HARRISBURG (NO. 5) COAL RESERVES OF SOUTHEASTERN ILLINOIS

M. E. Hopkins

ILLINOIS STATE GEOLOGICAL SURVEY Urbana, Illinois

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OF SOUTHEASTERN ILLINOIS

M. E. Hopkins

ABSTRACT

In southeastern Illinois, the Harrisburg (No. 5) Coal
Member of the Carbondale Formation is widespread and has
been extensively mined near its outcrop. This report ex-
tends the known resource area, which has been confined to
within several miles of the outcrop, northward into the Fair-
field Basin (the deeper part of the Illinois Basin) by inter-
pretation of coal thickness from conventional electric logs.
From this study it appears that the known area of potential
relatively low-sulfur coal (sulfur content usually less than
2.5 percent) lying mostly in northern Saline County can be
extended northeastward in a belt 4 to 10 miles wide running
through parts of Hamilton, White, Wayne, Edwards, and
Wabash Counties, and thence into Indiana. Coal thick-
nesses in this belt are quite variable, and in some areas,
thicknesses of 8 feet or more are estimated. Another char-
acteristic of this belt is that the No. 5 Coal is overlain by
a gray silty shale, herein named the Dykersburg Shale Mem-
ber, which intervenes between the coal and the overlying
black shale and/or St. David Limestone Member. Maps are
presented showing coal thickness estimations and areas
where the coal is overlain by either (1) black shale and/or
limestone, (2) Dykersburg Shale from 1 to 20 feet thick,
or (3) Dykersburg Shale more than 20 feet thick. The coal
is absent from a narrow sinuous area one-half to three-
quarters of a mile wide, generally within the Dykersburg
Shale area. This elongate area represents a sandstone-fill-
ed channel believed to be in part contemporaneous with the
coal. In places, the coal is split by silty shale units of the
Dykersburg, indicating that the shale, in its lower part, is
also contemporaneous with the coal.

1

Estimated No. 5 Coal reserves for the area included in this study total 11.8 billion tons in the ground, of which 7 billion tons lie under black shale and/or limestone roof, 2 billion tons under Dykersburg Shale 1 to 20 feet thick, and 2.7 billion tons under Dykersburg Shale greater than 20 feet thick. Coal in this last category represents potential relatively low-sulfur coal reserves.

INTRODUCTION

The area of southeastern Illinois included in this report is shown in figure 1. All of Edwards, Hamilton, Saline, Wabash, and White Counties, and portions of Gallatin (north of the Shawneetown Fault), Franklin (eastern half), Jefferson (eastern half), Wayne (southern three-fifths), and Williamson (northeastern third) Counties, which are underlain by the Harrisburg (No. 5) Coal, are included. The southern boundary of this area is formed by the outcrop of the Harrisburg (No. 5) Coal Member.

In this region, the Harrisburg (No. 5) Coal has been and is being mined rather extensively along and within a few miles north of the outcrop in Williamson, Saline, and Gallatin Counties (pl. 1A). Detailed prospecting in southeastern Illinois has been confined to this area. The coal also is mined rather extensively in western Kentucky where it is called the No. 9 Coal and in southwestern Indiana where it is termed Coal V. The mining has been confined here also to a relatively short distance from the outcrop, at depths not exceeding a few hundred feet, except in Kentucky, where structural dips are relatively high and greater depths are encountered closer to the outcrop.

The purpose of this report is fourfold: (1) to determine the general extent of the Harrisburg (No. 5) Coal and its thickness variations in southeastern Illinois; (2) to determine the extent of the relatively low-sulfur No. 5 Coal and to increase our understanding of the geologic occurrence of low-sulfur coals in the Illinois Basin; (3) to increase fundamental knowledge of the variations in the strata associated with coals; and (4) to show that reasonably
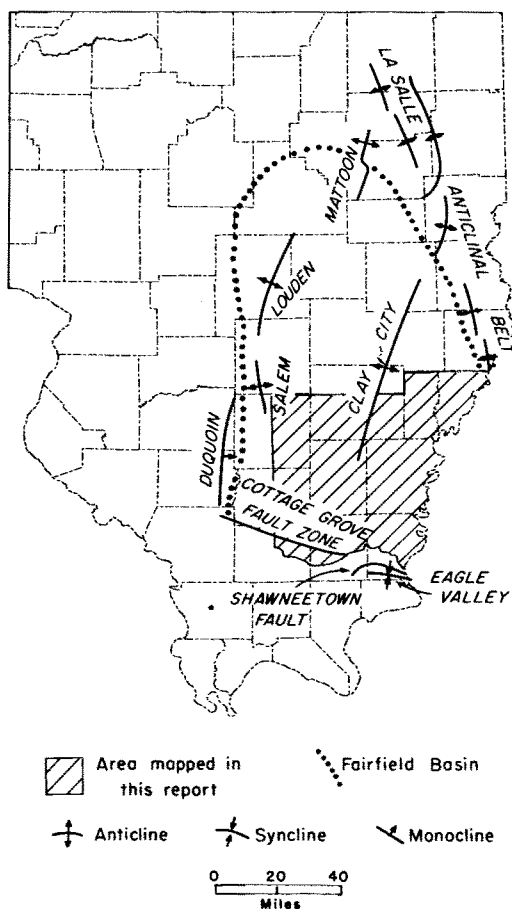
Figure 1 – Index Map.

accurate estimations of coal thicknesses can be obtained from conventional electric logs, particularly where the coal is overlain by at least a few feet of gray shale.

Previous studies with data on the Harrisburg (No. 5) Coal in this area include a report on Jefferson, Franklin, and Williamson Counties by Cady (1916). Cady (1919), in a report on Saline and Gallatin Counties, published a structural map on the No. 5 Coal and discussed the geologic and economic aspects of this coal. More detailed structural mapping of strata in this part of Illinois was accomplished by Cady and others (1938) for the western part of the area now under consideration and also by Cady and others (1939) for Hamilton, White, Saline, and Gallatin Counties. Both of these reports dealt with the structure of the Herrin (No. 6) Coal.

A later series of county reports utilizing oil tests (principally electric logs) for coal bed identification were published for Wayne County (Sims, Payne, and Cady, 1944; Dubois and Siever, 1955), Hamilton County (Rolley, 1951), Edwards County (Smith and Cady, 1951), Gallatin County (Pullen, 1951), and Wabash County (Cady and others, 1955). The above reports all present structure maps on the No. 6 Coal, as well as some data on the No. 5 Coal.

A statewide study of coal resources (Cady and others, 1952) provided data on reserves for the 10 counties covered in this report; however, electric logs of oil tests were not used in determining reserves in this study. Strippable reserves for the No. 5 Coal in this area were delineated by Smith (1957).

An important contribution to the study of the No. 5 Coal was made by Trescott (1964), who used electric logs to determine the thickness of the coal. He presented a map (published by Wanless, 1965) covering much of Edwards County and adjacent parts of Wayne, White, and Wabash Counties showing thickness variations in the coal. Trescott indicated the coal to be as much as 8 feet thick in parts of this area.

Gluskoter and Simon (in press) have delineated known areas of relatively low-sulfur coal in Illinois. Their compilation, with numerous analyses available from mines and drill holes, indicates that parts of Saline, Williamson, and Hamilton Counties contain relatively low-sulfur No. 5 Coal. The present report extends this area of relatively low-sulfur No. 5 Coal northeastward.

STRATIGRAPHY

The Harrisburg (No. 5) Coal Member occurs stratigraphically near the middle of the Carbondale Formation of the Kewanee Group, Desmoinesian Series, Pennsylvanian System (fig. 2) and is widespread in southeastern Illinois. It is contained within the St. David Cyclothem and is generally continuous in southeastern Illinois, being absent only where removed by present or pre-Pleistocene erosion or where its position is occupied by a lenticular sandstone apparently deposited in a stream channel (pl. 1, in pocket). Throughout most of the area, the coal is directly overlain by 1 to 3 feet of black, sheety, hard marine shale, termed "black slate" in the mining industry. This, in turn, is overlain by the St. David Limestone Member, an impure fossiliferous marine limestone, which is generally less than 2 feet thick. This uniformity is interrupted in an area about 4 to 10 miles wide, extending generally southwestward from the Illinois-Indiana border in southern Wabash County to the outcrop in Saline County (pl. 1B). In this elongate area,

the immediate roof is silty gray shale with minor amounts of sandstone, which intervene between the coal and the black shale. The thin black shale and the overlying St. David Limestone act as a unit and rise above the gray shale. These relations can be seen on the two cross sections shown on plate 2 (in pocket).

This gray silty shale is herein named the Dykersburg Shale Member of the Carbondale Formation. The type locality is designated as SE$\frac{1}{4}$ SE$\frac{1}{4}$ NE$\frac{1}{4}$ sec. 34, T. 9 S., R. 4 E., Williamson County, Illinois. This outcrop, on the Carrier Mills 7$\frac{1}{2}$-minute Quadrangle, occurs on the highwall of the abandoned Delta Collieries Corporation strip mine near the settlement of Dykersburg (shown as Absher on the 15-minute Marion Quadrangle). Here the Dykersburg Shale is about 15 feet thick and is overlain by 3 feet of black sheety shale, which is in turn overlain by the St. David Limestone Member, which consists of about 15 inches of dark gray marine limestone. The Dykersburg Shale is underlain by the Harrisburg (No. 5) Coal Member, which has been mined in this locality. To the east, for a distance of about 15 miles, the coal has been strip mined and many exposures of the Dykersburg Shale can be seen. For most of this distance the shale is considerably thicker than at the type locality, usually making up all of the bedrock exposed in the highwall above the coal.

Named Members

—Danville (No. 7) Coal
—Allenby Coal
—Bankston Fork Ls.
—Anvil Rock Ss.
—Conant Ls.
—Jamestown Coal
—Brereton Ls.
—Herrin (No. 6) Coal

—Vermilionville Ss.

—Briar Hill (No. 5A) Coal

—St. David Ls.
—Dykersburg Shale
—Harrisburg (No. 5) Coal

—Hanover Ls.
—Summum (No. 4) Coal

Scale feet
100
50
0

Figure 2 - Generalized columnar section of a portion of the Carbondale Formation in southeastern Illinois.

