UNDERGROUND MINES METROPOLITAN DES MOINES

LEGEND

Area potentially disturbed by documented mining.

Area of overlap between two or more mines which may have worked the same or different seams.

Indicates area where mining probably occurred but no specific information is available.

Indicates general location of a known mine for which specific location and/or extent are unavailable.

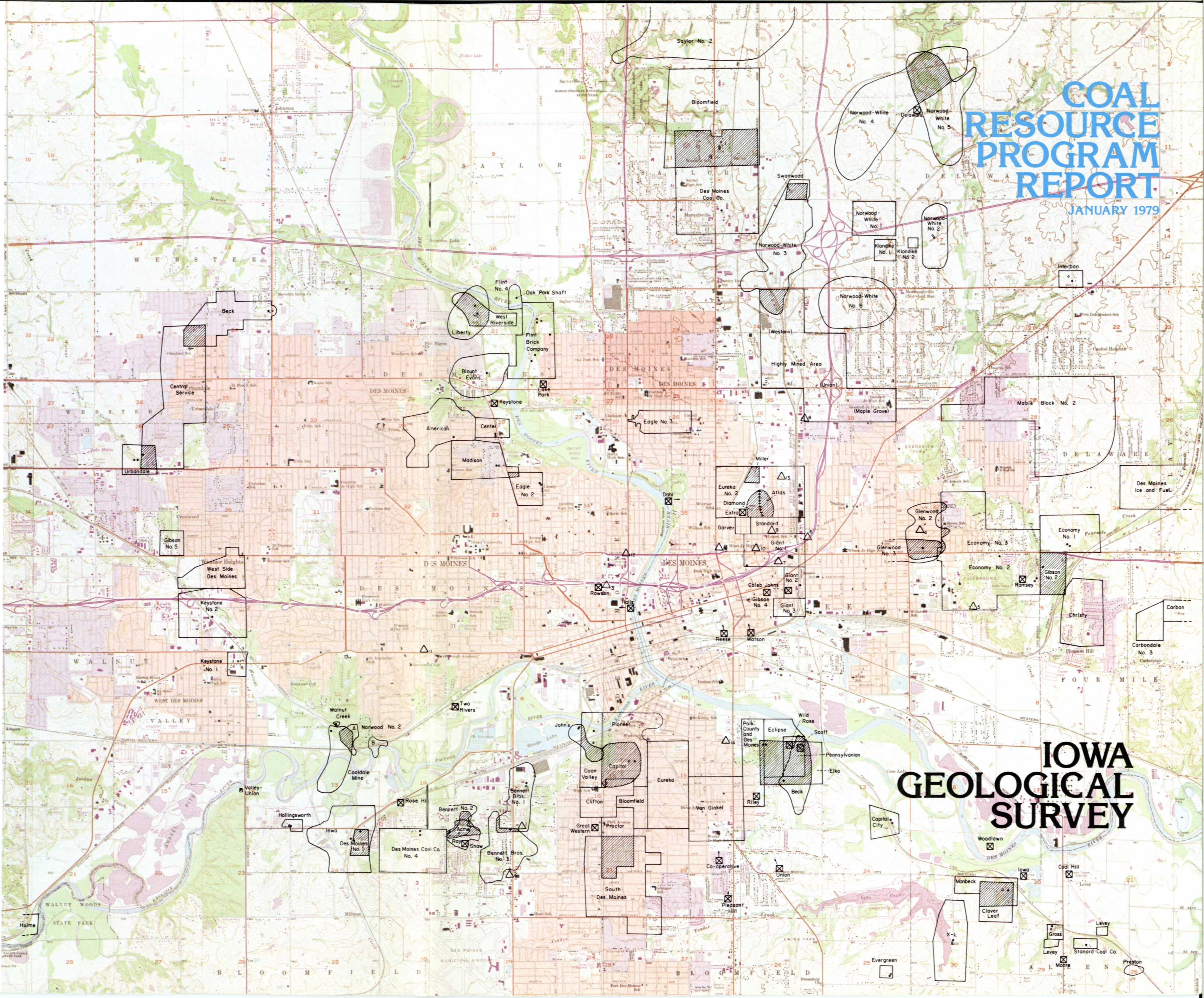
Indicates probable direction of mine development based on topographic or geologic interpretations.

Air shaft

Hoisting shaft

0 ½ 1 2 Miles

IOWA GEOLOGICAL SURVEY
Research and Service 1855-1858 1866-1869 1892-
Water - Minerals - Environment



COAL RESOURCE PROGRAM REPORT

JANUARY 1979

IOWA GEOLOGICAL SURVEY

Foreword

The Iowa Geological Survey Coal Resource Program was established to conduct research on the coal resources of the State. A program of exploration drilling and laboratory studies was designed to permit a more accurate evaluation of the quantity and quality of Iowa's coal deposits.

Iowa has large reserves of coal that could be used for power generation. Much of this coal is comparable in quality to that of adjacent coal-producing states. With developments in combustion technology that will reduce environmental hazards, Iowa coal is becoming an increasingly valuable resource.

Short-term economic factors related to environmental restrictions have had a negative impact on Iowa coal production, but rising costs of coal from other states enhance the potential for using more Iowa coal to meet our energy needs.

This progress report will bring you up-to-date on developments in the Coal Resource Program.

Stanley C. Grant
State Geologist and Director
Iowa Geological Survey

Cover Explanation

The map on the cover shows the location and extent of known underground mining in Des Moines and environs. Because several U.S. Geological Survey topographic map sheets were used to construct the base map, the light red color which designates urban areas is variable in tone. Purple shaded areas indicate highway construction or urban areas which have developed since the original maps were published in 1956.

Iowa Geological Survey Coal Division

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COAL RESOURCE PROGRAM REPORT

Energy for Iowa
A New Look at an Old Friend

The subject is coal. For many the term still is associated with nostalgic memories of coal bins and clinkers. However, for increasing numbers of Americans today, discussions about coal are inseparable from matters of environmental quality, energy options, business and economic concerns, and governmental regulations. Iowans have a special interest in coal and its role in today's society, because hidden beneath the fertile soils of our state lie extensive deposits of the soft black rock that is our geologic heritage from the vast tropical swamps that existed here millions of years ago.

Our job at the Iowa Geological Survey is to provide the best information to the policy and decision makers on important aspects of coal today: where is it; how much is there; what is its quality; and how can it be mined without impairing the environment. Without answers to these questions, the role of Iowa coal at the state and national level cannot be thoroughly assessed. Research through the Survey's Coal Resource Program will provide the answers.

