STATE OF ILLINOIS
WILLIAM G. STRATTON, *Governor*
DEPARTMENT OF REGISTRATION AND EDUCATION
VERA M. BINKS, *Director*

DIVISION OF THE
STATE GEOLOGICAL SURVEY
JOHN C. FRYE, *Chief*
URBANA

REPORT OF INVESTIGATIONS 183

SUBSURFACE GEOLOGY AND COAL RESOURCES OF THE PENNSYLVANIAN SYSTEM IN WABASH COUNTY, ILLINOIS

BY

G. H. CADY, M. B. ROLLEY, ADABELL KARSTROM,
M. A. PARKER, AND M. E. HOPKINS

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ABSTRACT

Wabash County lies along the southeastern border of Illinois and is in the Illinois Basin. Pennsylvanian strata lie directly under unconsolidated surficial deposits and are 1400 to 2100 feet thick. Several Pennsylvanian beds, particularly those in the McLeansboro and Carbondale groups, are discussed, with special reference to their use as key structural marker beds. There are structure contour maps for the No. 7 and Herrin (No. 6) coal beds. Two faults, the New Harmony and the Mt. Carmel, occur in the southeastern part of the county.

Coal reserve estimates for Wabash County total 1,188,826,000 tons, of which 99,855,000 tons represent the Friendsville coal bed (upper McLeansboro), the only coal known to have been mined in the county. None of the reserves are classed as *proved*. Samples of the Friendsville coal were collected and chemical analyses and related data tabulated. Areas in which the Friendsville coal is less than 50 feet deep are shown.

INTRODUCTION

WABASH COUNTY is an area of 221 square miles on the southeastern border of Illinois (fig. 1). Strata of Pennsylvanian age, where not exposed, directly underlie unconsolidated surficial deposits. The few rock outcrops are discontinuous, confined mainly to areas bordering the Wabash River and its tributaries.

A. H. Worthen (1871, p. 51-65), who had only the log of an abandoned mine shaft and a few scattered drill holes as subsurface control, undertook the difficult task of correlating the outcrops. In spite of the scantiness of information at that time, many of the relationships suggested by Worthen seem to be correct.

Coal is reported to have been mined in Wabash County since 1865 (Schopf, field notes, 142); the Robert Chapman shaft mine in sec. 13, T. 1 S., R. 13 W., was opened during that year. Several other mines had been opened by 1875 in the vicinity of Mt. Carmel (Worthen, 1875, p. 61).

Charles Baston opened the first mine in the southern part of the county at McClearys Bluff on the Wabash River, about 1896. Mines were opened in the vicinity of Friendsville about the same time. Coal had been mined by 1904 at localities north, east, and south of Friendsville, at Sugar Creek, Maud, McClearys Bluff, and at several places a short distance northwest of Mt. Carmel (Fuller and Clapp, 1904). Since then a considerable number of small shafts at scattered locations operated from time to time. The last mine to operate in Wabash County was the Hillcrest Mine,

FIG. 1.—Index map of Wabash County and the Illinois Basin.

which was abandoned in 1943 (NE¼ NE¼ sec. 29, T. 2 S., R. 13 W.).

When oil was discovered in Wabash County in 1912 (Skewes, 1917, p. 33), additional subsurface information became available from logs of oil test holes. Drilling activity prior to 1939 was mainly in T. 1 N., R. 12 W. Test holes have since been drilled, mainly by rotary drills, in almost every section in the county.

The Illinois Geological Survey undertook in 1942 a program of collecting and describing the Pennsylvanian rock cuttings of selected drill holes (Leighton, 1944, p. 7-8). The detailed lithologic record obtained for such a drill hole could be used to interpret the electrical log of that drill hole and others nearby (Taylor et al., 1944). Thirteen of these holes, called *control drill holes,* are in Wabash County and two others are close by, in adjacent counties (fig. 2). The logs of these holes have been of great value in working out the relationship between the exposed and subsurface strata.