Where the Dykersburg Shale exceeds about 30 feet in thickness, either the black shale and/or limestone thin to zero, and the Dykersburg is then overlain by the unit above the limestone, which is usually another gray shale or, in some cases, sandstone belonging to the overlying Briar Hill Cyclothem. It is difficult to determine the true thickness of the Dykersburg in the absence of the black shale and/or St. David Limestone. It is estimated that this unit may exceed 100 feet in some places.

Another disruption in the continuity of the coal in this area occurs in a long sinuous area about half to three-quarters of a mile wide, which lies almost entirely within the gray shale area and extends generally southwest from the Illinois-Indiana state line to the outcrop of No. 5 Coal in Saline County (pls. 1 and 2). Data indicate that the coal is absent because of nondeposition or erosion, or a combination of both. Sandstone, normally less than 40 feet thick, deposited in the form of a channel, occupies the position of the coal. It is thought that this sandstone may be the coarse facies of the Dykersburg Shale and is perhaps therefore partially the same age as the Dykersburg.

Also present in the gray shale area are places where the No. 5 Coal is split into two or more benches by shale partings, frequently rendering the coal unminable. Also (pl. 1A), the coal may occur in isolated areas as only one thin bench (generally less than 3 feet thick). It is thought that in such places, the reason normal thick- nesses of coal were not deposited was because of interruption by deposition of gray muds, and not because of the general cessation of plant accumulation, which occurred over the general area as the coal swamp was eliminated.

STRUCTURE

The Harrisburg (No. 5) Coal crops out in an east-west line across southern Illinois through Gallatin, Saline, and Williamson Counties (fig. 3). It also occurs
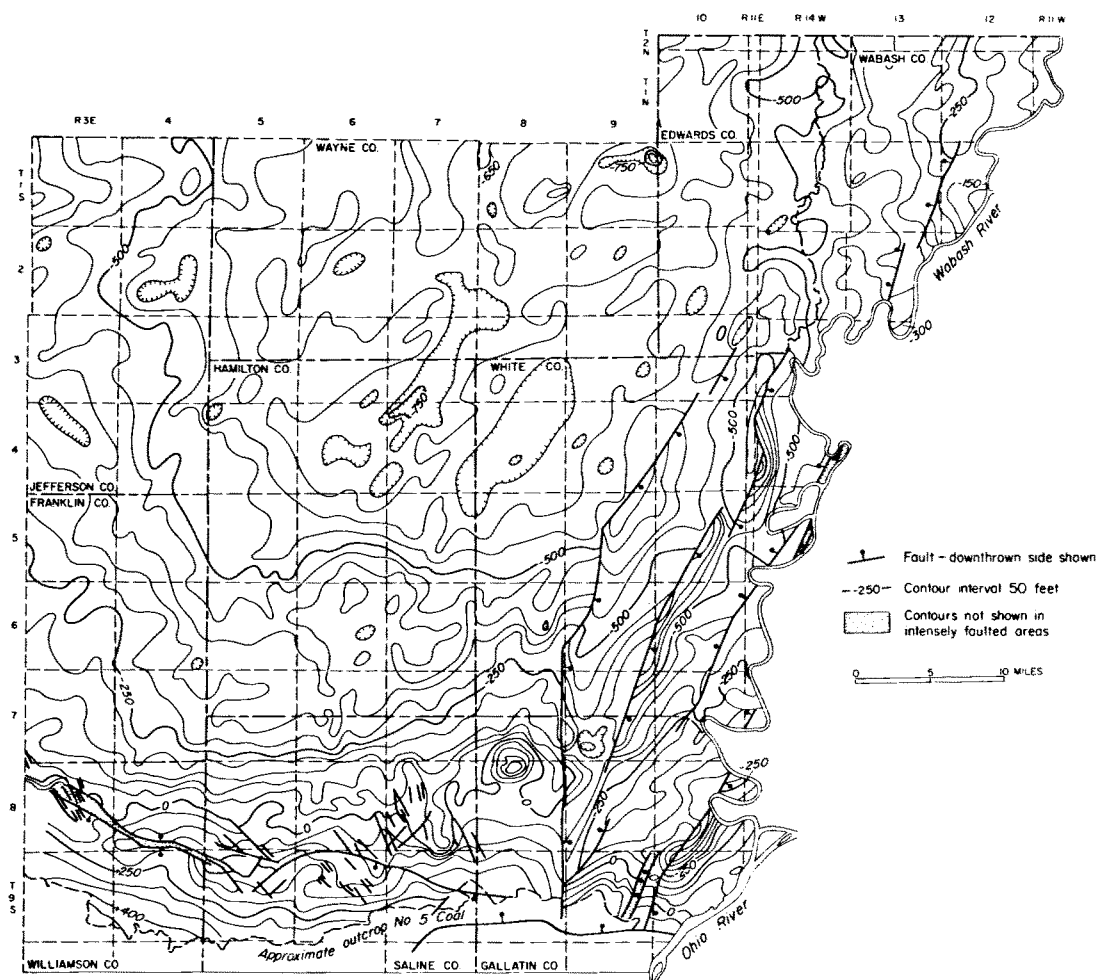
Figure 3 - Structure map of Harrisburg (No. 5) Coal, southeastern Illinois.

in the Eagle Valley Syncline, south of the Shawneetown Fault, in southern Gallatin County, but this area was not included in this study. From the east-west outcrop line, the coal dips toward the north at a rate of about 25 to 50 feet per mile into the Fairfield Basin (the deeper part of the Illinois Basin), where it is found at elevations as low as 786 feet below mean sea level (depth 1162 feet) in northeastern Hamilton County (fig. 3). The structurally lowest known point in the study area, however, lies in northeastern Wayne County in sec. 12, T. 1 S., R. 9 E., where the coal is found at an elevation of 816 feet below mean sea level. Another point almost as low is found in sec. 30, T. 4 S., R. 14 W., White County, where the coal occurs near a fault at an elevation of 805 feet below mean sea level.

Major faults affecting the coal are shown in figure 3: (1) the east-southeast-trending Cottage Grove Fault Zone extending from north-central Williamson County to western Gallatin County; (2) a system of north-south and northeast-southwest-trending faults in Gallatin, White, and Wabash Counties; and (3) the Shawneetown Fault, which affects the coal only in eastern Gallatin County and western Kentucky.

Several small faults are also shown in Saline and Williamson Counties where encountered in mining or in closely spaced coal-test drilling.

USE OF ELECTRIC LOGS

This study is based primarily on the estimation of coal thickness from conventional electric logs of oil tests (pl. 1A). In the files of the Illinois State Geological Survey, there are about 70,000 such logs, which cover a large area of southern Illinois. This collection of logs is essentially complete, representing practically all logs of this type run on holes drilled for oil and gas in Illinois. Intensive prospecting and mining of coal, for the most part, has been confined to the shallower portions of the Illinois Basin in the southern, southwestern, western, and northern areas where the coals are relatively shallow. Large tracts in the deeper parts of the basin have never been explored for coal.

Several economic reasons exist for the dearth of coal data in the deeper parts of the basin, but the principal reason was that adequate reserves were available in the shallower areas. Energy demands in the near future are such that relatively large tracts required by modern power plants, and in the future by liquid and gas conversion plants (Risser, 1967), will be needed from the deeper parts of the Illinois coal field.

The conventional electric logs, which are made immediately after total depth is reached in oil test holes, usually include two types of curves, the spontaneous- or self-potential curve, which is shown on the left side of the log, and the resistivity curves, which are shown on the right. Several varieties of resistivity curves result from variations in the spacing and arrangement of the current and potential electrodes on the measuring device. Two principal types of resistivity curves are usually shown on the logs, the normal and the lateral curves. Usually there are two normal curves, one called the short normal and the other, the long normal. The terms short and long refer to the vertical distance between the current and the potential electrodes, which is more or less directly related to the depth of penetration of the electrical field into the rock layers adjacent to the sides of the drill hole.

Two desirable functions of these curves are the delineation of the thickness of the lithologic units and the determination of the amount and character of fluids contained in the pore spaces of the rocks. Of the normal curves, the long normal comes
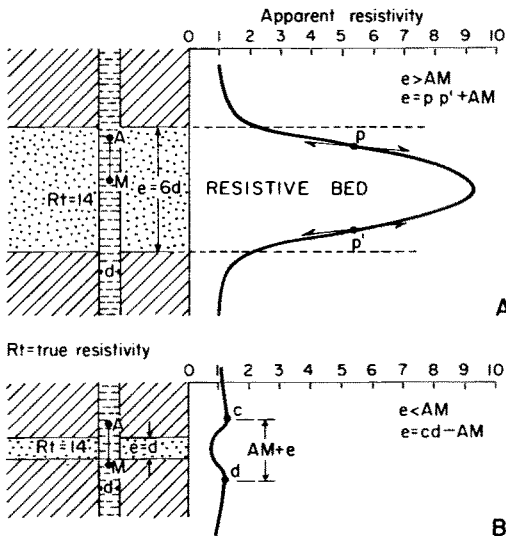
Figure 4 - Idealized resistivity curves for normal device showing relations of electrode spacing and bed thickness (from Tixier, 1958).

closer to supplying the character of the fluids inasmuch as it more nearly records the true formation resistivity. The short normal, however, is of more value in determining the position of the boundaries between the lithologic units. In particular, the bed thickness, when greater than the electrode spacing, is related to the normal (short or long) curve, as shown in figure 4A where the bed thickness is equal to the vertical distance between the inflection points (p, p') plus the electrode spacing (in the case of most Illinois wells, the short normal spacing is 16 inches, the long normal, 54 to 71 inches). If the formation thickness is less than the electrode spacing, a "crater" or inflection to the left develops in the normal curve (fig. 4B), and the highly resistive bed is shown as a conductive or low resistive bed. Two small symmetrical peaks occur on each side of the depression, forming the so-called "crater."

The commonly used spacings of the normal curves enables one to readily determine which of three possible thickness intervals the bed falls into:

(1) less than the short normal spacing—both curves show depression or craters;

(2) between the short and long spacing—short normal shows inflection to right, long normal shows crater (No. 5 Coal, fig. 7);

(3) thickness more than long spacing—both curves show inflection to the right (No. 6 Coal, fig. 8).