As anticipated, the acquisition of substantive data from field and laboratory research has resulted in a growing responsibility to provide a variety of technical information services. Requests for these services derive from private individuals, government agencies, coal exploration and coal consuming companies, and individual scientists.

The purpose of this report is to bring you up-to-date on our Coal Resource Program and to describe

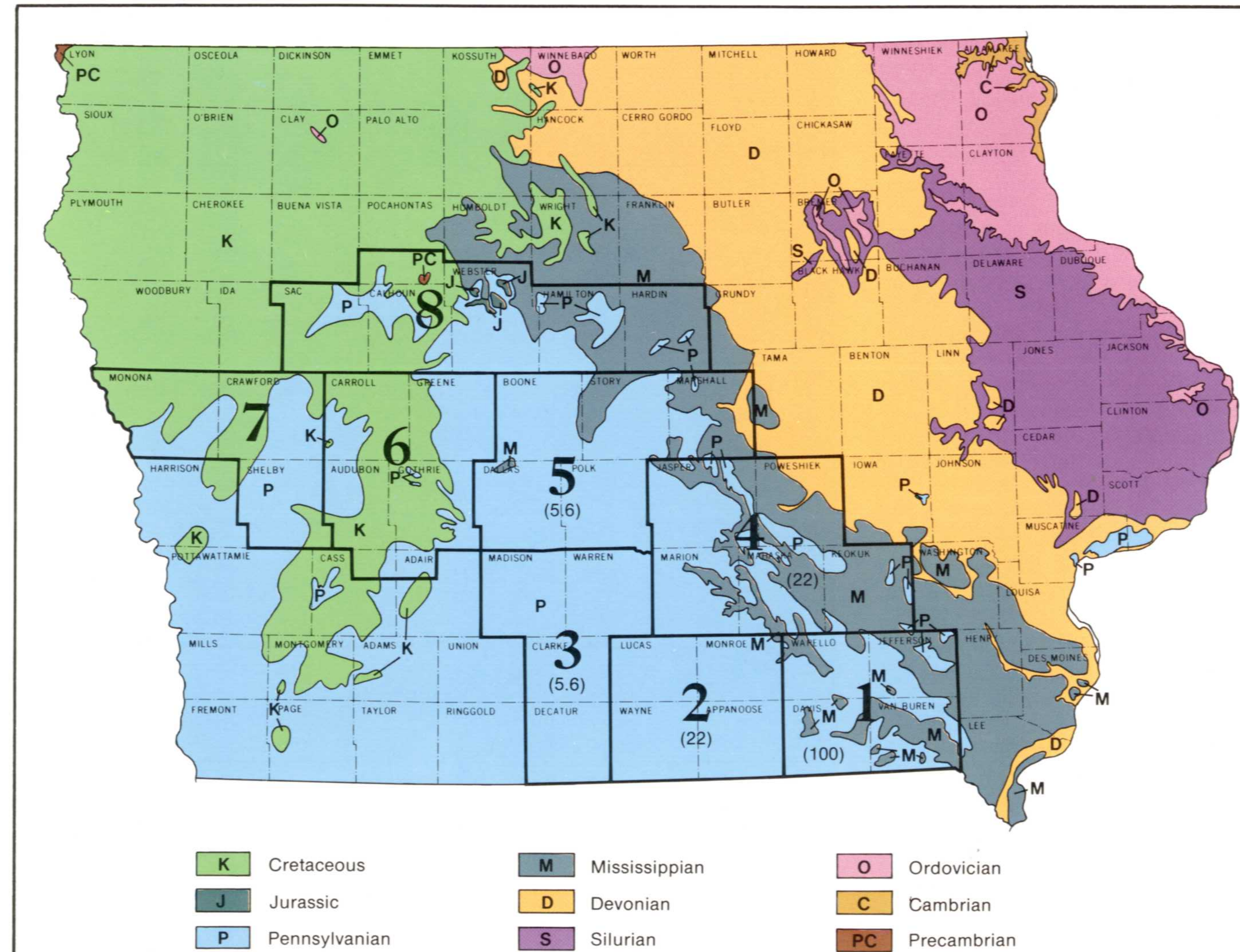

Figure 1. Bedrock geology map of Iowa with Iowa Geological Survey Coal Resource Program study areas delineated. Numbers in parentheses show percentage of drilling completed in each study area.

some of the important facts that we have discovered about Iowa coal. Some of the old myths have gone by the wayside. Scientific research has paved the way for re-evaluating the viability of Iowa coal as an important source of energy.

Growth and Decline of an Industry

Coal mining began in Iowa during the early 1840's. The coal was used primarily for home heating and for smithing operations. Production increased steadily as coal replaced wood fuel for the home and for boat traffic on the Des Moines River, but did not top 100,000 tons per year until the late 1860's. The coal industry accelerated with the coming of the railroads, and continued to expand into the early 1900's with production reaching a maximum of almost 9 million tons in 1917. Then, a long gradual decline occurred. Even though total production to date is slightly over 350 million tons, Iowa's current annual production is only about 600,000 tons.

Many explanations have been advanced for the decline of Iowa's coal industry. Low quality and sporadic occurrence have been cited most frequently. However, better than 80% of Iowa's coal could meet environmental standards if it were washed (a common practice elsewhere) and/or "scrubbed" (a technology that the Environmental Protection Agency plans to require for all new power plants).

Economics is the principal factor that has affected production of Iowa coal. Western coal deposits, even though of lower BTU (heat) content, are much thicker than coal beds in Iowa. Most of the coal deposits in states such as Illinois, Kentucky and Indiana are slightly higher in quality compared to Iowa coal. Although the mined coal beds in these states generally are not much thicker than Iowa coal deposits, the beds are more uniform in thickness, and there are fewer undulations of the coal seams. Because of these factors, the coal is less expensive to mine.

Recently, the economic situation has been changing. Gas and oil have become increasingly expensive, and current regulations limit their use for

a.


a. Drilling operation
b. Field description of core
c. Selection of samples for further testing
d. Splitting crushed coal sample for fossil recovery and chemical analyses
e. Processing of coal sample for spore and pollen recovery
f. Sorting fossil species for identification

c.


e.


b.


d.


f.


power generation. Coal from eastern states has risen in cost because the more accessible coal has been depleted or has been committed to long-term contracts. Western coal has been losing its economic advantage because rail rates, which constitute the major cost factor, have been rising dramatically. These economic changes could make it possible for Iowa coal to supply much of our energy needs at lower cost.

