were the Keystone, Morgan, Blancquardt and Carroll mines. Directly east of What Cheer the coal is near the surface and is reached at several points by means of slopes.

Six miles directly south of What Cheer is the town of Delta. Two miles south of this place on the North Skunk river is an exposure of coal, while both up and down the river the Saint Louis limestone outcrops. The Coal Measures here apparently lie in narrow troughs. Several openings have been made in this vicinity (Tp. 75 N., R. XIII W., Sec. 13, SE. qr., NE. ¼). The coal lies a short distance above the river bed and is reached by drifting from the valley. The seam is from three to three and one-half feet in thickness, and is covered by a black shale. The mines are local; the two principal ones being the Fisher and the Hickman & Chandler.

North of Sigourney, the county seat, a small coal seam has been encountered and has been worked to some extent by drifts. The vein lies along Bridge creek, about two and a half miles from the town. Several openings have been made, but only one, the Rowley (Tp. 76 N., R. XIII W., Sec. 23, SE. qr.) is now in operation. The same coal has also been reached by means of a shaft from the top of the hill. The coal is from three to four feet in thickness. A section measured in the opening is as follows:

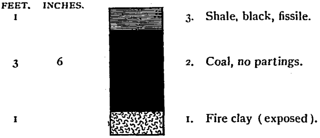


Figure 143. Coal Bed at Rowley Mine. North of Sigourney.

This mine supplies coal for only local use.

Near Richland, in the southeastern part of Keokuk county, is a small coal field apparently more closely connected with the Jefferson county area than with either that of Washington or the remainder of Keokuk county. The coal lies at a depth of about eighty feet. The greater portion of the covering is drift, only a few feet of a light shale being found over the coal. It usually runs from three and a half to five feet, but in places is only four inches thick or thins out altogether. It is apparently distributed in small basins of no great extent. The coal is of fair quality and in the main of good workable thickness, but it is quite irregular in its distribution and usually has a poor roof. These difficulties make the mining a matter of considerable extra expense, and were it not for the lack of competition and the resulting high price, the coal could probably not be taken out profitably. A number of local mines have been opened here, but only two, the Smith and the Cordis, are now working. Both supply considerable coal for local trade. The Smith mine is located about four miles south of Richland (Tp. 74 N., R. X W., Sec. 31, SE. qr., NE. ¼) near the old Rambo mine. The coal averages four feet in thickness. The roof is a gray clay shale from six to ten feet thick and requires considerable timbering. The section seen in the mine is:

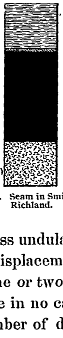


Figure 144. Seam in Smith Mine. Richland.

The coal is more or less undulatory and shows in places step faults with a total displacement of six feet or more. A few clay seams and one or two "pinch outs" have been met with. The latter are in no case of great extent.

Near this mine a number of deserted mines exist. It is customary in this field to work only a small area from each shaft and when any difficulty is encountered the mine is abandoned and a new one opened. In this way as many as five shafts have been sunk on a forty acre tract.

About one mile east of the Smith mine is the Cordis mine, which is on a branch of Richland creek. This mine works in coal similar to that at the Smith mine and probably belonging to the same coal horizon. The roof here is of the same character and the coal from three to four feet thick. The fire clay under the coal here is said to be fifteen feet in thickness. In the vicinity are also many abandoned mines.

In the southwestern portion of the county coal is said to occur at a few points. It has been encountered about one and a half miles northeast of Fremont at a depth of 154 feet, but has never been worked.

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, the 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.

No Lower Carboniferous limestones are exposed at the surface within the limits of the county. They have, however, been reached at different points in boring and are known to lie at depths of from 300 to 400 feet or more from the surface. They present the same irregularities of the surface as are developed at other places where the Coal Measures are very much thinner. At Cleveland and Lucas, in the western part of the district, the limestone has been encountered at one point at a depth of 300 feet.

The drift of this county, though having a considerable thickness over most of the area, is apparently not so great as it is known to be in some of the adjoining counties.

The stratified rocks immediately underlying the drift belong entirely to the Coal Measures, by far the greater part of which is the lower division. Along the western margin of the county the Upper Coal Measures have been recognized in a few places. Several coal horizons have been recently found in Lucas county. In general there appears to be a zone of horizons near the surface. These are exposed east and north of Chariton and in the north-eastern corner of the county. Another horizon is about 250 feet below, which yields a much greater amount of coal. The seam varies in thickness from one to seven feet.

Whitebreast Valley.—The most extensive developments of the lower Coal horizons have been made along Whitebreast creek in the western part of the county where the seams are a considerable distance beneath the surface. The mining industry of the county has been carried on more vigorously near Cleveland and Lucas than anywhere else. In this locality four and in some places five seams of coal are known to occur. The first is very thin and often absent in many places on account of preglacial erosion. A short distance below this one is a seam of rather poor quality. It is about eighteen inches in thickness. At a depth of from sixty to eighty feet there is a third vein of coal varying from eighteen to thirty inches in thickness, with an average of about two feet. This coal is well shown in the Lucas and Cleveland mine, where the section is:

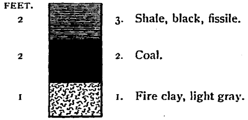


Figure 145. Coal Bed at Lucas and Cleveland Mine. Cleveland.

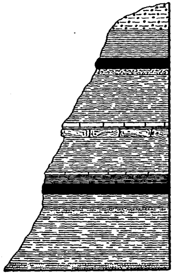
The coal is of very good quality and while the seam is somewhat irregular it has been worked with profit at a number of localities. Below this, at the depth of from 270 to 300 feet from the surface, is the vein which has been the principal one worked in the district. The coal is from three and one-half to seven feet in thickness. The roof is a rather soft shale and consequently not very good in places. Another thin seam has been found below this one, while thirty-five feet below the principal seam the Saint Louis limestone has been encountered at certain points.

The Whitebreast Coal Company formerly operated three large shafts in this region which were at one time the most extensive and best equipped mines in the state. No. 1 was near the town of Lucas (Tp. 72 N., R. XXIII W., Sec. 13, SE. qr., NE. $\frac{1}{4}$); while Nos. 2 and 3 were about five miles farther west. These mines were operated for several years and during that time large quantities of coal were taken out. The combined annual output at one time was nearly half a million of tons.

About half a mile northwest of the Whitebreast No. 1 is the old Chariton mine. Half a mile southwest of the same mine is the Eikenberry shaft; while about the same distance still farther in the same direction is the new Lucas shaft where, though down 300 feet to the lower coal, only the upper seam is at present mined. The Whitebreast mines have been abandoned for some time and the top works removed. Recently the Cleveland Coal Company has purchased No. 1 and is now engaged in taking out the upper coal.

From Cleveland down the valley to the county line numerous outcrops are found in the bluffs. They have been worked by drifts for many years, but at the present time comparatively little mining is being carried on. The seams are similar and perhaps identical with those exposed still farther down the creek, in Warren and Marion counties. In the former, one of the most important seams was called at one time after the town of Lacona not far from the Lucas county line. A mile below Cleveland several small mines have been opened at various times and a little coal is now taken out during the colder months of the year. Four miles to the northeast there are two seams of coal exposed in the bluffs at several points. St. John's section taken at Wheeler mill is essentially the same as that now exposed, though at the present time the outcrop is somewhat obscured. It is shown in figure 146.

Several other exposures are met with between here and the confluence of the creek with the Little Whitebreast where a seam has been mined to some extent. The coal is rather poor, but has a thickness of from two to three feet. It is said to be exposed at several points in the bed of the creek. Eight miles northwest of Cleveland, in the valley of English creek, coal has been mined but not extensively. It is also exposed in the bluffs of



		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	⅔
4.	Shale, black, bituminous, fissile	1½
3.	Coal	1½
2.	Fire clay	2
1.	Shale, light colored, sandy in places.	10

Figure 146. Section on Whitebreast Creek. Five Miles Northeast of Cleveland.

the same stream. It is about eighteen inches thick and is covered by a stratum of black shale of about the same thickness.

Little Whitebreast District.— Coal has been mined in a desultory manner along this creek for a long time. The present groups of openings are a few miles north and a few miles east of Chariton. No deep mining has been done. The coal mined is quite near the surface and crops out at short intervals along Little Whitebreast and its tributaries. Two seams of coal have been opened at different times. These have been drifted into at numerous points, but shallow shafts are now used. The upper vein is the thinner of the two and varies from fourteen to sixteen inches in thickness. It has a hard roof of impure bituminous limestone about twelve inches in thickness and is underlain by one and a half to two feet of fire clay. Twelve feet beneath is the second seam of coal about thirty inches in thickness. It is separated into an upper bench of twenty-four inches and a lower one of five inches by a thin seam of clay. The strata encountered in the workings at the old Smith mine were:

FEET.	INCHES.	
2		. Limestone, light gray, shaly.
1	4	7. Coal.
2		6. Fire clay, light gray.
10		5. Shales, calcareous, gray clay graduating into 6.
2		4. Coal.
	1	3. Clay parting.
	4	2. Coal.
2		1. Fire clay.

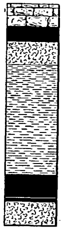


Figure 147. Section of Strata on Little Whitebreast Creek, at Smith Mine. Near Chariton.

In places the two seams come close enough together to be worked as one, but as a rule they are worked independently. The coal is rather soft and is often mined by the pick alone.

On the border of the creek directly east of Chariton, a distance of two and one-half miles, mines have been opened for more than thirty years. Many of the old diggings are now deserted. At the present time the Williamson mine (Tp. 72 N., R. XXI W., Sec. 15, SW. qr., SE. $\frac{1}{4}$) is one of the more important openings. It is a shaft and has worked an area of about 300 feet east and west and 400 feet north and south. The seam is quite undulatory but has a general dip to the southwest of four or five feet in a hundred. In sinking the shaft at this point the following strata were passed through :

FEET.	INCHES.	
7		7. Drift.
16	6	6. Shales, variable from loose gray to firm black fissile.
2	4	5. Coal.
	6	4. Clay parting.
	2	3. Coal, impure and shaly.
	8	2. Coal, firm and pure.
	2	1. Fire clay, gray, shaly in part.

Figure 148. Strata Encountered in "Williamson Shaft." Near Chariton.

Half a mile to the southeast is the Wilson mine which has only recently been opened. About a half a mile north of the Williamson are two others, the Munson and the Perry mines.

Directly north of Chariton, a distance of three miles, a vein of coal one and a half feet in thickness crops out in the creek a short distance above its bed. In the various drifts which have from time to time been opened the coal varies from one and one-half to two and one-half feet in thickness. Several slopes have also been operated and considerable coal taken out to supply local demands. At the present time the principal mines working are six or eight in number. The Smith and Maxwell opening is a new drift (Tp. 73 N., R. XXI W., Sec. 32, NW. qr., SW. ¼). Near it is the Smith mine which works two seams by separate drifts. Half a mile to the west are several small openings, among which are the Spear and Richmond mines. In the latter the following strata have been encountered:

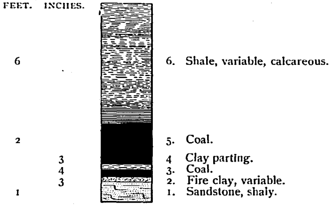


Figure 149. Coal Bed at Richmond Pit. Northeast of Chariton.

A quarter of a mile to the south is the old Maxwell drift; while a little farther on is the Porter mine. About a mile to the southwest is the Hall mine where coal is reached by a shaft twenty-five feet deep.

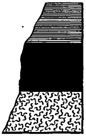
Minor Coal Localities.—In the northeastern corner of the county a few local mines have been opened in the same vein of coal which is mined to some extent in parts of Monroe and Marion county. This vein lies near the surface and is reached by means of drifts. It is from two and one-half to four feet in thickness, but has a rather poor roof in places. The mines are all on Cedar creek or its tributaries. The principal opening, the Stotts, is in the extreme northeastern corner of the county (Tp. 73 N., R. XX W., Sec. 1, NE. qr.). The Buchanan mine is a half a mile southwestward, and the Van Loon a mile directly west.

At Zero, in the extreme eastern portion of the county, on the main line of the C., B. & Q. railroad, a mine was formerly operated by the Creston Mining Company. The shaft is 260 feet deep, with coal five feet in thickness. At the place opened the seam was quite irregular, on which account the mine was finally abandoned. Just beyond the boundary of Lucas, in Marion, coal has been mined at several places; also to the eastward in Monroe. In Appanoose, a couple of miles from the Lucas county line, mining has been carried on just above Milledgeville; and also a little to the west of that place, in Wayne county.

MONROE COUNTY.

This county is in one of the most productive portions of the Iowa coal field, and as a coal producer is becoming more important every year. The stratified rocks at the surface are almost entirely made up of coal bearing strata. Everywhere they are covered by drift deposits, in some localities to a very considerable depth. In the extreme northeastern corner of the county, along the Des Moines river and for a short distance up Miller creek, the Lower Carboniferous limestones are exposed. They rise in the banks of the streams to a height of from fifteen to twenty feet, presenting the usual character of the Saint Louis formation. Although these are the only outcrops of Lower Carboniferous limestone, borings along the south and west boundaries of the county show that it lies at no very great depth below the surface. The Coal Measures of this portion of the district are there, therefore, relatively thin. In this part of the county the Saint Louis limestone presents the same stratigraphical character as elsewhere in the state; that is, the upper surface is very irregular, having been carved into hills and valleys previous to the deposition of the Coal Measures. In the center of the county and along the western and southern margins, the Coal Measures are very much thicker than elsewhere, probably more than 300 feet in many places. There are probably few localities of any great extent within the limits of Monroe where coal cannot be mined profitably, since the principal belt of the Coal Measures in the state passes through this region. The county contains some of the largest mines in the state.

Avery District.—In the northeastern part of the county including the areas comprising Pleasant Valley and Mantua townships coal has been mined extensively since the first settlement of the region. Early settlers knew of its occurrence in the Des Moines valley and it was mined at various points opposite Eddyville. Of late years coal has been worked but little in this vicinity, and at present the exposures are greatly obscured. The upper part of the bluff directly opposite Eddyville shows indications of a coal seam, probably the same found by Worthen in his trip up the Des Moines valley nearly forty years ago. This section is as follows:



FEET.	INCHES.	
3		3. Shale, bituminous.
4	6	2. Coal.
1		1. Fire clay (thickness not fully ascertained).

Figure 150. Bluff on Des Moines River, showing Coal Seam. Opposite Eddyville.

The coal now worked in the northeastern part of the county lies at a somewhat greater depth than the seam just referred to. It varies considerably in thickness, ranging from three and a half to six feet, with an average perhaps of about four feet.

Four miles southwest of Eddyville, at Coalfield, the Pleasant Valley mine is operated on a small branch of Miller creek (Tp. 73 N., R. XVI W., Sec. 16, SW. qr., SW. ¼). Different mines have been successively operated here at various times, but this is the only mine now taking out coal. It is a slope which has been driven back into the hill for a distance of 800 feet or more. The coal varies from three and a half to four and a half feet in thickness and is quite hard and clean. The vein dips slightly to the south and is covered with a heavy black shale which forms an excellent roof. The beds associated with the coal are:

Figure 151. Bed in Pleasant Valley Mine. Coalfield.

Three miles southwest of Pleasant Valley is the Hickory mine apparently operating the same seam. The roof at this point is a sandstone instead of a shale. The dip is to the southwest and quite noticeable, being about ten feet in a hundred. Half a mile east of the Hickory is the Chisholm mine. It now belongs to the Whitebreast

Coal Company. It is a large mine, and is situated about half a mile from the C., B. & Q. railroad.

Near the station of Avery, coal is mined quite extensively. The Smoky Hollow mine, which is situated two miles east of the station (Tp. 72 N., R. XVI W., Sec. 10, NE. qr., SW. $\frac{1}{4}$), has connection with the C., B. & Q. by means of a private railroad. The coal is five feet in thickness and is reached by a slope, the main entry having been driven back nearly three-quarters of a mile. In the course of this work several channels filled with Carboniferous strata were encountered, showing that immediately after the deposition of the coal it was cut out and removed by strong currents. In places the coal is replaced for about one hundred feet by soft, buff sandstone. The same gray clay shale forming the roof has filled another cut out. In this mine five seams of coal are known to occur; there are two, varying in thickness from one to two feet, which are found twelve and twenty-five feet above the coal now mined. The section is:

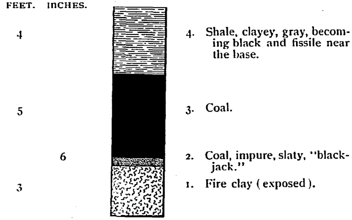
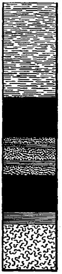


Figure 152. Coal in Smoky Hollow Mine. Avery

At several localities there were formerly small mines operating in this neighborhood, but as the territory controlled was worked out, they were deserted. The Moyle mine, a quarter of a mile west of Smoky Hollow, is one which was only recently abandoned.

Two miles northeast of Avery station, at Fredric, is a small group of openings, only one of which is now in active operation. This one is worked by the Fredric Coal Company. It is a shaft about forty feet in depth, and works a seam three and one-half feet thick. A band of clay ironstone, thirty-two inches in thickness, runs through the middle of the seam and causes considerable trouble in mining. The difficulty is overcome to a certain extent by the adoption of the long wall plan. The arrangement of the details is:



FEET.	INCHES.	
4		6. Shale, gray, bituminous in part.
1	10	5. Coal.
1	8	4. Shale, bituminous, containing band of impure coal and clay ironstone.
1	7	3. Coal.
	6	2. Shale, bituminous, with streaks of impure coal.
2		1. Fire clay (exposed).

Figure 153. Part of Fredric Shaft. Fredric.

Immediately east of this mine is the Akers, and about half a mile to the northwest is the old Eureka shaft.

Albia District.—In Troy township, in which Albia and Gifford, lying immediately to the west, are located, quite a number of large mines have been operated for some time. North of the town two thin seams of coal have been worked. They lie near the surface and are easily reached by slopes. The upper one is usually about twenty inches thick. The second lies eleven feet below and is slightly thicker, running as high as three feet. It is more extensively worked than the other. A hard black shale overlies the seam, forming a good roof wherever it is mined, while the comparatively soft under clay greatly facilitates the work of removing the coal. "Troubles" are few, but the vein is more or less undulatory. The coal is taken out at the King mine, about one and a half miles north of Albia (Tp. 72 N., R. XVII W., Sec. 10, SE. qr., SE. ¼) and at the Brewer shaft in the northwestern part of the same section. Three miles north of the town (Sec. 2, NW. qr.) is the Barnhill mine. Other openings have been made, reaching the coal at various points, but none are now in operation.

West of the city is an important group of large openings known, collectively, as the Cedar mines. The coal here varies from four to six feet in thickness and is from 120 to 150 feet below the surface, the difference of course being due mainly to the inequalities of the surface. The coal is somewhat undulatory, the variation of the different parts of the bed being eight to ten feet. The roof is a hard, black shale which is four feet or more in thickness. The Enterprise mine is located about one and a half miles west of Albia (Tp. 72 N., R. XVII W., Sec. 17 NW. qr., SE. ¼). Near it is the Iowa and Wisconsin mine, locally known as the Jack Oak, giving the following section:

	FEET.	INCHES.
3. Shale, gray, becoming bituminous below....	2	
2. Coal, normal thickness 4½ feet, here decreased by a "roll" to..................	1	7
1. Fire clay (exposed)........................	5	

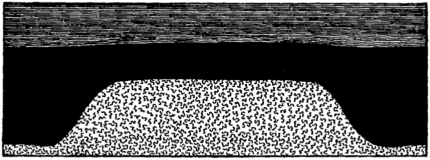


Figure 154. Coal Bed and "Horseback" in Iowa and Wisconsin Mine. Albia.

A short distance to the west is the Chicago and Iowa mine. These are all important mines with a large annual output.

About four miles northwest of these mines (Tp. 72 N., R. XVII W., Sec. 11, NE. qr., SW. ¼) is the Heitman, owned by the Wapello Coal Company. This is one of the largest mines in the state. It is connected with the main line of the C., B. & Q. railroad by a private track. The shaft is 142 feet deep and entries have been driven north 2,400 feet, south 800 feet, and west 2,500 feet. The coal runs from five to six feet in thickness, and is in good position for mining. A smaller eight-inch seam occurs about eighty feet above the one now worked, but is nowhere thick enough for profitable mining.

Soap Creek Valley.—In the southeastern part of the county at least three seams of coal have been at different times opened up. One of these now exposed, on a small ravine southeast of Foster, is eighteen inches thick. It is covered by a black shale which at the exposure is thin, but is said to thicken considerably, farther in the hill. This coal has been opened at several points but is almost too thin for profitable working, so that very little of it has been taken out.

In the banks of the creek itself just north of Foster (Tp. 71 N., R. XVII W., Sec. 24, SE. qr., SW. ¼) are the old workings of the Soap Creek Coal Company. These consist of a couple of drifts which have been driven a considerable distance back into the hill. The coal is now only partly exposed, a section measured in an old slope showing:

	FEET.	INCHES.
4. Shale, gray, clay	2	
2. Coal	2	3
3. Clay		7
1. Coal		10

This property has passed into the hands of the Deep Vein Coal Company, which has abandoned the upper workings and has recently put down a shaft 200 feet deep about 300 yards to the south. Three veins of coal were encountered. The first, at a depth of fifty-four feet, is thirteen inches thick; the second, at ninety feet, is eight inches, and the third, the one worked, runs from four to seven feet. The seam is exceedingly undulatory. In one entry the coal rises twenty feet in 300 and thins out from five to two feet, while the fire clay beneath thickens correspondingly. At another place the coal goes down sixty feet in 400. In some places the slopes in the mine are so steep as to require gins for moving the loaded cars. Faults of greater or less extent are also frequently met with. The throw is usually small, though in places a displacement of six feet has been observed. One is shown in figure 155.

The slides frequently form step-faults with parallel trends. In one portion of the mine there is an area about one hundred yards wide and two hundred yards long in which the coal lies sixty feet below the general level. Entries have been driven along three sides of this sunken area and its structure is now fairly well made out. The coal on all sides dips down toward the center, in places at an angle of 20°. Parallel to its edge slips, or true geological faults, are found. These have slickensides and all the phenomena usually accompanying them. The displacements have a down throw averaging about two feet. They are most frequent at the extreme edge of the basin and decrease towards the center. The coal along the lines of fault is badly seamed and cracked. The crevices are lined with calcite in broad sheets, the surface of which are

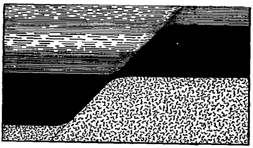


Figure 155. Fault in Deep Vein Mine. Foster.

thickly studded with beautiful crystals of dogtooth spar. Siderite is also very frequently found closely associated.

About a mile and a half west of the Deep Vein shaft is a smaller mine working in the same seam. It is owned by the Monroe Coal and Prospecting Company.

Minor Districts.— Outside of the large areas described coal has been found at numerous points and its presence at many other places may be readily inferred. In the northwestern part of the county and the adjoining portions of Marion, Lucas and Monroe, a coal field of considerable extent is known. It is probably more or less intimately connected with that of Marysville, in Marion county. The coal mined in this area varies from three to four feet in thickness. It lies near the surface and is reached by drifts.

Two mines have been opened in this portion of Monroe county. One is the May drift, a rather important local opening in the extreme northwest corner of the district (Tp. 73 N., R. XIX W., Sec. 6, NW. qr., SE. ¼). About one mile south is a smaller mine known as the Bingham drift.

In the northern part of Appanoose county, which adjoins Monroe on the south, a seam of coal which has been mined extensively is known to closely approach the county line at several places. It has been mined at Milledgeville, about two miles south of the boundary line. Another coal vein has been mined at Zero, in Lucas county, two miles west of the county limits. In Wapello county coal has been opened at Blakesburg, within a half a mile of the Monroe line; while in Marion county, on the north, the extensive Marysville coal field has been opened up within a couple of miles of the divisional line.

WAPELLO COUNTY.

The surface of Wapello county is considerably broken. The valley of the Des Moines river, which runs through the county from northwest to southeast, is bordered by steepsided ravines which branch out in all directions toward the more level upland. The drift is comparatively thin as a rule, though in places sufficiently thick to prevent the indurated rocks below from cropping out. Lower Carboniferous limestones are exposed in the bed of the Des Moines river and often rise from thirty to forty feet above low water level. These rocks, which are chiefly the Saint Louis limestones, are also found in the beds of many of the smaller water courses. The Coal Measures, however, may be regarded as occupying by far the greater part of the county immediately beneath the drift. There are exposures on all the leading streams, at many of which good coal seams have been opened by drifting. At several points veins of coal are exposed in the bed of the Des Moines river and have been quarried quite extensively. Along the river and steep bluffs, which often form high mural escarpments, these also border many of the smaller streams of the county. The principal coal mines have been opened in the bluffs on either side of the Des Moines river, the leading mining center of the county being Ottumwa.

Cedar Valley.— Although no mines of any great extent have been opened in the northeastern part of the county there are numerous indications that good deposits of coal exist in this part of the district. In the near future they will probably assume commercial importance.

Des Moines Valley.— As already stated the principal mines of the county are confined to the immediate neighborhood of the river. In the extreme northwestern corner of the county, in the vicinity of Eddyville, coal has been mined from the earliest settlement of the region. Several mines have been opened, not only in Wapello, but in the adjoining portions of Mahaska and Monroe counties. A mile below Eddyville, on the west side of the river, a vein three and one-half feet thick was mined for a number of years near the top of the bluff. The principal mines now working in the vicinity of Eddyville are about two and one-half miles east of the railroad station. The most important of these is the Dotts (Tp. 73 N., R. XV W., Sec. 3, SW. qr., SE. $\frac{1}{4}$). The average thickness of the coal seam is about four feet, but it sometimes runs as high as five feet. The vein is somewhat undulatory, but has a slight general dip northward. A mile north of the Dotts is the Clarke mine, and a mile and a half southeastward is the McGlothlin, neither of which is working at the present time. In the same neighborhood ten or a dozen or more country banks have been in operation from time to time during the last twenty years. Four miles below Eddyville coal is exposed in the bed of the Des Moines river and is sometimes quarried for local use.

Near Kirkville mining has been carried on along a small creek. The mines are located chiefly south of the town, between the village and Kirkville station. The most easterly is the Wadell. A mile directly south of the town is the Davis mine (Tp. 73 N., R. XIV W., Sec. 18, NE. qr., SE. ¼). The section in connection with the coal is as follows:

FEET.	INCHES.	
2		5. Shale, gray, somewhat sandy.
	8	4. Shale, black, fissile.
4	6	3. Coal.
	3	2. Shale, bituminous, fissile.
1		1. Fire clay, hard, sandy (exposed).

Figure 156. Bed in Davis Mine. Kirkville.

In the same vicinity were located the extensive mines of the Wapello Coal Company which are now abandoned. Coal is exposed and is mined at short intervals along the creek for a distance of several miles. Among the mines now opened here are the Bennett, which is three-fourths of a mile southeast of the Davis; the Lancey, a mile and a half southward of the same place, and the Vanderpool, which is a short distance east of the Lancey.

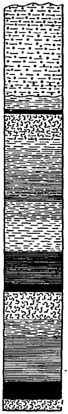
The most extensive mining in the county is northwest of Ottumwa. Near the old Union mine now deserted (Tp. 73 N., R. XIV W., Sec. 33, SE. qr., SW. ¼) coal crops out at many points.

A mile directly east of the Union working is the Daniel mine, and a few hundred yards to the south of the latter is the Keb slope or Whitebreast No. 22. It works in a vein four to four and one-half feet in thickness, probably the same which crops out for a considerable distance along a ravine opening to the south. The section shown in connection with the coal is:

Figure 157. Coal Seam with Clay Parting, Keb Mine. Keb.