The thicknesses, as determined for the No. 5 Coal from the electric logs used in this study, should be regarded as estimates. With a simple condition of relatively thick low resistive rocks above and below the coal, the entire inflection of the short normal curve is an expression of the coal and the distance between inflection points (p, p', fig. 4A) plus the spacing (usually 16 inches), which equal the coal thickness. A rapid inspection of the long normal curve indicates whether or not the coal thickness is greater or less than the long normal spacing. Thicknesses determined by this method were checked against nearby diamond drill holes in an area in Saline, Gallatin, and Williamson Counties. Agreement between the two sources of information was good. Some variability is found from diamond drill hole to a nearby electric log, but this is to be expected, as coal thickness normally varies in any area.

In actual practice, coal thicknesses were rapidly estimated by comparison of the resistivity peaks with the footage marks on the log. No attempt was made to actually measure the distance between the exact location of the inflection points and then add on the electrode spacing. It was felt that for the purpose of regional mapping, thickness figures thus obtained were sufficiently accurate. Also, a certain

degree of confidence was obtained by first working in an area where there were several coal test holes with accurate coal thicknesses located close to oil tests with electric logs.

When the thickness of the resistive bed is less than about 3 feet, the re-sistivity peaks lose much of their character, approaching a >shape, which makes estimation of thickness more difficult. For this reason, no determinations of thickness less than 3 feet were attempted. For the same reason, but to a lesser degree, the estimates of 3 and 4 feet are probably less accurate than higher figures. In economic investigations using electric logs, this difficulty might cause some problems in determining a minimum thickness cutoff line.

In the areas where either the St. David Limestone, or limestone lenses, or concretions in the black shale lie directly on or within a short distance above the coal, the resistivity peaks may be essentially together, and thickness determinations are made more difficult. In the section dealing with reserves, areas where this problems exists are discussed. However, throughout most of the study region there is some separation on the electric logs, and the coal apparent resistivity is sufficiently greater than that of either of the limestones, thus making delineation relatively easy.

In figure 5, two records from sec. 10, T. 8 S., R. 6 E., Saline County, located about one-third mile apart, are shown. The diamond drill coal test indicates the No. 5 Coal to be 6 feet 8 inches thick. The electric log pattern shown is a 16-inch normal curve, the only normal curve run on this particular well. The lithologic symbols are drawn within the electric log space, but are actually the driller's log record of the diamond drill hole. From the electric log record, the No. 5 Coal is estimated to be about 7 feet thick, which is in good agreement with the 6 feet 8 inches from the nearby coal test record.

Incidentally, good agreement also exists when thicknesses of the Nos. 5A, 6, and 7 Coal Members are compared on the two logs. One complication that exists is the Brereton Limestone Member, which closely overlies the No. 6 Coal. In this case, it is frequently difficult to distinguish between the two resistive units, the coal and the limestone.

Two records in sec. 16, T. 8 S., R. 6 E., Saline County, one a diamond drill hole and the other from an electric log less than a quarter mile away, are shown in figure 6. On the driller's log, the No. 5 Coal is 8 inches thick, but on the nearby electric log, it appears to be 2 to 3 feet, or at least more than the short normal spacing, which is 16 inches. This is considered to be normal variation
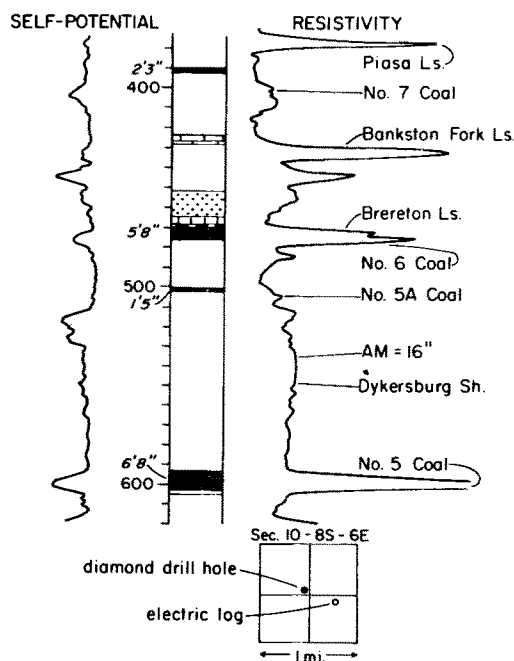
Figure 5 - Electric log of oil test compared to nearby diamond drill hole.

SELF-POTENTIAL   RESISTIVITY
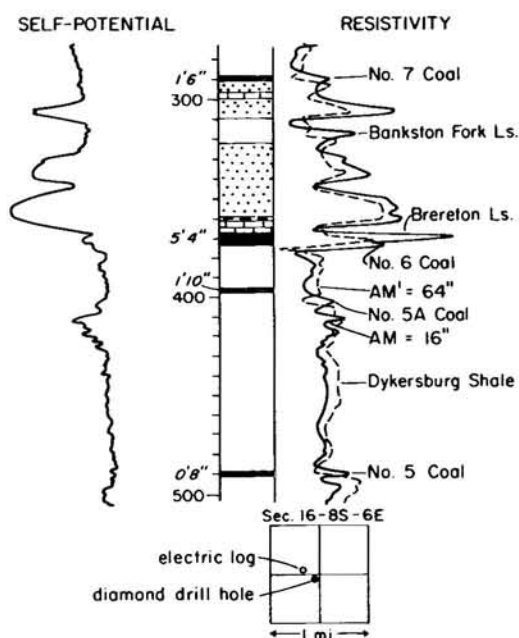
Figure 6 - Electric log of oil test com-
pared to nearby diamond drill hole.

in coal thickness due to depositional
conditions. Again, fairly good compari-
son in thickness can be made for the Nos.
5A, 6, and 7 Coals on these two records.

In figure 7 the logs of two holes
are shown that are about one-eighth mile
apart, located in sec. 7, T. 8 S., R. 8 E.,
Gallatin County. The No. 5 Coal is 4
feet 9 inches thick in the diamond drill
hole and estimated at 5 feet on the elec-
tric log. The "crater" or inflection to
the left on the long normal curve indi-
cates that the bed is less than the spacing,
which is 64 inches. The deep inflection
of the short normal curve to the left im-
mediately above the No. 5 Coal is char-
acteristic of black shale roof. Normally
the thin, very argillaceous St. David
Limestone overlies this black shale and
frequently shows on the resistivity curve
as a small inflection to the right. The
thickness of the Nos. 5A and 6 Coals
can be estimated fairly accurately on this
electric log. Again, with the No. 6 Coal,
it must be recognized that the upper part
of the double peak is the Brereton Lime-
stone and not part of the coal. A thin
black shale unit separates the two. The No. 5A Coal exhibits a rather unique sit-
uation of being essentially the same thickness as the short normal spacing (16 inches).
Here there is little inflection of the short normal, but the crater on the long normal
points to the presence of a resistive bed thinner than the long normal spacing (64
inches). From the character of the short normal, one would estimate the thickness
to be very close to the electrode spacing.

A case where the St. David Limestone and the underlying black shale occur
some distance above the No. 5 Coal is shown in figure 8. Here, two logs located
about one-eighth mile apart in sec. 21, T. 8 S., R. 3 E., Williamson County, show
very good agreement between the thicknesses of both No. 5 and No. 6 Coals. In
the diamond drill hole, No. 5 Coal is 4 feet 4 inches thick; on the electric log, about
4 feet is indicated. A double peak at a 350-foot depth is characteristic for the St.
David Limestone and the underlying black shale. The lower of the two peaks pro-
bably indicates a zone of relatively large limestone lenses or concretions, as is
present in the core from the diamond drill hole and which is frequently seen in out-
crops and strip mine highwalls in Illinois. The material intervening between the
black shale and the coal is gray to dark gray shale, which does contain some in-
vertebrate fossils (in the log these were not specified as to types).

The section including the No. 6 Coal is very well displayed on the electric
log. Again, however, some lithologic control is necessary for correct interpretation.
On the electric log, one would probably conservatively estimate the No. 6 Coal to
be at least 6 feet thick. On the diamond drill log, it is 7 feet 6 inches. Here,
strict application of the formula (p to p' plus spacing) would yield the correct thick-

ness. The overlying Brereton Limestone
and the underlying nodular limestone
form prominent electric log peaks. In
this area the No. 5A Coal is not devel-
oped, but its position is indicated on
the electric log at about 337 feet in
depth.

SULFUR CONTENT AND RELATION
TO CHARACTER OF ROOF

The normal range in total sulfur
content of Illinois coals on the as-re-
ceived basis is from less than 1.0 per-
cent to 5 percent (Gluskoter and Simon,
in press). Those containing less than
about 2.5 percent sulfur are termed re-
latively low-sulfur coals and often
command premium prices on the market.
In each important occurrence of rela-
tively low-sulfur coals in the Illinois
Basin, it has been observed that the
roof is relatively thick gray shale (Cady
and others, 1952, p. 35) rather than the
more common black shale and/or marine
limestone, which usually overlie the

Figure 7 - Electric log of oil test com-
pared to nearby diamond drill hole.

coals in the higher sulfur areas. This is the case for the Herrin (No. 6) Coal in a
large area of Franklin, Jefferson, and Williamson Counties, and a smaller area in
Madison and St. Clair Counties; for the Harrisburg (No. 5) Coal in Saline County
and northeastern Williamson County; for the Murphysboro Coal near Murphysboro,
Jackson County; and for the Colchester (No. 2) Coal in Grundy and Will Counties.
There are other cases in Illinois where isolated or relatively few analyses suggest
low-sulfur areas (Gluskoter and Simon, in press). This gray shale overlying the
coal in the low-sulfur areas has a definite position relative to other members of
the cyclic succession (cyclothem) of strata, which is characteristic of Pennsylvanian
strata in the central United States. The shale occupies a position between the coal
and the black shale. In the occurrences that have been observed in Illinois, the gray
shale begins as a feather edge and thickens towards the axis of an elongate area.
As this occurs, the black shale and/or the "cap rock" limestone ride up over the
gray shale. When the thickness of the gray shale exceeds 30 to 50 feet, the
black shale and/or limestone thin to 0. Data are not available that would enable
one to determine if the sulfur content is inversely proportional to the gray shale
thickness, but from the limited data and from general experience, it would seem
that some such relation does exist and that the lowest sulfur content of the coal does,
in general, correspond to the areas of thickest gray shale.
    On figures 9 and 10 are plotted all analyses of the No. 5 Coal from Gallatin,
Saline, and Williamson Counties, in the Illinois State Geological Survey files, for
which varieties of sulfur are available.