Still, important questions about Iowa coal have to be addressed. Most of the mining sites were located along or near river valleys where coal was readily accessible. Overburden thicknesses increased as mining progressed into the valley sides, and equipment subsequently was moved to new sites. Did the coal seams become thinner away from the valley walls? Are there other topographic positions where strip mines and shaft mines could be developed? Are there variations in coal quality from place to place?

The Coal Division of the Iowa Geological Survey (IGS) was established in September, 1973, one of several major efforts initiated by the State to develop an effective energy program. Predictions for 1985 indicate that annual coal consumption in Iowa will exceed 17 million tons, while current annual production in Iowa is only about 600,000 tons. If all of the short-fall is imported, there will continue to be a major cash outflow even under the most optimistic cost estimates. Therefore, the need for utilizing more of Iowa's coal deposits is greater than it has been in many years. Expansion of a coal industry in Iowa might not be an immediate reality, but all indicators point to significant development within the next ten years.

Drilling and Fossils Determined to be Key to Needed Information

Available information on the occurrence of Iowa coal deposits was not adequate to answer the detailed questions now being asked. In the portion of Iowa underlain by coal-bearing strata, there are insufficient surficial exposures of rock to provide answers. Also, the geology of these Pennsylvanian-age strata is very complex, and interpretations based on work in the adjacent states of Kansas, Missouri and Illinois are not entirely adaptable to Iowa. The existing literature also contains a considerable amount of inconsistent and unreliable data. Overcoming this lack of understanding about the nature and extent of the state's coal resources is the primary goal of the IGS Coal Division. Because of these limiting factors, it was clear that adequate data could be obtained only through core drilling and careful laboratory work, especially biostratigraphy — correlating the sequence of sedimentary rocks using fossils.

Two important facts are obvious from existing literature. First, most of the commercial coal extracted in Iowa has come from near the base of the Pennsylvanian sequence, and secondly, these key rock units dip toward the southwest corner of the state and thus become deeper beneath the ground surface in that direction. With this information, and using 800 feet as a practical limit for the development of underground mines, a research program was designed for the 15,500 square miles underlain by coal-bearing strata within the defined study areas. Figure 1 shows the designated study areas and the percentage of drilling completed in each. Test holes are drilled using a grid spacing of approximately six miles.

As work progressed, it became clear that the geology was even more complex than originally believed. An acknowledged expert was contracted as a consultant to guide research in palynology — the study of fossil spores and pollen grains from vegetation which eventually lithified to become coal. Work was also begun with conodonts, important microscopic fossils which, like spores and pollen, are vital to establish traceable horizons within a sequence of rocks, and to define the environments of deposition. This information is needed in order to map the distribution of coal beds on a regional basis.

To date, 78 exploration test holes have been drilled for a total footage of over 22,000 feet. Approximately 65 percent of this footage has been recovered in the form of cores — con-

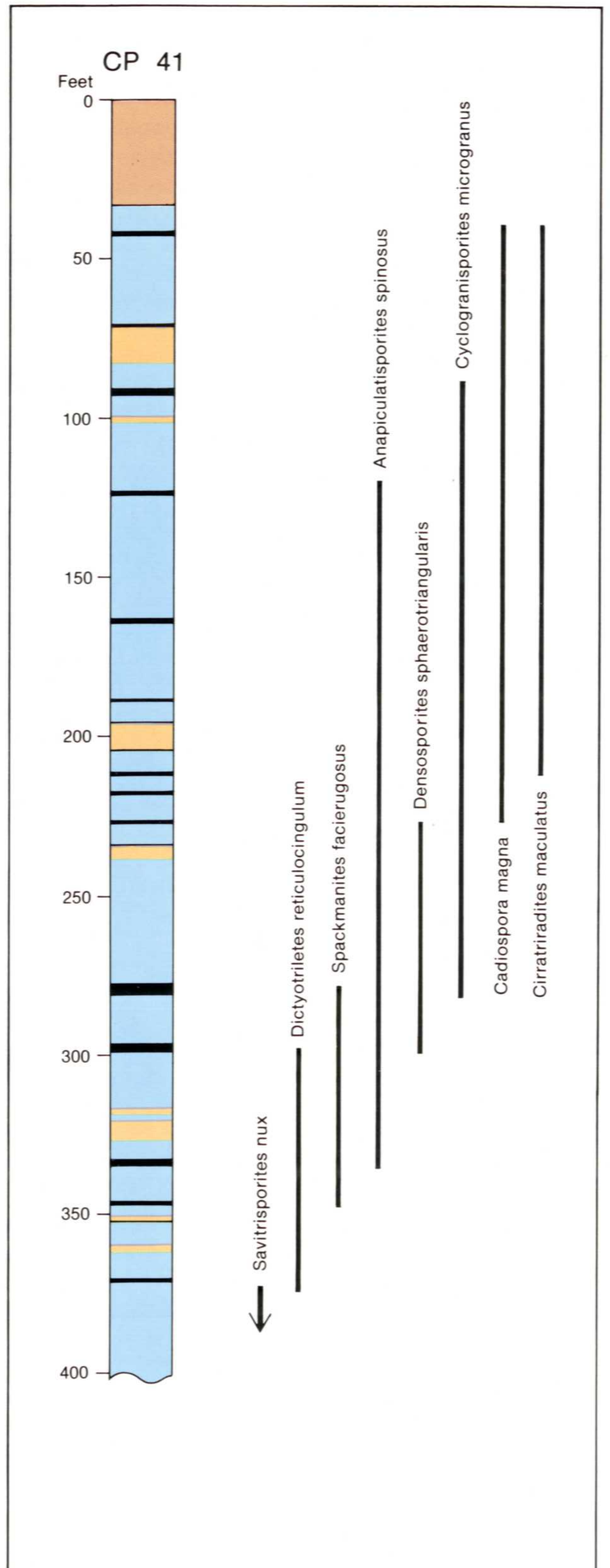

Figure 2. Time ranges of representative spore taxa.

tinuous two-inch cylinders of rock extracted by means of a circular diamond-studded drill bit. The core material is subjected to detailed examinations once back in the IGS laboratories. Coal seams two feet thick or greater are split, with one portion submitted for chemical analysis under a cooperative agreement with the U.S. Geological Survey. All coals are split for spore and pollen analysis, and selected rock samples above and below the coals are chemically disaggregated to recover conodonts for study.