The workings of this mine and the one just north of it come within a few hundred yards of one another, but the seam of the one is about thirty feet higher than that of the other mine, and a fault is thought to exist between the two. Directly south of Keb, a short distance, are several mines, the nearest of which is about a quarter of a mile away and is known as the Baker mine. The others are the Metzgar and Tailor, both of which are situated on Crockett run. A mile and a half southeast of Keb are several larger mines (Tp. 72 N., R. XIV W., Sec. 12, NW. qr., NW. ¼). These are the Phillips Nos. 2

and 4. The latter is the most northerly and is a new mine. The section of the prospect shaft is as follows:



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 158. Section of Shaft of Phillips No. 4. Ottumwa.

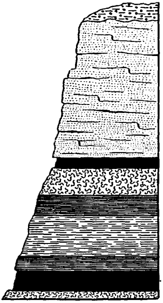
The coal seam, which is four feet in thickness, is quite even and has an excellent roof. Shaft No. 2 is a short distance southward and works in the same vein of coal. It has opened out for a distance of more than a mile to southeast from the bottom of the shaft. The Ream mine is a short distance towards the north. It is ninety feet in depth and works coal from two to three and one-half feet in thickness. Half a mile south of the Phillips No. 4 is No. 3 of the same company, and in the same vicinity are the Hawkeye, now abandoned, and the Black Diamond mines, the latter being a shaft sixty feet in depth.

In the brick yard in the western part of Ottumwa (Tp. 72 N., R. XIV W., Sec. 14, NE. qr., NW. ¼) the following section is seen:

		FEET.
10.	Shale, light colored	5
9.	Shale, dark, bituminous	3
8.	Coal	2
7.	Fire clay, and light colored shale	7
6.	Shale, bituminous, fissile below	5
5.	Coal	⅓
4.	Shale, gray and often sandy	3
3.	Shale, black	6
2.	Coal	4
1.	Fire clay (exposed)	2

The strata at this point have a slight dip eastward. A mile and half to the southeast is the Spring Hill mine, which is a shaft located within the corporate limits of Ottumwa. There are two seams of coal, one three and one-half, and the other four feet in thickness. In the middle of the upper seam, which is the vein principally worked at the present time, is a thin band of slaty coal. In Ottumwa, on the Fourth street hill, two thin seams of coal are exposed, and it seems quite probable that thicker veins exist below the visible outcrop.

Farther eastward, in the vicinity of Dahlonega, the presence of workable coal is known along the valley of Sugar creek, and country banks have been opened at intervals. Directly east of the city on the same creek several small mines are also open. Near the mouth of the creek (Tp. 72 N., R. XIII W., Sec. 31, SW. qr., SE. ¼) the following section is shown in connection with the coal worked:



		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 159. Bluff in Sugar Creek. East of Ottumwa.

About one hundred yards farther down the creek from the section given, near the wagon bridge, a thick limestone is exposed in the bed of the stream. On the south branch of Sugar creek are several exposures of coal and coaly shale with the associated fire clays and shales, the whole overlain by a massive sandstone of considerable thickness. Two seams of coal have been opened. The higher vein lies immediately beneath the sandstone and has a thickness of eighteen inches. The lower vein is thirty to forty inches in thickness and lies below the bed of the creek, about twenty-five feet below the upper seam. Considerable coal has been mined along the bluffs by stripping or quarrying. Near the mouth of Sugar creek, in the bed of the Des Moines river (Tp. 72 N., R. XIII W., Secs. 32 and 33) a seam of coal two and one-half to four feet in thickness is exposed at low water level.

Recently it has been extensively quarried by three different companies, the water being kept out by means of cribs. The coal is separated into two benches, the upper of which is more friable than the lower and contains small concretionary masses of impure limerock. A mile farther down the stream is the Vangant and Dixon mine, which at the present time is not in operation. Coal has also been taken out a short distance below this point, in the bluffs along the Des Moines river and in the sides of a small creek coming in from the north. Three miles below Cliffland station, at a place formerly known as Alpine dam, considerable mining has been carried on, especially in the early days of the settlement of the region. Between the last two points perpendicular cliffs of brown and yellow sandstone rise to a height of from twenty-five to fifty feet above the railroad track at the base.

At Eldon, above the wagon bridge, a coal seam is exposed in the river bank just above the Saint Louis limestone. Two miles directly south of Eldon, on the southwestern line of the C., R. I. & P. railroad, is the Eldon mine (Tp. 71 N., R. XII W., Sec. 32, SE. qr., SE. ¼). The section is shown in figure 160.

On the south side of the Des Moines considerable coal has been mined in Wapello, but not to the extent that it has on the opposite side of the river. In the extreme northwestern corner, near Eddyville, several mines were formerly operated but at the present time they supply only small local demands. A mile south of Dudley, on a branch of North Avery creek (Tp. 72 N., R. XV W., Sec. 4, NW. qr., NE. ¼), is the old Arnold mine which at the present time is not in operation.

Five miles west of Ottumwa and about a mile directly west of the C., B. & Q. railroad bridge across the Des

Moines river the old Union mine is located, besides several other drifts and slopes. Seven feet of coal are reported in places. Most of these openings are now aban-

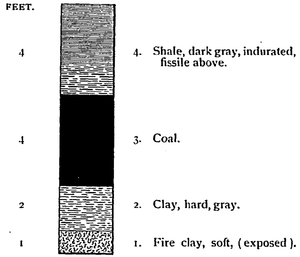


Figure 160. Coal Bed at Eldon Mine. Laddsdale.

doned, but the industry has recently been revived in this vicinity by the sinking of a shallow shaft a short distance west of the others.

Two miles directly south of Ottumwa several openings have been made, the principal one of which is the Pickwick mine (Tp. 71 N., R. XIV W., Sec. 1, SW. qr., NW. $\frac{1}{4}$). The section shown in connection with the coal is given in figure 161.

The seam is very slightly undulating and has a general dip northward. Several slips have been observed but none of the faults are very extensive. In several instances drops having a throw of five or six inches have been observed in the top of the vein, the line of dislocation dying out before reaching the bottom of the stratum. A quarter of a mile westward is the Lewis and Jones mine, a shaft ninety feet in depth and operating in coal three and a half to five feet in thickness. Several other shafts are located in this vicinity, among which is the Styre mine. The seam of coal worked here is probably the

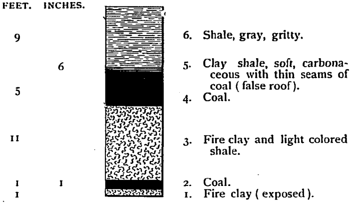


Figure 161. Bottom of Shaft in Pickwick Mine Ottumwa.

same as that found in the bed of the Des Moines river three miles to the east.

Bear Creek.—This stream rises near the western county line, near Blakesburg, and runs directly eastward, emptying into the Des Moines at Ottumwa. Mines have been opened at various points along the creek, especially since the C., M. & St. P. railroad has built its southwestern line in the valley of this stream. Three miles northeast of Blakesburg is the Appanoose mine (Tp. 72 N., R. XV W., Sec. 33, NW. qr., NE. ¼). The main entry has been driven nearly half a mile from the bottom of the shaft, the coal thickening towards the northeast. The section is as follows:

	FEET.
4. Clay shale, black, somewhat fissile	10
3. Coal	4
2. Fire clay	2
1. Shale, carbonaceous, fissile (exposed)	1

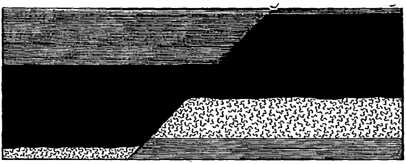


Figure 162. Coal Bed, with Fault, in Appanoose Mine. East of Blakesburg.

A mile and a half northwest of the Appanoose are several openings, among which is the Major mine. East of the Appanoose are also mines, the Willard being the most important A few miles below, the coal crops out in the bed of the stream. Farther down it is overlain by massive sandstone. Between this point and Ottumwa coal appears at many places and country banks have been opened.

JEFFERSON COUNTY.

Coal has been mined in commercial quantities in Jefferson county for a greater period probably than in any other similar district in the state. This is probably due partly to the early settlement of the region and partly to the fact that the veins worked are confined chiefly to the hills, where many natural exposures occur and where the coal may be readily reached by drifts, slopes and shallow shafts. Consequently for many years this county has ranked among the more important coal districts of the state and the production at one time was upwards of 50,000 tons per annum.

Although the county is underlain everywhere, at no great distance below the surface, by the great limestone series of the Lower Carboniferous age, this formation has a comparatively limited surface distribution. It appears only in the immediate vicinity of the larger streams in the eastern part of the county; along the Skunk river, where it extends in places well up into the bluffs, and in the beds of some of the smaller tributaries of this stream, where it is exposed for a distance in some cases of several miles above their mouths. On Cedar creek the Lower Carboniferous limestones extend more than half way across the county to a point three miles directly southwest of Fairfield. The rocks of the same age probably occur in very limited areas in the southwestern corner of the county where it nearly reaches the Des Moines river. The basal limestone which is exposed in Jefferson belongs to the Saint Louis formation—the only member of the Lower Carboniferous series known to occur in the district. Like in all of the neighboring counties, the Saint Louis rocks present an upper surface which is very uneven, showing evidence of profound erosion previous to the laying down of the Coal Measure strata. In this county the thickness of the Coal Measures varies greatly, even if measured from a perfectly level horizon above.

With the exception of the smaller areas of the Saint Louis limestone just mentioned, Jefferson is entirely underlain, immediately beneath the drift, by Coal Measure strata. The thickness varies greatly in different places from a few feet to a maximum of possibly 200 feet, the average vertical measurement being probably in the neighborhood of seventy-five feet. Although the coal has been mined at numerous localities throughout the county, its disposition is not in a single layer or in two layers extending entirely over the region, as was formerly supposed, but is formed into innumerable pockets of quite limited extent. These small basins are situated at many different horizons and overlap and interlock one another on all sides. In most cases the coal lies but a short distance above the limestone basement and, towards the eastern margin especially, even comes in contact with the underlying calcareous rocks. The occurrence of the

FEET.	INCHES.	
33		28. Drift.
3		27. Sand.
20		26. Clay, dark, shaly.
6		25. Shale, black.
3	6	24. Coal.
10		23. Fire clay and shale.
3	6	22. Coal, shaly.
2		21. Fire clay (exposed).

Figure 163. Section of Shaft of Washington Mine Perlee.

coal deposits in many small basins is, perhaps, more apparent in Jefferson county than in any other district in the state.

Near Perlee, seven miles northeast of Fairfield, the preceding section (figure 163) was passed through in sinking a shaft of the Washington Coal Company about a mile east of the station.

A prospecting hole, put down by I. P. McElhaney, beginning just below the coal vein worked, gave the following section:

		FEET.	INCHES.
21.	Mixed clays	18	
20.	Gray shale	10	
19.	Sandstone	12	
18.	Limestone, gray, impure	8	
17.	Sandstone, fine grained, with brown flinty partings, laminated, yellowish color	22	
16.	Sandstone, bluish, fine grained, heavily bedded	20	
15.	Sand shale	10	
14.	Limerock, impure	2	4
13.	Sand shale, gray, fine grained	8	
12.	Clay shale, blue	3	
11.	Sand shale, blue, with thin, irregularly bedded, impure sandrock	37	
10.	Limestone, impure, buff colored, fragmentary	2	
9.	Clays, marly, blue, with small fossils	1	
8.	Limestone, impure, bluish	3	
7.	Sand shale, light blue, with sandstone partings	7	
6.	Limestone, compact, gray, fragmentary and concretionary	2	
5.	Shale, argillaceous, blue, and limestone	2	6
4.	Shale, argillaceous, gray	3	6
3.	Limestone, concretionary, compact, light gray	4	
2.	Marl, gray	2	6
1.	Limestone, concretionary, light, with gray clay partings	22	6

Below No. 10 the strata belonged to the Lower Carboniferous. The entire thickness of the Coal Measures at this point is, therefore, about 175 feet.

The most extensive mining operations ever carried on in the county were at Perlee, the chief mines belonging to Washington County and to the Jefferson County Coal Companies. The Washington shaft which has just been mentioned and a section of which has already been given, was located some distance from the railroad (Tp. 73 N., R. IX W., Sec. 32, NE. qr., SE. ¼) and the company was obliged to haul the output over a tramway in order to load the coal directly on the cars. The coal vein formed a rather extensive pocket with a solid seam from three and a half to four feet in thickness. The middle eighteen inches was considered to be a very good quality of coal for the manufacture of gas and was used for this purpose. According to the best information obtainable the coal was deposited in a rather narrow trough, probably not over one-fourth or one-third of a mile in width and trending northeast and southwest.

The Jefferson mine was a shallow shaft near the railroad (Tp. 73 N., R. IX W., Sec. 23, NE. qr., SW. ¼).

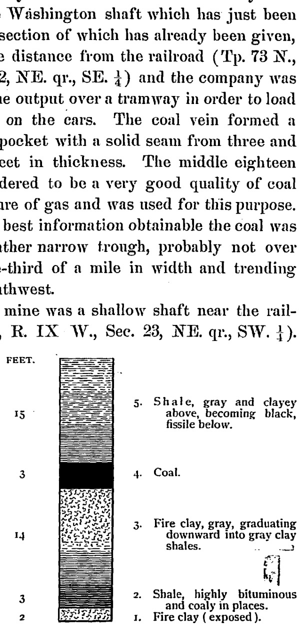


Figure 164. Part of Jefferson Shaft. Perlee.

The coal mined was practically the same as that worked at the Washington mine. The roof was a dark shale, four to eight feet in thickness, while the floor was fire clay and light colored shales, having a thickness of ten to fourteen feet. Immediately beneath is a vein three and a half feet thick, of rather shaly coal. This arrangement is shown in figure 164.

Almost the entire output of this mine was taken by the railroad company for use in the locomotives. Both the Jefferson County and Washington County mines have been abandoned for several years. During the latter years of their existence they furnished considerable more than one-half of the entire output of the county.

Recently the Sheckelton mine, a country bank, has been operated and some coal taken out. This and several other small banks are the only ones now in operation in the vicinity of Perlee.

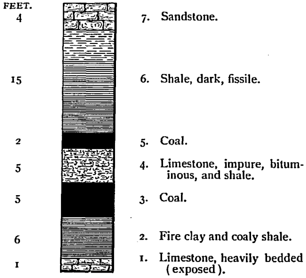


Figure 165. Section of Coal Seam. Coalport.

At Coalport, near the east edge of the county, coal has been mined for more than thirty-five years. During most of this time the Brown mines have been actively operating. The present shaft is about seventy-five feet in depth and is situated about a mile from the C., B. & Q. railroad, to which the coal is hauled over a tramway. The coal worked is from four to five feet in thickness and lies only a few feet beneath the bed of the neighboring creek. The seam appears somewhat uneven and in places the coal has been washed out by preglacial streams the old channels being occupied by sandstone. A section at this mine is indicated in figure 165.

Most of the coal is sent to Mount Pleasant and the neighboring towns.

Ten or a dozen shafts have been worked at various times in the immediate vicinity of the present Brown mine, but at this time none of them are being operated, except during the winter season. Across the creek a number of small country banks have been opened in the hillside, but at present they do not take out much coal.

Along Cedar creek south and west of Fairfield coal has been worked for many years. Directly south of town and just west of where the Birmingham road crosses the creek the Bates mine is located. It is a shaft sixty feet deep with coal four feet in thickness. The base of the shaft shows:

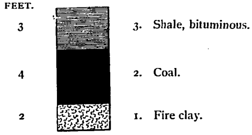


Figure 166. Coal Bed at Bates Mine. Fairfield.

Most of the production from this mine is taken to Fairfield. An exposure on Cedar creek, about half a mile to the northwest, gives the following section:

		FEET.	INCHES.
7.	Drift	4	
6.	Sandstone, buff, rather soft and somewhat shaly	4	
5.	Shale, argillaceous, dark blue	10	
4.	Coal		10
3.	Fire clay	4	
2.	Shale, dark color	8	
1.	Sandstone (exposed)	1	

Along both sides of the stream, between the point mentioned and the Reed mill, four miles above where the C., R. I. & P. railroad crosses the stream, numerous country banks have been opened from time to time, several being now worked during the winter season. At Reed mill the section is as follows:

		FEET.	INCHES.
10.	Drift	6	
9.	Shale, dark colored, with thin coaly seams	2	
8.	Shale, light colored	3	
7.	Shale, somewhat sandy in places, graduating below into No. 6	2	6
6.	Sandstone, fine grained, buff, containing plant remains	6	
5.	Shale, bituminous, with seams of coal three to six inches in thickness	4	
4.	Shale, light colored	8	
3.	Shale, dark colored, bituminous	2	
2.	Coal	3	6
1.	Fire clay (exposed)	1	

The coal is sometimes exposed in the beds of the streams. A mine was operated here by Mr. Reed for a number of years, the machinery being worked by power from the mill. Half a mile northeast of this point, where the Libertyville road crosses the railroad track (Tp. 71 N., R. X W., Sec. 3, NE. qr., NW. $\frac{1}{4}$), a mine has been operated by Mr. Radcliff in a vein which is supposed to be the same as the thin seam near the top of the Reed mill section. At this place it is three feet in thickness. Immediately west of Fairfield, in the valley of a small creek running eastward into the Cedar, and along the line of the railroad, numerous openings have been made from which considerable coal has been taken. Many of these are now abandoned. At the West mine, about two miles and a half from Fairfield, the coal is three feet thick and is only thirty feet below the surface. Between Fairfield and the western county line a number of country banks have been operated from time to time. At and in the vicinity of Batavia prospecting holes put down recently show a vein of coal to be well developed, and mining will be commenced on a rather extensive scale at this place in the near future.

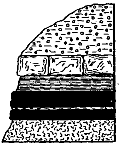
South of Libertyville about three miles, on Lick creek, near the county line, considerable coal has been mined.

The Zimmerman shaft (Tp. 71 N., R. X W., Sec. 29, SW. qr., NW. $\frac{1}{4}$) operates in a three-foot vein of good coal, the roof of which is an impure limestone. A quarter of a mile to the west is the Beyer bank, the coal of which is thought to belong to a higher horizon than that worked at the Zimmerman mine. Other country banks are also in operation in the neighborhood. A half a mile southward is the Laughlin bank, operating in a vein three and a half feet in thickness.

Another point where coal has been mined to a considerable extent is two miles south of County Line, where it crops out along the small stream known as Black creek. The Snooks bank is the chief mine operated, but is worked only in the winter. The coal is reached by a shaft twenty-four feet in depth, and varies from three and a half to five feet in thickness. In a few places the coal is cut out completely by channels, but these obstructions are not very extensive.

WAYNE COUNTY.

For the most part Wayne county lies on the western limits of the Lower Coal Measure zone of Iowa. The greater part of the district is thickly covered by drift, often to a depth of 200 feet or more. Up to the present time mining has been confined almost entirely to the extreme eastern part of the county. The coal worked is the Mystic seam and is a continuation of the principal layer which is worked so extensively in Appanoose county. In the northeastern corner the coal crops out in the valley of the Chariton river, also along the South Chariton and some of its tributaries five or six miles southward. On Little Walker creek the following strata are exposed:



FEET.	INCHES.	
4		7. Drift.
1	8	6. Limestone, blue, fossiliferous, thick bedded.
1	4	5. Shale, bituminous, fissile.
1	5	4. Coal.
	2	3. Clay parting.
	9	2. Coal.
2		1. Fire clay, gray, impure.

Figure 167. Bluff on Little Walker Creek. North of Confidence.

In the southeastern part of the county, at Seymour, this coal is found 250 feet from the surface. The strata containing the coal have a dip to the southwest of approximately five feet to the mile, which corresponds essentially with the observations made along the same line in Appanoose. It is quite probable that at least the eastern third of Wayne is underlain by the Mystic coal in sufficient thickness for profitable working.

Along the Chariton river small drifts have been made in a number of places, while just east of the county line, a mile or two, in Appanoose county, important mines have been opened. The principal local development of the coal industry of Wayne is in the vicinity of Confidence, three or four miles from the Chariton river. The coal here crops out in a number of places and is reached by slopes and shallow shafts. In this vicinity the coal has been mined for local use for the past twenty-five or thirty years. The largest of these mines now in operation is the Frey shaft (Tp. 70 N., R. XXI W., Sec. 26, NW. qr., NE. ¼). The section in the shaft is:

FEET.	INCHES.	
28		11. Drift.
3		10. Limestone, gray, thinly bedded.
3		9. Shale, firm, bituminous.
3	5	8. Shale, clayey, dark drab.
4		7. Shale, light gray to blue.
4		6. Limestone ("cap rock").
1		5. Shale, drab, clayey ("clod").
	10	4. Shale, black, fissile.
2	6	3. Coal.
1	6	2. Fire clay, impure, gray.
2		1. Limestone, gray, fossiliferous.

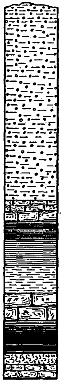


Figure 168. Section of Frey Shaft. Confidence.

This mine has been operated a dozen years or more. The coal is reached by a shaft fifty feet deep. The seam has a good roof and the coal is taken out by the long wall method. The details of the coal bed are:

FEET.	INCHES.	
1		7. Shale, bituminous, fissile.
1	8	6. Coal.
	2	5. Clay parting.
	7	4. Coal.
	½	3. Clayey parting, containing much pyrite.
	1	2. Coal.
1		1. Fire clay, impure.

Figure 169. Coal Seam in Frey Mine. Confidence.

A short distance northeast of the Frey mine is the Matley shaft, while immediately to the northwest of it is the Burns mine, where the section gives:

FEET.	INCHES.	
2		6. Shale, bituminous, fissile.
1	6	5. Coal.
	2	4. Clay parting.
	9	3. Coal.
1	8	2. Fire clay, gray, shaly in part.
1		1. Limestone (exposed).

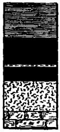


Figure 170. Coal Bed in Burns Mine. Confidence.

In the southwestern part of the same section is the Jared mine, and in the same vein is the Davis and Radcliff. All of these mines are operated for local trade only. They are located along Little Walnut creek and reach the coal at various depths.

At Seymour, fifteen miles south of Confidence, on the C., B. & Q. railroad, coal is mined at a depth of 240 feet.

There are two companies now operating. The Seymour mine is on the east edge of town, while the Chicago mine is farther west. Both companies have well arranged plants and handle considerable coal. At the former the base of the shaft shows:

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 171. Part of Seymour Shaft. Seymour.

Seven miles west of Seymour, a short distance southeast of Harvard station, is located the Winger mine (Tp. 68 N., R. XXI W., Sec. 14, SE. qr., SE. ¼). The shaft is 165 feet deep with the following section at the bottom:

FEET.	INCHES.	
3		6. Shale, black, fissile.
1	2	5. Coal.
	2	4. Clay parting.
	8	3. Coal.
2	6	2. Fire clay.
3		1. Limestone, gray.

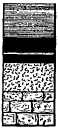


Figure 172. Bed of Winger Mine. Howard.

Coal is mined in several places a mile or two to the east of the county, at Milledgeville, in the northern part of the adjoining county, at Plano in the central, and Livingston in the southern. Coal seams also appear a few miles south of the western part of Wayne county, in Mercer county, Missouri.

APPANOOSE COUNTY.

Appanoose county is located in the midst of one of the most extensive coal fields of the Iowa-Missouri area. The vein of coal which is principally worked is believed to have the greatest geographical extent of any of the seams of the region. For this reason and on account of the exceptionally regular character of the beds of the county, it ranks among the foremost of the coal producing districts of the state. The first reliable statistics in regard to the output of the Iowa coal fields were made in 1860. At that time Appanoose ranked eleventh among the counties of Iowa. The total production was less than 1,500 tons and had a market value of about $2,700. Since that time the production of coal has steadily increased until in 1891 the county was credited with a grand total of nearly 400,000 tons, with a valuation of more than half a million of dollars, thus raising the rank of Appanoose to third among the coal counties of the state. More than fifty mines are now in operation within the limits of the county besides the country banks, which get out a very considerable amount for local use.

The geological features of Appanoose county and the region adjacent to it in the west and south differ from those of the other coal counties in the Lower Coal Measure belt in presenting great regularity in the arrangement of the coal bearing strata. No Lower Carboniferous limestone is known to have a surface exposure within the limits of the county, though no doubt it occurs at no very great distance beneath the surface, especially in the eastern part of the district. The Lower Carboniferous layers present gentle folds which, taken into consideration with the very uneven eroded surface of elevations and depressions, greatly affect the thickness of the coal bearing rocks in different places.

Another element giving a variable thickness to the Coal Measures of the county is preglacial erosion which has grooved and channeled the upper surface of the coal beds; these effects now being hidden by the thick deposit of glacial material.

The Lower Coal Measures underlie the entire county. The lithological characters of the beds differ very materially from those in other portions of the Lower Coal area of the state. The argillaceous shales make up the greater part of the formation. The sandstones are rather unimportant; while on the other hand there are a couple of rather thick limestone bands which occur in nearly all portions of the county.

A general section of the strata at Centerville shows:

		FEET.	INCHES.
16.	Soil, fine black	2	
15.	Clay, yellow	33	
14.	Boulder clay, blue, containing fragments of wood, coal, limerock and boulders	30	
13.	Limestone	6	
12.	Clay shale, blue ("soapstone")	3	
11.	Clay shale, red ("soapstone")	11	
10.	Sandstone, soft, containing thin, harder layers	8	
9.	Clay shale	10	
8.	Limestone, compact, gray	3	
7.	Shale, bituminous, frequently containing nodules and pyrite	7	
6.	Limestone ("cap rock")	3	6
5.	Shale, hard, black ("slate")	1	2
4.	Coal	1	8
3.	Clay partings		2
2.	Coal	1	2
1.	Fire clay	3	

It is fairly representative of the character of the rocks over most of the county, as far down as the coal vein worked so extensively at present. The thickness and the character of these different layers vary within certain limits, but the general features of the section may be considered as fairly constant. Other bands of limestone make their appearance occasionally and the character of the shale is of course inconstant. The presence of Nos. 8 and 13 is tolerably constant throughout the field. They are known respectively as the "seventeen" and "fifty-foot" limestones, from their general occurrence at about those heights above the coal. They may be relied upon as being fairly accurate guiding marks, though they have in certain places been removed by later erosion. As compared with the other coal seams in the state the extent of the vein in question is, as has been said, somewhat exceptional. An examination of the exposures on Little Walnut creek, at Mystic, will well show several features of the vein which are particularly characteristic and which make its recognition easy and certain. The association of strata found here is perhaps one of the best examples in the state showing the value of certain layers as guides to coal seams.

The principal coal vein worked has been called the Mystic coal, and is one of the few veins in the state which has a considerable geographical extension. It is named from the town where it has been mined so extensively. The quality of the coal is excellent. It is a clean lustrous variety having, in small pieces, the appearance of anthracite, though softer and more brittle. In mining, no powder is used, as the coal is readily broken by the pick in suitable sizes along the lines of natural cleavage. Analyses show that much of it would make an excellent coal for the manufacture of illuminating gas. Already it has been used largely as a steam coal. It is especially well adapted for domestic use on account of its cleanliness and good heating qualities. Although small quantities of "sulphur" (iron pyrite) is present, the quantity is not sufficient to depreciate the value of the coal.