SELF-POTENTIAL   RESISTIVITY
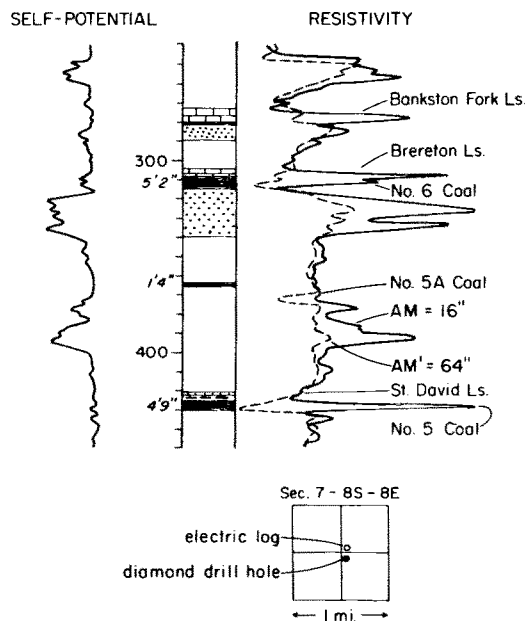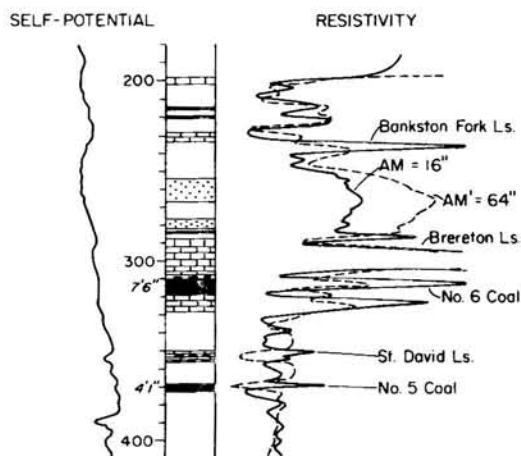
Figure 8 - Electric log of oil test com-
pared to nearby diamond drill hole,
sec. 21, T. 8 S., R. 3 E.,
Williamson County.

It is apparent from these figures that the significant difference in total sulfur content of the various samples is a function of the variation in pyrite content and not to changes in organic sulfur. On figure 9, the total sulfur varies from less than 1 to more than 7 percent. The pyritic sulfur content of these samples varies from less than 0.25 to more than 6 percent, and the least squares line has a slope of essentially 1. The correlation coeffecient is 0.953, which indicates a very strong correlation between the pyritic and total sulfur contents. On figure 10, the organic sulfur varies from less than 0.25 to slightly more than 2 percent, with most of the samples falling between 0.5 and 1.5 percent. In this case, the least squares line is very steep, with a slope of 20, and the correlation coefficient of 0.25, indicating essentially no correlation between organic and total sulfur contents. The average organic sulfur content is 0.90 percent with a standard deviation of only 0.084 percent, which is relatively low. All of this data suggests that the organic sulfur content is fairly constant.

One must at this stage speculate on the origin of the pyrite and its relation to (1) the environment of the coal-accumulating swamp, (2) the environment existing immediately after accumulation, during the first stages of burial, and (3) the subsequent diagenetic history.

The close association of pyrite to the nature of the immediate roof raises several possibilities as to the origin of the pyrite:

(1) the presence of the gray shale over the coal prevented the recently deposited peat access to sea water from which either iron or sulfur or both were derived,

(2) some of the iron sulfide was derived from the black muds and carried into the adjacent coal during compaction, and

(3) some difference in the chemical nature of the environment of accumulation of the coal existed between the low-sulfur and normal-sulfur areas and this difference is also expressed in the depositional conditions immediately following coal accumulation, giving rise to the variation in roof character.

These three possibilities are not exhaustive, and perhaps others should be considered. In the light of the evidence available, a combination of (1) and (2) seems to be the most reasonable. We do know that the coal, away from the gray shale area, was not covered by sediment for a period of time, and that its upper surface was either in free contact with the atmosphere or was exposed at the bottom of the body of water into which black muds were later deposited. In either case, there was no deposition over the coal until after the gray shale was deposited, after which the

black shale was laid down over a wide area, being absent only where the gray shale is the thickest. Probably the black muds did not succeed in topping a compactional high over the gray shale. The same is true for the succeeding limestone. During this period of nondeposition over the coal away from the gray shale area, if the coal were in contact with sea water, there would have been ample opportunity for the taking of ions from sea water. Just how long this system of depositional equilibrium was maintained is not known, but from the nature of the material and the stratigraphic relations, it is assumed that there was no great span of time involved in the deposition of this gray mud. Under atmospheric conditions there would be much bacterial activity, which might result in pyrite precipitation if the proper ions were there in the necessary quantities. After burial by the gray mud and the succeeding black muds, additional material could have been added to the coal from waters derived from the black muds and,

Figure 9 - Pyritic sulfur compared to total sulfur of the No. 5 Coal in southeastern Illinois. Note strong correlation coefficient (r = .953).

of course, from the underlying sediments. But only the coal in the normal-sulfur area would be in contact with the black muds. Where relatively thick, the gray silty shale would serve as a blanket protecting the coal from any influence of the black muds. That some mechanism such as this may be operative is suggested by the observation that the sulfur content of the coal appears to increase in the areas where the gray shale is less than 20 feet thick. It would thus seem as if very little of the sulfur in the No. 5 Coal in these areas is secondary and that the sulfur present is principally organic plus that from the finely disseminated pyrite, which most workers consider primary (i.e. formed at the same time as the accumulation of the coal).

Coal analyses used in figuring averages discussed below are principally from two sources, the Illinois State Geological Survey (Cady, 1935; Cady, 1948; unpublished analyses in Coal Section files) and the annual report of the U. S. Bureau of Mines listing analyses of tipple and delivered samples (Snyder and Aresco, 1953; Aresco and others, 1953-1967).

Certain impurities (pyrite and shale) are removed from face-channel and core samples when analyzed by the Geological Survey. Mineral bands, lenses, and nodules greater than 3/8-inch thick are excluded from the coal following U. S. Bureau of Mines standards (Holmes, 1918).

The total sulfur content of the No. 5 Coal varies from less than 1 to more than 5 percent with the lower values occurring in northwestern Saline County where the Dykersburg Shale is well developed. However, within this elongate area of thick shale, there are a few analyses with sulfur content slightly over 3 percent. The highest percentages are from Gallatin County, where the Dykersburg Shale is
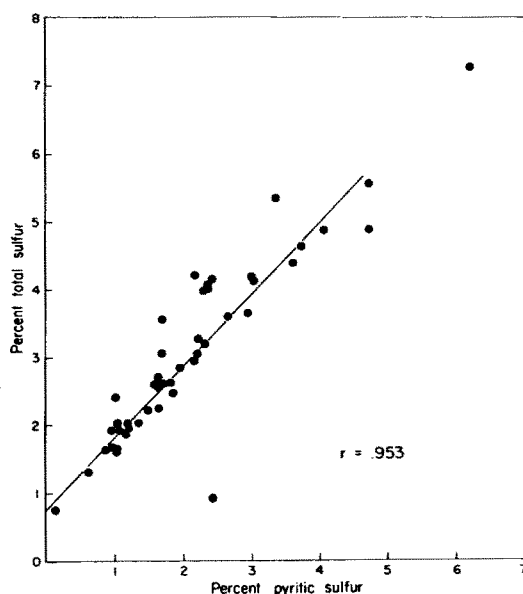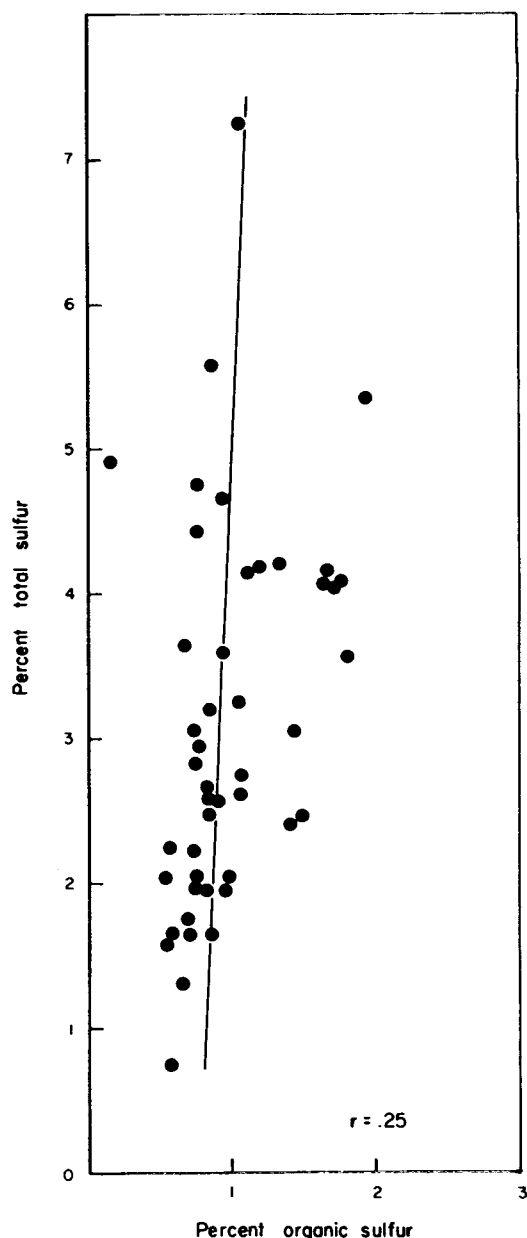
Figure 10 - Organic sulfur compared to
total sulfur of the No. 5 Coal in
southeastern Illinois. Note weak
correlation coefficient (r = .25).

absent and black shale-limestone con-
stitute the immediate roof. Here the
coal contains 3 to more than 5 percent
total sulfur. Average total sulfur (dry-
basis) for 57 face-channel and core
samples of the No. 5 Coal from Gallatin
County is 3.88 percent, ranging from 2.86
to 5.28 percent. This county lies wholly
within the black shale-limestone roof
area.