Reconstruction of Geologic Environments Shows the Way to Location, Quantity and Quality of Iowa Coal

Without some means of showing the continuity of the layered rock units from one drill site to the next, much of the data provided from test holes would be practically useless. It is at this point that the application of the fossil studies becomes important, for they are a mechanism by which geologists can match similar units between two widely separated points. For example, certain known types of spores and pollen existed during a limited range of geologic time. This characteristic is demonstrated in figures 2 and 3, where a number of representative time-indicative spores are illustrated, as well as their relationship to the sequence of rocks being studied. Based on these specimens, as well as others, it usually is possible to assign a coal bed to a specific interval of the rock sequence. In addition to the limited time-range characteristics of individual fossil forms, each Pennsylvanian-age swamp had a distinctive set of environmental characteristics which are reflected in the fossil plant populations. Thus, identification of the spore and pollen grains recovered from a coal seam provides an environmental profile — an ecological thumbprint of the coal seam and the swamp deposits from which it formed. Previously, only tenuous correlations could be made.

The value and application of this information is illustrated by the geologic cross-section through Wapello and Davis Counties shown in figure 4. With the correlations made possible by use of the fossil spores and pollen, the geologic history of the area begins to unfold, as well as information on the thickness and distribution of discrete coal seams. For example, it is obvious that the entire rock sequence has been deformed since its deposition, a circumstance sufficient to confuse an unwary coal exploration company. Also clear is the fact that the thicker coal seams occur near the bottom of the section. Note the thick sandstone found in hole No. 18. This sandstone records the former existence of a major river channel which developed sometime after the thick coal in hole No. 19 was deposited. This river eroded all of the previously deposited Pennsylvanian sediments, and later, because of changing conditions, the channel was filled with sand.

The presence of a sandstone unit of this type is important in coal exploration because it interrupts the continuity of the coal seam. The cross-section also illustrates a number of other interrelationships which occur in the coals, such as the "pinching out" or thinning of a rock unit, and "splitting" or the separation of a coal bed into two or more seams with intervening rock units. All of

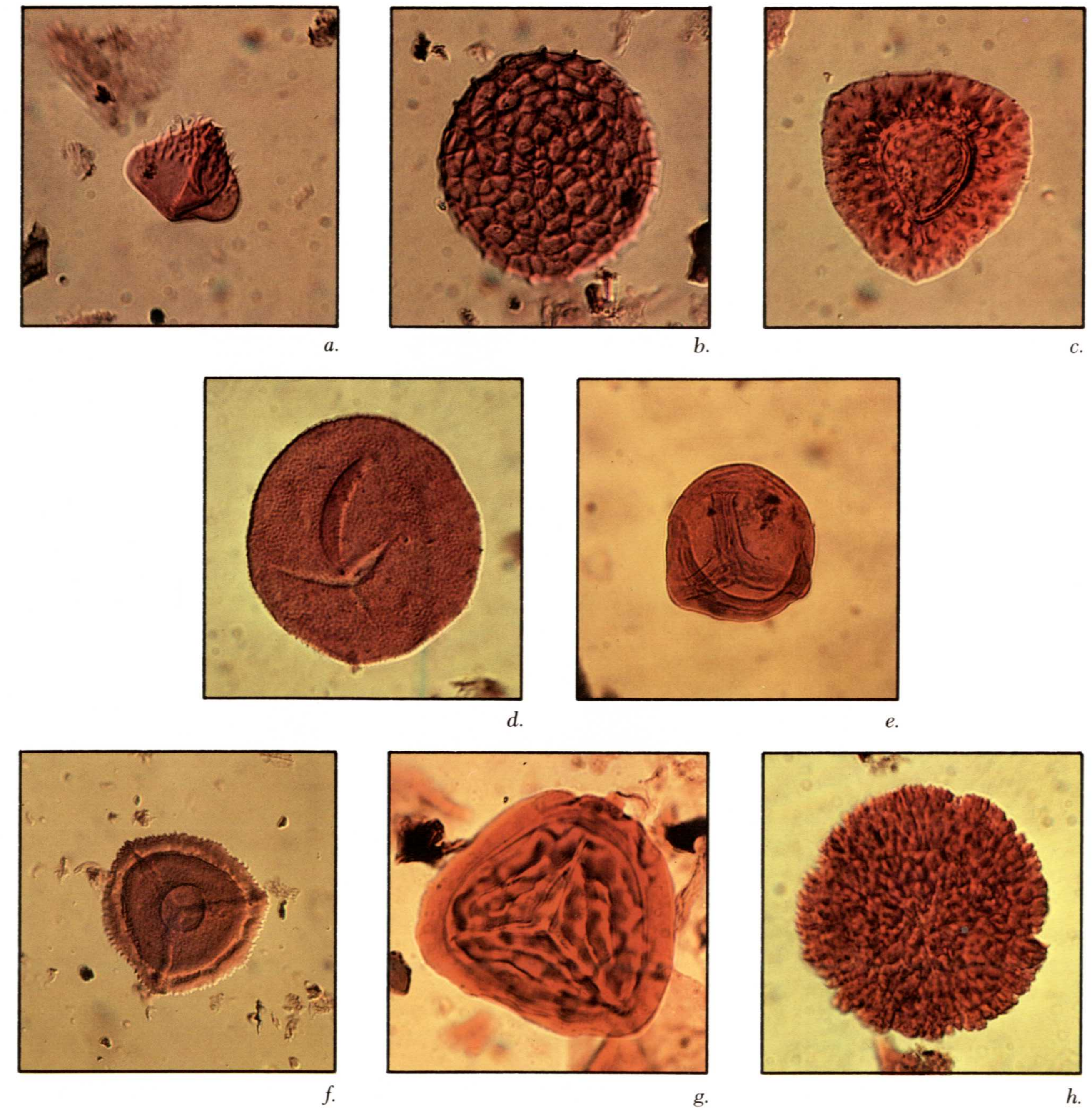

Figure 3. Representative spore taxa.
a. Anapiculatisporites spinosus (x800),
b. Dictyotriletes reticulocingulum (x800),
c. Densosporites sphaerotriangularis (x800),
d. Cyclogranisporites microgranus (x800),
e. Cadiospora magna (x500),
f. Cirratriradites maculatus (x500),
g. Savitrisporites nux (x800),
h. Spackmanites facierugosus (x800)