In the Appanoose coal district the arrangement of the various beds enclosing the coal is very much more simple than in most other parts of Iowa. Almost everywhere the developed coal beds of the state are of rather limited extent. They form small but thick basins, often quite numerous and interlocking with one another. As distinguished from the other fields the Mystic coal has a wide geographical extent. It is known to extend almost continuously over an area nearly fifty miles long and at least forty miles wide, covering nearly all of Appanoose and the adjoining portion of Lucas and Wayne counties, in Iowa, and Putman and Schuyler counties, in Missouri. The associated beds are spread out in even sheets which appear to have a slight inclination southwestward. In the northeastern portion of central Appanoose the coal is exposed near the surface in the bluffs along all the larger streams, where it can be readily worked by drifting, or easily reached by shallow shafts. To the west and south it becomes more and more deeply buried until at Centerville it is mined at a depth of 125 feet. At Numa and Jerome the shafts are 150 to 160 feet deep; while at the west county line and at Seymour, in Wayne county, it is necessary to go a distance of nearly 250 feet in order to reach the seam.

In arrangement, the Mystic coal is well adapted to the long wall mining method, which under favorable circumstances is very much more economical than the ordinary room and pillar plan. The roof is remarkably good and a short distance above the coal is a thick bed of lime-rock. The two, thin, persistent clay seams running in the coal throughout its range enables the coal to be parted readily. The amount of shale and fire clay removed in mining the coal and making the entries of the requisite height is ample for packing or "gobbing." In those mines which have been worked on the long wall plan the results have been exceptionally good. The method is coming more and more into use throughout the district and is rapidly taking the place of the more expensive room and pillar plan. At the present time, however, it may be said that the majority of the mines in the county work upon the room and pillar plan, though in some cases a somewhat modified plan is adopted which is called the "semi-long wall."

The excellent character of the roof and the presence of fire clay of considerable thickness as the floor, allow the use of the various forms of mining machinery, some of which are more or less dependent upon these factors for their successful operation. The machines at present used are chiefly those of the Harrison, Legg and Mitchell types and the Stanley Header, all of which have given good satisfaction.

While the Appanoose coal field is known to be very regular geologically in its arrangement, there are, nevertheless, some "troubles" encountered in different places. They are chiefly normal faults which, however, do not greatly interfere with mining operations. "Horsebacks" and "cut-outs" are also sometimes met with; the latter especially where the coal comes up near the surface. These "cut-outs" are chiefly due to preglacial erosion, the coal and the associated strata having been removed and the cavities and depressions filled up with glacial débris. Some of the more important of the different kinds of "troubles" will receive consideration in connection with the descriptions of the mines in which they occur.

Moravia.—This is about the only locality in the northeastern corner of the county where coal has been mined. East of the village for a couple of miles along Mormon creek a number of country banks have been opened at various points. The vein mined appears to be the same as the Mystic coal, but this supposition has not as yet been fully substantiated. The thin clay seam at the typical locality is here said to be four inches in thickness. Although no mines of any consequence have been opened east of the Chariton river except in the vicinity of Dennis, the entire area may be well supplied with veins of workable coal, but in this case the beds probably lie some distance below the horizon of the Mystic seam.

Milledgeville.—There are no railroads nearer Milledgeville than eight or ten miles, and consequently the coal that is mined is largely for local use. The coal vein is doubtless the same as that at Centerville. It is exposed at a number of places along the Chariton river both above and below the Milledgeville bridge and is also said to outcrop on the South Fork of the Chariton near Griffinsville. The nearness of the vein to the surface enables it to be worked readily. Most of the mines now in operation are along the south branch of the river two to four miles south and southwest of the town. West of Milledgeville, about two miles, is the old Morland mine, now known as the Young No. 3. It was not operated for a number of years, but was recently reopened through a change of ownership. The section here is:

FEET.	INCHES.	
2	6	6. Limestone, gray, fossiliferous.
1	6	5. Shale, bituminous.
1	3	4. Coal.
	2	3. Clay parting.
	9	2. Coal.
2		1. Fire clay (exposed).

Figure 173. Coal Bed at Young Mine. Milledgeville.

Near the west county line, four miles directly southwest of Milledgeville (Tp. 70 N., R. XIX W., Sec. 30, SW. qr., SW. ¼) is located the Mosby shaft. A mile directly east of this place, on the river bank, are several openings which are now deserted. The principal ones were the Phillips and the Bennet mines. In the extreme northeastern corner of the same section is the Gurnsey slope. The Fenton mine is one of the largest openings in the vicinity. The coal was formerly taken out through two shafts, but at present a slope is in use. Two miles directly south of Milledgeville and in the immediate neighborhood of Griffinsville, are two shafts, both about fifty feet in depth, which are known as the Young mines. A short distance south of Griffinsville several small openings have been made in the valleys of the branches leading into the South Chariton river. Two miles northeast of Walnut City were also a number of openings, the most important of which were the Foster bank and the Nash shaft, neither of which is now in operation.

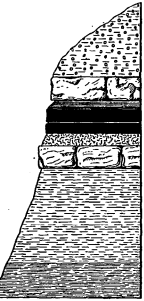
Walnut Valley.—This stream enters the county at a point midway between the north and south extremities of the western limit. It flows northeasterly about fifteen miles into the Chariton river. The C., M. & St. P. railroad runs down the valley, crossing the Chariton and thence up Buck creek. For nearly the entire distance coal is mined to a greater or less extent; the entire valley forming almost one continuous mining camp now known by the different names of Jerome, Diamond, Brazil, Mystic, Orrsville, Rathburn, Clarksdale and Darbysville. Along the stream the Mystic coal crops out in numerous places and is mined by means of drifts. Away from the immediate vicinity of the water course the same vein is reached by means of shafts. The first mine met with in passing down Big Walnut creek east of the west county line is the Houser opening (Tp. 69 N., R. XIX W., Sec. 32, SE. qr., SE. ¼). The coal is of the typical Mystic seam and has the normal thickness.

Two miles eastward and about a mile from the creek is the village of Jerome, where a number of openings have been already made and where more mines will soon be opened. Just east of the town is the Big Four mine (Tp. 68 N., R. XIX W., Sec. 2, NW. qr., NW. ¼). This shaft is 125 feet deep. A mile directly north of the latter place is the Gladstone shaft. At this place the upper limestone was not encountered in sinking the shaft, but a short distance away it was found in place when putting down the air shaft, thus indicating that preglacial erosion had acted quite vigorously, though not operating sufficiently deep to cut out the coal. The thickness of the seam is thirty-three inches, with good "slate" roof and fire clay floor, the latter being a foot or more in thickness. Like in other mines of the vicinity, the faults encountered are chiefly slight slips which seldom interfere with mining operations. The Gladstone company is sinking another shaft, No. 2, about half a mile west of the town. A mile north of the village is the Knight mine, a local shaft forty feet deep and situated directly on the creek. Near by is the opening of the old Morris bank, formerly worked for local use. Three miles north of Jerome, on the ridge on the opposite side of the creek near the station of Plano, coal was formerly mined at a depth of about ninety feet.

About four miles northeast of Jerome, and within two miles of Mystic, is an important mining locality known as Brazil. The Keokuk and Western railroad is here built along the branch flowing northward into the Big Walnut. Coal crops out along this stream at a number of places and has been worked by means of slopes for many years, the annual production being quite large. Between Jerome and Brazil the Hazelton shaft reaches the coal at a depth of about seventy feet. Tipton No. 1, now operated by Campbell and Phillips who also work two other mines in the vicinity, known as Tipton Nos. 3 and 4, is a slope, and has been worked back into the hill for a distance of nearly a mile. The other two are shafts opened near the crossing of the C., M. & St. P. and K. & W. railways by the Phillips Fuel Company, but have not been worked quite so extensively. Just south of the Tipton No. 1 is the Phœnix mine; and in the same neighborhood are several others, of which the Silknetter and the Philby and the Walnut Creek are the most important. The Walnut Block Coal Company is the most extensive operator in this vicinity, working three slopes. Southeast of Brazil at a switch called Laneville, on the Keokuk and Western railroad, is the Lane shaft, seventy feet deep, which has been operated for some years. Northeast of the village, about half a mile, is the small mine known as the Campbell slope, which is worked chiefly for local trade. The Eagle Coal Company operates a small local mine near here.

Mystic is probably the most important mining center in the valley. In the immediate vicinity of the town the coal is reached by means of slopes or drifts, but both east and west of this point shafts are necessary. Besides the leading mines now in operation there are a few small openings. Two miles southwest of here near the K. & W. crossing, is the Peerless No. 4, a shallow shaft. A quarter of a mile east are two mines about twenty-five feet deep known as the twins. They are the Peerless Nos. 5 and 6. A half a mile still farther east is the Raven mine, formerly known as the Silknetter No. 2. Immediately north is the Brown and Bowers slope, operated by a Kansas City firm. A short distance west of this is a new and well equipped slope belonging to the Columbia Coal and Mining Company. Still farther west, about two and a half miles from Mystic, the Mystic Fuel Company are developing a large area in which several mines will soon open. At Mystic station, opposite the depot, is the Lone Star mine (Tp. 69 N., R. XVIII W., Sec. 17, SW. qr., NE. $\frac{1}{4}$). The coal crops out and is reached by means of a slope. The vein is worked by the "semi-long wall" method, the props being left to protect the main roadway while the face of the work is carried on in the usual manner. A section of the bluff is shown in figure 174.

Immediately east of the depot is the large slope of the Iowa-Missouri Company. A short distance northeast of Mystic (Tp. 69 N., R. XVIII W., Sec. 16, NE. qr., NW. $\frac{1}{4}$) are the Lodwick mines, two slopes on the opposite sides of a small ravine which opens into the Big Walnut, just east of the town. A new double track slope is being driven so that the two mines may be worked as one by cross entries. In the development of the mine a glacial channel has been encountered. It was filled in with clay, boulders and other drift material. The channel has been traced in a northeasterly direction for some distance, and is probably the same interruption which was met with in the old "Sandbar mine," which was located immediately



	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 174. Bluff on Walnut Creek. Mystic.

southeast. The width of the channel, as revealed by working, is in the neighborhood of 1,200 feet. Traces of this channel or its branches have been found in other parts of the mine, but the coal has not been cut out.

East of Mystic, on the south side of the creek, are a number of openings which collectively are known as the Turkey river mines. They include the Orr No. 1, the Arnott, and slopes Nos. 2, 3 and 7, the latter being a new opening just east of the others, belonging to the Peerless Coal Company.

Two miles east of Mystic (Tp. 69 N., R. XVIII W., Sec. 15, NE. qr., NE. $\frac{1}{4}$) is the Clarke shaft, seventy feet deep. A short distance northeast of it is the Orr No. 2; to the northward about a mile is the Star shaft, ninety feet in depth; while still farther in the same direction, near the point where the C., M. & St. P. railroad crosses the Chariton river, is the Darby mine, with the Superior Block mine on the opposite side of the river, half a mile distant.

The vein of coal which is worked by all of the mines just mentioned is exposed on Snort creek and in Chariton river, north and northeast of Centerville. It was formerly mined at Dennis and is well exposed near the old mill at that place.

Another important mining center of Appanoose is around the county seat, Centerville. About four miles north of the town, at a place called Forbush, there is located the Whitebreast No. 19. In this mine are seen:

FEET.	INCHES.	
2	6	6. Limestone, gray to black, with pyrite in lower part.
1		5. Shale, gray to black.
1	5	4. Coal.
	2	3. Clay parting.
1	2	2. Coal.
1	6	1. Fire clay (exposed).

Figure 175. Coal Seam at Whitebreast No. 19. Forbush.

It is one of the largest and best equipped mines in the county, and employs a large number of men. The coal is worked by the long wall method, the Stanley Header and other mining machines being used.

In the north edge of the town is the new Frisby shaft which will soon be in operation. Just west of the town, at Relay, is the Centerville shaft, one of the most important mines of the county (Tp. 68 N., R. XVIII W., Sec. 35, NE. qr., NW. $\frac{1}{4}$). Coal in this vicinity has been mined for more than thirty years near the old site of Talbot mill. In the northern part of the town is the Monitor shaft which is thirty feet deep and which operates largely for local trade at Centerville. Directly east of the town (Tp. 69 N., R. XVIII W., Sec. 31, SE. qr., SW. $\frac{1}{4}$) is the Star, a small mine.

In the southeastern part of town, at the crossing of the K. & W. and the C., R. I. & P. railroads, is the Standard shaft, and a little farther eastward is Diamond No. 1, a large and well equipped mine. In the southwestern part of town, on the K. & W. railroad, is the Scandinavian mine, which has a shaft 100 feet deep; and a short distance north of it is the small shaft operated by the Happy Coal

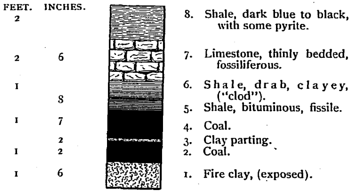


Figure 176. Base of Diamond Shaft No. 1. Centerville.

Company. The National mine, southeast of the Scandinavian, is one of the oldest and most important mines in the vicinity.

Directly south of Centerville a couple of miles is the Anchor No. 2, which has recently been opened. West of it a mile and a half is the Eldon No. 2, belonging to the Eldon Coal Company of Ottumwa.

Southwest of Centerville five or six miles is the station of Numa, on the southwestern branch of the C., R. I. & P. railroad. There are two openings at this point, the principal one of which is the Diamond No. 2, a shaft 145 feet deep. A section at the bottom of the pit is indicated in figure 176. The Coal Valley mine just south of the town is a local shaft.

Cincinnati.—This is a station, on the southwestern branch of the C., B. & Q. railroad, which is rapidly increasing in importance as a coal center. The coal seam at this place is reached at depths varying from 60 to 120 feet. The roof is usually quite good. There are three mines in active operation and several others are making preparation to open shortly. North of the station half a mile is a small mine operated by the Cincinnati Coal Company (Tp. 67 N., R. XVIII W., Sec. 34, SW. qr., SW. ¼).

East of the town about a mile is the Thistle mine. The strata exposed are:

		FEET.	INCHES.
7.	Shale, black, highly carbonaceous		6
6.	Coal	1	9
5.	Clay parting		2
4.	Coal	1	
3	Clay, with pyrite		1
2.	Coal		8
1.	Fire clay (exposed)		6

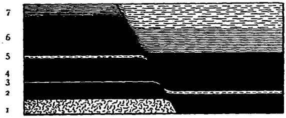


Figure 177. Fault in Thistle Mine. Cincinnati.

The section at this place also shows a small fault, one of many found in the mine. Few are of very great extent.

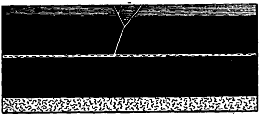


Figure 178. "Wedge" Fault in Thistle Mine. Cincinnati.

Another fault is one in which a V-shaped portion of the coal has been depressed five inches. The seams are filled with clay which contains pyrite. The disturbance

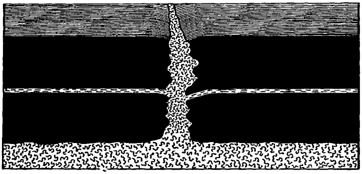


Figure 179. Fissure in Seam at Thistle Mine. Cincinnati.

does not extend into the lower bench of coal. A clay fissure is also shown near the same place. (Figure 179.)

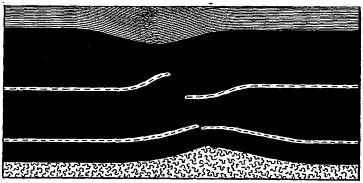
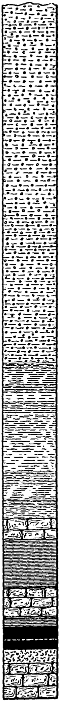


Figure 180. "Pinch" in Appanoose Mine. Cincinnati.



FEET.	INCHES.	
57		11. Drift.
22		10. Shale, gray to black, varying in character and hardness.
3		9. Limestone, thinly bedded, gray, fossiliferous.
7		8. Shale, black, with pyrite in part.
4		7. Limestone, gray, heavily bedded.
1	4	6. Shale, black, fissile.
1	8	5. Coal.
	2	4. Clay parting.
1	3	3. Coal.
2		2. Fire clay.
5		1. Limestone, hard, heavily bedded (exposed).

Figure 181. Section of Albert Shaft. Cincinnati

Directly south is the Hyatt mine, a shaft owned by a company at Saint Joseph, Missouri. At the edge of the village is the Appanoose mine, which is somewhat troubled with preglacial channels. In this mine a small "pinch" is shown, as represented in figure 180. Southwest of this shaft about a mile is the Albert mine, and a little farther in the same direction is the Streator mine. The section of the former shaft is shown in figure 181.

Three miles south of Cincinnati the coal crops out at numerous places in the bed of a small stream. Near the next station is the Pearl City mine. The coal bed shows the following association of strata:

FEET.	INCHES.	
	2	8. Shale, drab, clayey (exposed).
1	2	7. Shale, black, highly bituminous.
1	6	6. Coal.
	3	5. Clay parting.
	10	4. Coal.
	1	3. Clay parting.
	2	2. Coal.
2		1. Fire clay (exposed).

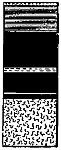


Figure 182. Coal Bed in Pearl City Mine. Four Miles South of Cincinnati.

Farther southward in Missouri, at Mendota and Blackbird hill, coal is also extensively mined from the same vein. Six miles west of Cincinnati, at Livingston, there is a mine which has been operated for eighteen or twenty years, known as the Parker shaft. It is 110 feet deep and takes out sufficient coal for all local purposes.

Hilltown.—In the southeastern part of Appanoose coal has been mined since the first settlement of the county. The seam crops out in the east bank of the Chariton river at a number of places, and was mined at a place formerly known as Hilltown, two miles directly south of Dean station, on the K. & W. railroad.

At present there are only four mines at this point on the Iowa side of the line, though there are several more in operation a short distance south in Missouri, just west of Coatsville. The Dickinson mines are the most important operating here. They are two in number and are located half a mile south of the bridge (Tp. 67 N., R. XVI W., Sec. 21, NW. qr., NW. $\frac{1}{4}$). One of these has been driven into the hill, a distance of 150 feet, and the other 140 feet. The section of the seam is:

FEET.	INCHES.	
4		5. Shale, bituminous.
1	9	4. Coal, with three ¼-inch bands of pyrite in places.
	2	3. Clay parting.
1	2	2. Coal, with two pyrite bands.
2		1. Fire clay (exposed).

Figure 183. Seam in Dickinson Mine. Hilltown.

A large local trade is supported and some of the output is hauled to the railroad and loaded on the cars for shipment. A short distance north of this is the Heim mine and immediately east of it is the Tompson, locally known as the "Troublesome" mine. The latter has worked into a hill with two rather deep ravines on either side. In the course of the work the entry has been driven entirely through the hill, a distance of 700 feet.

Northwest of Hilltown four or five miles, at Exline, coal was formerly worked in a number of places.

Not far from the state line, in Missouri, two other veins of coal, below the seam exposed in the Chariton river, have been reported. They are one and one-half, and two feet in thickness and are about twenty feet apart, the upper vein being in the neighborhood of 100 feet beneath the vein just referred to.

At Foster, in Monroe county, a vein of coal is extensively mined at a depth of 200 feet. This probably extends over part of the adjoining portion of Appanoose county.

DAVIS COUNTY.

Although this county is surrounded by the leading coal counties of the state, it has never ranked as one of the more important of the coal producing districts. The entire county is doubtless underlain by valuable coal deposits, but because of the thick beds of drift there are exposures of Coal Measure strata in but a few places. The prospecting which has been carried on in the county has been in large part unsuccessful, in most places the drill holes not having penetrated through the glacial covering.

In the northeastern corner of the county the Lower Saint Louis limestone is found outcropping along the Des Moines river. This is also the only part of the county in which the Carboniferous limestone is exposed at the surface. Borings in various parts of the northeastern portion of the district show, however, that this limestone is at no very great distance beneath the surface. At Bloomfield, the county seat, it is found to be at a depth of about 230 feet, while westward and southward it becomes more and more deeply buried. Up to the present time the chief coal mining has been carried on in the northeastern corner of the county. Along Soap creek there are a number of coal exposures.

Near Laddsdale a coal vein outcrops which is from two to two and a half feet in thickness. It has been mined in this vicinity by drifts and shallow shafts for a long period of years. The Sickels mine, recently opened (Tp. 70 N., R. XIII W., Sec. 8, NE. qr., NW. $\frac{1}{4}$), works a seam of excellent quality. The lower eight inches is slightly firmer than the upper part, and of a dull black color. The section is:

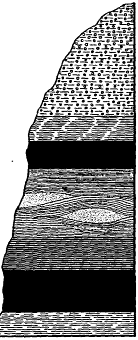
FEET.	INCHES.	
2		6. Sandstone, coarse, with pyrite concretions, (exposed).
	6	5. Shale, bituminous, fissile.
2	6	4. Coal.
	8	3. Coal, firm, ("smithing coal").
	3	2. Coal, impure, shaly, ("black-jack").
2		1. Fire clay, impure, gray, (exposed).

Figure 184. Coal Bed in Sickels Mine. Laddsdale.

Close by is the Dye drift, the entry penetrating the hill a distance of more than 600 feet. Considerable coal is taken out to supply an important local trade. A few years ago the owner became interested in coke and experimented upon the coal from time to time. A rude oven was built and some 300 bushels of coal burned. The samples of coke obtained were quite clean and firm, and were used by the brewery and iron works at Ottumwa. The coke was found to possess excellent heating qualities though somewhat soft. A short distance to the northeast is the Fite mine, a small drift, which is located on Soap creek and operates in the same vein of coal as the other two just mentioned. The coal is from thirty to thirty-two inches in thickness, quite regular and free from faults.

In the same vein are the Quigly, Dial, Dotson and other mines. There is said to be another vein of coal ten feet below the vein now worked. It was exposed while excavating for a bridge near the Sickels mine.

At Floris, three miles southwest of Laddsdale, numerous wells and borings show the drift to be at least 100 feet thick, and prospecting for coal has not been carried on much below that level. The deep channel of drift which appears to extend through this part of the county is fairly well marked and is known to extend from 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 185. Bluff on Soap Creek, near old Brown Cannel Mine. Carbon.

one mile west of Floris nearly to Laddsdale. A mile northwest of Floris (Tp. 70 N., R. XIII W., Sec. 15, NW. qr., NW. $\frac{1}{4}$) was the Howard shaft, which opened a vein of good coal four to six feet in thickness. This seam has never been mined extensively. South and west of this place the coal is undisturbed, but a short distance to the east of the shaft a bore hole shows that drift continues to a point thirty feet below the calculated depth of the coal seam. Outcrops of Coal Measure strata are found a mile directly west of Floris, on a small tributary of Soap creek. Coal is also found three miles northwest of town, on the same stream. At this place two seams of coal are exposed in the bluffs. The lower seam is here made up, in part at least, of cannel coal. The bluff is shown by figure 185.

A few years ago a company was organized under the name of the Brown Cannel Coal Company, which took out some coal. The entry was driven a short distance and one or two rooms opened, but owing to financial troubles further development was prevented. A third seam, three and a half feet in thickness, was said to exist a few feet below, but this is not now exposed. This coal is of a dull black color, rather difficult to ignite, but burns with considerable heat. The section at the Brown Cannel mine is:

FEET.	INCHES.	
2		7. Shale, bituminous.
4		6. Coal, in places reaching a thickness of four feet.
10		5. Shale, black, fissile in part.
4	6	4. Coal.
1	6	3. Fire clay, shaly below.
3		2. Coal, not exposed but found in trenching.
2		1. Fire clay, impure.

Figure 186. Seams at Brown Cannel Mine. Carbon.

On the opposite side of the creek there is a small drift known as the Dunn mine. The output is mainly local, but a part of it is taken to Carbon and shipped over the Wabash railroad.

At Bloomfield, a few years ago, a prospect hole was put down to a depth of 500 feet. Though no careful record of the strata encountered was kept, it is known that three thin seams of coal six to eighteen inches in thickness were passed through. A thin seam of coal was also encountered in sinking a well eight miles southwest of the town. Six or eight miles northwest of Bloomfield, in the vicinity of Drakeville, a good vein of coal is said to have been struck recently in boring for artesian water, and a company has been organized to develop it. On Soap creek, northwest of Drakeville, outcrops of Coal Measure strata are known to occur. Thin seams of coal are also exposed in the bluffs of the stream in the southwestern part of the county.

The Hilltown district, in which considerable coal is mined, is only three or four miles from the Davis county line. The Mystic seam probably extends over only a small portion of Davis county. A section taken in the "Troublesome" mine at Hilltown, in Appanoose county, showed:

FEET.	INCHES.	
2		9. Clay shale, gray, very hard.
1	2	8. Shale, drab, clayey, ("clod.")
1		7. Shale, black, fissile.
1	8	6. Coal.
	2	5. Clay parting.
	10	4. Coal.
	½	3. Clay parting, with pyrite.
	2	2. Coal.
2		1. Fire clay, gray.

Figure 187. Bed in Troublesome Mine, near southwest Corner of Davis County, in Appanoose.

In the northwestern corner of the county deposits of coal also probably occur since extensive mines are in operation a few miles away on Soap creek, in Monroe county.

At Laddsdale is the shaft of the Eldon Coal Company, the coal mined lying across the line in Wapello county. The seam here is about eighty feet below the surface and consists of four feet of good, solid coal.

VAN BUREN COUNTY.

This county is one of the first in which coal was extensively mined in Iowa. Near the eastern margin of the Coal Measures the Lower Carboniferous rocks are found in the beds of all the larger streams. The upper beds of the Burlington appear to crop out in a few places, but the majority of the exposures show the Keokuk and Saint Louis limestones. The former was well exposed along the Des Moines river, from the southeastern nearly to the northwestern corner. It may also be found in the valley of the Fox river. It is the massive blue limestone which is so well exposed at Farmington, Bonaparte, Bentonsport, and Keosauqua. The Saint Louis limestone is found in the eastern part of the county, along the Cedar creek; in the northwestern part, along the Des Moines, and probably also crops out on the Fox river in the southwestern part of the county. The Coal Measures may be considered as underlying the entire county immediately beneath the drift, though at some points they are probably quite thin and do not yield a workable seam.

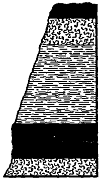
Cedar Valley.— The principal mining in this part of the county is on the south side of Cedar creek, a short distance from Hillsboro, near the Henry county line. Here is the Cox shaft (Tp. 70 N., R. VIII W., Sec. 24, NE. qr., NE. ¼). Coal has been mined in this vicinity for upwards of thirty years. The principal opening is a drift which has been operated for more than a dozen years. The coal has a thickness of from five to six feet in places with a good shale roof and soft clay floor. The section at the bottom of the shaft is:

Figure 188. Base of Shaft at Cox Mine. Hillsboro.

The coal is at a depth of 100 feet from the surface. It crops out in the bed of the creek a short distance away. The coal in this vicinity is apparently disposed in comparatively small basin-like areas whose maximum thicknesses are centrally. In all directions the seams dip toward the middle. In the same neighborhood are a number of other small openings, among which are the Yardus, the Taylor and the Rice mines. These are worked only during the colder months of the year.

Near Birmingham, in the north central portion of the county, coal is known to exist, but no mining is carried on at the present time.

Des Moines Valley.—The principal mining in the county is done in the immediate vicinity of the Des Moines river. In the northwestern part, near Selma, coal has been mined for many years. The principal opening on the south side of the river is the Lafever, a mile below town. The section here is:



FEET.		
1	5.	Coal.
3	4.	Fire clay.
9	3.	Shale.
4	2.	Coal.
2	1.	Fire clay.

Figure 189. Coal Beds at Lafever Mine. Selma.