This report is one of a series on subsurface geology and coal resources of the Pennsylvanian strata in Illinois Basin

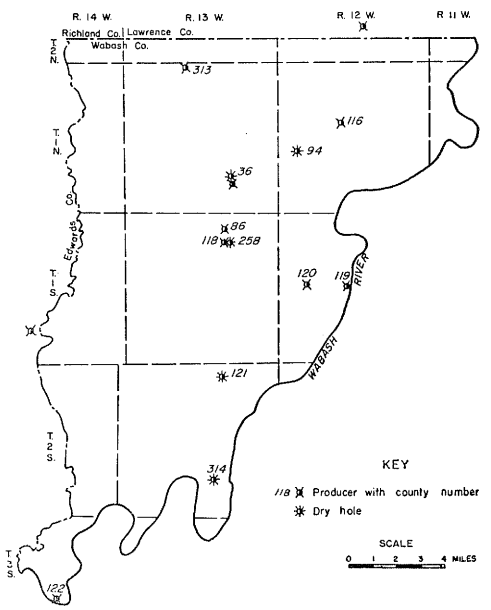

FIG. 2.—Distribution of control rotary drill holes in Wabash and adjacent counties.

counties. Previous reports include Wayne (Sims, 1944), Clay (Lowenstam, 1951), Edwards (Smith and Cady, 1951), Gallatin (Pullen, 1951), Hamilton (Rolley, 1951), Richland (Siever and Cady, 1951), White (Harrison, 1951), Shelby, Moultrie, and portions of Effingham and Fayette (Du Bois, 1951) counties.

ACKNOWLEDGMENTS

J. M. Schopf and G. M. Wilson visited most of the outcrops in Wabash County during the fall of 1942. Their field notes were of great value in the preparation of this report and provided the source for locations, sea-level elevations, and other pertinent data regarding outcrops in the county. Special acknowledgment is due J. M. Schopf, who started the investigations in Wabash County and did much of the early work.

K. E. Clegg of the Coal Division made final revisions of the No. 7 coal structure map and the isopach map of the interval between the Ditney coal bed and No. 7 coal bed. Other members of the Survey staff assisted in preparing the final manuscript.

DESCRIPTION OF PENNSYLVANIAN KEY BEDS

The use of key beds facilitates identification of important coal beds and provides a basis for structure contour maps of Pennsylvanian strata. Information on the position and lithologic characteristics of important beds is based upon outcrops and study of cuttings obtained from the control drill holes. The position and, to some extent, the thickness of key beds can be determined from electric logs. For some of the prominent limestone beds and several of the coal beds, electric logs provide most of the data.

The Pennsylvanian system of rocks in Illinois has been subdivided into four groups (Weller, 1940, p. 36, footnote 13): McLeansboro, Carbondale, Tradewater, and Caseyville, in order of increasing age. A generalized section of part of the Penn-

sylvanian rocks in Wabash County is shown in figure 3. The four groups together are between 1400 and 2100 feet thick; the variation in thickness is due partly to erosion of the McLeansboro beds at the top and partly to the unevenness of the surface upon which the oldest Pennsylvanian rocks were deposited (Siever, 1951). Minor thickness variations are also related to sedimentation factors. Strata composing the Pennsylvanian system show a rough, but far from complete, parallelism, as is shown by isopach maps.

McLeansboro Group

The McLeansboro group in Wabash County has an average thickness of about 850 feet and includes all Pennsylvanian rocks above the Herrin limestone, the caprock of the Herrin (No. 6) coal bed. The strata exposed or seen in shallow mines in the county represent discontinuous portions of about 300 feet of the upper part of the McLeansboro group.

The Friendsville coal bed, Reel limestone, and Mt. Carmel sandstone are only partially satisfactory as key strata in the upper McLeansboro because each is discontinuous in outcrop, lithologically irregular, and not traceable continuously in electric logs. Other beds high in the McLeansboro group are exposed in Wabash County, but they cannot be identified with any assurance in drilling logs or in outcrops a mile or more apart.

Strata above the Friendsville coal bed.— The strata above the Friendsville coal bed (which is approximately 675 feet above the base of the McLeansboro group) are generally thin and not well exposed. A drill hole in the NW¼ sec. 36, T. 1 S., R. 13 W. (County 389), shows 85 feet of strata above the Friendsville coal bed.