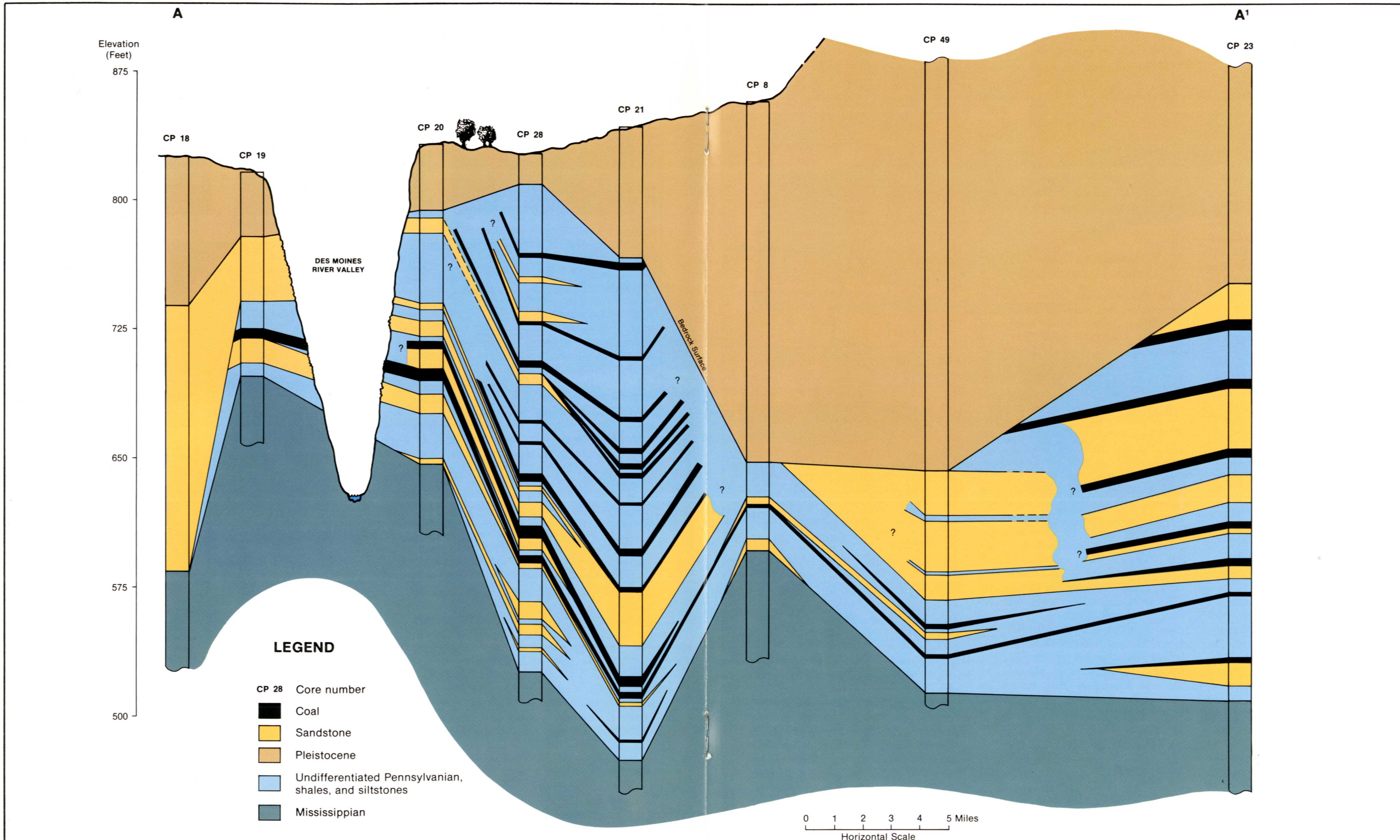

Figure 4. Cross-section A-A' illustrating a number of interrelationships common to Pennsylvanian-age rock units.

these conditions affect the economic potential for coal mining.

Figure 5 represents a second stage of the analysis process. Here an attempt has been made to remove the effects of deformation and to reconstruct the sediments in the position they occupied at a specific point in time. The adjusted cross-section shows the position of the sediments below the coal at the beginning of coal formation, thus enabling us to examine the physical environment of deposition.

Several conditions are apparent from this cross-section. For example, the top of the underlying Mississippian-age rocks is a gently rolling surface. Also, it is apparent that the first coal seam is thicker away from the axis of the underlying valley, while the second seam is thickest directly over the valley axis. These changes in thickness are the result of geologic processes and events associated with a fluctuating Pennsylvanian sea level. These fluctuations produced cyclical sequences of deposition inland along river valleys which drained to the sea. In response to these events, the ground-water levels also rose. Where ground-water levels locally were elevated above land surface, swamp environments developed, partially decayed vegetation accumulated, and conditions were favorable for the development of peat — the precursor of coal. Thus, the environments of deposition for the lower coals in the cross-section center around a relatively simple terrestrial system.

Changes in sea level had other, more direct effects on coal-forming environments. Later in Pennsylvanian time the sea actually penetrated into this area and produced a series of "transgressive" and "regressive" deposits which tend to have greater lateral extent than do the earlier deposits. These factors all exerted significant controls on resulting coal thickness, continuity, and chemistry. Most of the upper coals, which reflect these periodic marine invasions, are thin but continuous. Where these coals are thicker, they generally cover a large geographic area and thus may acquire considerable economic significance. Another important characteristic of the upper coals is a tendency to concentrate a different set of trace metals than do the lower coals, some of which may be environmentally deleterious.

By defining the sequence of rock strata, and by precise correlation of individual coal beds, the Coal Division can interpret the geologic history of the Pennsylvanian rock sequence in Iowa and develop a model of coal deposition. The establishment of such a working model will provide well-defined target areas for future commercial exploration based on factors such as coal location, quantity, and quality.

Environment of Deposition Affected Coal Chemistry

At this point our other important correlation tool becomes particularly significant. In addition to spores and pollen, considerable research effort is being directed toward the microscopic fossils known as conodonts, the preserved hard parts of an unknown marine animal. Examples of these fossil forms are shown in figure 6. Conodonts have been used worldwide in the study of rocks of different geologic time in much the same way as palynology is used in the study of Pennsylvanian-age rocks. Their usefulness is based on their ubiquitous occurrence in rocks deposited in the ancient seas and their generally rapid evolution. So far in this program, conodont research has produced only a very coarse correlation tool. Its usefulness gains considerable importance, however, in this matter of environments of deposition and coal chemistry. Figure 6 shows two cross-sections through the depositional system which existed at maximum transgression of the sea. The upper cross-section shows the physical conditions that existed, as reconstructed from the rock sequence found in Iowa and a knowledge of modern depositional systems. The bottom cross-section shows the distribution of the various conodont types relative to the different physical environments.

This analysis illustrates that different rock types were deposited in different chemical environments. The high concentration of several trace elements, including uranium and thorium, in several of the upper coals is directly related to the environment of deposition. These coals currently are sub-economic, but they may be mined in the future. The ability to predict the occurrence of potential pollutants thus will become increasingly important.