East of Selma a couple of miles several mines have been opened, the principal one being the Hinkle. The coal is three to three and one-half feet in thickness, with a good roof of black shale. Not far away is the Overtaff, where two seams of coal are exposed, one three feet and the other one and a half feet in thickness. Along Lick creek, northeast and east of Douds station, several mines are in operation. On this creek, near the Douds mine, the following section is exposed:

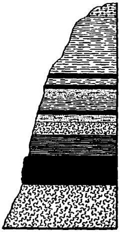


Figure 190. Section of Bluff at Douds Mine. Douds Station.

		FEET.	INCHES.
11.	Shale, argillaceous, blue, exposed.	10	
10.	Coal		5
9.	Shale, arenaceous, containing plant remains		10
8.	Coal		6
7.	Shale, arenaceous, becoming argillaceous below	3	
6.	Coal..............................		6
5.	Sandstone, ferruginous, hard	1	
4.	Fire clay..........................	1	2
3.	Shale, black, fissile, containing nodular masses of bituminous limestone............................	2-5	
2.	Coal	3¼	
1.	Fire clay..........................		7

At the north county line is the Beal mine (Tp. 70 N., R. X W., Sec. 6, NE. qr.). The coal is two feet in thickness, but is not mined at the present time. Three miles southward is the Mather mine, a new shaft showing:

		FEET.	INCHES.
7.	Drift, brown and red clay, and sand	37	
6.	Coal		7
5.	Sandstone, yellow	2	9
4.	Limestone, blue, compact	1	3
3.	Shale, bituminous below	23	
2.	Coal	3	
1.	Fire clay, (exposed)	1	

Three miles east of the mine mentioned is the Taylor bank (Tp. 70 N., R. X W., Sec. 14, NW. qr.). This mine is located in a limited basin, which has been worked more or less extensively for thirty-five years or more. South of the Taylor is the Yarger, and still farther southward is the Smith mine.

In the vicinity of Keosauqua coal was formerly mined in the bluffs at various points. West of the town, on the Chequest creek, a seam of coal from eighteen to twenty-four inches thick is seen in the bluffs. It was formerly operated for local use but at the present time no coal is being taken out. The same vein is apparently exposed at several places south of the town. Four miles southeast of Keosauqua and about two miles west of Bentonsport two seams of coal twenty-five feet apart are found. The principal mine in the vicinity is the Boyer (Tp. 68 N., R. IX W., Sec. 3, SE. qr., SW. $\frac{1}{4}$). The seam is about three feet in thickness and has been worked to some extent for local use. Northeast of Keosauqua, within two miles of Utica postoffice, several openings have been made in a seam of coal, most of it being removed by quarrying. The Downard, the Teal and the Warner are the chief openings in this neighborhood. On Coates creek, north of Bonaparte, several mines exist, the principal one being the Whitman (Tp. 68 N., R. VIII W., Sec. 5, NE. qr., SE. $\frac{1}{4}$). The section at this place is:

FEET.	INCHES.		
		10.	Drift.
2		9.	Shale, dark blue.
1	5	8.	Coal.
2	5	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.

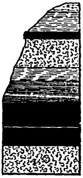


Figure 191. Seam at Whitman Opening. Bonaparte.

A mile and a half to the eastward is the Lydolph mine, where the coal lies near the surface and is reached by shallow shafts, drifts and quarrying. The seam is

FEET.		
6	7.	Drift.
3	6.	Coal.
2	5.	Fire clay.
18	4.	Shale, light colored.
2	3.	Shale, bituminous.
2	2.	Coal.
1	1.	Fire clay, (exposed).

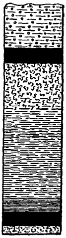


Figure 192. Coal Veins in Well on Honey Creek. Bonaparte.

somewhat undulatory, but has a general slight dip to the northward. North of the Whitman mine are several other mines, chief among which is the Haywood. A couple of miles to the northward is the Hawk mine which is adjacent to a small branch on which the coal crops out. Not far away is the Hawk and Lackey mine and the Alexander. Northeast of the latter about two miles coal crops out in the bed of a small stream on the Vale farm (Tp. 69 N., R. VIII W., Sec. 15, SW. qr., NW. ¼). The coal is from two to three feet in thickness. The section as shown at a well put down near this point shows another vein of coal below the one opened. (See Figure 192.)

In the southeastern corner of the county, near Farmington, several mines are in operation. The coal occurs in small basins, several of which on the north side of the river have been entirely worked out. The coal is about three feet in thickness. The Ketchum mine is located north of the town (Tp. 68 N., R. VIII W., Sec. 36, NW. qr., NW. ¼). A short distance from this mine the new Turner mine is being put down.

CHAPTER XI.

COAL DEPOSITS OF SOUTHWESTERN IOWA.

This district comprises approximately the southwestern quarter of the state and includes most of southern Iowa drained by the Missouri river. The general structure is comparatively simple. The strata exposed are made up of various successions of marine beds. Everywhere the present surface is covered with a greater or less thickness of drift, and the country being comparatively even the glacial deposits hide from view most of the indurated rocks. In the northwestern half of the area, immediately beneath the drift, the Cretaceous deposits extend over considerable districts. These overlie everywhere the Coal Measure strata. By far the greater part of the region is made up of the Upper Coal Measures, a formation which is characterized by calcareous shales and massive limestones. Fully three-fourths of the district may be regarded as occupied by beds of this character. Owing to few exposures at the surface relatively little coal in commercial quantities has been mined in the region. The principal coal seam now known near the surface is the Nodaway vein, which is exposed, in several counties, along the branches of the Nodaway river. Its thickness is commonly from eighteen to twenty-five inches, though in places it is somewhat thinner. Other thin seams of coal are known to exist in different parts of the area, but none as yet have been opened. The Lower, the most productive Coal Measures in the state, are nowhere exposed at the surface within the limits of the district. But just beyond the boundaries to the eastward, in Lucas county, shafts have been sunk to depths of from 200 to 300 feet and have successfully mined coal for some years.

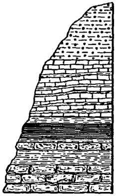
The counties included in this district are: Harrison, Shelby, Audubon, Pottawattamie, Cass, Adair, Mills, Montgomery, Adams, Union, Clarke, Fremont, Page, Taylor, Ringgold and Decatur.

HARRISON COUNTY.

This is the most northwesterly of the Iowa districts in which the Coal Measures appear at the surface. The strata are exposed in Harrison only in the beds of the larger streams, in the southern part of the county. On the Missouri river the Carboniferous rocks are seen to pass beneath the Cretaceous a short distance above the south county line of Harrison. On the Boyer river the same rocks are known to crop out for a number of miles along this stream as far as Woodbine, ten miles northeast of Logan. The Cretaceous rocks occupy the surface of most of the county immediately beneath the drift and loess, both of which form extensive deposits in western Iowa. As the Cretaceous rocks spread over so much of the surface of Harrison and form such a very considerable thickness, especially in the northern part, it is not improbable that the brown coals which are known to occur in this region may be found also in workable seams within the limits of the county.

No coal has thus far been mined in the Carboniferous rocks of the district. Black bituminous shales are known to exist in the Coal Measure deposits at various points.

One of these sections showing the carbonaceous shales was examined near Logan, and is essentially the same as that observed by St. John years ago in the same vicinity. It is:



FEET.		
6	8.	Drift.
8	7.	Limestone, thinly bedded, somewhat shaly.
1	6.	Shale, yellowish.
2	5.	Shale, black, bituminous.
1	4.	Shale, yellowish.
1	3.	Limestone, bluish, somewhat earthy.
2	2.	Shale, light colored.
4	1.	Limestone, gray, compact, (exposed).

Figure 193. Bluff on Boyer River. Near Logan.

SHELBY COUNTY.

Although Shelby is deeply covered by loess and drift, allowing but few natural outcrops of the stratified rocks, it is quite probable that extensive deposits of Cretaceous exist over most of the county, and that the Coal Measures extend under all at no very great depth. The Carboniferous rocks near the surface all belong to the Upper Coal Measures, the Lower Division lying at a very considerable depth. Information pertaining to the strata passed through in the few wells and borings which have been made is quite inexact and discloses little in regard to the true character and sequence of the rocks below. At the present time no deposits of coal are known to exist at the surface nearer than twenty-five miles from the limits of the county. These localities are in Guthrie to the east, and in Adams to the southeast. In the northwestern part of Adair county coal has been opened up at a depth of 260 feet. This is the nearest mine to Shelby which is now in operation. There is, perhaps, little reason for believing that workable seams do not exist within the limits of Shelby at depths quite considerable, yet not great enough to preclude profitable working. Owing to the few natural exposures in this and the surrounding counties, the difficulties of obtaining exact information in regard to the coal deposits are much greater than in any other portion of the coal field; and it is necessary to investigate carefully the surrounding districts in order to determine just what may be expected in Shelby county. The depth necessary to go, in prospecting for workable coal, probably need not be over 400 or 500 feet. All drill holes, therefore, should be carefully recorded as regards the beds passed through, for the reason that although no coal seams may be encountered, other easily recognizable horizons may be met with in which will be found data for more accurate estimates.

Brown coals are known to exist in certain parts of the counties towards the northwest, and it is not improbable that workable seams of lignite will be eventually found in the rocks of the same age in Shelby.

AUDUBON COUNTY.

This county is so deeply covered with drift that there are few natural exposures of the stratified rocks. The Cretaceous deposits probably underlie a large proportion of the surface beneath the drift. In this formation there may be seams of brown coal of sufficient thickness for mining to be carried on, as these layers are known to exist farther to the eastward in Guthrie county. On the whole, the Cretaceous deposits probably have not a very great thickness. The Upper Coal Measures extend over much of the county and doubtless underlie, at no very great depth, the entire district.

No coal is yet known to be mined within the limits of the county, and no systematic prospecting for the mineral has been undertaken. Six miles east of the Audubon boundary, in Guthrie, coal has been mined quite extensively, and it is not unlikely that the same seam extends farther westward into the northeastern portion of Audubon. In sinking deep wells in different parts of the county special attention should be given to preserving the records. They have a very important bearing upon the problem as to the extent of the coal deposits underlying Audubon. If workable coal is found it will be at a very considerable depth.

POTTAWATTAMIE COUNTY.

The bluffs rising on the east side of the Missouri river form a series of rather steep knobs, made up largely of loess. So thick is the deposit that few outcrops of the stratified rocks exist. Those which do appear indicate that most of the county is underlain by the Upper Coal Measure limestones and shales, with probably a considerable extent of Cretaceous rocks near the surface, especially to the northward. Prospecting for coal has been done to some extent, but with little success. A few miles north of Council Bluffs, near Crescent station, a shaft was put down some years ago to the depth of about twenty feet. In it there was passed through a layer of dark, bituminous shale, not unlike the seam exposed farther northward above Logan, in Harrison county. Beyond this, little effort has been made to search for coal. It is known that coal bearing rocks form a very considerable thickness beneath the county, and in order that the horizons which produce coal farther eastward may be reached, depths of upwards of 500 feet must be penetrated.

CASS COUNTY.

Little of the surface of Cass is as yet deeply trenched by the water courses. The county is everywhere covered by drift and consequently there are few good exposures of stratified rocks. All the outcrops examined indicate that the entire region at no very great depth is underlain by the Upper Coal Measures. Broad areas of Cretaceous beds also occupy portions of the county, but the thickness of this formation is not very great. Little systematic prospecting for coal has been done thus far, owing, doubtless, to the fewness of natural exposures.

Coal has been mined to some extent, however, in the southeastern part of the county, just north of Briscoe in Adams county. In this vicinity coal was first discovered exposed in a deep ravine, just north of the place mentioned. The principal mines in Cass were the Briscoe and the Hughes, both being shallow shafts. The section of the strata penetrated in reaching the seam is essentially the same as in those mines a short distance southward. The vein is apparently the Nodaway coal, the same as that which occupies a considerable portion of Adams, and probably also the adjoining portion of Montgomery. It is from ten to twenty-two inches in thickness. At the Plowman shaft, just over the line in Adams county, the strata indicated in figure 194 are shown.

With the proper railroad facilities a considerable development of the seam would probably be undertaken.

In the vicinity of Lewis, in the western portion of the county, a black calcareous shale two and a half feet in thickness is exposed. The same stratum also outcrops at a number of places near by. The proper investigation of this carbonaceous seam may eventually lead to the finding of workable beds of coal in connection with it.

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 194. Coal Bed in Plowman Shaft. At Briscoe, in Adams, near south County Line of Cass.

Directly east of Cass, within a mile of the boundary, in Adair county, a short distance from the town of Bridgewater, recent borings have indicated that a seam of coal about a foot and a half in thickness exists at a depth of 160 feet.

ADAIR COUNTY.

The drift covers this county deeply. Immediately beneath it the Upper Coal Measures are known to exist. The few exposures which do occur in the various streams traversing the county show little indication of the presence of coal above the water level in the streams. At one place, near the extreme eastern margin of the county, on a small branch running into Middle river, a few inches of coal occurs in connection with two feet of black bituminous shale.

A few borings have been put down in different parts of the county, but little systematic prospecting for coal has been done. At Bridgewater, in the southwestern part of the county, a seam of coal eighteen inches in thickness was struck at two points at depths of 150 and 200 feet. A better vein at a somewhat greater depth is reported. A few miles east of Bridgewater, at Fontanelle, two drill holes have been put down reaching to depths of 370 and 470 feet. It is reported that in the former a seam of coal five feet in thickness was struck. In the other hole, a short distance to the south, two feet of coal were encountered.

The only coal known to be mined in the county at the present time is six miles directly south of Adair, at the Eureka shaft (Tp. 76 N., R. XXXIII W., Sec. 4, NW. qr., NE. $\frac{1}{4}$). The shaft is 262 feet in depth, the coal varying from twenty to thirty-two inches in thickness. The roof is a bituminous shale. The bottom of the shaft shows:

FEET.	INCHES.	
2		4. Clay shale, (exposed).
2		3. Coal.
	8	2. Fire clay.
1	4	1. Shale, dark, (exposed).

Figure 195. Coal Bed at Eureka Shaft. South of Adair.

The mine is worked on the long wall plan. There are a few unimportant clay seams, but no other breaks in the continuity of the bed. This is a new mine. The coal has been taken out only from about 150 to 200 feet to the east and to the west of the bottom of the shaft. It is reported that there are two other seams below the one now worked, one at a depth of about forty-five and the other at a depth of about fifty-five feet from the bottom of the shaft.

MILLS COUNTY.

Mills, like Pottawattamie, has comparatively few exposures of older rocks, owing to the heavy deposits of loess which border the Missouri river and extend eastward over the county. In the northeastern corner of the county there are a few exposures of sandstone of Cretaceous age. This formation probably occupies a considerable portion of the eastern part of the district. With the exception of the sandrock just mentioned the indurated rocks all belong to the Upper Coal Measures. No exposures are known to exist in which coal is shown. As in the neighboring counties, the Lower Coal Measures can only be reached at considerable depths. Bituminous shales have been noticed in various places; one of the best exposures being near Glenwood, which is as follows:

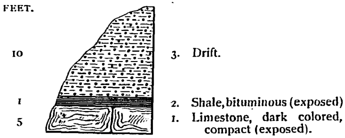


Figure 196. Bluff near Glenwood.

MONTGOMERY COUNTY.

This is one of the counties underlain everywhere by Upper Coal Measure strata; but, as in the adjoining districts, the surface is covered to a considerable depth by drift. A large outlier of Cretaceous sandstone and shale also occupies a considerable area. The outcrops in various parts of the county show the usual characters of the Upper Coal Measure limestones and calcareous shales. Borings made in different parts of the county all agree in bringing out the predominence of limestone and light colored shale for a considerable depth below the surface. In some parts of the district a vein of coal has been struck not far from the surface. Everywhere that the Coal Measures have been penetrated for any considerable distance the thicknesses given for the coal are from a few inches to a couple or more feet, but as a rule the veins appear to be rather thin. As most of the drilling has been done with an ordinary churn drill the exact thickness and characters of the strata passed through cannot be regarded as very reliable. The few borings made by diamond drills have given much better results.

Workable coal has been known to exist in the northeastern part of the county for many years. The principal opening in this region was the Westrope mine (Tp. 73 N., R. XXXVI W., Sec. 1, SE. qr., SW. ¼). The vein was

FEET.	INCHES.	
3		5. Drift.
2		4. Shale, dark colored.
1	3	3. Limestone, impure, compact.
1	8	2. Coal.
2		1. Fire clay.

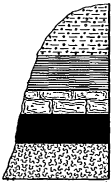


Figure 197. Coal Bed at Old Westrope Mine.

at one time exposed 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 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 forty tons. At the present time the exposures here are somewhat obscured, but the section appears to be as indicated in figure 197.

About three-fourths of a mile southward a well put down near the top of a hill passed through apparently the same vein of coal. During the past twelve years but little mining has been done in Montgomery county.

ADAMS COUNTY.

The Upper Coal Measures may be regarded as underlying the entire county. In the western part the Cretaceous sandstones occupy a considerable area; and the entire region is mantled by drift. The chief outcrops of rocks are along the larger streams in the western portion of the county. The strata are very regular and have a gentle slope towards the southwest. Most of the exposures show only limestones and calcareous shales. At the present time there is but one coal seam known to exist near the surface within the limits of the county, and this is well exposed along Middle Nodaway river. The vein is from fifteen to twenty-two inches in thickness and outcrops at short intervals for a dozen or more miles along the stream mentioned. It appears to be the same bed which is exposed farther southward along the Nodaways and their branches in Taylor and Page counties. From what is at present known of its extent it may be safely said that the vein occupies at least one-fourth of the entire area of the county. Although the mining at this region has never been very extensive in any one locality, coal has been worked uninterruptedly for more than a quarter of a century. At the present time the principal mining districts are located at Briscoe, in the northwestern portion of the county, and at Carbon and Eureka, eight and ten miles northwest of Corning.

At Briscoe, coal mining was begun sixteen or seventeen years ago, and ever since mines have been operated and worked, to some extent at least, almost continuously. As the coal is worked out of an opening or the distance from the bottom of the shaft becomes too great for profitable removal, new shafts are put down elsewhere in the same area. The vein varies in thickness from twelve to twenty-two inches, and in order that the coal may be handled advantageously a considerable amount of the associated clay must be removed. With a good roof above the seam and a comparatively soft fire clay beneath, it is usually the latter layer which is taken up to make room for the proper handling of the output. At the present time there are only two shafts in active operation. At the Plowman mine (Tp. 73 N., R. XXXV W., Sec. 2, NW. qr., NW. $\frac{1}{4}$) the shaft is sixty feet deep, with coal varying from ten to twenty inches, with an average of about sixteen inches. The following is a section of the strata passed through in sinking the shaft:

		FEET.	INCHES.
10.	Soil	2	
9.	Clay, yellow	18	
8.	Sandstone	2	
7.	Shale	3	6
6.	Limestone, impure		8
5.	Coal		16
4.	Shale, black, bituminous	3	
3.	Fire clay	1	6
2.	Limestone		8
1.	Shale, gray, sandy	3	

Nos. 1 to 7 are shown in the accompanying figure. Less than a quarter of a mile to the southwest is the Miller mine, a shaft ninety-two feet in depth. The section showing the coal is:

FEET.	INCHES.	
4		6. Shale, gray, clayey.
1		5. Shale, thin bedded, calcareous.
	8	4. Limestone, gray.
1		3. Coal.
	3	2. Shale, bituminous, compact, finely laminated.
1	6	1. Fire clay.

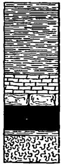


Figure 198. Bed at Miller Mine.
Briscoe.

There are other mines which have been worked largely in this vein, but their strata do not differ materially from that shown in the Plowman opening.

Five miles southeast of Briscoe, a short distance west of the Nodaway river, there are located three or more

FEET.	INCHES.	
2		6. Shale, gray and yellow.
1	6	5. Limestone, in three layers.
1	6	4. Limestone, impure.
1	8	3. Coal.
1	10	2. Fire clay.
2		1. Limestone (exposed).

Figure 199. Coal Seam at Spurrier Opening.
Eureka.

shafts which are occupied in getting out coal during six or eight months of the year. The coal seam was formerly exposed in the banks of the branches of the stream, but at the present time all of the mining is carried on by means of shafts. The most easterly mine is the Spurrier (Tp. 73 N., R. XXXIV W., Sec. 29). The section of the layers associated with the coal seam may be taken as representative of the other mines of the vicinity. (Figure 199.)

In this mine is a small fault, having a throw of fourteen inches. A mile northwest of this shaft a pit was

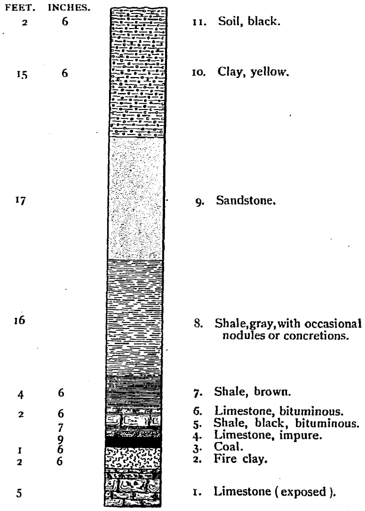


Figure 200. Section of Wyles Shaft. Carbon.

sunk to a depth of thirty feet and eighteen inches of coal reached. A third of a mile west of the Spurrier are three shafts, the most northerly of which is the Hartshorn No. 2, which is twelve and a half feet in depth and works sixteen inches of coal. On the opposite side of a ravine, in the same valley in which all the mines are situated, is another shaft, the Hartshorn No. 1. It is thirty feet deep, with coal of about the same thickness as in the other mines. Just south is the Hinton which is sixty-four feet in depth and operates in coal fourteen to twenty inches in thickness.

Three miles down the river from Eureka and six miles directly northwest of Corning, the county seat, is the mining camp of Carbon. There are nine shafts here, but only five are in operation at the present time. The general depth at which the coal is reached is eighty feet. Near the river (Tp. 72 N., R. XXXV W., Sec. 12, NE. qr., SW. $\frac{1}{4}$) is the Wyles shaft, sixty-one feet in depth with coal twelve to twenty inches in thickness. The section of the shaft is shown in figure 200.

Directly south of the Wyles is the Gibson shaft, and to the southeast the Reese, which is seventy-two feet

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).

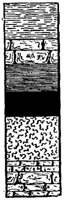


Figure 201. Vein at Syfert and Jones Mine. Carbon.

deep and works from twelve to twenty inches of coal. A quarter of a mile to the southwest of the Wyles shaft is the Syfert and Jones mine, seventy-seven feet deep. The sequence of strata is indicated in figure 201.

A little farther to the southward are three mines, the Gebbie, the Chafey and the Jones. A short distance down the river from the Wyles shaft is the location mentioned by White where a pit was sunk years ago by Bartlett and Smith with a view of finding a deeper and better seam of coal. The following is the section given for a distance of forty-five feet below the seam of coal worked:

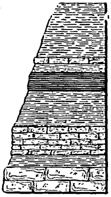
		FEET.
6.	Limestone, dark gray, somewhat shaly	5
5.	Shale, dark colored, carbonaceous	2
4.	Limestone, dark colored, fossiliferous	1
3.	Limestone, light colored	5
2.	Shale, gray, clayey	6
1.	Limestone, alternating with shale	25

Two miles west of Carbon (Tp. 72 N., R. XXXV W., Sec. 10, NW. qr., NW. $\frac{1}{4}$) considerable coal has been taken out at the Barker and Hart shaft. It is ninety-two feet in depth with the seam quite regular and from fourteen to sixteen inches in thickness. Two miles directly south of the latter is the Neill shaft, which, however, for the past year or two has not been in operation.

UNION COUNTY.

Drift covers Union county to a very considerable depth, but the entire district is known to be underlain by Upper Coal Measure strata. The chief natural exposures are along the Grand river, yet few of the outcrops appear to show that coal in workable seams is to be expected above the level of the water courses. In many places a bituminous shale is found. One, a short distance east of

Talmage (Tp. 72 N., R. XXVIII W., Sec. 20, NW. qr., NW. ¼), is shown on the east bank of the river.



FEET.	INCHES.	
4		8. Shale, hard, laminated, with occasional irregular bands of limestone.
	4	7. Limestone, gray, compact.
	6	6. Shale, argillaceous.
1		5. Shale, black, fissile.
2		4. Shale, hard, laminated, gray.
1	6	3. Limestone, compact.
	8	2. Shale, light colored.
1	6	1. Limestone, compact, gray, fossiliferous.

Figure 202. Section on east Bank of Grand River. Talmage.

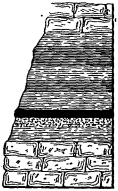
Although no coal is at present known to be exposed near the surface in Union county, considerable deposits are known farther westward at the same horizons; and the deeper horizons which are nearer the surface farther eastward will doubtless be found to extend beneath Union county.

CLARKE COUNTY.

Clarke county forms another one of those counties which is entirely underlain by Coal Measure strata, but which is deeply covered with drift, and in which no coal has yet been mined. The few natural outcrops which are exposed within the limits of the county show the characteristic features of the Upper Coal Measures with few or no indications of workable coal at the surface. Although no coal is yet known to be mined in the county, some of the largest mines in the state were located within a mile of the east county line. The shafts were fully 300 feet in depth. In order to reach this horizon in the eastern part of Clarke it would, therefore, be necessary to prospect to this depth at least, and in the central and western part of the county perhaps 100 feet farther. Mining has also been carried on near the surface in Warren county, not far from the north county line of Clarke, and it is not improbable that some of these veins also extend into this district.

FREMONT COUNTY.

This is the most southwesterly county in the state. The stratified rocks belong entirely to the Upper Coal Measures and are made up largely of limestones. The superior portion forms the lower section of the so-called Permian of the Kansas-Nebraska region, but all of the layers occurring in Iowa may be regarded as properly



		FEET.	INCHES.
9.	Limestone, in two layers	2	6
8.	Shale, yellowish, calcareous	1	3
7.	Shale, dark, bituminous	1	9
6.	Shale, bluish	1	3
5.	Shale, black, carbonaceous	1	
4.	Shale, bluish, calcareous, fossiliferous	1	6
3.	Coal		10
2.	Clay, light colored (fire clay)	2	
1.	Limestone, bluish	4	

Figure 203. Section of Bluff southeast of Bartlett.

forming part of the Coal Measure formation. There are in the county numerous good exposures. All of the sections show clearly the predominance of the indurated calcareous rocks. The entire county is deeply covered with the loess or bluff deposit and considerable drift.

No coal is known to have been mined yet within the limits of the county. Prospecting for the mineral has been carried on only in a desultory manner and, consequently, with but little success. The only seam of coal at present known is in the northwestern part of the county, three miles southeast of Bartlett station (Tp. 70 N., R. XLIII W., Sec. 23). It is known as the section at Wilson's. The upper portion, as also given by White, is shown in figure 203.

If deep prospecting is to be carried on in the search of coal in this county it will probably be necessary to sink borings to depths of from 800 to 1,200 feet. Down the Missouri river at Leavenworth, Kansas, coal is mined extensively at a depth of 750 to 800 feet.

PAGE COUNTY.

The Upper Coal Measures occupy nearly all of the county immediately beneath the drift. The Cretaceous outliers, which are so well developed northward, extend into this county but short distances. Wherever the stratified rocks come to the surface they present a remarkable similarity of lithological and stratigraphical details. The strata are almost entirely limestones and light colored shales which are arranged very evenly with no perceptible dip.

Although Page cannot be regarded as one of the important coal counties of the state, mining has been carried on within its limits for a long period. The coal near the surface appears to form a single bed and probably occupies at least one-fourth of the entire area of the district. It is apparently the Nodaway seam and presents all the usual characters which are found associated with it farther to the northeast, in Adams county. In Page county there appear to be very slight undulations in the strata, by which the coal vein is brought a few feet higher above the water level in the Nodaway river at some points than at others. Coal mining in the county has been carried on chiefly in the valley of the West Nodaway river, east and south of Clarinda, the county seat.