In Saline County, the average
total sulfur for 113 face-channel and
core samples of coal, which was over-
lain by Dykersburg Shale greater than
20 feet in thickness, is 2.45 percent,
ranging from 0.74 to 3.41 percent. In
this same area, the average for 99 tipple
and delivered samples, also from the
No. 5 Coal, which underlies thick Dykers-
burg Shale roof, amounts to 2.21 percent,
with the average for individual mines
ranging from 1.63 to 2.97 percent. Where
the Dykersburg Shale was less than 20
feet thick, 12 face-channel and core sam-
ples averaged 3.49 percent total sulfur,
ranging from 3.09 to 4.04 percent, and 9
face-channel samples from one mine in
the black shale-limestone area averaged
4.45 percent total sulfur.

In Williamson County, two core
samples from the area where the Dykers-
burg Shale is less than 20 feet thick aver-
aged 3.01 percent total sulfur, and in the
areas where the Dykersburg Shale is more
than 20 feet thick, 10 face-channel and
core samples average 2.81 percent, rang-
ing from 2.48 to 2.94 percent.

For tipple and delivered samples
in Williamson County, 13 samples from
that area where the coal is overlain by
gray shale less than 20 feet thick averaged
2.78 percent total sulfur, with a mine
average range of 2.35 to 2.98 percent.
In the thicker shale area, 27 samples
average 2.39 percent, with mine averages
ranging from 2.30 to 2.55 percent.

In western Gibson County, Indiana,
on the other end of the Dykersburg Shale
area mapped in this study, 16 tipple and delivered samples of No. 5 Coal (Coal V
of Indiana) show an average total sulfur of 2.11 percent from one mine. Farther

east in Gibson County, outside the Dykersburg Shale area, 4 tipple and delivered samples show 3.95 percent average total sulfur, also from one mine.

RESERVES

A sampling density pattern of one log per section was decided upon at the beginning of this study (pl. 1A). In those places where it was necessary to determine the general trend of either the sandstone channel along which the coal is absent or the boundary between the three roof categories mapped, more logs were used. Also plotted as additional points on the map are thickness estimates from electric logs of certain oil tests from which detailed cuttings were taken by members of the Geological Survey and for which detailed drilling-time logs were kept (Taylor et al., 1944). The wells are termed "control wells" (Cady and others, 1952). In much of White County, where conditions were uniform, with the coal being about 4 feet thick and overlain by black shale and/or limestone, the sampling pattern density was decreased to about 5 wells per township.

Certainly the density used in this study cannot accurately portray the variability that exists in the thickness and character of the roof of the No. 5 Coal, especially in the Dykersburg Shale area, where extremely variable conditions are known locally. However, the thicknesses and the roof character as portrayed are thought to provide an adequate framework, which should aid in more detailed prospecting.

Reserves were calculated for the No. 5 Coal in southeastern Illinois in the following manner. Areas between the isopach lines on work maps for plate 1A were measured by planimeter, excluding mined out and closely drilled oil field areas, following methods described by Cady and others (1952). In Illinois, most of the oil field areas are drilled on a 10-acre spacing, resulting in wells spaced 660 feet apart on a grid system. Reserves were measured only for those areas having a thickness greater than $3\frac{1}{2}$ feet. It was felt that estimation of coal thickness on the electric logs was not accurate below this figure and that this would be a reasonable cut off. The $3\frac{1}{2}$-foot isopach line was drawn more or less equidistant between those datum points estimated at 3 feet and those estimated at 4 feet. A similar procedure was used for the $5\frac{1}{2}$-foot, the $7\frac{1}{2}$-foot, and the $9\frac{1}{2}$-foot ispachs. The area between the $3\frac{1}{2}$- and the $5\frac{1}{2}$-foot isopach was considered to have an average thickness of $4\frac{1}{2}$ feet for the purpose of reserve calculations. As to coal tonnages, this average thickness was multiplied by the map area and this times a factor based on the assumption of 1800 tons of coal per acre-foot. A factor based on 1770 tons per acre-foot is probably more reasonable for Illinois coals, but the 1800-ton factor follows U. S. Geological Survey practice for high-volatile bituminous coals. Tonnages were calculated for average thickness values of $4\frac{1}{2}$, $6\frac{1}{2}$, $8\frac{1}{2}$, and $10\frac{1}{2}$ feet and are shown in summary form in table 1.

After the tonnages were calculated and totaled for each township, an estimation was made of that portion of each township in which the coal was overlain by (1) black shale and/or limestone, (2) Dykersburg Shale less than 20 feet thick, and (3) Dykersburg Shale more than 20 feet thick. These percentages were then multiplied by the total for that township, resulting in a rough estimation of the coal reserves overlain by each of the three roof categories, as shown in table 1.

In previous reports of the Illinois State Geological Survey, reserves have been divided into classes based on reliability and kind and density of data using

TABLE 1 - RESERVES OF NO. 5 COAL IN SOUTHEASTERN ILLINOIS (MILLIONS OF TONS)

County	By average thickness*				By roof character			Total
	54"	78"	102"	126"	Black shale and/or limestone	Gray shale 1-20' thick	Gray shale more than 20' thick	
Edwards	417	412	139		748	166	54	968
Franklin**	890	105			446	306	243	995
Gallatin**	1,007	20			1,027			1,027
Hamilton	1,147	827	157		966	602	563	2,131
Jefferson**	1,284	146	1		1,413	18		1,431
Saline	530	420	34		202	156	627	985
Wabash	308	253	198	2	372	127	262	761
Wayne**	993	46	†		765	185	89	1,039
White	923	800	206	5	1,086	220	626	1,933
Williamson**	557				14	269	274	557
TOTAL	8,056	3,029	735	7	7,039	2,049	2,738	11,827

*Thicknesses below 42" were not considered in this study.
**Study area includes only a portion of these counties.
†Less than 1 million tons.

such terms as "proved," "probable," "strongly indicated," and "weakly indicated" reserves (Cady and others, 1952) or "primary" and "secondary" reserves (Smith, 1957). Such classes were not employed in this study, as most of the thicknesses are estimated from electric logs, and no distinction was made between data from coal tests and that from electric logs.

No attempt has been made to assess the minability of the coal seams other than to indicate their presence at specified average thicknesses. This report does not exclude from the compilation coals that underlie dwellings, communities, cemeteries, or similar features. Therefore, the reserves as given represent the tonnages estimated to be in the ground and $3\frac{1}{2}$ feet or more in thickness, the only exclusion being the closely drilled oil pool areas and mined-out areas (pl. 1A).

Previous estimates of coal reserves for this portion of Illinois were given by Cady and others(1952) and were listed by county total for various thicknesses and in four categories of reserves. Ten counties in southeastern Illinois were shown to have reserves in the No. 5 Coal of about 14 billion tons. This includes coals 28 inches or more in thickness. Data in areas north of Saline and Gallatin Counties were obtained principally from a number of oil tests from which cuttings were carefully taken and logged, and drilling time was kept by geologists from the Coal Division of the Illinois State Geological Survey during the 1940's (Taylor et al., 1944). These wells provided framework for identification of the various key lithologic units, including coals, on the great number of electric logs available in the Illinois Basin. In the remainder of the area, reserves determined by Cady were based on coal tests, mines, and outcrops.

In this present study, total reserves of 11.8 billion tons were determined for this portion of southeastern Illinois. This is not comparable with the 14 billion tons as determined by Cady and others (1952) because a different minimum thickness was used (28 inches for Cady and $3\frac{1}{2}$ feet for this study). Also, his total is for 10 complete counties, whereas in the present study, portions of 5 of those 10 counties were

not included (fig. 1). Extensions to existing fields and a few newly discovered oil fields since 1952 have reduced reserves locally because of an increase in close-ly drilled areas. Data available in the Coal Section files indicate that for the area of this report, the study by Cady and others (1952) estimated 11.2 billion tons of No. 5 Coal in the ground as compared to 11.8 billion tons for the present report.

It is felt that this study has resulted in increasing our knowledge of the location of potentially minable, relatively thick coal, which had not been fully known and which was not considered in previous estimates of reserves. Potential relatively low-sulfur content of some of this coal is another factor that increases the economic outlook for coal in this part of the state.

Saline County

Reserves (remaining in the ground) for the No. 5 Coal in Saline County, as tabulated for this study, total 984,816,000 tons. These reserves were estimated to be as follows regarding the roof strata:

   (a) overlain by black shale and/or limestone—202 million tons
   (b) overlain by gray shale less than 20 feet thick—155 million tons
   (c) overlain by gray shale more than 20 feet thick—627 million tons.

The No. 5 Coal crops out along an east-west line (fig. 3) running through T. 9 S. at an elevation of from 250 to 300 feet above mean sea level in the eastern part of Saline County and 300 to 350 feet above mean sea level in the western part. The coal dips regionally to the north and is from 200 to almost 400 feet below mean sea level along the northern border. The coal is interrupted by the west-northwest-trending Cottage Grove Fault Zone, which is upthrown on the north along most of its trend. The displacement varies considerably but is usually less than 50 feet. Numer-ous smaller faults and some igneous dikes have been encountered in mining and coal prospecting in T. 8 S., R. 6 and 7 W. The Cottage Grove Fault Zone becomes more complex in western Saline County in T. 9 S., R. 5 W.