Other trace elements that have been documented, such as zinc and

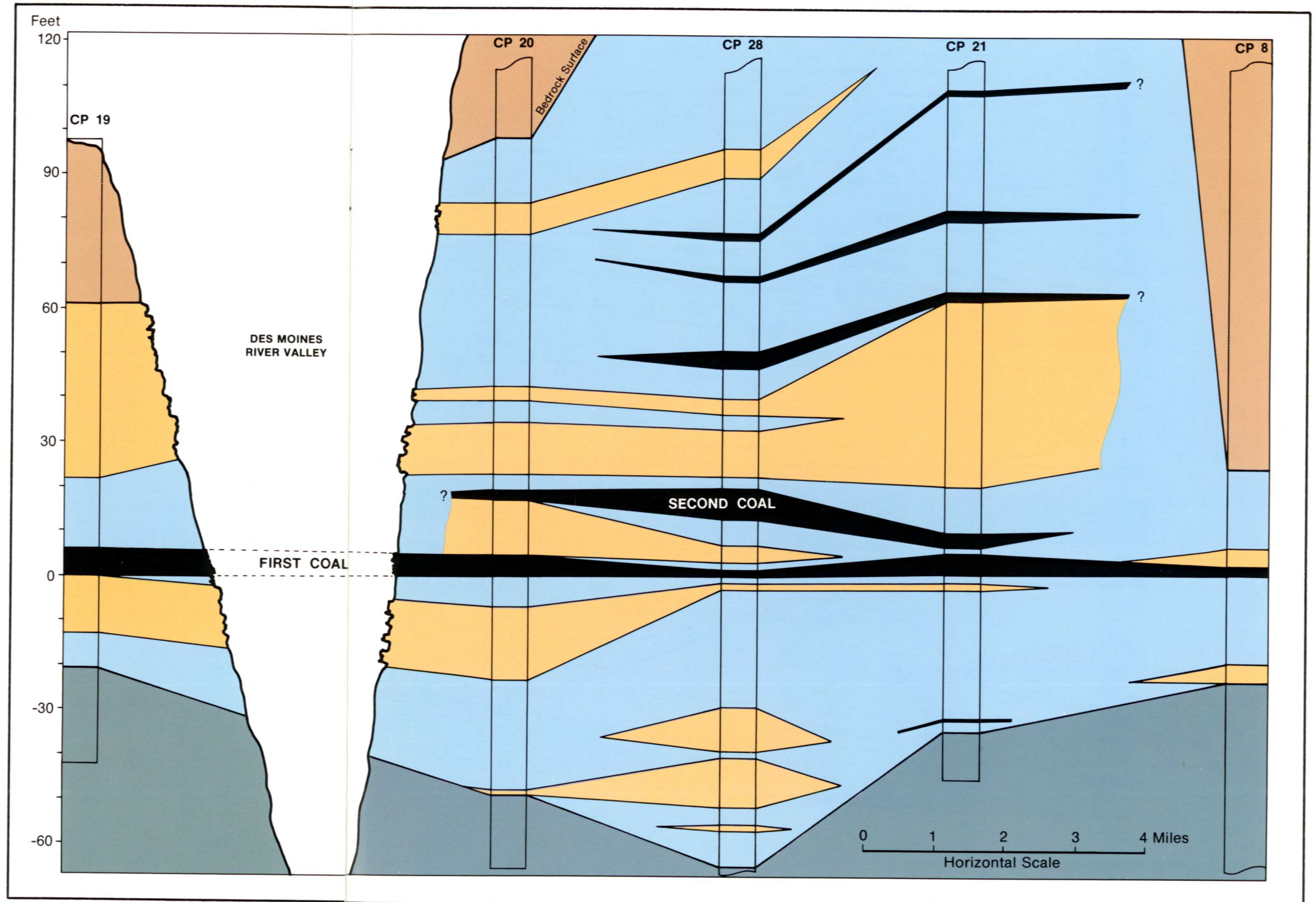

Figure 5. Expanded portion of cross-section A-A' with the first coal readjusted to a horizontal position which approximates its position at the time of deposition.

cadmium, appear to be unrelated to the environment of deposition. However, they hold some potential as economic by-products of coal mining, and their distribution may provide indications of economic deposits of zinc in deeper rocks below the coal-bearing sequence. Similarly, additional information generated by the coal program will facilitate exploration for other resources such as oil.

Maps Show Target Areas for Mining Companies

One of the primary objectives of the Coal Division's research is to develop maps that show the economic potential for mining coal in Iowa. The work done to date has enabled us to construct an Economic Potential Map for the four-county area shown in figure 7. Four geologic components are incorporated in its construction: (1) coal thicknesses, (2) depth of burial, (3) continuity of the deposits, and (4) past mining activity.

Computer programs are being developed to facilitate the handling of all data. With computerization it will be possible to manipulate the information more easily and to produce Economic Potential Maps under different economic conditions that affect commercial mining.