Near Hawleyville the Coal Measure limestones and shales are well exposed in the banks of the East Nodaway river. Although coal has been mined quite extensively just over the line, in Taylor county, no extensive openings have yet been made in Page, in this neighborhood.

A mile southeast of Clarinda, on the east side of the river, coal has been mined near the Shambaugh mill (Tp. 68 N., R. XXXVI W., Sec. 7, SE. qr., NW. $\frac{1}{4}$) where the bed crops out in the river bluffs. At the mill there is a good exposure showing the coal seam with both the underlying and overlying layers. The section is represented below:

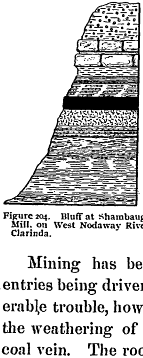


Figure 204. Bluff at Shambaugh Mill, on West Nodaway River. Clarinda.

	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	

Mining has been carried on here on a small scale, entries being driven into the perpendicular bluffs. Considerable trouble, however, has been met with on account of the weathering of the various beds associated with the coal vein. The roof thus became too soft and friable to withstand the removal of the coal, and consequently the mining has been transferred to the sidehill, a short distance below the mill site. Several openings were made at this place, and altogether a considerable amount of coal taken out.

About a mile northwest of the town of Shambaugh, five miles south of Clarinda, several shafts have been put down and are in active operation from September to April. The principal opening is the Howard mine (Tp. 68 N., R. XXXVII W., Sec. 36, NW. qr., SE. $\frac{1}{4}$). The entire output from these mines is consumed within the county.

The Nodaway seam is also exposed farther down the stream at and just beyond the south county line, in Missouri. The section, also measured by White, near the Braddy mill is:

FEET.	INCHES.	
14		5. Shale, yellow.
4		4. Limestone, impure, somewhat shaly.
1		3. Shale, carbonaceous.
	10	2. Coal.
2		1. Fire clay.

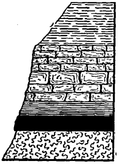


Figure 205. Section on the Nodaway River, below Braddyville. Near the south County Line of Page.

A few miles still farther southward, at Quitman, several shafts are in operation, the coal being from thirteen to fourteen inches in thickness.

Northwest of Clarinda about ten miles, in the valley of the Middle Tarkio river, coal has been mined on the land of Charles Linquist (Tp. 70 N., R. XXXVIII W., Sec. 24, NW. qr., NW. $\frac{1}{4}$). The coal was first discovered at the base of a low hill near the river. Tunneling was attempted, but here the "caprock" was too badly weathered to form a good roof. A shaft was then sunk to a depth of twenty-two feet, reaching coal eleven to eighteen inches in thickness. At this point sections were obtained by combining the record found in the shaft and the exposure at the quarry just south of where the coal is taken out, the cut showing from number 6 upwards:

FEET.	INCHES.	
3		12. Soil, black.
4	6	11. Clay, reddish, with sand and gravel.
9		10. Clay, yellow.
2	6	9. Sand and gravel.
3		8. Limestone, rather impure, with shaly partings.
1	8	7. Coal.
3		6. Fire clay.

Figure 206. Shaft at Linquist Mine.
Near Nyman.

	FEET.	INCHES.
5. Shale, light gray and bluish	1	6
4. Limestone		6
3. Clay, gray.		6
2. Limestone, gray and blue	2	
1. Shale, reddish, (exposed)		4

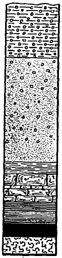
The coal and associated strata appear to have a slight southerly or southeasterly dip. During the first season about 600 bushels of coal were taken out of the mine, the output being utilized in the immediate neighborhood. The coal is of good quality, firm and well adapted to domestic uses.

TAYLOR COUNTY.

There are comparatively few natural exposures within the limits of Taylor county; and these are largely in the western part along the east side of the East Nodaway. From what is now known, however, there is but little doubt that in the entire county the stratified rocks at the surface all belong to the Upper Coal Measures. In the valley of the stream just mentioned, and along the small tributaries entering it from the east, outcrops are numerous. There are also a number of exposures on the East Fork river in the vicinity of Bedford.

Coal has been mined in this county only in the western and northwestern portions. The vein is manifestly the Nodaway seam, which is also exposed to the westward in Page county, and to the northward in Adams county. It doubtless occupies a very considerable area in Taylor. Considering the fact that there is but one vein of coal yet opened and that this one averages not more than eighteen inches in thickness, the mining industry of the district has proven to be quite important, increasing in extent from year to year. The coal mines now in operation are situated chiefly in two localities, one in the most northwestern township of the county, northeast of Hawleyville, along the bluffs and confluents of the East Nodaway, and the other near Newmarket, eight or nine miles northwest of Bedford, in the valley of the West Fork river and along a branch flowing into this stream from the west. For nearly thirty years coal mining has been carried on in this county. The mineral was first discovered in the northwestern part, and for some years the mining industry was unimportant, the annual output being quite small. In more recent years a rapid development has taken place, other mines having been operated in different localities.

On the East Nodaway, a short distance from Hawleyville, mines have been opened from time to time, and altogether a considerable amount of coal taken out. Farther northward mining on a small scale has been carried on for a number of years. One of the principal openings at the present time is the new Beynon shaft (Tp. 70 N., R. XXXV W., Sec. 20, NE. qr., SW. ¼). The section passed through in sinking the shaft is as follows:



FEET.	INCHES.	
3		11. Soil.
3		10. Clay.
10		9. Gravel and boulders, with but little clay.
1		8. Sand, white.
1		7. Gravel.
1	4	6. Shale, light colored, with calcareous nodules in the lower part.
3	2	5. Limestone, with clay partings.
1		4. Shale, black.
1	6	3. Limerock, impure.
1	6	2. Coal.
2		1. Fire clay.

Figure 207. Section at Beynon Shaft. Near Hawleyville.

Just west of the Taylor county line (Tp. 69 N., R. XXXVI W., Sec. 12, SE. qr., SE. ¼) there is an exposure of strata above the bed of a small brook emptying into the river, the top of which lies apparently immediately beneath the fire clay. It shows:

	FEET.	INCHES.
6. Shale, yellowish, with limestone bands......	4	6
5. Limestone, impure, dark gray in color		6
4. Shale, black, compact......................	1	
3. Limestone, hard...........................	5	
2. Shale, compact, black......................	2	4
1. Limestone, bluish......	1	2

A quarter of a mile west of the new Beynon, on the opposite side of the creek, is the new Burnside mine. It is eighty-three feet in depth. At the Ankeny mine, on the east bank of the river, a mile and a half southward from the Beynon shaft, the strata met with are very similar in character and thickness to those shown in the latter. At both places the coal is from twelve to twenty inches in thickness. Much coal has been mined in the several slopes and shafts in this vicinity. A mile southeast of the Ankeny shaft is the Wilcox mine (Tp. 70 N., R. XXXV W., Sec. 32, NW. qr., SW. $\frac{1}{4}$), where the coal is from twelve to eighteen inches in thickness. The section here is:

FEET.	INCHES.	
2		7. Limestone, gray, fossiliferous.
1	6	6. Limestone, more compact, massive layer.
3		5. Shale, black, finely laminated, with masses of clay ironstone, a bituminous, calcareous, ferruginous ore.
2		4. Shale, bituminous, with streaks of impure coal, ("black jack").
1	3	3. Coal.
2		2. Fire clay.
2		1. Shale, light gray (exposed).

Figure 208. Coal Bed at Wilcox Mine. Five Miles north of Newmarket.

On the south side of a ravine known as Coal Hollow, along which the shaft just mentioned is being worked, there are a number of abandoned slopes. Some of these were opened more than a quarter of a century ago. In one place the coal crops out just above the bed of the creek, but the dip of the stratified beds is quite perceptible and the coal soon disappears below water level.

The second locality where coal has been mined extensively is seven or eight miles south of the last, and from a mile to two miles and a half east of Newmarket, on the

Humeston and Shenandoah railroad. This road runs alongside all of the mines and switches have been extended to some of the shafts. Two miles directly east of Newmarket station are two shafts known as the Campbell mines (Tp. 69 N., R. XXXV W., Sec. 33, SW. qr., SE. ¼). They are shafts 120 and 110 feet respectively in depth with coal from fourteen to twenty-two inches in thickness. A few hundred feet to the east are three openings, called the Anderson shafts, though only two are now used as hoisting shafts, the other answering as an air shaft. Two of them are 132 and the other is 120 feet in depth with the thickness of the coal averaging about the same as in neighboring mines. More than twelve acres of coal have been removed from these shafts during the past nine years. The section at the most westerly of the Anderson shafts may be taken as typical of all the others in the vicinity, Nos. 2 to 6 being 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 209. Seam at Anderson Shaft. Newmarket.

	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 209.	
1. Shale, bluish, with thin layers of limestone	12

At the bottom of the shaft a boring 200 feet in depth was put down, but no accurate record was kept. On the east side of West Fork river, near the railroad bridge, is the Adams mine. It is a shaft fifty-two feet deep with coal fifteen to eighteen inches thick. The section, with Nos. 1 to 4 given in the cut, is:

	FEET.	INCHES.
8. Soil, black, alluvial	6	
7. Clay	20	
6. Shale, dark gray	12	6
5. Shale, light colored	6	

Figure 210. Bed at Adams Mine. Newmarket.

Directly north of the Adams is the Powell and Lathrop mine, sixty feet in depth, with coal averaging seventeen inches in thickness.

RINGGOLD COUNTY.

There are few indications of the existence of commercial seams of coal near the surface in Ringgold. The entire county is underlaid by the Upper Coal Measure strata, which are largely limestones and light colored calcareous shales. Yet coal has been mined successfully for over a quarter of a century, in apparently the same horizons as are found here, in the county immediately to the west.

Dark colored shales are met with in a number of places throughout the county. One of the thickest strata of this kind known to have been passed through is at Knowlton station, in the northwestern part of the county, where a well was sunk to a depth of sixty feet. Like in several other counties of southwestern Iowa the outcrops of the Coal Measures are so few that it requires careful investigation in some of the neighboring counties before reliable estimates can be made in regard to the probable depth at which coal can be found and the character of the rocks to be encountered.

DECATUR COUNTY.

The stratified rocks of Decatur county belong to the Upper Coal Measures which are deeply mantled everywhere with drift. The outcrops in the county are comparatively numerous but as yet give little indication of the existence of workable coal seams above the water levels of the streams. Nevertheless, several thin beds

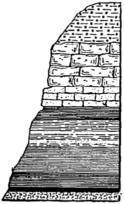


Figure 211. Section on Creek, near Spring Valley.

	FEET.	INCHES.
9. Limestone	1	
8. Shale, yellow, calcareous	1	3
7. Limestone, gray	10	
6. Shale, buff and gray	2	6
5. Shale, black, fissile		10
4. Shale, with thin calcareous bands	3	
3. Shale, dark drab	1	
2. Coal		1
1. Shale, gray (exposed)	2	8

have been recognized at different points along Grand river. Two miles directly west of the town of Decatur, on Sand branch, which flows into Grand river (Tp. 69 N., R. XXVI W., Sec. 29, NW. qr.) a section showing one inch of coal is indicated in figure 211.

Two miles south of the latter section and three miles directly southwest of the same town, on the river just mentioned, a very similar section is shown. The same bituminous shale, but with greater thickness, is also found farther down the river, at Davis City and elsewhere.

In the southern part of the county, two miles west of Spring Valley, a thin seam of coal is exposed on a small branch (Tp. 67 N., R. XXV W., Sec. 14, NE. qr., NW. ¼). At the face of the outcrop the coal is three inches thick, but in driving back into the hill about twenty feet it was found to increase to eight inches. The section given is:

	FEET.	INCHES.
9. Drift	6	
8. Limestone	6	
7. Limestone, arenaceous	3	
6. Shale, black, fissile	2	
5. Shale, with hardened bands	4	
4. Shale, light colored	4	
3. Shale, bituminous	2	
2. Coal		8
1. Shale, gray (exposed)	1	

So far as known no prospecting for coal has been carried on systematically or to any great depth. It is probable that in order to reach the same horizons which supply the coal in Lucas and Wayne counties a depth of from 200 to 400 feet would have to be penetrated.

CHAPTER XII.

CARBONIFEROUS DEPOSITS OF EASTERN IOWA.

Beyond the margin of the Iowa coal field to the eastward there are Carboniferous areas of greater or less extent. Some of these contain coal, others do not, but their age is known with certainty from the fossils they contain. These areas are more or less separate from one another and are surrounded on all sides by rocks much older. There are two classes of these Carboniferous outliers; first, those which were deposited in isolated basins, and second, those which have been separated from the main coal field through erosion. At the present time it is perhaps difficult to determine in any particular case to which one of the two classes a given outlier may belong. These outliers are known to occur as far as 75 or 100 miles beyond the margin of the continuous coal field. Geologically there are many interesting problems centered around these outlying beds. In the first place, they throw much light upon the history of the Coal Period, particularly in showing that the Coal Measures were deposited on a gradually sinking continental shore. Thus they approximately determine the limits of the ancient Carboniferous seas. In the second place, they may be regarded as forming a connecting link between the Western Interior coal field of Iowa and Missouri and the Eastern or Central Interior basin of Illinois. It is not probable that at any time during the Carboniferous the region between the two basins was ever as deeply covered by oceanic waters as the districts on either side, yet it seems quite likely that at some time or other before the close of the Coal Measure period the two were connected, but to what extent is not definitely known.

Most of the outliers occur in counties which are largely or entirely made up of rocks much older than the Coal Age: the Lower Carboniferous, the Devonian and the Silurian. Although it is not to be expected that mineral fuel in commmercial quantities is to be found wherever these outliers exist, workable coal beds do exist in some of the districts, as is well shown in the Carboniferous deposits of Scott and Muscatine counties.

The counties in which outliers have been recognized are Grundy, Delaware, Linn, Jones, Jackson, Clinton, Johnson, Iowa, Scott, Muscatine, Washington, Henry, Des Moines, and Lee.

GRUNDY COUNTY.

Although this county cannot yet be classed among the coal counties of the state, there is every reason to believe that workable coal will yet be found within its limits, the western portion being so near the Eldora district where mining has been carried on for many years, and in which no less than four coal veins are known to be present. Here the coal bearing rocks are at least 150 feet in thickness, and at a distance of less than four miles from the Grundy line. Hence, it is reasonable to expect that the coal bearing deposits extend into the adjoining county. Besides, isolated outliers, or pockets, in all likelihood occur in the district, but as the entire county is so situated as to present few natural exposures of the underlying rocks the discovery of the exact locations of the basins must be largely due to accidental borings rather than systematic prospecting.

DELAWARE COUNTY.

West of Rockville, near the eastern county line, there is a deposit of ferruginous conglomerate found capping the bluffs and lying unconformably upon the old Paleozoic rocks of the region. In lithological characters it is essentially the same as is observed in the other Carboniferous outliers of northeastern Iowa, except that it is more distinctly conglomeratic. This deposit has been referred to the Cretaceous, but its lithological features, stratigraphical position and geographical location seem to suggest that it is more probably Carboniferous. This is rendered still more likely by the recent discovery of a number of outliers with plant remains in the neighboring counties. One of these is as far southeastward as north-central Jackson.

LINN COUNTY.

At the present time only a single locality is known in which the rocks may be referred to the Coal Measures. This is a few miles northeast of Cedar Rapids. Lithologically the beds are a ferruginous sandstone not unlike the other Carboniferous outliers of northeastern Iowa. Although the existence of the sandstone has been known for some time, no fossils were known to occur in it until quite recently, when Prof. W. H. Norton discovered quite an extensive flora of characteristic coal plants.

JONES COUNTY.

This county lies far outside of the coal field of Iowa. In the district, however, is an outlier resting on Silurian rocks, which is now believed to be of Carboniferous age. It is in the southeastern part of the county, two miles northeast of Oxford Junction (Tp. 83 N., R. I W., Secs. 13 and 14). The formation is a dark brown, ferruginous sandrock, similar to that which is found in Jackson county and elsewhere, and contains plant remains. There are perhaps other outliers of the same geological age in different parts of the county, but the one mentioned is the only one whose character and location is definitely known. Although thin seams of coal may occur in these outliers, it is not to be expected that coal in commercial quantities will ever be found in connection with any of them.

JACKSON COUNTY.

Although this county is far removed from the productive coal field it is interesting to know that within its borders outliers of Carboniferous strata are found. It is not improbable, therefore, that thin seams of coaly material of quite limited extent may eventually be encountered in this part of the state. The Coal Measure outlier of this district has recently been made known by Professor Osborn, of the Iowa Agricultural College. The situation is in the southwestern corner of Jackson county, in the neighborhood of Monmouth. It is well exposed in the Stewart lime quarry and is said to crop out near the top of the hills in the vicinity for a distance of about three miles. The beds are made up chiefly of a compact ferruginous sandstone, and contain characteristic coal plants.

Specimens of lepidodendrids and calamites obtained were two to four inches in diameter and from one to two feet in length.

CLINTON COUNTY.

Only two areas, and these very limited, which can be referred to the Carboniferous, are known to occur in this county. One forms a small outlier of brown, ferruginous sandrock, lying in the northwestern corner of the county. It is probably continuous with a similar bed in the adjoining parts of Jones. The other is on a small branch of Deep creek in the northcentral part of the county, near Charlotte. Although these outliers carry characteristic Carboniferous plant remains, it is not probable that workable seams of coal will ever be found in connection with them.

JOHNSON COUNTY.

Johnson county is almost entirely made up of Devonian rocks, the exceptions being a small area in the northeastern corner, which is Silurian, and one in the southwestern part, which is Lower Carboniferous. There are, in addition, a few isolated beds of soft, ferruginous and often shaly sandstone which are found overlying the Devonian rocks. These beds are exposed chiefly along the Iowa river. The largest exposure is in the northern part of the county bordering the northern bluff of the stream and it probably is continuous with a similar formation in Iowa county. It forms a broken area fifteen to twenty miles long and three or four miles wide. The sandstone beds apparently rest unconformably upon the Devonian limestone. The thickness is from forty to fifty feet or more in places. Intercalated are bands of shale some of which are carbonaceous and pass into thin seams of impure coaly matter. The rocks are said to contain remains of Coal Measure plants. At Iowa City, near the milldam, an excellent exposure of thinly bedded sandstone is seen filling an old gorge cut from Devonian limestone, the line of contact, which is inclined at a high angle, being clearly visible for thirty or forty feet. The ancient bed of the water course opens out to the westward, the present channel of the river being at right angles and cutting directly across the old one.

IOWA COUNTY.

Although Iowa county cannot yet be regarded as one of the coal producing districts, it is quite probable that workable coal seams will be found in the southwestern part of the region. The greater portion of the strata below the drift is made up of Devonian and Lower Carboniferous limestones. In the southwestern corner the Coal Measure strata of Keokuk county probably extend over into this county, as one of the principal mining districts of Keokuk is situated within a few miles of the Iowa county line.

In the northeastern part of the county, along the north bluff of the Iowa river, there exists an extensive deposit of brown, ferruginous sandstone, moderately compact but very irregularly bedded. There is no direct evidence as to the geological age of this formation, but it is thought to belong to the Coal Measures. No indications of coal has been found in connection with it. Though perhaps representing one of the Coal Measure outliers, no workable coal deposits need be sought for in connection with it.

SCOTT COUNTY.

The northern half of the county is composed almost entirely of Upper Silurian dolomites. They are well exposed at LeClaire and other points along the Mississippi, as well as along many of the smaller interior streams. They often show considerable disturbances, the strata frequently being tilted as high as thirty or forty degrees. The southern half of the county is made up almost entirely of Devonian rocks, which are largely limestones, with some sandrock and shale. These beds are best exposed along the Mississippi, from a point below LeClaire to the Muscatine county line.

There are a number of Carboniferous outliers within the limits of Scott county. The beds are for the most part sandstone with occasionally some shale. One of the most notable basins of Coal Measure strata is just below the town of LeClaire, where the apparently level strata are seen resting on the upturned edges of the Silurian limerock, the angles between the two planes of stratification being from fifteen to twenty degrees. Another outlier of the same kind is known to exist a few miles below the one just mentioned. On the Iowa side of the river no coal is known to occur in these beds, but on the opposite side a thin seam of coal and its accompanying bituminous shale is said to exist. In east Davenport another similar outlier of Carboniferous strata has been reported. Coal has been prospected for here, and it is said that workable seams have been found.

From a few miles below Davenport to the west county line the upper portion of the bluffs is occupied by the eastern extension of the Muscatine outlier. Although only about one-third of the entire outlier rests in Scott, the majority of the mines now worked in it are situated in this county. Like in Muscatine county there are two sandstones found closely associated with one another, the lower one being of Devonian and the upper of

Carboniferous age. Probably all the mines now in operation are not working in the same vein, as is generally supposed, for it is quite possible that several seams exist. The coal worked varies from one to six feet in thickness, and is of the ordinary bituminous variety. Below the chief seam a short distance and lying just above the Devonian limestone a cannel coal is said to exist in some places. As reported by Hall the cannel portion is from one foot to one and one-half feet in thickness and is situated between black shales, the upper one of which is from two to two and a half feet and the lower about one and a half feet thick.

Coal has been mined in Scott county for upwards of forty years. At the present time the mines operated are all near Buffalo. There are two well defined groups of mines, the first located on Stillwater creek, about a mile west of the railroad station, and the other about three miles north, in the vicinity of Jamestown.

In the district west of town there are at present only two mines working. The Friedley (Tp. 77 N. R. II E., Sec. 17, SE. qr., SE. ¼) is a shaft about fifty feet deep, located a short distance from the creek. The section of the coal as found at this place is as follows:

	FEET.	INCHES.
4. Shale, gray, argillaceous	32	
3. Shale, black, fissile		8
2. Coal	3	
1. Shale, clay, hard, black	9	

In mining, the black shale (number 3) is taken down and the gray shale allowed to form the roof, which is exceptionally good. The coal is bright, clear and clean, running from two and one-half to four and one-half feet in thickness, and dips to the east about three feet in a hundred. Small slips occur and low "horsebacks" are occasionally encountered. The coal is worked by the room and pillar plan. The entry has been driven 130 feet east and 200 feet south. The output is quite large for a country bank, and an important local trade is supplied. A half mile south is the Kantz mine which has been operated in a small ravine leading into the Stillwater. The coal here worked is reached at a depth of 106 feet, and is apparently the same as that worked at the Friedley bank, the difference in the depths of the shafts being due largely to surface irregularities, though a slight dip northward has been noted. The coal averages about three and a half feet in thickness. The gray shale is left for the roof. The shale underlying the seam is quite sandy and in many places passes into a characteristic compact sandstone. A short distance directly west of the Kantz mine is the Webster shaft which is not now in operation. In former years several other mines were also worked in the immediate neighborhood.

Around Jamestown coal has been mined for a long time, and at present four mines are in active operation. The coal here appears to run in a trough trending southeast and northwest, and has been traced for over two miles. Near the Mackin and James mine it apparently bends westward. It is not exposed beyond this point. The workable coal varies from 200 to 400 feet in width, being thinner at the edges than in the middle. The seam along the median portion of the trough is called by the miners "swamp coal" and is said to be more than six feet in thickness in places. On both sides the bed rises so that the "swamp" is fully ten feet below the margins. Along the edge of the basin, in some portions of the field, a roll or "pinch-out" has been traced for a considerable distance. As a rule, however, the vein is quite free from "troubles," the small slips and low "horsebacks" occurring not interfering seriously with mining.

In the Hanlon and Blackwell mine (Tp. 77 N., R. II E., Sec. 11, NW. qr., NW. ¼) the coal is reached by a shaft seventy feet deep. The section measured may be taken as representative of the coal of the basin:

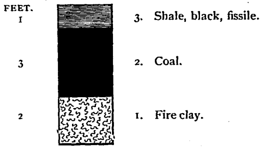


Figure 212. Seam in Hanlon and Blackwell Opening. Jamestown.

On the same land is the old Williams mine, and just across the road the deserted Mackin opening. About a quarter of a mile directly west is the Friedley and Hoyt shaft which is about seventy feet deep. In this mine the "swamp coal" was also measured. The section is:

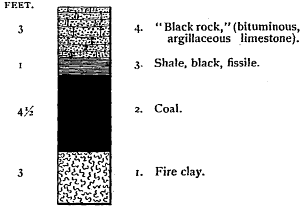


Figure 213. Coal Bed at Friedley Mine. Jamestown.

The black shale roof is covered in places by a hard, compact, black, calcareous limerock, carrying some iron.

Irregular nodules of this dark clay ironstone called "niggerheads" attain a measurement sometimes of five feet.

Near the Jamestown schoolhouse a section of a shaft sunk several years ago was given as:

		FEET.
8.	Soil	1
7.	Clay, yellow, drift	48
6.	Sandstone, soft, yellow	10
5.	Shale, carbonaceous	20
4.	Shale, black, fissile	9
3.	Clay ironstone	4
2.	Coal	4
1.	Fire clay	2

About half a mile west of the Friedley and Hoyt mine is the Mackin and James shaft, which is probably the most important one in the district, supplying a large local trade. The coal is five feet thick in places, with an average thickness of perhaps three feet.

A mile directly south is the Rowan mine, working apparently the same vein. There are two veins of coal said to be present in this place about thirty-five feet apart. The thickness of the seam averages about three feet. The dip is to the southeast, four feet in a hundred.

Besides the mines mentioned there are a number of others which have been worked from time to time. With facilities for loading the output directly on a railroad track an important commercial trade might soon be developed.

MUSCATINE COUNTY.

The coal bearing strata of Muscatine county forms an irregular belt from one to five miles in width extending along the course of the Mississippi river from a short distance below the city of Muscatine nearly to Davenport. With the exception of this zone the entire district beneath the drift is made up of rocks much older, Devonian chiefly. At the time of the early explorations under the auspices of the Federal Government during the latter part of the forties the outcrops were best exposed in the vicinity of the former place, and consequently the Carboniferous area was widely known as the Muscatine outlier. In reality it forms part of the Illinois field from which it is now separated only by the comparatively narrow, recent channel of the Mississippi, The coal bearing strata form the upper part of the bluffs and occupy an eroded depression in the Devonian rocks.

Over most of the region there are two sandstones quite similar in general appearances and closely associated. The one is Devonian in age and carries a very distinct and characteristic fauna; the other is a Carboniferous accumulation and its organic remains are chiefly those of plants. Although the latter rocks are largely sandstones there is some shale near the base. The formation is quite extensively developed for a distance of eighteen or twenty miles above the city of Muscatine. On Pine creek, a mile above its mouth in a narrow gorge, locally known as the Wild-cat den, more than a hundred feet of the brown and yellow sandstone rises above the creek level in perpendicular cliffs. The same rocks are also well shown at Wyoming hill, four miles above Muscatine, where abundant remains of plants are found. Just below Muscatine it is well exposed in a high mural bluff. At the present time the details of the section are somewhat obscured but appears to be essentially the same as that given by Hall more than thirty-five years ago, which is as follows:

		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, more shaly in the lower part	8½
4.	Thin bedded sandstone, with shaly parting	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, as originally described by Whitney, not very regular, but is divided into several smaller and somewhat irregular areas toward the river. To the west a short distance it becomes more regular, and attains a thickness of two and a half to three feet. A little farther westward it appears to thin out entirely, allowing the sandstones above and beneath to come together. There are perhaps several coal seams in this outlier. The thickness of the one worked varies from an inch to over three feet. It was formerly mined in the vicinity of Muscatine and at several other places along the bluffs from below the city to the mouth of Pine creek. For several years, however, little coal has been taken out, yet the openings of several of the deserted pits are still recognizable. The only place within the limits of the county where coal has been mined recently is at the Hoor bank, about three miles east of Muscatine (Tp. 77 N, R. I W., Sec. 29, NW. qr.). At the present time the mine is not in operation, owing to the death of the former owner. It is a drift which has been worked for some years. Two entries have been driven back into the hill a distance of about 1,000 feet. The coal averages three feet in thickness and is quite regular. The floor is a soft gray fire clay. The roof is a sandstone, quite firm and rather compact. Its excellent character and the freedom of the coal from irregularities or clay seams makes it quite probable that other mines could be operated here to considerable advantage. The section at the opening of the Hoor mine is given below:

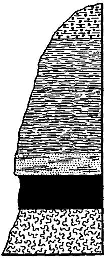


Figure 214. Coal at Hoor Drift. East of Muscatine.