The thin coal bed 60 feet above the base of the Friendsville coal bed may be the coal that has been observed at three outcrops on Keys Hill: NE¼ SW¼ sec. 25, T. 1 S., R. 13 W. (County 37); SW¼ NW¼ NW¼ sec. 13, T. 1 N., R. 14 W.

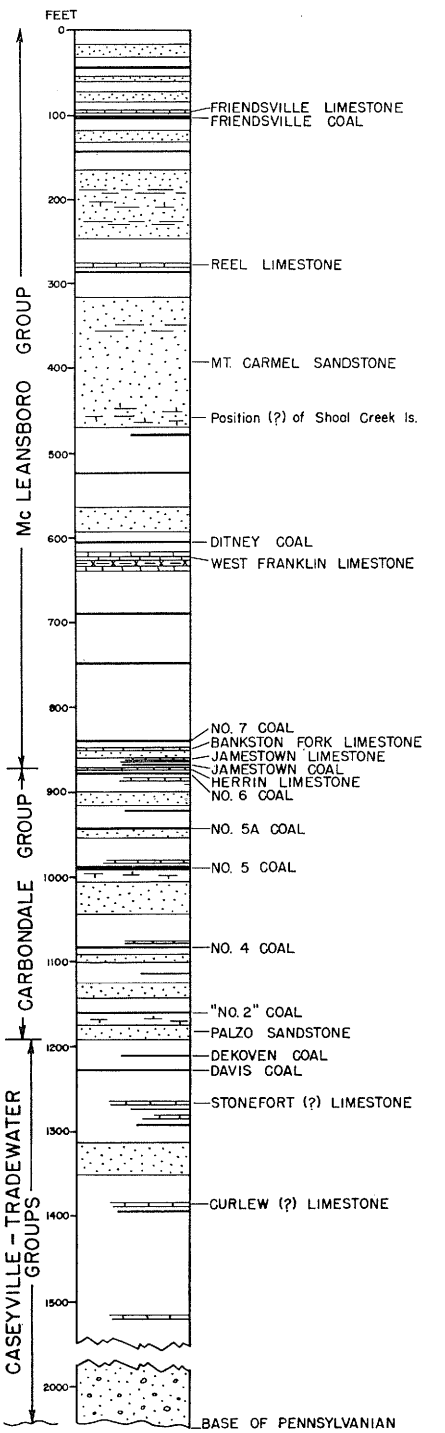

FIG. 3.—Generalized columnar section of the Pennsylvanian system in Wabash County.

Partial log of the Continental–Stelzner No. 1 well
NW¼ sec. 36, T. 1 S., R. 13 W., County 389
Surface elevation 494 feet
Compiled by M. B. Rolley
from 10-foot sample study, electric log, and driller's log

	Thickness feet	*Depth feet*
Clay-siltstone, brownish yellow, with a few black shale and coal fragments	10	10
Clay, brownish yellow to light gray with a few ironstone concretions	5	15
Sandstone, clear to slightly iron-stained, fine to medium grained, subangular to well rounded	3–4	19
Shale, dark gray, carbonaceous	4	23
Shale, black, and coal	5–6	29
Shale, medium gray, carbonaceous, micaceous, and calcareous	3	32
Sandstone, fine to very fine, silty in part, subangular, micaceous, carbonaceous, and slightly calcareous	10	42
Shale, medium gray, micaceous, carbonaceous, and shale, medium to dark gray	10–12	54
Siltstone, light gray, micaceous, calcareous, fossiliferous; a few limestone concretions, brownish white, very fine grained; occasional coarsely crystalline calcite stringers	12	66
Sandstone, fine to very fine, subangular, micaceous, and slightly calcareous	15	81
Shale, dark gray, calcareous	4	85
Shale, black, and coal (Friendsville)	3–4	89
Elev. 405 ft. at bottom.		

(County 1713); and at McClearys Bluff, NW¼ SW¼ SE¼ sec. 29, T. 2 S., R. 13 W.