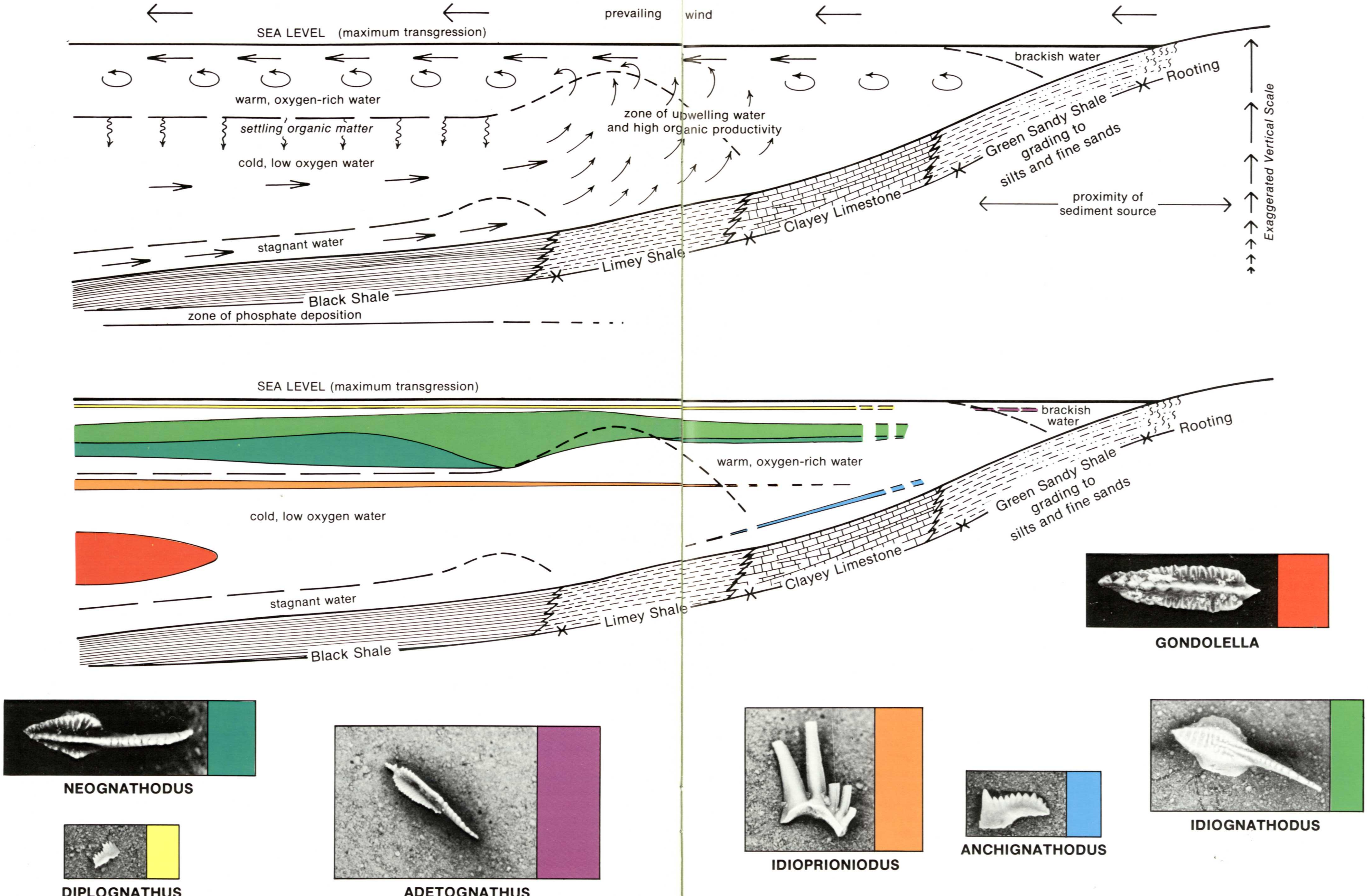

Figure 6. Cross-sections illustrating the interrelationships between environments of deposition, the conodonts present, and the relationship of both to the rock types formed.

Information Banked for the Future

A major attribute of this research is the continuing refinement which has been built into the program. Because of its particular mission, the Coal Division must collect and reposit data on many aspects of Iowa coal. Great care is being taken to assure the preservation of the data and samples, so that at some future date, when analytical techniques improve or new problems arise, the data and sample base will already exist to provide a solution or adequate background information without the necessity of mounting a new study. Other benefits of the drilling activity include sampling of the glacial sediments which overlie the bedrock. Knowledge of these materials will add significantly to the information base on the reclamation characteristics of Iowa's soils. Each core hole is also being logged using geophysical techniques. The resulting graphs exhibit curves of electrical and radioactive characteristics of the rocks with depth and provide information on the occasional zones where sample recovery is incomplete.

Service Activities Rank High Among Coal Program Functions

The Coal Division's service function takes many forms depending on the origin of the request. To date the Coal Division staff has provided assistance to private citizens, coal exploration companies, coal consuming companies, local governmental bodies, state agencies, federal agencies, and individual scientists.

The most asked questions from private citizens are: "What is the coal potential of my property?" and "Is there an abandoned mine under my property?" These questions are addressed as specifically as possible, and the responses prepared contain the data on which the conclusions have been based. Questions dealing with mineral rights and leasing are also frequently asked. In response to these questions, the Coal Division advises the individual in a general manner, explains how to evaluate the potential production of a property and recommends that the individual also seek professional legal advice.

Coal exploration companies generally want readily available information during their initial period of contact. However, if they become seriously interested in exploration in Iowa, the follow-up contacts and visitations can consume at least a week of staff time. Coal companies already operating in the state generally request very specific information, ranging from all available data in a limited area to maps locating abandoned underground mines on properties they are currently working.

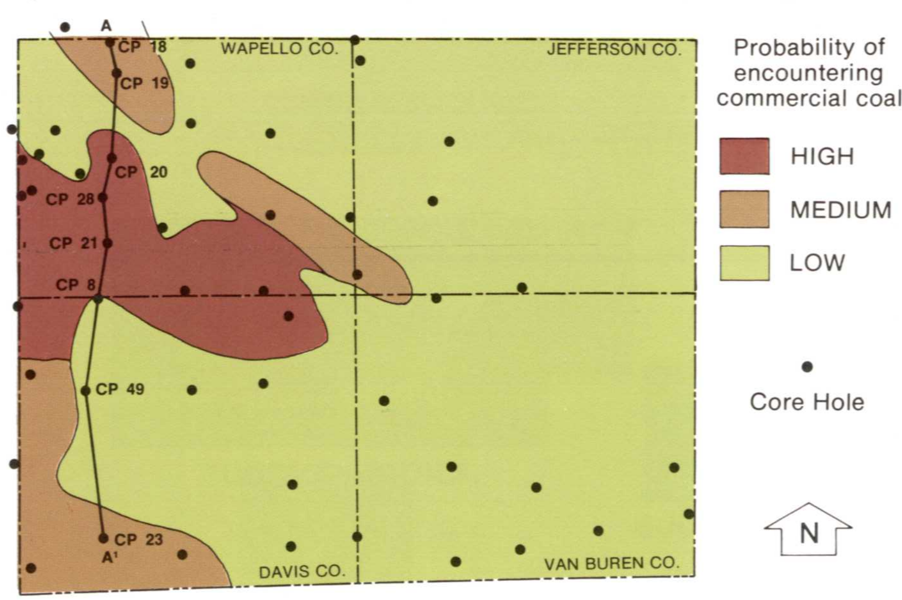

Figure 7. Economic potential map of Study Area No. 1.

The Coal Division has provided coal consumers with general and specific information on coal quality and availability and on locations of deposits and mines. On numerous occasions lists of coal companies with reserves in Iowa have been prepared for utilities and industrial consumers.