		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

WASHINGTON COUNTY.

Washington county lies beyond the boundaries of the main body of the Iowa coal field, and while there are workable coal seams in the limits of the district they apparently all belong to outlying areas. The greater portion of the county is occupied by Lower Carboniferous and Devonian rocks. The former are well exposed along the larger streams over more than two-thirds of the entire area of the county. The latter occur in the northeastern corner. There are a number of Coal Measure outliers in the county, but the only one in which coal has been mined is in the southcentral portion, near Verdi. The Saint Louis limestone outcrops in the beds of the several creeks in the neighborhood, but a small area of Coal Measure strata appears to have escaped complete erosion. Like the other deposits of this kind it is composed chiefly of coarse grained, ferruginous sandstone, with a few feet of shales intercalated at different places. At the present time the coal is exposed only in a few places a mile and a half west of the town named, in the shallow channels of the various water courses. The seam is not now worked, yet there are remains of numerous diggings. Thirty years ago there were several mines in active operation, and considerable coal taken out (Tp. 74 N., R. VII W., Sec. 4, NW. qr.). The section given by Worthen is:

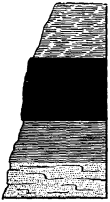


Figure 215 Coal Seam near Old Liebig Mine. Verdi.

		FEET.
5.	Shales, argillaceous	3
4.	Coal	3½
3.	Clay	2
2.	Sandstone, ferruginous, partially exposed	?
1.	Limestone, Saint Louis, (exposed)	10

Sandstone like the one outcropping near Verdi is exposed at a number of places in different parts of the county. At Wassonville, just north of Wellman, in the northern part of the county, a similar outlier of Coal Measure sandstone has been reported and considerable expense has been involved at various times in search for coal. The rocks, however, exposed at the surface here are almost entirely Lower Carboniferous. Beneath the main mass of earthy limestone containing bands of fossiliferous chert is ten feet of argillaceous shale, bluish and black in color. It is well exposed at the old Maple mill, two miles below, as well as at Wassonville. These shales appear to have been taken for Coal Measure formation and many prospectors have considered it a good indication of the existence of coal. At one place a shaft eighty feet deep, beginning in the Burlington limestone, was sunk down to it. Small pieces of the shale taken from a shaft were found to be more or less bituminous, and with a hot fire were made to burn.

HENRY COUNTY.

The indurated rocks of Henry county are largely Lower Carboniferous limestones. At least three members of this series are represented. The lowermost is the Burlington limestone which crops out in the eastern part of the county at several points. Above it comes the Keokuk limestone and shales which are well exposed along the Skunk river from the southeastern corner of the county to the mouth of the Big Cedar. There is also a small outcrop of the same rocks farther up the river in the northwestern corner of the county. The Keokuk beds also occur along Big creek, southwest of Mount Pleasant. The uppermost member of the Lower Carboniferous in the region is the Saint Louis limestone, which is the surface rock found immediately beneath the drift over most of the county. It outcrops along the Skunk and all of the smaller streams throughout the county. It presents the usual lithological characters. In places sandy layers are intercalated, the most noticeable occurrences being in the northwestern corner of the county, below Coppack. The Coal Measures are found chiefly west of the Skunk river. They rest in marked unconformity upon the underlying rocks. For the most part the beds are sands and shales, though well developed coal seams have been opened along the west county line.

West of Rome, near the Skunk river, the Coal Measure sandstones are exposed to the water's edge. In this vicinity a number of mines have been opened though at present most of them are deserted. There is said to be also a four-foot vein of cannel coal in the bed of the river some twenty feet below the seam worked. In the neighboring ravines the workable coal vein crops out at several points. The following is the section measured:

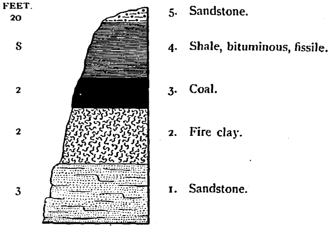


Figure 216. Bluff on Skunk River. Rome.

On the east side of the river, below the railroad bridge, yellow sandstones are seen at short intervals, deep gorges being formed by the minor tributaries as they enter the stream. On the west side, between the river and Cedar creek, is a long, narrow ridge almost entirely occupied by coal bearing strata. Coal from fifteen to twenty-five inches in thickness is known to exist. It has been mined at several places and also on the west side of the larger stream.

Above Oakland Mills and four miles west of Mount Pleasant, on the Skunk river, coal was mined for some years. North of Salem about two miles a thin coal seam has been opened in the valley of a small ravine. West of the same place, four or five miles, in the vicinity of Hillsboro, mining has been carried on quite extensively, although most of the openings are in Van Buren county, just across the line. The principal mine is the Cox pit (Tp. 70 N., R. VIII W., Sec. 25, NE. qr., NE. ¼). The section of the coal bed is:

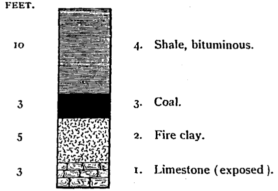


Figure 217. Coal Bed at Cox Mine. Hillsboro.

Although not running at present this is the largest mine in the vicinity. The opening is a drift and has been operated for more than twelve years. The thickness of the shale forming the roof is from four to twenty-five feet, the variability being due largely to preglacial erosion. Coal has been mined in the neighborhood for upwards of thirty years, half a dozen openings being still in operation. Directly east of Salem about five miles, at Boyleston, coal is exposed in the wagon road (Tp. 70 N., R. VI W., Sec. 26). It has been mined to some extent here, the vein being four feet in thickness at some points. The Coal Measure area of this region probably forms a portion of the larger tract which is known to occupy also the northern portion of Lee county, where considerble mining has been done, and to extend westward into Van Buren and Jefferson counties.

The outliers of Coal Measure strata in Henry county are quite numerous. The more important ones are along the east side of the Skunk river and Big creek. Southwest of Mount Pleasant, near the water-works, bituminous shales are well exposed, and in places contain some coaly material. There is also a small outlier directly west of Mount Pleasant, where the dark colored shales are seen a short distance above the Saint Louis limestone. The section here is as follows:

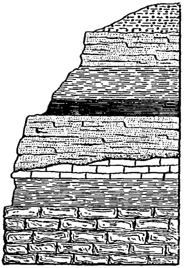


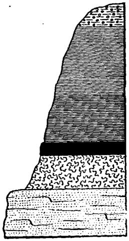
Figure 218. Contact of Coal Measures and Saint Louis Limestone, on Branch of Big Creek. Mount Pleasant.

		FEET.
8.	Drift	4
7.	Sandstone, light yellow	5
6.	Shale, gray	5
5.	Shale, dark, bituminous	2
4.	Sandstone, unconformable upon 3.	6
3.	Limestone, light gray, compact	3
2.	Shale, light, ash colored	4
1.	Limestone, compact, heavily bedded (exposed)	8

Southeast of Mount Pleasant a distance of three miles is a small basin of coal where mining has been attempted for some years. In the southeastern corner of the county another outlier of Coal Measure strata is known forming part of the small area which extends into Des Moines county. A coal vein one foot in thickness is known to occur in this pocket.

DES MOINES COUNTY.

The rocks of this county are almost entirely Lower Carboniferous limestones. There are, however, several small outliers of Coal Measure strata within the limits of the district. These are chiefly confined to the southwestern portion of the county. Two miles directly northeast of Augusta are several exposures of brown, massive sandstone which rise in high bluffs. No coal or the accompanying shales are noticed in connection with these outcrops. Seven miles to the northwest and about three miles southwest of Danville, on Cedar creek, there are a number of exposures indicating clearly that a Coal Measure basin of several miles in extent exists in this part of Des Moines county and the adjoining portion of Henry. The clays are now used chiefly in the manufacture of pottery and tiling. A thin coal seam is found in connection with the shales. At one place (Tp. 70 N., R. IV W., Sec. 30, SE. qr.) the vein was formerly worked to a small extent for local use. At the present time the coal is not well exposed. The section given by Worthen is as follows:



	FEET.
5. Drift	2
4. Shale, bituminous	10
3. Coal	1
2. Fire clay	3
1. Sandstone, brown, ferruginous (exposed)	4

Figure 219 Bluff on Cedar Creek. Southeast of Danville.

LEE COUNTY.

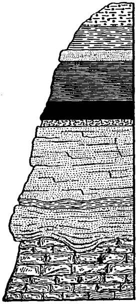
Lee forms the extreme southeastern corner of the state. For the most part the rocks underlying it are older than the Coal Measures, all of them belonging to Lower Carboniferous limestones which form the great floor of the coal bearing series in Iowa. In the extreme northeast, along Skunk river, below Augusta, the Burlington limestone is well exposed near the base of the bluffs. The Keokuk limestone, which outcrops along the Skunk river above Augusta, along the Mississippi from Fort Madison to Keokuk, and northwestward from the latter place along the Des Moines river to the Van Buren county line, forms the surface rock of much of the county. Capping the bluffs in the southeastern part of the district and making up probably a considerable portion of the interior surface rock, is the Saint Louis limestone, the white, compact brecciated beds of which are so well exposed in many places.

The coal bearing strata are composed almost entirely of isolated outliers of the Iowa coal field on the one side and of the Illinois field on the other. Most of the Upper Carboniferous basins consist of brown sandstones which form the basal member of the Coal Measnre series. This sandstone is found in many localities in the northern part of the county, in the southeast between Montrose and Keokuk and elsewhere. It is a compact, brown sandrock, rather heavily bedded and withstands weathering well.

Coal has been mined in a very desultory manner for a number of years, and the seams now continue to be worked a little from time to time. As the coal layers are chiefly in limited pockets or outliers it cannot be expected that the county will ever rank among the coal producing districts of the state. The principal places where coal is known to exist are in the northern part of the county, near the middle of Pleasant Ridge township, and in the northeastern part of Franklin township; also short distances north and west of the city of Keokuk.

In the vicinity of Keokuk the principal places where coal has been taken out is below the city, just above Nassau slough.

The section near one of the openings is as follows:



		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 unconformibly upon the next	10
1.	Limestone, gray, compact, brecciated, (Saint Louis formation)	5

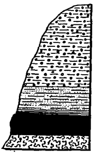
Figure 220. Top of Bluff on Mississippi River at Nassau Slough. Below Keokuk.

Below number 1 of the above section the full thickness of the Saint Louis limestone, the "Warsaw," the "Geode bed," and part of the Keokuk limestone is exposed. The coal mined here is of very good quality. It has been worked at different times during the last thirty or forty years. No coal, however, has been taken out since 1890.

North of the city, in the bluffs near Rand park, coal was formerly mined by means of drifts. The openings, however, are now abandoned. Very little coal was taken out at this point, and the entry is at present blocked or filled by débris from the fallen roof.

Still farther up the river, and a mile beyond Sandusky station, a Coal Measure outlier is exposed in the top of the bluff, but no coal is known to exist at this point.

In the northern part of the county, three miles northwest of Denmark and a couple of miles from the Skunk river, coal is worked at the Stevenson bank. The output is entirely local. A mile to the north (Tp. 69 N., R. V W., Sec. 14, NE. qr., NW. ¼) coal is obtained by stripping. Of late years, however, only small quantities have been taken out. An outcrop near the road shows the following section:



FEET.	
6	4. Drift.
2	3. Sandy shale.
1½	2. Coal.
1	1. Fire clay.

Figure 221. Outcrop southeast of Denmark.

On the opposite side along the creek, sandstone, shales and the Saint Louis brecciated limestone appear at a slightly lower level. The coal here dips westward. A mile and one-half directly west, on Sutton creek, coal is also known to exist on both sides of the stream. It is obtained both by drifting and by stripping. At one time the beds were worked to a considerable extent, the output being used principally at West Point, a few miles to the south. The seam is said to be from twenty to thirty-five inches in thickness. At the present time but little coal is being mined at this point, and the few tons which are taken out each year are obtained by stripping along the creek bottom.

Two miles west of West Point coal has been obtained in small quantities for many years. Along the road side (Tp. 68 N., R. VI W., Sec. 1, NE. qr., NW. ¼) coal has been exposed in recent washouts. A mile and a half directly south of this point are several abandoned workings which formerly supplied all local demands. Three miles northwest, also a mile northeast of Denmark (Tp. 68 N., R. V W., Sec. 10, NW. qr., NW. ¼) on a tributary of Sugar creek, several openings have been made at various times. In a ravine leading into the creek from the south is an old drift where the following section is shown:

	FEET.
5. Drift	5
4. Coal	1½
3. Fire clay	2
2. Sandstone	5
1. Limestone, Saint Louis (exposed)	14

A mile directly north of the last named locality, on the opposite side of the creek, in section 4, is the old Hard-

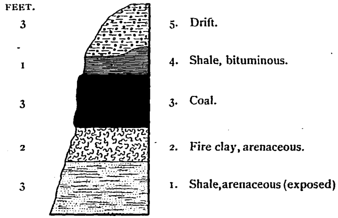


Figure 222. Coal Bed at Old Harwick Mine. Near West Point.

wick mine. It was worked by a shaft, which is now abandoned, and by a drift in a ravine. Coal was formerly taken out of this mine in sufficient quantities to afford abundant local supplies. It was also worked by stripping in several places near by. The coal was reported by the present owner to have a thickness of three to three and one-half feet. The section at the opening of the drift is shown in figure 222.

A short distance northwest is another small shaft in which coal has been mined for local use.

The coal of this portion of the county, though manifestly occupying an isolated position, belongs to an outlier having an extent of twenty-five or thirty square miles altogether. With the proper railroad facilities and systematic prospecting it is not improbable that coal in commercial quantities could be obtained for a number of years at least.

CHAPTER XIII.

COMPOSITION OF IOWA COALS.

INTRODUCTORY.

In beginning investigations on the composition of the Iowa coals attention has been directed chiefly to the merchantable product just as it comes from the mines and is sold on the market. As will be shown more in detail in another place there is nowhere in the state any special preparation of the coal for the different uses to which it is put. No instance is known at the present time where the slate, "sulphur" balls, ironstone nodules, or other gross impurities are systematically removed before the output is loaded for shipment. This elimination of the larger masses of impurities from the coals in other places has made some of the neighboring states formidable competitors in the Iowa home markets. With the sorting out of some of the substances detrimental to the Iowa coals quite different analyses of the commercial article would be obtained.

The chemical analyses tabulated farther on were made chiefly by Prof. G. E. Patrick, of the Iowa Agricultural College. The methods of sampling have varied somewhat in accordance with different problems which required solution, but in all cases careful checks have been kept in comparing results received in the different ways. As the discrepancies between the several methods are very small they may be for all practical purposes ignored. To be sure, many of the analyses are doubtless quite different from those made elsewhere of essentially the same coals, but it is to be remembered that in the large majority of cases the results obtained by the latter are largely from picked samples, while those here given are representative of the product as it is sold to the public. On the whole, the merchantable coals of Iowa with proper preparation would be much better than the presented analyses indicate at first glance. As it is, however, they compare very favorably with the other coals of the Western Interior basin.

KINDS OF COAL.

The commercial varieties of coal are classified principally according to the different proportions of fixed and volatile components contained. The combustible portions are made up of the lighter volatile hydrocarbons, which are driven off when the coal is moderately heated, and the fixed carbon. The proportion of the former in the total amount of combustibles determines the character of the coal. Thus of volatile matter the percentage contained is in:

Graphite	0
Anthracite	10
Semi-anthracite	20
Bituminous coal	40

Graphite, the pure massive variety of carbon so common in crystalline rocks and areas exhibiting regional metamorphism, is practically devoid of volatile matter.

Anthracite, or hard coal, contains but a small proportion of the volatile hydrocarbons. Its comparatively great hardness, weight, lustrous appearance, conchoidal fracture, difficulty of ignition, and the burning with blue flame, accompanied by little or no smoke, are characters readily distinguishing it from other varieties of coal.

Semi-anthracite possesses properties about midway between those of true anthracite and the bituminous coals. The hardness and density are less than in the former, the volatile combustibles greater. Fractured surfaces are not so glistening. When ignited a yellowish flame appears, but gradually disappears as combustion continues.

Bituminous coal is commonly quite soft, and breaks easily. It contains a large percentage of volatile matter, burns with a strong yellowish flame, and gives off in ignition a more or less dense smoke. The Iowa coals are largely of this kind. There are, however, three more or less distinct varieties. These are: (1) the dry, open burning or furnace coals; (2) cementing or coking coals; and (3) the cannel coals. "Of these the first and second varieties are sometimes classed as cubical or block coals, from their tendency to break into more or less cubical blocks. The first variety enumerated includes those that do not coke and adhere in the furnace, and such as can be used in the raw state for the manufacture of iron. They have generally a distinct laminated structure, and are composed of bituminous layers separated by thin partitions of cannel or mineral charcoal, materials which do not coke. Hence the bitumen in them—relatively small in quantity—is held in cells, and cannot flow together so as to give the mass a pasty, coherent character.

The second class, or cementing coals, are such as have few partitions, but show upon fracture broad surfaces of pitch-like bitumen. These, to a greater or less degree, melt or agglutinate by heat, forming what blacksmiths term a hollow fire. This property causes them to choke up the furnace and arrest the equal diffusion of the blast through the charge; hence they cannot be used in the raw state for the manufacture of iron, but must be coked. This process of coking consists in burning off the bituminous or gaseous portion, which leaves the coal in the condition of anthracite, except that as this change is effected without pressure, the resulting material is cellular and spongy. Coals of this character, when free from sulphur—their great contaminating impurity—are used for the manufacture of gas; the volatile portion driven off in the retorts serving the purpose of illumination, while that which remains is coke and may be used as fuel." (Newberry.)

The third class, or cannel coal, occurs rather sparingly in Iowa, and there is very little mineral fuel that can properly be called by this name, though there are a number of seams in different localities which closely approach in character. In the formation of this variety of coal there seem to have been somewhat different physical conditions than those under which the ordinary bituminous kinds originated. Newberry held the opinion that this coal formed in the lagoon of open waters in the coal marshes, and that in these lagoons the completely macerated vegetable tissue accumulated as a fine carbonaceous mud. The evidence he deduces may be summarized as follows:

First. The cannel coals in their intimate structure are more homogeneous than the cubical coals, and show nothing of the alterations of bright and dull lines to which reference has been made, and which may be considered as proofs of changing surface conditions in the coal marsh.

Second. Though laminated in the sense that the cubical coals are, the cannels are more distinctly stratified like other rocks which are deposited from aqueous suspension.

Third. The cannel coals generally contain a greater percentage of volatile matter than the cubical coals, and the gas made from them consists more largely of hydrogen, and has higher illuminating power. All of which is a natural result of their deposition in a hydrogenous medium which prevented oxidation.

Fourth. Cannel coals, as a rule, contains more ash than the cubical coals, and they frequently pass into bituminous shales. This occurs where the water from which they were deposited had a more rapid motion and greater transporting power. It then carried and mingled with its carbonaceous sediment an increasing and ultimately preponderating amount of mineral matter.

Fifth. Cannel coal contains, as characteristic fossils, aquatic animals, such as mollusks, fishes, amphibians and crustaceans. These are sometimes so abundant and of such a character as to prove conclusively that they inhabit the pools of water in which cannel coal was deposited as a sediment. Where plant remains are found in cannel they are usually floated fragments which show the effect of long maceration, fern fronds, for example, being usually skeletonized.

Sixth. In the lagoons of open water in our modern peat marshes fine carbonaceous sand accumulates, which, when dried, closely resembles in appearance and properties our cannel coal.

Lignite.—There are two other sources of mineral fuel in Iowa which require passing mention here. They form a part of the coal series. The one is lignite, or brown coal, and the other is peat. Neither of these substances come within the scope of the present work; but they will form subjects of special consideration at another time. Lignite is a compact woody or charcoal-like material having many of the properties of common bituminous coal, but is very soft, easily crumbled, and contains a high percentage of hydrocarbons and moisture. By proper preparation, and by manufacturing it into briquettes a very serviceable fuel is often obtained. Several beds of this material are known to occur in the Cretaceous deposits of northwestern Iowa, one of them being upwards of four feet in thickness.

Peat.—This is one of the first stages in coal formation. The thick matted mass of vegetable matter gradually becomes more and more compact, lose much of their hydrocarbons, and finally, with heat and pressure, may turn into coal. Extensive deposits are found in the northern portions of the state.

PHYSICAL PROPERTIES OF COALS.

In their ordinary physical properties the Iowa coals have a very considerable range of variability. The character of the fractures, hardness, specific gravity, and color of the ash when burned, all change very materially with the locality.

Fracture.—This is quite characteristic for different places. In nearly all cases ordinary breakage of the coal yields more or less cubical blocks of varying size. Sometimes the broken surfaces show glistening faces not unlike anthracite. This is notably the case with the Mystic seam of southern Iowa. Commonly, however, the fractures show alternate bright and dull bands. The tendency towards lamination is one of the most noticeable physical characters of many of the bituminous coals. This feature enables them to be broken up readily into more or less cubical masses, hence they have been called "block" or "cubical" coals. An examination of a block of ordinary bituminous coal will show an alternation of bright and dull lines. The bright lines on further examination will be found to be made up almost entirely of hardened bitumen; the dull lines to be mineral charcoal. The bright folia are very much harder than the dull plates. In striking the block of coal with a hammer it cleaves readily along the dull lines. These cleavage faces are found to be made up of a matted mass of what appears to be pressed or flattened charcoal. When the coal seam is examined in the mines before it is removed, it is found that the bright and dull lines are always parallel to the planes of sedimentation.

Recognizing the fact that the coal was originally a vegetable accumulation, and was subsequently covered by deposits of clay and sand, it will be readily inferred that, in a mass of matted plant remains on a gradually sinking shore, a constantly increasing pressure upon the beds would be the result of an increasing deposition of sediments, and that the vegetable matter would continually be made more and more compact as the overlying beds became thicker, and as time went on. Gases arising from the slow decomposition of the plant remains gradually escape. Both the pressure above and the loss of gases allow the bulk of the seams to greatly diminish. This process probably continues, though slowly, until the coal bed has become perfectly hard and massive like anthracite. When ironstone nodules and concretions are found in the coal seams the laminations are very distinct both immediately above and below the foreign mass. The thin leaves which are perfectly horizontal elsewhere in the beds bend upwards and downwards around the nodules, closely following every curve and inequality in the surface. Large nodules five or six feet across and imbedded in coal seams considerably thinner protrude above the top of the coal layers. The upper portion of the nodules, however, is commonly covered with the coal to a thickness of from one to four inches. In the immediate vicinity of the nodules the coal is so strongly laminated that it cleaves like ordinary slate into extremely thin leaves. The arrangement and position of these ironstone nodules in the coal veins leave but little doubt that the coal seams have decreased greatly in thickness since the time the concretions became thoroughly hardened.

In regard to the differences between the two kinds of laminæ, the bright and the dull, it seems probable that they may have been due to a great extent to the original condition of vegetable materials. In a swamp such as that in which most of the coal was formed there would probably be times when the woody stems of plants would accumulate in the marshes more abundantly than at other periods. There would also very likely be times when fine sediments would enter the swamps. This might have been yearly or in cycles of years when there were unusual growths, or floods.

Hardness.—With every handling of soft coal there is greater or less loss through crushing and attrition. Every degree of hardness diminishes the waste in movement from the mine and in transportation. The hardness of the Iowa coals may vary greatly according to the locality and the seam worked. This is well shown at the mines where the waste in slack and fine coal or dust is from four to fifteen per cent of the total amount taken out. Some of the Iowa coals are too soft to endure a great deal of hauling, and, consequently, the output of mines operating in such veins must be used almost entirely locally. Most of the coal of the state when not taken from faces of natural exposures or at the immediate surface, has sufficient strength to withstand considerable hauling and transportation without marked depreciation in the weight of the merchantable product.

CHEMICAL ANALYSIS.

Determinations Made.—All the tests as yet made in regard to the composition of Iowa coals have been proximate and not ultimate analyses. The ultimate analysis, while giving accurately the proportions of the different elements present, is unreliable as a basis for the computation of heat equivalents in making comparisons. The method employed in making these analyses is the one commonly used in determining the relative values of different beds. The process is much more simple than that necessary for a complete elemental determination and still serves to bring out the proportions of the various components affecting the fuel values of the coals. The determinations commonly made are:

Moisture.
Volatile Combustible Matter.
Fixed Carbon.
Ash.
Sulphur, in sulphides.
Sulphur, in sulphates.

Methods of Analysis.—The moisture is determined by heating a known weight of coal for one hour at a constant temperature of 105 degrees, Centigrade, or slightly above the boiling point of water. From the loss in weight the percentage of moisture may be calculated.

For the other components, excepting sulphur, a second weighed portion of coal is heated in a covered crucible to a dull red heat for three and a half minutes; the temperature is then raised to a bright red heat which is maintained for an equal length of time. After subtracting the amount of water previously determined, the loss in weight represents the volatile combustible matter. Longer subjection to heat would be at the expense of the fixed carbon.

The coke, which remains in the crucible after the volatile matter has been driven off, is now subjected to a high degree of heat until the remaining carbon is consumed, which may then be reckoned as fixed carbon. The weight of the residue gives the percentage of ash. The ash may also be determined separately.

The value of the investigations which have just been considered depends entirely upon the maintenance of similar conditions for each sample in the series of coals.

The estimation of the sulphur is in no sense approximate. It is made independently, both as to the sulphates and the sulphides, no attempt being made to distribute it among the factors of the previous analyses. However, that portion of the sulphur already oxidized in the coal and which is separated as sulphate will be found in the ash.

Suggestive as such an analysis is, experience has shown that too much reliance may be placed upon it as an indication of the true value of a coal for any particular purpose. The physical properties already mentioned must be also taken into consideration. Thus for metallurgical purposes analyses may point to a coal low in sulphur and ash which may be still totally unfit for use in the furnace because of its coking qualities. Such a coal, however, is worthy of fuller investigation regarding the physical properties of its coke, for at the present time very little raw coal is used in blast furnace practice since the porosity, compressive strength, energy, and intensity of heating power possessed by the better classes of coke render them superior to the best anthracite coal, regardless of the somewhat larger proportion of impurities.

For purposes of gas making a high percentage of volatile combustible constituents and at the same time low proportions of sulphur are required. In this case the adaptability of a coal for producing gas of high illuminating power can best be judged only from an ultimate analysis.

Moisture.—Water, being the product of the perfect oxidization of hydrogen, is evidently incapable of combustion. Its presence is doubly deleterious, causing a negative loss by adding to the weight without increasing the heating value, and a positive one by requiring evaporation, thus diminishing the available power of the fuel.

In the amount of moisture present in the different Iowa coals there is very considerable range, from 2.06 per cent, the lowest, to 11.72 per cent, the highest, the average probably being in the neighborhood of seven per cent. This amount compares very favorably with the Illinois coals, with which the Iowa product is brought into chief competition. It is, however, from one and one-half to three per cent higher than the average moisture found in Ohio, Missouri or Kansas coals.