As seen on plate 1A, the coal thickness varies considerably, especially in the gray shale area. The sandstone channel along which the coal is absent winds gener-ally southward through the county from sec. 21, T. 7 S., R. 7 E., near Broughton (in Hamilton County) to the outcrop east of Ledford in sec. 33, T. 9 S., R. 6 E. Areas of relatively thick coal (pl. 1A) occur on the west side of this channel in the eastern parts of T. 9 S., R. 5 E., and T. 8 S., R. 5 E. Generally speaking, in this part of the county, the coal is much thinner east of the channel, except for a less well defined area in the northern part of T. 8 S., R. 6 E., where several square miles of coal $5\frac{1}{2}$ feet or more is indicated. Close by, in T. 7 S., R. 6 E., on the north side of the channel, again considerable thickness is indicated.

The No. 5 Coal has been mined rather extensively in much of the southern part of the area underlain by the coal in Saline County, especially to the west, north-west, and northeast of Harrisburg. Much of this coal has been of medium- or low-sulfur content. Mining along the Penn Central Railway extending to the northeast from Harrisburg has been limited on the northwest by relatively thin coal (generally 4 feet or less) in T. 8 S., R. 6 E., and on the north, in the northeastern part of T. 8 S., R. 6 E., and T. 8 S., R. 7 E., by the presence of shale splits in the coal and much variability in coal thickness. On the southeast side of these mines, the coal condi-tions are more uniform, but the coal is 5 feet or less thick and is overlain by black shale, indicating a higher sulfur content.

Several areas of split coal and/or thin coal should be pointed out (pl. 1A):

(1) on the west side of the sandstone channel in T. 9 S., R. 6 E.,
(2) in the north-central part of T. 8 S., R. 5 E., and adjacent
    parts of T. 7 S., R. 5 E.,
(3) in the west-central part of T. 8 S., R. 6 E.

There are other scattered areas indicated on plate 1A, and undoubtedly still more would show up if additional drill hole data were used.

Northeastern Williamson County

No. 5 Coal reserves (remaining in the ground) for the portion of Williamson County studied total 557,389,000 tons. These reserves are estimated to be as follows regarding the nature of the immediate roof strata:

(a) overlain by black shale and/or limestone—14 million tons
(b) overlain by gray shale less than 20 feet thick—$268\frac{1}{2}$ million tons
(c) overlain by gray shale more than 20 feet thick—$274\frac{1}{2}$ million tons.

In this part of Williamson County the coal crops out along an irregular north-west-southeast-trending line at an elevation of 400 to 460 feet above mean sea level (fig. 3). The coal dips north-northeast and is about 200 feet below mean sea level in the northeast corner. The Cottage Grove Fault Zone continues from Saline County. Here it is for the most part a narrow horst, the northernmost fault downthrown to the north-northeast and the southern fault downthrown to the south-southwest. Displacements, as in Saline County, are highly variable, but are generally less than 50 feet.

Coal thicknesses are relatively uniform throughout northeastern Williamson County, with the average thickness about $4\frac{1}{2}$ feet. Most of the datum points used are coal test holes. All of the coal in T. 8 S., R. 4 E., and parts of adjacent townships is overlain directly by gray shale greater than 20 feet thick. This area, plus that part of Franklin County to the north, contains a relatively large reserve of probably low- to medium-sulfur coal where mining conditions might be expected to be relatively uniform. The only complication is the Cottage Grove Fault Zone, which strikes northwest-southeast across the southwestern part of T. 8 S., R. 4 E.

Eastern Jefferson County

Only the eastern half of Jefferson County is included in this study. Reserves of No. 5 Coal for this portion of the county total 1,431,043,000 tons, which is immediately overlain by black shale and/or limestone, except for about $2\frac{1}{2}$ square miles in the southeastern corner of the county where the coal is overlain directly by about 4 feet of gray shale, which intervenes between the coal and the overlying black shale and limestone. Of the total, 1413 million tons are overlain directly by black shale and/or limestone, and 18 million tons are overlain by gray shale less than 20 feet thick.

In eastern Jefferson County, the coal dips rather gently eastward. It ranges from 300 to 400 feet below mean sea level along the western boundary of the mapped area (fig. 3) to almost 600 feet below mean sea level on the eastern boundary of the

county. A depression with elevations more than 600 feet below mean sea level is found in T. 2 S., R. 4 E.

Over most of eastern Jefferson County, the No. 5 Coal is estimated to be 4 to 5 feet thick with an apparent gradual increase to the east. An area of coal more than $5\frac{1}{2}$ feet thick is shown extending from northwestern Hamilton County into east-central Jefferson County. The electric log pattern is somewhat unusual and in this area is nowhere documented by a reliable coal test hole. Therefore, these thicknesses should be regarded as questionable. There is a possible strong development of either the St. David Limestone Member or the calcareous lower portion of the black shale. This situation would make accurate coal thickness determination difficult.

Northern Gallatin County

Only that portion of Gallatin County lying north of the Shawneetown Fault is included in this study. To the south, lying within the Eagle Valley Syncline, The No. 5 Coal has been and is presently being mined and has been extensively prospected. As these occurrences have been described adequately in previous reports (Cady and others, 1952; Smith, 1957), this area was excluded. North of the Shawneetown Fault, throughout the remainder of the county, the No. 5 Coal is relatively uniform in thickness (almost entirely in the range of $3\frac{1}{2}$ to $5\frac{1}{2}$ feet) and in character of the roof, which is in all cases either black shale or limestone. It has been mined in several small operations in T. 9 S., R. 8 E. The total reserves calculated in this study are 1,027,363,000 tons.

North- and northeast-trending faults have broken the strata into relatively large blocks in this part of Gallatin County (fig. 3). In general, the coal dips northerly in western Gallatin County and northwesterly in the central and eastern parts, north of the Shawneetown Fault. The coal outcrop is an east-west line in T. 9 S., R. 8 E., and in T. 9 S., R. 9 E., the outcrop terminates against the east-west Shawneetown Fault, apparently a high-angle reverse fault with at least several hundred feet of displacement. Along the northern boundary of Gallatin County, the coal varies from 150 to 400 feet below mean sea level. One conspicuous structural feature is the Omaha Dome in T. 7 and 8 S., R. 8 E., which shows more than 200 feet of structural relief on the No. 5 Coal, bringing the coal up to almost 250 feet above mean sea level.

Hamilton County

Reserves (remaining in the ground) of the No. 5 Coal in Hamilton County have been estimated to total 2,131,151,000 tons. Considerable variation in roof character and coal thickness characterize this county. Reserves, when broken down into categories of roof nature, are as follows:

(a) overlain by black shale and/or limestone—966 million tons
(b) overlain by gray shale less than 20 feet thick—601 million tons
(c) overlain by gray shale more than 20 feet thick—563 million tons.

In Hamilton County, the coal generally dips towards the north and is deepest in the northeastern part of the county, where it lies at elevations lower than

750 feet below mean sea level (fig. 3). The structurally highest area is at the southeast corner of the county where the coal lies at an elevation of 200 feet below mean sea level.

Essentially all of the variations in thickness and roof character are to be found in Hamilton County. The channel sandstone belt along which there is no coal winds generally southward through T. 5, 6, and 7 S., R. 7 E. (pl. 1A, B). The area of thick gray shale (greater than 20 feet) occurs principally to the west of this channel. Very thin coal (only the coal position was identified on the electric logs) was found in the wells in secs. 22, 23, and 26, T. 5 S., R. 7 E.

Another variation that occurs in this county is the swinging of the sinuous sandstone channel outside of the gray shale area. This is found in parts of T. 6 S., R. 7 E., and T. 7 S., R. 7 E. (a portion of which is in Saline County).

Areas of relatively thick coal are as follows:

(1) Southeastern Hamilton County in T. 7 S., R. 7 E., and southeastern T. 6 S., R. 7 E., south and east of the channel. Here the coal is estimated to average 6 feet thick and is overlain by black shale and/or limestone.

(2) The north and west sides of the channel in the western part of T. 5 S., R. 7 E., and the northwestern half of T. 6 S., R. 7 E. For most of the area, the roof is thick gray shale, and the coal thickness is estimated to vary from 5 to 8 feet.

(3) In T. 4 S., R. 7 E., the coal, in most wells, has been estimated to be either 5 or 6 feet thick with some 8-foot thicknesses in the southeastern part of the township. Roof character varies from black shale-limestone in the northwest through gray shale less than 20 feet thick to gray shale more than 20 feet thick in the southeast.

(4) Another occurrence of thick coal lies in a northwest-southwest-trending area up to 2 miles wide in T. 3 S., R. 5 E., and T. 4 S., R. 6 E., into Jefferson County. Some doubt as to the reliability of these thicknesses was expressed in the discussion of Jefferson County. This may also apply here, but it is thought that these thicknesses are more reliable in Hamilton County.

(5) In the southwestern part of Hamilton County, in the southwestern part of T. 6 S., R. 5 E., and in the northwestern part of T. 7 S., R. 5 E., thicknesses up to 7 feet have been estimated. The roof in this area is mostly gray shale less than 20 feet thick in the north and more than 20 feet thick in the south.

Throughout the remainder of the county, the thickness at most of the datum points has been estimated to be 4 and 5 feet with a few areas having coal estimated to be less than $3\frac{1}{2}$ feet thick. The roof for most of this area is black shale-limestone.

White County

All of White County is underlain by the No. 5 Coal except for the area along which the coal is absent, which extends southwestward through the northwestern part of the county, plus a small portion in southwestern T. 5 and 6 S., R. 8 E. Reserves (remaining in the ground) of the No. 5 Coal are estimated to total

1,932,677,000 tons. Divided into the three roof categories these are as follows:

    (a) overlain by black shale and/or limestone—1086 million tons
    (b) overlain by gray shale less than 20 feet thick—220 million tons
    (c) overlain by gray shale more than 20 feet thick—626 million tons

       White County is characterized by several northeast-southwest-trending faults of the system that continues from Gallatin County to the south (fig. 3). The coal dips northwestward and is deepest in the northwestern part of the county, where it reaches elevations of about 700 feet below mean sea level. One exception to this is in T. 4 S., R. 14 W., where on the downthrown side of the fault, the elevation is 805 feet below mean sea level. This is one of the lowest points in the study area.