There are numerous requests for assistance and information from local, state and federal government agencies. An example is the project that led to the cover illustration for this report. During the summer of 1978, a large hole appeared in the front yard at 1908 East Capitol Street in Des Moines. In his attempt to obtain assistance, the property owner contacted the City Engineer's Office and the Division of Mines and Minerals (Iowa Department of Soil Conservation); mine subsidence was suggested as a possible explanation. The Coal Division was requested to research its files to check on the possibility of former mining in the area. The mine-map file contained no definite records, but the early geologic literature mentioned mining in the area. Because several major buildings are nearby, a grant was obtained from the Office of Surface Mining to study the possibility of further subsidence in the area. The City Engineer's Office also requested that a map of known mining be prepared to evaluate the cause of any future subsidence problems.

The Coal Division also provided technical expertise to analyze the samples obtained from test drilling. Data from the cores generated by this project suggest that two possible levels of mining existed in the area. Additional drilling was recommended for verification. The Coal Division itself subsequently cored three additional holes and definitely identified one level of mining. Presently, the three new cores are under study and a summary report is in preparation.

Personnel of the Coal Division also have provided ongoing advice to agencies such as the Iowa Department of Soil Conservation and the Soil Conservation Service in the development of their programs for mine reclamation. Often this service requires input from other Divisions of the Geological Survey, and the Coal Division staff serve in a liaison capacity. Figure 8 is an example of the assistance rendered by other IGS Divisions. The illustration is a color-infrared photograph of the Iowa Coal Project Demonstration Mine No. 1 and adjacent partially reclaimed surface mines. Color intensity is a measure of the vigor of the vegetation. The deeper the reds, the healthier the plants. Based on this criterion it is easy to evaluate the relative success of various management programs being tested by Iowa State University researchers. The obvious merits of this monitoring technique have convinced the Division of Mines and Minerals that the technique is extremely useful in augmenting ground-level inspections. Currently, they are developing their own capability for obtaining the necessary photography and its interpretation.

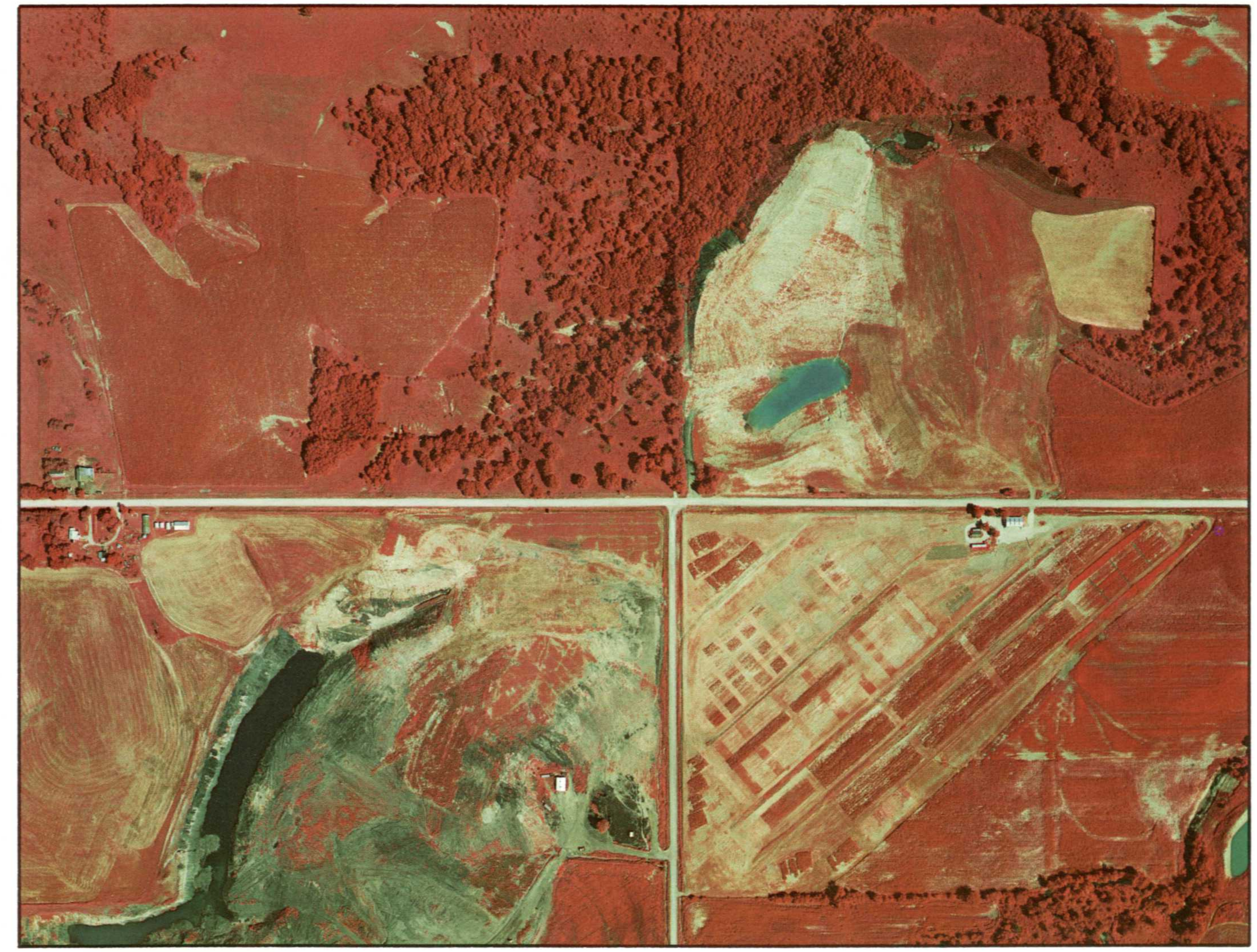

Figure 8. Color-infrared photograph of Iowa State University Demonstration Mine No. 1 southwest of Oskaloosa showing experimental revegetation plots and adjacent, partially reclaimed abandoned mines. (Photo by IGSRSL)

Assistance rendered the scientific community includes providing coal samples to researchers studying gasification or coal characterization, providing coal or water-chemistry data to environmental scientists, and helping researchers to locate pertinent literature sources. This assistance has opened valuable lines of communication with others who have acted as informal consultants and have provided important information to the Coal Division.

The Future

Although short-term economic factors have had a negative impact on the State's coal industry, we are better prepared to provide essential information that can aid in its revitalization. Research drilling has been completed in Study Area No. 1, but at least a minimum of drilling is needed in the other study areas in order to acquire similar data.

Like many other geological investigations, the new data from the Coal Research Program serves not only its intended purpose, but also is applicable to other ongoing geological research. Refinement of bedrock topographic maps, discovery of previously untapped aquifers, definition of engineering properties of soils, and information that may lead to the discovery of new mineral resources are but a few examples. Thus, the information generated through the Survey's Coal Research Program is an important investment in Iowa's future.

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LEGEND

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