Volatile Combustible Matter.—The volatile combustible matter comprises in a general way the gaseous constituents of the coal. The moderate heat employed in its determination is sufficient to expel the greater part of the various compounds of carbon and hydrogen. When their combustion is complete these gases have high calorific power, but owing to the devices in common use the volatile portions of bituminous coal are almost entirely wasted, passing off in dense black clouds of pure carbon, accompanied by the lighter gases of combustion and distillation. In this manner a very large part of the inherent virtue of the coal is worse than wasted. The introduction of automatic stokers and smoke consumers would obviate to a very large degree these disadvantages in the use of bituminous coal. So widely has this matter been considered that it is thought to be worthy of special ordinances in some manufacturing cities. Strange it is that those who use the largest quantities of coal must be forced to economize in their fuel. The attention of steam users should also be urged to the intelligent study of the proper relation of coal used to the grate employed. Coals show great individuality in their behavior, those of similar composition often showing wide differences in the same furnace, and coals whose analyses indicate a deficiency frequently giving better satisfaction than those of apparently better quality.

Fixed Carbon.—In the uncombined, or fixed, carbon lies the greatest value of a coal as now generally employed. Though in uniting with oxygen only about one-third as much heat is developed as in the union of an equal amount of the hydrocarbons, its non-volatile properties insure for this portion of the coal more complete consumption. The percentage of fixed carbon is usually the basis of comparison of coals. This is especially applicable to the valuation of steam coals, but for this use sufficient volatile matter must be present to insure easy ignition and free combustion, for quantity of heat as a desideratum here gives place to intensity. For this reason and because of the intense local heat developed by anthracite inducing rapid oxidization of the grate bars, bituminous coal is to be prefered for general use under steam boilers.

Ash.—Unlike water the residue left after combustion has no positive effect in reducing the efficiency of a fuel, but is generally an inactive addition from which nothing is realized but which must be handled, and this always at constant expense. In domestic fuels a high proportion of ash is more to be avoided than in steam coals. On locomotives, where it is possible to reduce the handling of the waste product to a minimum, coals having a large percentage of ash may be frequently used with economy. From the color of the ash an idea may often be obtained as to the amount of iron, and indirectly a rough estimation of the sulphur, since most all of the iron is in the form of the sulphide.

Sulphur.—While in a condition to be easily oxidized the injurious effects of sulphur more than offset any addition to the calorific power of the coal. The most notable influence of the presence of considerable percentages of this component is seen in the tendency of coals to slack and disintegrate upon exposure to atmospheric agencies. Even under cover sulphurous coals will not stand storing for any great length of time. Spontaneous combustion in coal mines is often due to the presence of this element. Even with all possible care in stopping old entries by means of air-tight partitions a considerable degree of heat is frequently developed, requiring a constant watching that possible fires may not gain headway. The process is one of true combustion. In the coal the sulphur is mostly combined with iron, forming pyrite or the sulphuret of the metal. This substance is ordinarily very susceptible to oxidizing influences, by means of which it is converted into other compounds, the action being accompanied by heat. The oxygen for the reaction may come from the air, or, this being excluded, may be furnished by the decomposition of percolating waters. If the heat produced in this way is in excess of radiation, the temperature of the coal may be raised to the point of ignition. High percentages of sulphur render the raw coal unfit for use in the blast furnace and forge; for here the iron must come in direct contact with the fuel. On account of its strong chemical affinity the sulphur is taken up largely by the iron.

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.
ADAMS COUNTY—									
Plowman shaft, Briscoe, top	8.97	80.48	10.55	36.44	44.04	54.59	3.15	.11	3.26
Same, middle of seam	9.09	74.95	15.96	32.04	42.91	58.87	2.46	.13	2.59
Same, bottom of seam	8.72	77.39	13.89	32.01	45.38	59.27	3.67	.27	3.94
Wyles mine, Carbon, average	8.01	80.12	11.87	35.26	44.86	56.73	4.25	.11	4.36
Reese mine, Carbon, average	9.12	81.51	9.36	35.71	45.79	55.12	3.89	.18	4.07
Hinton mine, Eureka, average	8.68	81.91	9.70	33.85	47.72	57.43	4.38	.19	4.58
APPANOOSE COUNTY—									
Diamond mine, Centerville, top	9.66	82.06	8.28	34.72	47.34	55.62	2.57	.14	2.71
Same, middle of seam	10.12	83.67	6.21	35.63	48.04	54.25	2.13	.07	2.20
Same, bottom of seam	10.28	84.64	5.08	36.89	47.75	52.83	2.67	.13	2.80
Scandinavian mine, Centerville, average	9.23	40.46	6.97	36.21	47.58	54.55	2.79	.12	2.91
Appanoose mine, Cincinnati, sample of room	6.54	80.37	13.09	36.20	44.17	57.26	4.40	.13	4.53
Same, vein above clay seam	6.20	78.11	15.69	34.00	44.11	59.80	3.67	.16	3.83
Same, vein below lower clay seam	7.53	75.14	17.33	29.31	45.83	63.16	6.73	.82	7.55
Thistle mine, Cincinnati, top	3.18	85.22	11.60	36.55	48.67	60.27	3.57	.11	3.68
Same, middle of seam	5.80	90.71	3.49	37.71	53.00	56.49	2.97	.05	3.02
Same, bottom of seam	6.02	87.80	6.18	36.90	50.90	57.08	3.13	.17	3.30
Same, below sulphur band	2.88	72.69	24.43	29.03	43.66	68.09	3.61	.43	4.04
Whitebreast No. 19, Forbush, average	9.70	82.98	7.31	35.84	47.14	54.45	4.14	.27	4.41

BOONE COUNTY—									
Angus mine, Angus, average	8.62	82.75	8.64	38.33	44.41	53.05	2.59	.08	2.67
Dalby mine, Angus, top of seam	2.71	87.26	10.03	39.90	47.36	57.39	5.17	.15	5.32
Same, middle of seam	2.13	92.14	5.73	44.21	47.93	53.66	3.72	.10	3.82
Same, bottom of seam	3.69	85.70	10.61	45.12	40.58	51.19	4.10	.16	4.25
Northwestern mine, Boonesboro, top	13.23	81.21	5.56	37.52	43.69	49.25	....	...	....
Same, bottom of seam	11.51	82.60	5.89	58.86	43.74	49.63	....	...	....
DALLAS COUNTY—									
Tudor mine, Dawson, top	4.64	81.73	13.63	39.84	41.89	55.52	2.08	.13	2.21
Same, middle of seam	5.62	79.86	14.52	36.79	43.07	57.59	4.69	.24	4.93
Same, bottom of seam	6.55	84.00	9.45	37.45	46.55	56.00	3.27	.08	3.35
Keeler mine, Linden, average	7.41	67.97	24.61	27.86	40.10	64.72	6.53	.65	7.18
Redfield mine, Redfield, top	11.36	78.15	10.49	38.46	39.69	50.18	2.76	.04	2.80
Same, middle of seam	10.55	75.60	13.85	30.18	45.42	59.27	3.83	.24	4.07
Same, bottom of seam	12.76	72.94	14.30	34.72	38.22	52.52	3.01	.10	3.11
Tabor mine, Woodward, average	7.15	77.94	14.90	35.54	42.40	57.30	5.74	.69	6.44
DAVIS COUNTY—									
Dye mine, Laddsdale, bottom	4.48	87.40	8.12	44.26	43.14	51.26	4.26	.12	4.38
Sickles mine, Laddsdale, top of seam	3.06	92.34	4.60	42.82	49.52	54.12	5.19	.23	5.42
Same, middle of seam	2.06	90.66	7.28	43.84	46.82	54.10	6.51	.29	6.80
Same, bottom of seam	2.59	75.41	22.00	36.97	38.44	60.44	7.05	.22	7.27
Same, average	2.57	86.13	11.29	41.21	44.43	56.22	6.25	.24	6.49
GREENE COUNTY—									
Bussey mine, Rippey	9.92	87.92	2.16	44.39	43.53	45.69	....	...	....
Kennedy mine, Rippey, top of seam	7.01	84.08	8.91	43.94	40.14	49.05	3.62	.06	3.68
Same, middle of seam	9.40	81.64	8.96	39.76	41.88	50.84	3.39	.05	3.44
Same, bottom of seam	9.70	82.90	7.40	40.36	42.54	49.94	2.94	.06	3.00
GUTHRIE COUNTY—									
Eclipse mine, Fansler, top of seam	7.73	86.44	5.83	39.85	46.59	52.42	3.62	.05	3.67
Same, middle of seam	7.04	83.61	9.35	37.94	45.67	55.02	4.32	.07	4.39
Same, bottom of seam	6.89	76.23	16.88	32.67	43.55	60.44	9.50	.68	10.18
Reese mine, Panora, cannel	4.88	59.09	36.03	30.80	28.29	64.32	10.57	.50	11.07
Same, average, bituminous	6.41	80.39	13.19	38.07	42.32	55.51	5.59	.13	5.72
Suggett mine, Stuart, top of seam	9.61	79.19	11.20	34.63	44.56	55.76	4.01	.11	4.12
Same, bottom of seam	9.30	81.07	9.63	36.80	44.27	53.90	3.48	.05	3.53

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.
HAMILTON COUNTY—									
Silver mine, Webster City	9.00	84.80	6.20	34.19	50.61	56.81	3.09	1.12	4.21
Stockdale mine, bottom of seam	7.22	82.61	10.17	35.16	47.45	57.62	5.80	.21	6.01
Same, top of seam	8.01	84.96	7.03	37.99	46.97	54.00	5.28	.11	5.39
HARDIN COUNTY—									
Fuller mine, Eldora	12.45	79.37	8.18	35.73	43.64	51.82	....	....	....
Chaffin mine, Eldora, top of seam	11.32	83.52	5.16	32.69	50.83	55.99	2.02	1.47	3.49
Same, middle of seam	10.90	80.17	8.63	38.98	41.49	50.12	1.76	1.89	3.65
Same, bottom of seam	9.63	84.29	6.08	34.44	49.85	55.93	2.25	.30	2.55
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
Same, middle of seam	8.38	77.86	13.76	35.78	42.08	55.84	1.11	.13	1.24
Same, bottom of seam	8.88	77.66	13.46	32.21	45.45	58.91	4.87	.05	4.92
Snook mine, Newton	4.61	87.71	7.68	44.41	43.30	53.44	....	...	....
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
Same, middle of seam	7.79	89.83	2.38	44.05	45.78	48.16	2.06	.39	2.45
Same, bottom of seam	5.56	86.16	8.28	38.37	47.79	56.07	2.45	.07	2.52
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
Same, middle of seam	5.96	82.16	11.88	35.89	46.27	58.15	6.56	.29	6.85
Same, bottom of seam	7.14	76.26	16.60	33.96	42.30	58.90	6.67	.40	7.07

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
Same, middle of seam	9.39	84.21	6.43	38.62	45.59	52.02	2.69	.06	2.75
Same, bottom of seam	7.46	82.11	10.43	36.99	45.12	55.55	2.97	.07	3.04
Same, average of seam	8.92	82.19	8.88	37.77	44.43	33.30	3.11	.07	3.18
Lucas mine, Lucas, average	11.29	79.88	8.83	37.13	42.69	51.52	2.89	.08	3.98
MADISON COUNTY—									
Clarey mine, Northbranch	6.75	77.28	15.97	31.85	45.43	61.40	...	...	....
MARION COUNTY—									
Bousquet mine, Coalport	5.69	90.79	3.32	43.25	47.54	50.84	....	...	....
Bussing mine, Knoxville	6.56	89.54	3.90	45.29	44.25	48.15	....	...	....
Clernen mine, Marysville	6.81	91.53	7.90	26.01	49.28	61.36	....	...	....
Sherwood mine, Marysville	5.62	92.58	1.80	36.61	55.97	56.77	....	...	....
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
Enterprise mine, average	5.09	89.51	5.39	44.62	44.89	50.28	4.91	.29	5.20
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
Same, middle of seam	4.94	83.26	11.80	38.23	45.03	56.83	4.96	.34	5.30
Same, bottom of seam	4.00	86.45	9.55	34.95	51.50	61.05	4.09	.29	4.38
Smoky Hollow mine, Avery, average	5.05	87.57	7.38	42.64	44.93	52.30	4.20	.59	4.79
Deep Vein mine, Foster, top of seam	5.75	81.04	13.21	40.36	40.68	53.89	4.24	.36	4.60
Same, middle of seam	6.67	91.03	2.30	44.75	46.28	48.58	3.34	.10	3.44
Same, bottom of seam	5.77	79.29	14.94	35.25	44.04	58.98	5.21	.20	5.41
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
Same, middle of seam	5.16	90.71	4.13	45.42	45.29	49.42	3.65	.06	3.71
Same, bottom of seam	4.45	83.33	12.22	36.46	46.87	59.09	4.17	.06	4.23
Same, cannel-like part	5.13	84.91	9.96	42.46	42.45	52.41	4.79	.41	5.20
Griffith mine, Given, average	2.84	83.85	13.31	41.01	42.84	56.15	4.41	.08	4.49
Burns mine, Oskaloosa	4.01	93.83	2.16	47.76	46.07	50.25	....	...	....
Carey mine, Rose Hill, average	4.91	84.70	10.39	41.69	43.01	53.40	5.00	.09	5.09

Chemical Analyses of Iowa Coals.—Continued.

LOCALITIES.	Moisture.	Total combustibles	Ash.	Volatile combustible matter.	Fixed carbon.	Coke—Fixed carbon plus ash.	SULPHUR. In sulphides.	In sulphates.	Total.
POLK COUNTY—									
Christy mine, Des Moines, top	5.53	88.05	6.42	44.70	43.35	49.77	4.78	.09	4.87
Same, middle of seam	6.18	84.12	9.70	38.65	45.47	55.17	5.41	.15	5.56
Same, bottom of seam	6.60	75.62	17.78	33.84	41.78	59.56	4.79	.19	4.98
Gibson mine, Des Moines, average	7.04	82.89	9.72	40.06	43.17	52.89	4.09	.16	4.25
Manbeck mine, Des Moines, average	6.82	76.58	16.19	36.93	39.65	56.34	4.44	.29	4.70
POWESHIEK COUNTY—									
Smith and Barrowman mine, Searsboro, top of seam	5.41	89.30	5.29	41.39	47.91	53.20	....	...	....
Same, bottom of seam	6.28	86.67	7.05	36.51	50.61	57.21	....	...	....
SCOTT COUNTY—									
Friedley and Hoyt mine, Buffalo, top of seam	3.48	89.79	6.73	41.32	48.47	55.20	4.99	.54	5.53
Same, middle of seam	3.66	87.46	8.88	41.44	46.02	54.90	3.72	.15	3.87
Same, bottom of seam	2.89	82.03	15.08	38.09	43.94	59.02	7.80	.38	8.18
Hanlon and Blackwell mine, Buffalo, top of seam	2.66	86.66	10.68	42.10	44.56	55.24	3.11	.05	3.16
Same, bottom of seam	5.07	83.59	11.34	39.33	44.26	55.60	4.38	.22	4.60
Friedley mine, Muscatine	3.94	92.98	3.08	37.46	55.52	58.60	3.03	.07	3.10
TAYLOR COUNTY—									
Adams shaft, New Market	8.00	79.68	12.31	35.41	44.29	56.58	5.29	.59	5.88
Anderson mine, New Market, average	8.06	80.57	11.36	34.99	45.58	56.95	4.72	.45	5.17
Campbell mine, New Market, top	7.44	80.64	11.92	37.79	42.85	54.77	3.54	.14	3.68
Same, middle of seam	8.21	82.77	9.02	35.28	47.49	56.51	3.85	.43	4.28
Same, bottom of seam	7.94	79.93	12.13	37.41	42.52	54.65	4.70	.54	5.24

VAN BUREN COUNTY—									
Slaughter mine, Farmington	8.62	85.50	5.88	38.08	47.42	53.30	....	...	....
Cox mine, Hillsboro	7.92	88.50	3.58	41.74	46.76	50.34	....	...	....
Manahard mine, Selma	7.76	88.34	3.90	40.23	48.11	52.01	....	...	....
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
Same, middle of seam	6.82	82.03	11.15	35.29	46.74	57.89	9.53	.16	9.69
Same, bottom of seam	7.55	79.09	13.36	33.43	45.66	59.02	6.05	.25	6.30
Same, sample of room	5.08	74.54	20.38	33.66	40.88	61.26	6.49	.28	6.77
Eldon mine, Laddsdale, top	3.81	93.39	2.80	41.69	51.70	54.50	2.57	.33	2.90
Same, middle of seam	3.72	85.37	10.91	42.88	42.49	53.40	2.93	.66	3.59
Same, bottom of seam	3.24	87.97	8.79	45.82	42.15	50.94	2.80	.56	3.36
Brown and Godfrey mine, Ottumwa	6.50	89.60	3.90	41.35	48.25	55.78	....	...	....
Evans mine, Chillicothe, top	5.35	87.65	7.00	42.41	42.41	52.24	....	...	....
Same, bottom of seam	3.89	77.77	18.34	36.94	40.83	59.17	....	...	....
Wyles mine, Eddyville	3.95	84.69	10.36	36.98	48.71	61.49	....	...	....
WARREN COUNTY—									
Dillard mine, Spring Hill, top	11.56	83.27	5.17	42.88	40.38	45.55	....	...	....
Same, middle of seam	14.13	80.60	5.27	36.59	44.01	49.28	....	...	....
Bennum mine, Summerset, top	7.31	82.09	10.60	36.63	45.46	56.06	5.02	.09	5.11
Same, bottom of seam	9.43	82.14	8.43	36.96	45.18	53.61	3.62	.16	3.78
WAYNE COUNTY—									
Frey mine, Confidence, below parting	9.26	80.45	10.29	34.21	46.24	36.53	4.71	.26	4.97
Same, above parting	9.39	78.69	11.92	34.71	43.98	55.90	2.97	.20	3.17
Same, middle of seam	8.01	75.41	16.58	37.22	38.19	54.77	3.24	.09	3.33
Same, top of seam	9.37	77.12	13.51	31.78	45.34	58.85	3.53	.37	3.90
WEBSTER COUNTY—									
Collins No. 6, Coalville, average	7.48	84.06	8.44	39.52	44.54	52.99	4.98	.26	5.24
Collins No. 4, Coalville, average	7.80	82.88	9.32	37.74	45.14	54.46	3.97	.12	4.09
Old Reese mine, Fort Dodge	9.92	48.77	41.31	29.69	22.08	63.39	....	...	....
Carlson mine, Kalo, average	10.10	76.53	13.36	32.83	43.69	57.06	1.68	.18	1.86
Craig Cannel mine, Kalo, "cannel" coal	5.87	78.26	15.87	39.04	39.22	55.09	6.87	.25	7.12
Craig slope, Kalo, bituminous	8.46	81.37	10.17	37.97	43.40	53.57	5.19	.10	5.29
Crooked Creek mine, Lehigh, top of seam	7.74	78.94	13.32	34.47	44.47	57.79	4.83	.81	5.64
Same, middle of seam	8.52	82.65	8.83	38.64	44.01	52.84	3.71	.48	4.19
Same, bottom of seam	8.57	81.86	9.57	37.57	44.29	53.86	3.47	.18	3.65
Crooked Creek shaft, Lehigh, average	6.99	76.66	16.34	34.40	42.26	58.60	5.67	.37	6.04
Corey mine, Lehigh, average	7.77	81.27	11.00	38.05	43.21	54.21	7.02	.68	7.70

CHAPTER XIV.

WASTE IN COAL MINING.

Perhaps one of the most difficult problems to solve in connection with the mining of coal is the reducing to a minimum the waste in the form of coal dust and slack. It is a well known fact that in getting out the coal from a mine there are more or less dust and small fragments which must be cast aside as valueless. When the coal reaches the surface of the ground and is screened, there is another very noticeable loss in the marketable portion, part in the form of dust, part in the condition of fine particles commonly called slack, which is sold very much below the regular price of the product. With the soft bituminous coals, such as are supplied by Iowa and the neighboring states, the depreciation is very much greater than in the case of the hard or anthracite varieties of eastern Pennsylvania. This average loss in fine coal, before the product leaves the mine, is at the present time a considerable per cent of the total quantity mined. Although the waste in coal before it gets to market is a subject which deserves thoughtful consideration, little attention has been paid to it in Iowa. In reality, this factor in mining economy has been largely disregarded in most mining districts, not only at home but abroad. In only a few of these places has careful investigation of coal waste been undertaken; and only within the past few years has serious attention been directed to the importance of such a line of work. In other industries, and especially in other mining activities, one of the most difficult problems of solution is the reduction of waste to a minimum. There is no doubt that in the Iowa field at least a very considerable portion of the waste could, with the proper precautions, be easily avoided. In the anthracite region of Pennsylvania inquiry into economy in coal production has already awakened interest, but as yet little work has been undertaken in the country as a whole, in the application of the principles to the bituminous coals.

While it is not possible to enter very deeply into this subject at the present time, a brief presentation of some of the leading points bearing on the subject may not be out of place. A more comprehensive treatment must wait until further detailed work concerning the nature and capabilities of Iowa coals has been accomplished.

Briefly it may be said that the principal sources of waste in the Iowa coal fields are three-fold:

(1) Waste resulting from the methods of mining, by which more or less of the coal is left in the ground undisturbed.

(2) Waste resulting from the breaking of the coal in mining and in the preparation of it for market.

(3) Waste resulting from failure to properly use the smaller sizes.

Waste Due to Methods of Mining.—In regard to the first source of waste it is to be remembered that in all mining a certain portion of the coal must always be sacrificed. Any method of mining now in use requires a certain amount to be left for pillars and fire walls, and the problem is in reality to find the method which is best adapted to the particular coal seam worked; one which allows the maximum amount of coal to be removed.

Most of the mines in Iowa are worked by the room and pillar method, or by various adaptations of this plan. The long wall system is in use in some places. The exact plan varies in different mines, being modified to meet the different conditions. In some mines the rooms are worked in panels and in some not. The coal vein is in all cases never highly inclined and the thickness is seldom very different from an average, so that the conditions for this kind of work are exceedingly favorable. In this way some of the best results have been reached. Careful estimates based upon work done in some of the larger mines in Mahaska county show that under favorable circumstances seventy-eight per cent of the total amount of coal has been removed. This makes no allowance for faults and is only valuable in showing what may be done by this method. As a matter of fact the average percentage of coal removed in the whole field is very low. A large number of small mines are run on a haphazard plan, often without maps, and they render almost valueless much good territory without an adequate return.

A considerable number of the mines are now worked by the long wall plan and many more could adopt the same method with profit. This plan, where it can be used, seems to give the best of results, especially with the thinner seams. Much might be done to reduce the amount of coal left in the ground by the introduction of better engineering skill and the more liberal investment of capital. At present capital is at such a premium that quicker though smaller returns are usually preferred.

Waste in Removal of Coal.—The second source of waste is perhaps that in which the greatest improvement may ultimately be expected. In all mining it becomes necessary to break the coal in order to carry it to the surface. This is usually done by some form of mining machinery, wedging or blasting. The last is the method in general use in the Iowa mines. Too much powder, of course, shatters the coal badly and allows much to be wasted in the form of dust or small pieces which are not handled; too little fails to accomplish the purpose, and leaves the coal in pieces too large to handle. In many of the mines of the state a much larger quantity of powder is used in loosening the coal for handling than is necessary. The deleterious effect on the coal is readily seen in the unnecessarily large proportion of dust and pieces too small to be profitably moved. In these cases not only does the operator loose a goodly percentage of the total output it would be otherwise possible to ship, but it is very extravagant for the miner, who could otherwise make from twenty to thirty per cent more in wages. Operators should, therefore, endeavor to encourage undermining the seam and wedging, with a judicious use of smaller amounts of powder. The results would doubtless be eminently satisfactory to both parties; and the economy resulting would be a matter of considerable surprise.

In the preparation of the coal for the market it becomes necessary to break it more or less in order to separate the slate, "sulphur" and dirt from the merchantable product. This is a process which in the large eastern mines is accomplished by various machines together constituting the breaker. At present no such process is known to be carried on at any Iowa mine. The miner usually, in loading his car, separates the trash from the coal as well as he is able with his hand tools and poor light. The result is that a large percentage of material properly classed as fuel is thrown into the gob or upon the dump. The amount of waste from this source alone is extensive. The almost utter lack of system in preparing the coal for shipment is largely responsible for much of the total waste. It is customary to dump the coal into the railway cars, causing it to pass over a series of screens which allow a rough separation into three or occasionally four sizes. In many mines not even this separation is made but the coal is sold "run of the mine" with corresponding dissatisfaction to the consumer and low prices to the producer. The full value of Iowa coal cannot be realized until more systematic methods are introduced by which it may be cleaned and sized.

Waste in Fine Coal.—The third source of loss is that arising from the depreciation in the value of coal when it becomes fine. This is quite important with the soft bituminous coals, such as are supplied by Iowa and the neighboring states, and the depreciation is very much greater than in the case of the hard or anthracitic varieties of eastern Pennsylvania. This average loss in fine coal before the product leaves the mine is probably not far from twelve per cent of the total quantity mined in the state. This proportion, of course, varies in the different localities, in some it is somewhat greater, in others considerable less. After deducting the amount returned by the sales of slack, the net loss for the entire state each year is probably not far from a half million of dollars; that is, if the fine coal now wasted or disposed of at a low figure could be sold at the average price of lump coal it would have the valuation just named. In all coal fields this subject has attracted more or less attention. The utilization of the slack has been carefully studied in many localities, while quite recently a state commissioner has investigated it in connection with the anthracite fields of Pennsylvania. Up to the present time the bituminous coals of the western fields have not been so closely studied, though it is believed that a greater percentage is wasted here than in the eastern districts. A number of remedies have been proposed, and most of them are in more or less successful operation.

The manufacture of both coke and gas from fine coal has been experimented upon, in some cases quite successfully. How far the Iowa coals could be used for such purposes is not known and can only be determined by the proper tests. Slack coal has been used in some instances in clay work. The coal, reduced to a fine powder, is mixed with clay and thus a great saving in the fuel used in burning the bricks is effected. Coal dust may, therefore, be utilized to great advantage in the manufacture of certain grades of clay goods.

Probably the greater portion of the fine coal could be used just as it comes from the mine. This may be accomplished in several ways. By means of grates especially adapted to its use all but the finest particles may be burned. It also has been used as a powder, the fire being fed by fine jets of coal dust driven by steam or air pressure. More recently it has been proposed to grind the coal, mix it with water and burn it under pressure in this form, pumping it across the country like oil instead of employing the ordinary means of transportation. All of these plans have proven to be more or less successful, but each requires a special furnace to burn the coal. They are also largely dependent for their success upon the cheapness of the fuel. Among other ways of dealing with the problem various methods of pressing into cakes or blocks have been tried. In this direction Spring, in his many experiments showing the behavior of different substances in a powdered condition under great pressure, has subjected coal dust to a pressure as high as 90,000 pounds. Under this enormous weight the fine particles are welded together into a bright block, hard and perfectly solid. Commercially the operation is known as briquetting and might in this region be quite successful. In general the process consists in mixing the powdered coal with some cement or bond, and then under pressure molding it into blocks of suitable size. This method has been in quite general use in Europe for some time; and recently several plants have been established in America. Since the subject has had attention directed to it a company has been organized in Iowa for the special purpose of utilizing the dust and fine slack of the mines in manufacturing briquettes. Arrangements have been made by which the fuel will probably soon be placed upon the market. The method of preparation is essentially the same as that followed in some parts of Europe, and which has recently been described by Dumble in connection with the brown coals of Texas. From his work the following has been largely gleaned.

The manufacture of briquettes consists of two processes: the preparation of the coal and the briquetting proper. In the first part of this process the coal must be separated, crushed and cleaned.