       Considerable variation and, locally, relatively thick coal are found adjacent to the sandstone channel, especially along a 2- to 3-mile wide area on the southeast side of the channel, where thicknesses up to 12 feet have been estimated (pl. 1A). This area is also characterized by several localities with split coal (pl. 1A). Most of the area of thick coal is here overlain by thick gray shale roof. Conditions on the northwest side of the channel appear to be more uniform, with relatively large areas of coal from 5 to 8 feet thick. This coal is overlain by thick gray shale, except in parts of T. 3 S., R. 10 E., where the gray shale is thin or absent.

       Throughout the southeastern half of the county, depositional conditions for both the coal and the roof strata were much more uniform than in the northwest. The coal was estimated to be from 3 to 5 feet thick and is overlain by black shale-limestone over essentially all of this part of the county.

Eastern Franklin County

       Only the eastern half of Franklin County was included in this study. Reserves (remaining in the ground) of No. 5 Coal for this area, none of which has been mined, have been estimated at 994,994,000 tons. Of this total, the reserves are estimated to be divided into the following roof categories:

    (a) overlain by black shale and/or limestone—446 million tons
    (b) overlain by gray shale less than 20 feet thick—306 million tons
    (c) overlain by gray shale more than 20 feet thick—243 million tons

       The structural relations of the coal in this part of Franklin County appear to be rather simple with a regional dip from 50 feet below mean sea level in the southwest to 500 feet or more below mean sea level at the northeastern corner of the county (fig. 3).

       The thick gray shale area lies in T. 7 S., R. 4 E., and small portions of adjacent townships. Throughout most of the remainder of Franklin County studied, the coal is either overlain by black shale and/or limestone or gray shale generally less than 5 feet thick. Only along a narrow zone adjacent to the thick gray shale area in southeastern Franklin County does the gray shale thicken up to more than 5 feet. Coal thicknesses are rather uniform, with most estimations being either 4 or 5 feet, with a few exceptions. The thickness appears to increase gradually from west to east.

Edwards County

A total of 967,980 tons of No. 5 Coal reserves (remaining in the ground) were estimated for Edwards County. These reserves are divided as follows into three categories of roof character:

(a) overlain by black shale and/or limestone—748 million tons
(b) overlain by gray shale less than 20 feet thick—166 million tons
(c) overlain by gray shale more than 20 feet thick—54 million tons

In Edwards County, the strata dip toward the west into the deeper part of the Illinois Basin, and the No. 5 Coal varies from 450 to 500 feet below mean sea level along the eastern boundary to 600 to 650 feet below mean sea level along the western boundary (fig. 3). The faults to the south in White County extend into southern Edwards County. Detailed mapping may show them to be more extensive than seen on figure 3.

Considerable variation in thickness and in character of the No. 5 Coal is found in Edwards County. The area along which the coal is absent winds through the southern half. Normally this area is contained within the broader area of Dykersburg Shale, which immediately overlies the coal. Such is not the case in the northern part of T. 2 S., R. 10 E., where the sandstone channel extends from a shale area on the east through a region where black shale-limestone immediately overlies the coal to another gray shale area on the west in southwestern Edwards and adjacent Wayne and White Counties (pl. 1B).

In a general way, the No. 5 Coal thickens from an estimated 3 and 4 feet in the northern third of the county to 5 and 6 feet in the central part, to an excess of 7 feet throughout much of the southern third. In this southern part, one should expect more variability in coal thickness as well as the presence of shale splits.

Southern Wayne County

This study is concerned with the southern three-fifths of Wayne County. Estimated reserves (remaining in the ground) of No. 5 Coal total 1,038,990,000 tons, which are divided as follows into the three roof categories:

(a) overlain by black shale and/or limestone—765 million tons
(b) overlain by gray shale less than 20 feet thick—185 million tons
(c) overlain by gray shale more than 20 feet thick—89 million tons.

This part of Wayne County marks the deeper part of the Illinois Basin and the rocks are relatively flat-lying. The No. 5 Coal varies from about 500 feet below mean sea level on the west to almost 750 feet below mean sea level in the south-central part of the county. A localized depression brings the coal to 816 feet below mean sea level in sec. 12, T. 1 S., R. 9 E. (fig. 3).

Throughout most of the part of Wayne County included in this study, the No. 5 Coal is overlain by black shale-limestone and is for the most part estimated to be 3 or 4 feet thick. Only in the southeastern part of the county is there any appreciable area overlain by gray shale (T. 2 and 3 S., R. 9 E.). Here, however, the thickness remains rather constant at 3 to 4 feet, with a few estimates of 5 feet. A portion of the sinuous sandstone channel is found in the southeastern part of T. 2 S., R. 9 E.

Wabash County

Reserves (remaining in the ground) of No. 5 Coal, as estimated for Wabash County, total 761,302,000 tons, which are divided as follows into the three categories of roof character:

(a) overlain by black shale and/or limestone—372 million tons
(b) overlain by gray shale less than 20 feet thick—127 million tons
(c) overlain by gray shale more than 20 feet thick—262 million tons.

The regional dip in Wabash County is to the west, and the No. 5 Coal varies from slightly lower than 100 feet below mean sea level in the northeastern part of the county along the Wabash River to 400 to 500 feet below mean sea level along the western boundary (fig. 3). Two northeast-trending faults are found in southern Wabash County. These are part of the fault system extending from Gallatin and White Counties.

Thickness variations in the No. 5 Coal are somewhat similar to Edwards County with a general southward thickening of the coal. The area along which the coal is absent extends generally east-west across the southern part of the county. South of this, the coal generally is estimated to be from 5 to more than 8 feet thick and is overlain by relatively thick gray shale. Some split coal is believed to occur in this area. Coal thicknesses can be expected to vary considerably, especially near the channel. North of this area of no coal, the gray shale is generally less than 20 feet thick, but there does exist a considerable area of relatively thick coal in the southwestern part of T. 1 S., R. 13 W., and the southern part of T. 1 S., R. 14 W. A fingerlike extension of this thick coal extends northward into sec. 33, T. 1 N., R. 13 W.

SUMMARY

From this study it is suggested that the Harrisburg (No. 5) Coal attains thicknesses of 6 feet or more over substantial areas of southeastern Illinois in the Fairfield Basin, as determined primarily from electric logs of oil test holes. A comparison of geologic conditions in the well known relatively low-sulfur area of Saline County to those in parts of Hamilton, White, Wayne, Edwards, and Wabash Counties indicates that this low-sulfur area extends north and east of Saline County. The principal geologic feature that can be used to predict occurrence of relatively low-sulfur No. 5 Coal is the appearance of a gray silty shale intervening between the coal and the overlying black shale and St. David Limestone. When this shale, named the Dykersburg, attains a thickness of about 20 feet or more, the No. 5 Coal has been found to have a relatively low-sulfur content (usually less than 2.5 percent). The occurrence of this shale can be readily determined from electric logs; thus, indirectly, one can estimate areas of potentially low-sulfur coal from these logs.

Because of the geologic similarity of this occurence of relatively low-sulfur No. 5 Coal to the well known low-sulfur area of No. 6 Coal in Franklin, Williamson, and Jefferson Counties, it is suggested that this type of occurrence (i.e. the intervention of a gray shale between the coal and the overlying marine black shale and/or limestone) provides a valuable clue to the nature of the coal. This condition does exist for other coals, and in view of the cyclic (repetitive) nature of the Pennsylvanian sediments in the Illinois Basin, this association might be expected

for many of the coals that normally have black shale-limestone roofs. Observations in the Murphysboro mining district suggest that such is the case with the Murphysboro Coal. Samples of coal with sulfur contents as low as 0.66 percent (Cady, 1938) have been obtained where there is about 40 feet of gray shale between the coal and the overlying black shale-limestone. In the Illinois Basin, the association of low-sulfur coal and relatively thick gray shale roof has been known for some time. It is here suggested that it is not just "gray shale" but more specifically the gray shale that occurs at the particular stratigraphic position described above. Occurrences of normal sulfur (more than 2.5 percent) coals under gray shales are not uncommon in Illinois, but this gray shale occupies a stratigraphic position other than between the coal and the black shale-limestone.

An exception to this generalization is the Francis Creek Shale, which occurs between the Colchester (No. 2) Coal and the black shale-limestone unit and which does not everywhere mark the presence of relatively low-sulfur No. 2 Coal. The No. 2 is a "normal sulfur" coal in some areas and relatively low in others, even when apparently overlain by relatively thick Francis Creek gray shale in both cases. The relation of the sulfur content of the No. 2 Coal and the thickness and character of the Francis Creek Shale should receive further study.

From this study, it is shown that conventional electric logs can be used to determine coal thicknesses, especially where the coal, a high-resistive unit, is overlain by low-resistive shale. Complications occur when a high-resistive unit such as a limestone occurs near the top of the coal. It is suggested that with proper caution and with adequate lithologic control, these logs, of which there are about 70,000 in Illinois, can be used to a greater extent in delineating coal resources.

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EXPLANATION

Closely drilled areas

Mined-out areas

Sandstone channel, coal absent

Coal thin or split (area indefinite)

Coal thickness (feet)

Electric log – oil test

Diamond drill – coal test

Control well – oil test

See figure 3 for faults

MILES

A – ESTIMATED COAL THICKNESS

EXPLANATION

Black shale and/or limestone

Dykersburg Shale – 1 to 20 feet thick

Dykersburg Shale – more than 20 feet thick

Sandstone channel, coal absent

Electric log – oil test

Diamond drill – coal test

Control well – oil test

See figure 3 for faults
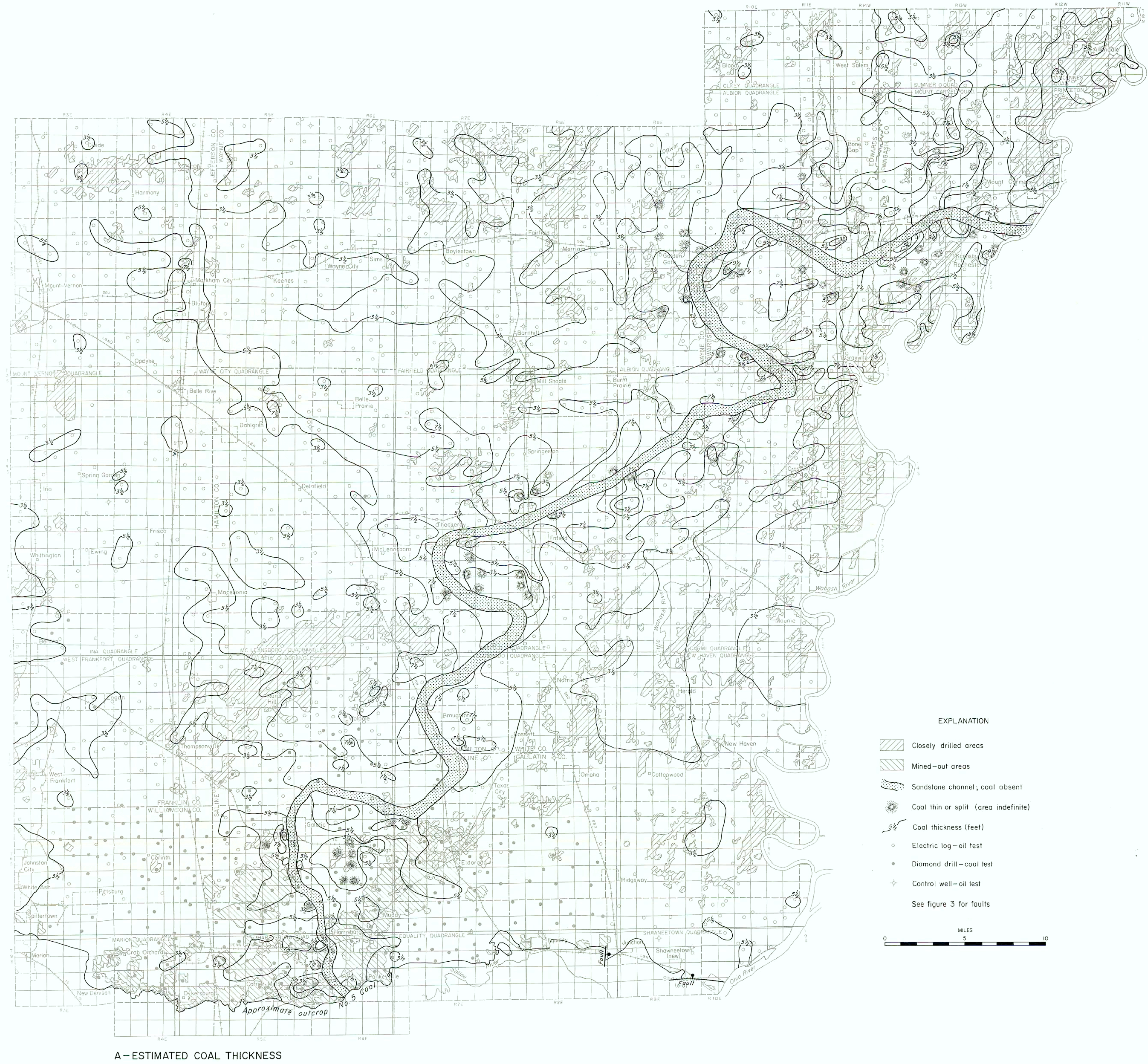
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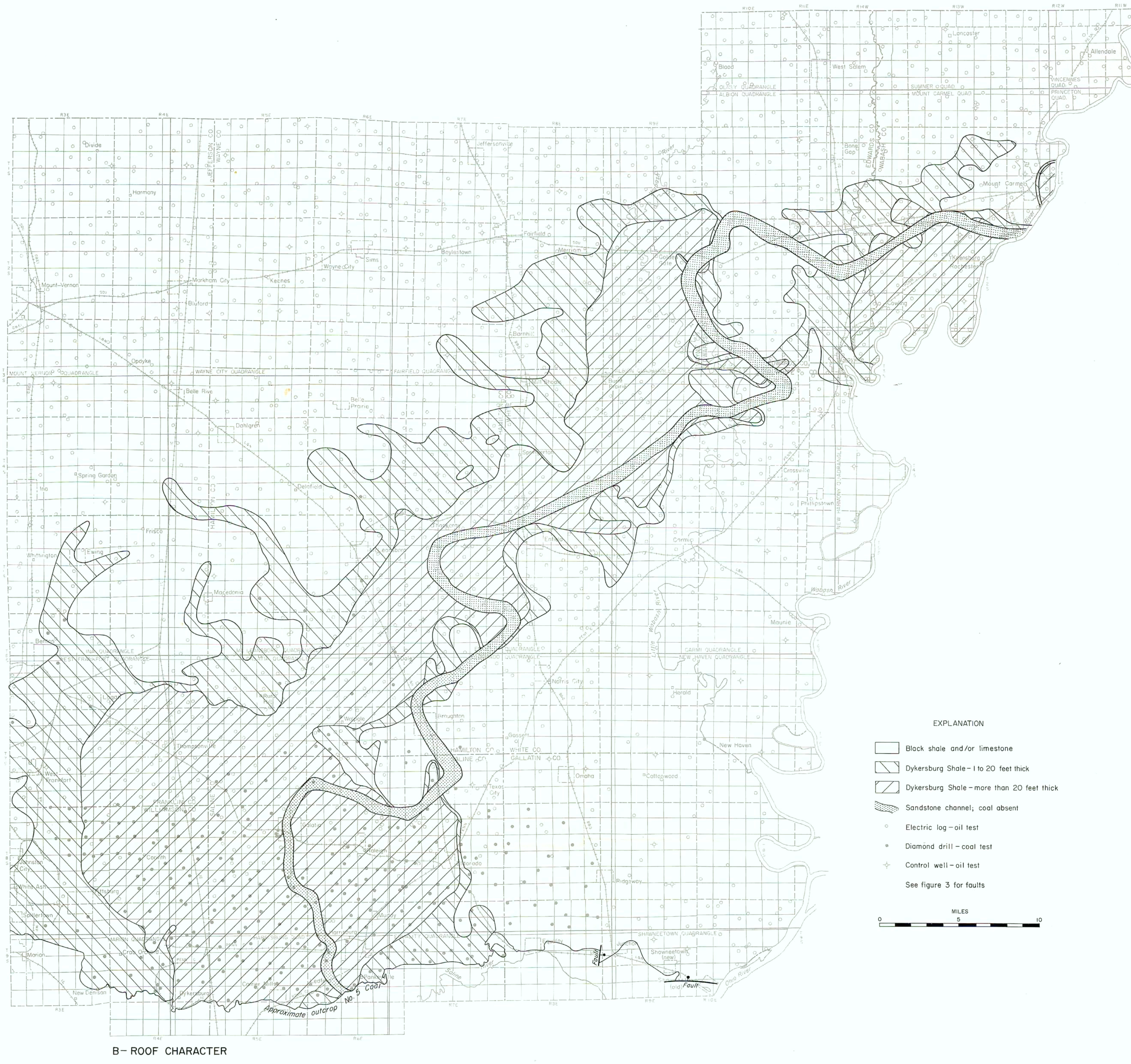
B – ROOF CHARACTER

HARRISBURG (NO. 5) COAL - SOUTHEASTERN ILLINOIS

by

M. E. HOPKINS

1968

A ... **A'**

Stanford	Nation	National Assoc.	National Assoc.	National Assoc.	Wiser	National Assoc.	Ryford	National Assoc.	National Assoc.	National Assoc.	Eason
No. I Flannigan	No. I Endicott	No. I Erskine et al	No. I White	No. 3 Downen	No. 3 Johnson	No. 5 Johnson	No. A-6 Johnson	No. I Prince	No. 2 Rubenacker	No. I Payne	No. I Veach Est.
11-4S-6E	29-4S-7E	3-5S-7E	3-5S-7E	10-5S-7E	10-5S-7E	10-5S-7E	10-5S-7E	15-5S-7E	15-5S-7E	13-5S-7E	17-5S-8E
SE NW SE DF 379'	SE SE NW DF 418'	SE SW NE DF 437'	SE SW SE DF 459'	NE NW NE DF 479'	NE SW NE DF 532'	NE NW SE DF 434'	SE NW SE DF 498'	NW NE NE DF 492'	SE NW NE DF 481'	SW NW NW DF 420'	SW SE NW DF 419'

Labels (section A): AM=16", AM=64", No. 7 Coal, No. 6 Coal, St. David Ls., Datum, No. 5A Coal, No. 5 Coal, Hanover Ls., No. 2 Coal, Dykersburg Sh., St. David Ls.?, AM=71", AM=118", AM=18"

Index map (A): R6E 7 R8E / T3S HAMILTON WHITE / Sandstone Channel / A ... A' / 4 / T5S

DF 407' = Derrick Floor Elevation

B ... **B'**

Miles	M and M	Norman and Graef	Norman and Graef	Norman and Graef	Skiles	Skiles	National Drlg.	Bump and Moser	Ryan	F. B. Drlg.
No. I Alka	No. I Alka	No. 3 Keepes	No. 2 Keepes	No. I Pohl	No. II Parmenter	No. 2 Alka	No. 3 Bump	No. B-1 Bump	No. I Bucholz	No. I Bucholz
28-IS-13W	28-IS-13W	33-IS-13W	33-IS-13W	33-IS-13W	33-IS-13W	4-2S-13W	4-2S-13W	4-2S-13W	4-2S-13W	4-2S-13W
NW NE SW DF 423'	NW SE SW DF 413'	NE NE NW DF 408'	SE NE NW DF 408'	SE SE NW DF 405'	NE SE SW DF 407'	909' N. Line 1033' W. Line DF 406'	330' W. of NE cor. SW NW DF 407'	1899' S 330' E NW cor. NE fr NW DF 406'	330' S 1010' E NW cor. SE DF 410'	SE SE SE DF 402'

Labels (section B): West Franklin Ls., AM=16", AM=71", AM=64", No. 7 Coal, No. 6 Coal, Datum, No. 5A Coal, St. David Ls., No. 5 Coal, Bankston Fork Ls., Dykersburg Sh., Hanover Ls., No. 2 Coal

Index map (B): R14W 13 12 R11W / T1N WABASH / Sandstone Channel / T1S / B ... B' / T2S

ELECTRIC LOG CROSS SECTIONS

CIRCULAR 431

ILLINOIS STATE GEOLOGICAL SURVEY

URBANA