In the crushing of coal various forms of machines may be used, either grinding it by means of an exaggerated coffee mill or passing it between rolls. The rolls formerly used were of cast iron with an irregular surface, very little attention being paid to the details of their construction. The best forms now in use are set with interlocking steel teeth. They do their work thoroughly and effect a considerable saving over the older forms. In some places a disintegrator of special construction is preferred, the object being to produce a very fine coal of uniform size and homogeneity.

The cleaning of the coal is usually done by washing, by which the coal is freed from its clay, sand and pyrite. Thus a considerable reduction in the percentage of ash is effected. In some cases it amounts to a reduction from twenty-five to five per cent. A process of dry cleaning is known which, while it costs more to install the plant, effects a diminution as high as twenty per cent in the cost of cleaning, the whole cost of drying being saved.

The bond used is a matter of considerable importance. So far it has not been found practicable to make a good briquette without bond from bituminous coal, though it may be done with some other forms of coal. Practically but two bonds are largely used at present, one being pitch and the other magnesia cement. In the plant of the Anthracite Pressed Fuel Company, of Mahanoy City, Pa., eight per cent of pitch is added to ninety-two per cent of pure anthracite coal. The pitch, while usually more expensive, has several advantages over the magnesia cement. The latter does not increase the heating power of the coal and adds considerably to the percentage of ash. In mixing the bond with the coal heat is in most cases required. If pitch be used it may be pulverized and mixed with the coal dust and then the mixture raised to a suitable temperature, preferably by superheated steam, or either or both may be heated separately. It is, of course, important that the two materials be thoroughly mixed. This may be accomplished by a modified form of the pug mill used in clay work. The pressure is applied in different ways, depending on the intended form of the product. In considering the form to be adopted the object for which the particular briquette is to be used must be kept in view. It may be said in general, however, that an irregular form is usually found better, especially for domestic use. Such a form does not allow the coals to pack tightly enough to exclude a natural draft. In the briquettes made on the Loisseau press, which is in use at several points in North America, the material is pressed into egg form. This is accomplished by passing the mixture between two heavy rolls whose faces contain semi-oval cavities, arranged so that the two halves on the opposite rolls match. The other forms, cubical, oblong and irregular, are produced by presses of various kinds which do not vary much in principal from each other, and are essentially modified forms of the hydraulic press. The power used is usually steam.

It is of importance that briquettes should be of a size easily handled, so as to avoid loss in transportation or breaking in the fire, they must have a low per cent of ash and moisture and must be easily kindled and burn with a lively and as nearly as possible smokeless flame. The superiority of such a fuel for the better kinds of domestic use is apparent at once. Another superior point is the well proven fact that briquettes have a higher heating power than the coal from which they are manufactured, and that, too, more than can be attributed to the addition of the pitch in the bond. It seems probable that the preliminary cleaning of the coal as well as the form in which it is put has considerable to do with this. A more complete combustion is obtained. Another advantage is in the fact brought out by its use in the French marine that it is possible to stow in the same space ten per cent more briquettes than coal.

The cost of manufacture will of course be largely a controlling factor in the introduction of briquettes. Some years ago the Whitebreast Coal Company experimented at its mines, in Monroe county, upon briquetting coal for steam purposes. It was decided that, while the briquettes could be made readily, the profit was not great enough to warrant the erection of a plant. This was, so far as now known, the first series of experiments on a large scale which were carried on with the western coals.

More recently the Fuels Patent Company have established a plant at Huntingdon, Arkansas, which is in successful operation. The Anthracite Pressed Fuel Company, at Mahanoy City, Pa., are producing an excellent fuel from anthracite waste, at a cost of $1.80 per ton. A number of other plants have been recently erected and it seems probable that this fuel will grow in favor.

A considerable amount of anthracite coal is annually imported into Iowa, being used largely for base burners and other domestic uses where a considerable heat with little ash is desirable. This coal brings a high price, usually from $7.00 to $9.00 per ton. The consumer is willing to pay the extra price because of its better heating qualities, cleanliness and the little care needed in burning it. It seems probable that briquettes properly made would be able to command a large share of this trade. The competition the new fuel would meet would not be with the bituminous coal used for steam, but with the more expensive anthracite. The cleanliness and many other advantages which such a fuel possesses renders it especially desirable for open fires.

CHAPTER XV.

EXTENT OF THE COAL INDUSTRY.

The extent and importance of the industrial activities connected with or dependent upon the production of coal is seldom fully appreciated. It is known vaguely, perhaps, that in the state coal is one of the principal mineral resources, but beyond this no adequate conception is held in regard to the part played by it in the State's domestic economy. In the marketing of coal, its mining, storing and transportation, and in the operations necessary to be gone through with in getting the product to the consumer there is employed a much larger amount of capital and a much greater force of laborers than is commonly supposed. Mining alone gives employment to fully 9,500 men and upward of $5,000,000 are annually expended at the mines for labor. In the other occupations which have to do with the taking of the output from the mines and the distribution of it to its final destination, the money employed and the men needed can only be roughly estimated, but it is known to exceed several times that directly connected with mining.

The deposits of mineral fuel in Iowa were brought to the notice of the world through the explorations of Dr. David Dale Owen, who was sent out by the Federal Land Office to survey the mineral lands of the Northwest. His report on the region occupied by Wisconsin, Iowa and

Minnesota appeared in the year 1852. In Iowa his most important exploration was made in canoes up the Des Moines river from its mouth to the Lizard fork near Fort Dodge. A number of localities were pointed out where good coal could be obtained. A few years later A. H. Worthen went over the same ground and called attention to a number of additional places in which coal was being taken out. Up to this time all fuel mined was for local use.

Growth of the Production.—In 1860 appeared the first attempt to gather definite information regarding the extent of the coal mined in Iowa. According to the figures of the report of the Eighth Census of the United States the valuation of the product for the previous year was $92,180, representing about 48,263 tons. The production by counties was approximately as follows:

	TONS.	VALUE.
Appanoose	1,438	$ 2,740
Boone	630	1,200
Davis	577	1,100
Guthrie	289	550
Hardin	262	500
Jasper	2,336	4,450
Jefferson	6,143	11,750
Keokuk	472	900
Lee	315	600
Lucas	945	1,800
Mahaska	3,412	6,500
Marion	1,548	2,950
Monroe	2,756	5,250
Muscatine	1,785	3,400
Polk	1,858	3,540
Van Buren	4,252	8,100
Wapello	17,062	32,500
Warren	2,283	4,350

The state census of 1862 gives a total somewhat less, though work had begun in a dozen counties more

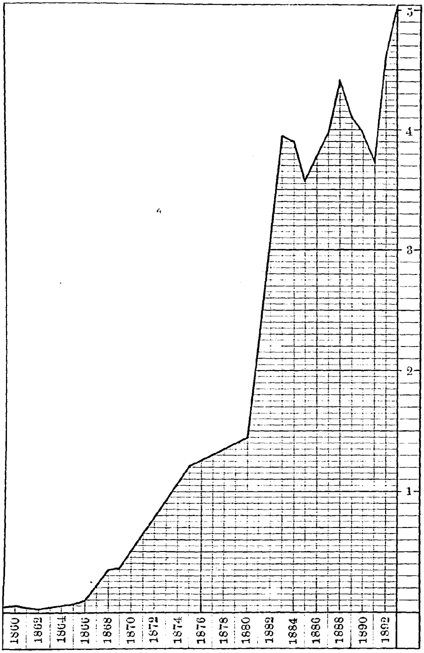


DIAGRAM SHOWING GROWTH OF THE COAL PRODUCTION.

than had been reported before. In 1865 the state record shows an output of 69,574 tons, which in the following year rose to 99,320 tons. In 1868 the output had become still larger, 241,453 tons being given for that year.

At the Ninth United States Census, of 1870, eighteen of the counties, chiefly small producers, were not enumerated, yet the total production, 283,467 tons, was a considerable increase over the state figures presented two years before. Coal had by this time assumed an important rank among the resources of the state, the value for this year being over half a million dollars.

The state census of 1875 showed that several new counties had begun to produce coal, and an output of 1,231,547 tons, valued at $2,500,140, is recorded for that year.

The Tenth Federal Census, of 1880, indicated a total tonnage of 1,461,166 for the census year, the product being valued at $2,507,453. This was a total of more than five and one half times the amount mined a decade previous. By the year 1883 the amount of coal mined had increased to 3,979,946 tons. For the next four years the annual output remained about the same. In 1888 great activity was developed in the coal industry, the production for that year reaching the grand total of 4,421,822 tons. The two years following showed a slight decrease, the output for the former year being given by the Eleventh Census of the United States as 4,095,358 tons, and for the latter by the state mine inspectors as 3,980,502. This still farther decreased in 1891, the latter authority giving 3,721,981 tons as the output for that year. Since then the increase has been quite marked.

In 1892 the output reached a total of 4,047,479 tons, as given by the mine inspector's report, and in 1893 the returns to the Iowa Geological Survey show a total of 5,043,007 tons. Between the years 1879 and 1889, as indicated by the United States census reports, the advancement of the coal product of the United States was 37 per cent. Iowa in the same period increased her product 279 per cent.

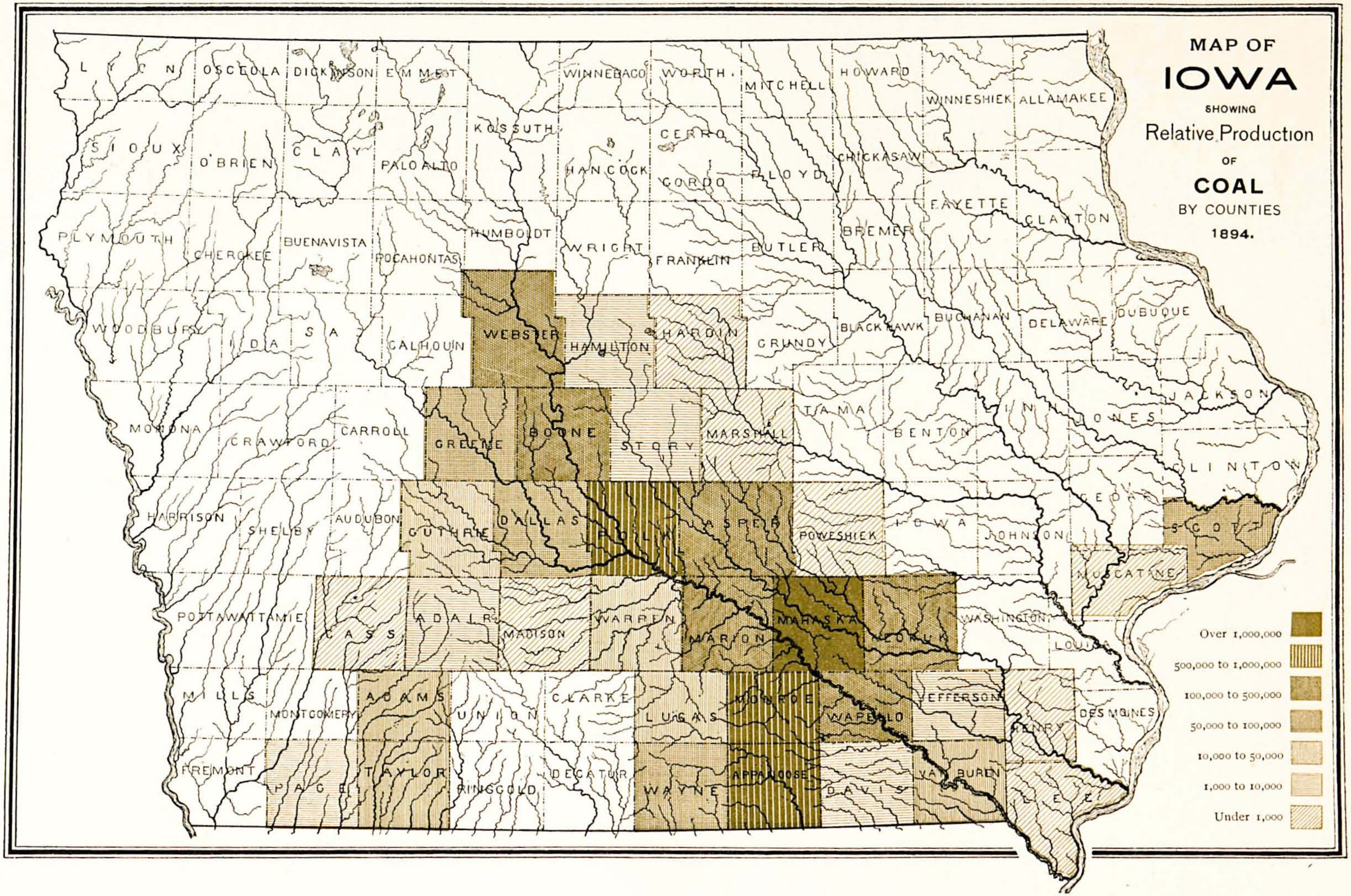
The apparent decrease during the years 1889–91 was due largely to strikes, and in part also to the importation of a considerable quantity of Illinois coal, which by means of the low rate of transportation obtainable for certain river points was able to compete successfully with the home product.

During the last two years a large number of new mines have been opened. The development has not been due so much to the discovery of new fields as to closer prospecting and better work in coal territories already opened.

The returns for the last year cannot be compared with those of other states, as no results from them are yet published. In 1889, however, as shown by the Eleventh Federal Census, the rank of the different coal producing states was as follows:

1.	Pennsylvania	81,700,000
2.	Illinois	12,100,000
3.	Ohio	9,900,000
4.	West Virginia	6,200,000
5.	Iowa	5,000,000
6.	Alabama	3,300,000
7.	Maryland	2,900,000
8.	Indiana	2,800,000
9.	Missouri	2,500,000
10.	Colorado	2,300,000
11.	Kansas	2,000,000

From the foregoing it will be noted that as a coal producer Iowa ranks first among the states west of the Mississippi river, and fifth among the states of the Union.


MAP OF
IOWA
SHOWING
Relative Production
OF
COAL
BY COUNTIES
1894.
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
LYON
OSCEOLA
DICKINSON
EMMET
WINNEBAGO
WORTH
MITCHELL
HOWARD
WINNESHIEK
ALLAMAKEE
SIOUX
O'BRIEN
CLAY
PALO ALTO
KOSSUTH
HANCOCK
CERRO GORDO
FLOYD
CHICKASAW
FAYETTE
CLAYTON
PLYMOUTH
CHEROKEE
BUENAVISTA
POCAHONTAS
HUMBOLDT
WRIGHT
FRANKLIN
BUTLER
BREMER
WOODBURY
IDA
SAC
CALHOUN
WEBSTER
HAMILTON
HARDIN
GRUNDY
BLACK HAWK
BUCHANAN
DELAWARE
DUBUQUE
MONONA
CRAWFORD
CARROLL
GREENE
BOONE
STORY
MARSHALL
TAMA
BENTON
LINN
JONES
JACKSON
CLINTON
HARRISON
SHELBY
AUDUBON
GUTHRIE
DALLAS
POLK
JASPER
POWESHIEK
IOWA
JOHNSON
CEDAR
SCOTT
MUSCATINE
POTTAWATTAMIE
CASS
ADAIR
MADISON
WARREN
MARION
MAHASKA
KEOKUK
WASHINGTON
LOUISA
MILLS
MONTGOMERY
ADAMS
UNION
CLARKE
LUCAS
MONROE
WAPELLO
JEFFERSON
HENRY
DES MOINES
FREMONT
PAGE
TAYLOR
RINGGOLD
DECATUR
WAYNE
APPANOOSE
DAVIS
VAN BUREN
LEE

Number of Mines and Value of Product.—The coal mine operators employing ten men and upward are nearly 400 in number. Small owners having less than ten employees probably would increase the total number of separate organizations engaged in mining coal to something over 500.

A large majority of the mines have only a small output. Some, however, have a capacity of 1,000 tons daily and a few mine even a larger quantity. The companies having the largest output usually work several mines of smaller capacity rather than concentrating the work in one plant. The total output for 1893 of over five millions shows a very considerable increase over that of former years. The value of this amount of coal may be safely estimated at nearly eight million dollars.

Localities.—The most productive coal region of Iowa, as has already been stated, is a broad belt running approximately along the Des Moines river from the southeastern corner of the state to Fort Dodge, in Webster county. In 1893 twenty-four counties produced coal in commercial quantities. Arranged in the order of their rank they are as follows:

1.	Mahaska	1,093,530
2.	Polk	693,103
3.	Appanoose	650,775
4.	Monroe	648,300
5.	Marion	329,168
6.	Jasper	293,400
7.	Wapello	284,660
8.	Keokuk	270,350
9.	Boone	267,310
10.	Webster	249,100
11.	Wayne	47,121
12.	Taylor	35,570
13.	Dallas	33,800
14.	Van Buren	26,300

15.	Greene	25,200
16.	Adams	20,085
17.	Guthrie	19,080
18.	Scott	16,500
19.	Warren	14,725
20.	Lucas	12,330
21.	Jefferson	7,140
22.	Davis	2,620
23.	Adair	1,840
24.	Page	1,800

These figures, arranged geographically into districts which are fully described farther on, indicate the relative productiveness of the different sections of the state at the same time.

Northcentral Iowa, comprising the counties of Humboldt, Webster, Hamilton, Hardin, Greene, Boone, Story, and Marshall, 541,610 tons.

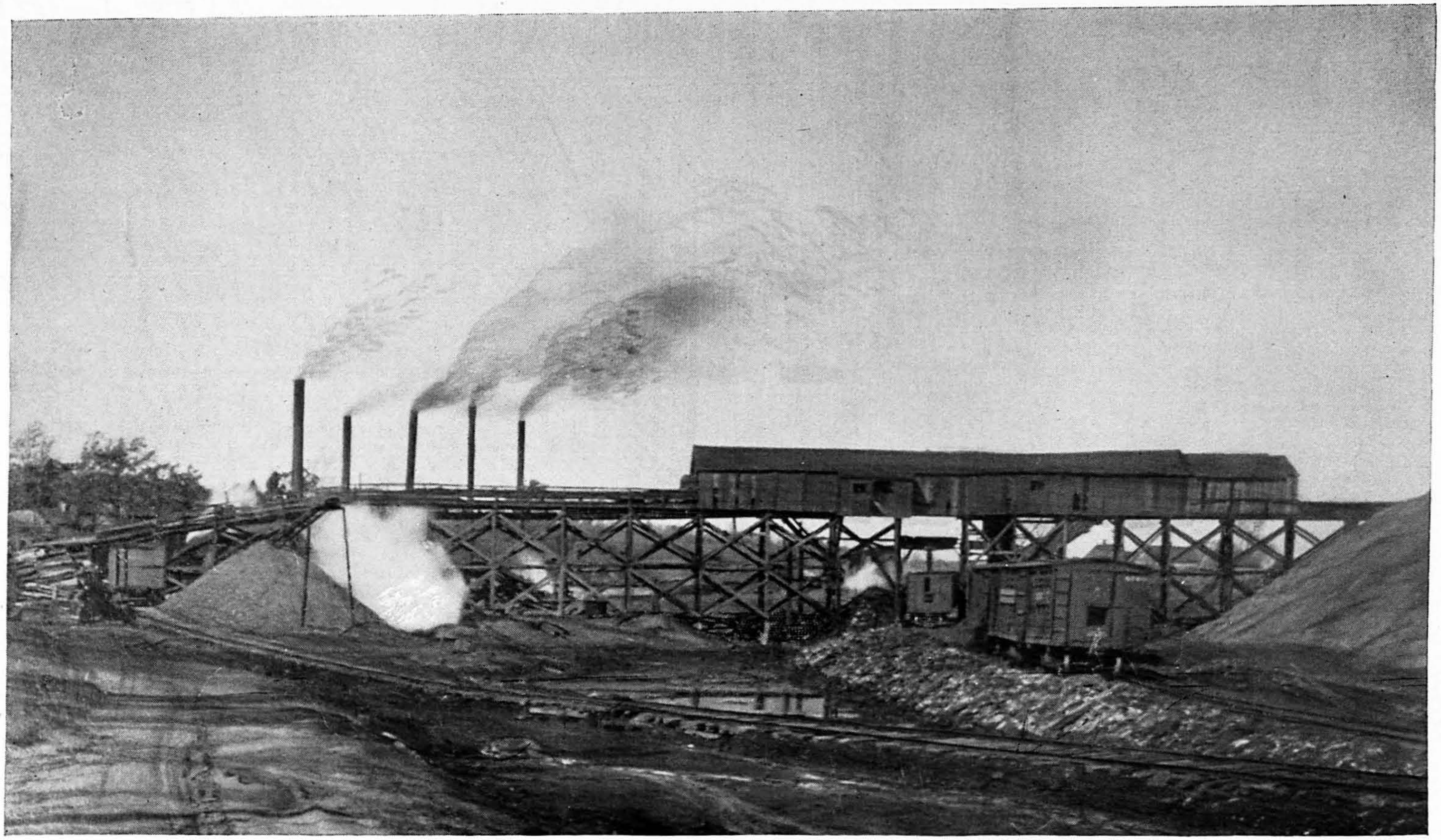
Central Iowa, including the counties of Guthrie, Dallas, Polk, Jasper, Poweshiek, Madison, Warren, Marion, and Mahaska, 2,476,806 tons.

Southeastern Iowa, counties of Keokuk, Lucas, Monroe, Wapello, Jefferson, Henry, Wayne, Appanoose, Davis, and Van Buren, 1,949,596 tons.

Southwestern Iowa: Shelby, Audubon, Pottawattamie, Cass, Adair, Mills, Montgomery, Adams, Union, Clarke, Fremont, Page, Taylor, Ringgold, and Decatur counties, 59,295 tons.

Eastern Iowa (counties containing outliers): Iowa, Johnson, Scott, Muscatine, Washington, Louisa, Des Moines, and Lee, 16,500 tons.

A comparison of the output of the various counties shows that central Iowa is the most productive portion of the field. Next to it is southeastern, and after that northcentral Iowa. A review of the output in past years shows that there has been a movement of the industry from the



TOP WORKS OF TYPICAL SLOPE MINE.—EVANS

northern to the southern counties as well as a corresponding movement westward from the Mississippi. At present the main industry is concentrated in the Des Moines valley. The considerable difference between the productiveness of the Lower and Upper Coal Measures is also shown in the same table. These various facts are well brought out in plate xv, graphically representing the present productiveness of the various counties.

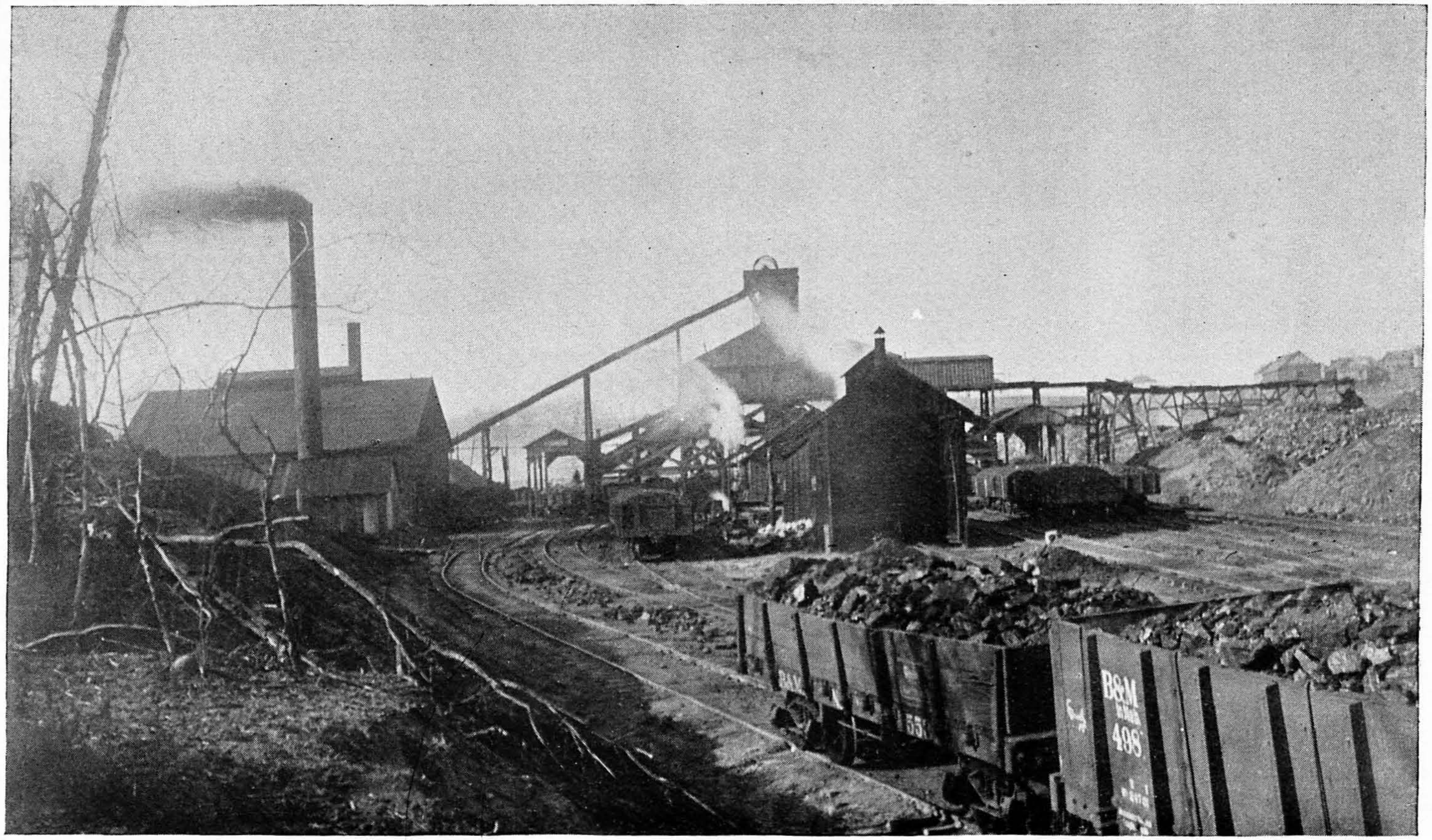
PRESENT TERRITORY SUPPLIED.

Markets.— By far the larger proportion of the coal mined in Iowa finds its market within the state, a considerable portion not leaving the county within which it is mined. In 1889 the production of coal in the state was 4,095,358 tons, while the consumption was only 3,411,044 tons, leaving a balance of 648,314 tons, or about sixteen per cent of the total product, to be marketed elsewhere. Applying this same percentage to the output in 1893, a total of 806,881 tons are found to be sent out of the state. It seems probable, however, that the per cent exported may now be somewhat greater, though there is not sufficient data at hand to give the exact increase. This brings into the state annually between one and two million dollars, and aids quite materially in building up the various industries directly or indirectly dependent upon coal mining.

The greater portion of the coal exported is sent north and west, to Kansas, Nebraska, South Dakota and Minnesota; a small amount is sent to Missouri and occasionally some to Illinois. During the present summer the trade with Kansas has been particularly brisk, owing to the strike in the coal region of that state. Probably Nebraska usually takes more of the Iowa coal than any other state.

The competition met here is principally that of Illinois, though the Kansas and Missouri mines supply part of the trade. Farther north, in South Dakota and Minnesota, eastern coal comes into competition, especially for domestic uses; the greater heating power and cleaner character of the Pennsylvanian anthracite being considered to counterbalance its greater cost.

Wherever a cheap coal is desired the Iowa coal operators are usually able to command a fair share of the trade. It seems reasonable to expect a continued steady growth of the export trade and a considerable enlargement of the market as new territory is opened up and better shipping facilities are provided.



TOP WORKS OF TYPICAL SHAFT.—HEITMAN.

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