A thin "cap-rock" limestone less than three feet above the Friendsville coal occurs in some places. It is two feet thick in the Hillcrest mine, although it was not reported throughout the mine. The limestone is medium gray, finely crystalline, fossiliferous, and very brittle. It is distinguished by thin, elongated buff fragments of a *Discotrypa*-like form of bryozoa (C. W. Collinson, personal communication). Data are not sufficient to determine the areal extent of this limestone, but fragments of limestone with brownish streaks have been reported in several mines in the Friendsville coal. A medium-gray calcareous somewhat fossiliferous shale underlies the limestone. The lowest one foot of this shale is black.

Friendsville coal bed.—The Friendsville coal bed, originally named in the Patoka folio (Fuller and Clapp, 1904), has few outcrops. It is possible to trace its position almost continuously north and south across the county (fig. 7) by means of the small shaft or slope mines along or near the eastern margin of the bed. West of this zone, the Friendsville coal bed has been identified in only two control drill holes (County Nos. 36 and 118). Its probable position in a number of other wells has been determined from electric logs by reference to the Reel limestone, which lies about 160 feet below it.

The Friendsville is the only minable coal bed in the upper part of the McLeansboro group in Wabash County. Reserves have been computed on average thicknesses of 28 and 35 inches of coal (table 4).

Friendsville coal has been mined in at least 38 mines, including two strip (County Nos. 77 and 96), four slope (County Nos. 12, 71, 76, and 97), and 32 shaft mines. Thickness varies from 18 inches to a reported, but unverified, 60 inches (County 26). The average thickness, where mined, appears to have been about 40 inches.

Information is not available to give a detailed description of the beds lying between the Friendsville coal and Reel limestone. The common interval between the Reel limestone and Friendsville coal bed (fig. 3) is about 160 feet.

Reel limestone.—The Reel limestone has been traced throughout most of Wabash County by study of drill cuttings and by its characteristic electric log pattern (pls. 3 and 4). It was described first by Worthen (1875, p. 55) from exposures on the Emmanual Reel farm (sec. 8, T. 1 N., R. 11 W.).

Limestone from exposures near Reel's Corner is faintly mottled in shades of dove to gray, has small irregular reddish-brown spots, and weathers grayish yellow. It is fine grained, compact, and contains many small fossil gastropods, pelecypods, and brachiopods. Some microscopic white cal-

careous cellular incrustations and possibly some foraminifera, the shells of which have a white chalcedenous appearance, are present. The limestone is somewhat sheety or slabby. The bed tends to weather along joint cracks into rounded boulders and slabs of irregular shape and size. Identification of the Reel limestone is not based on its lithologic characteristics but upon the relative position of the member and the general absence of other limestone beds for some distance above and below. One foot of dark-gray to black shale, somewhat iron-stained and friable in outcrop, underlies the Reel limestone and overlies a coal bed 7 to 10 inches thick.

Mt. Carmel sandstone.—The Mt. Carmel sandstone is the one Worthen (1875, p. 52-53) referred to as the sandstone "at Mt. Carmel," presumably the sandstone making the abrupt bluff in sec. 21, T. 1 S., R. 12 W., along the east side of the town.

Worthen also referred to a drill hole that penetrated the beds near the base of the bluff to a depth of 188 feet 8 inches and gave the record of the strata penetrated. Including the beds exposed, the total thickness of sandstone and sandy shale was about 80 feet. A coal bed 7 inches thick, possibly the Ditney, was found at a depth of 157½ feet. Below this, for about 30 feet, the strata consisted predominantly of limestone and shale which probably represent the West Franklin limestone zone.

A sandstone similar to that exposed at Mt. Carmel forms a bluff at Hanging Rock along the south side of sec. 4, T. 1 S., R. 12 W. Worthen suggested that the sandstone at Hanging Rock underlies the sandstone at Mt. Carmel, on the supposition that the beds rise to the north. Recent oil tests indicate that the No. 7 coal bed is 40 to 50 feet lower at Hanging Rock than at Mt. Carmel. Hence the Hanging Rock sandstone probably overlies the Mt. Carmel sandstone, or it may be the upper portion of the Mt. Carmel.

Drill cuttings of the Mt. Carmel sandstone consist of light-gray micaceous and carbonaceous medium-grained sand with minor amounts of very fine, fine, and coarse grains, mainly angular to subangular. The cuttings are slightly to very calcareous; the most calcareous zone is generally about 10 feet thick near the base. Some of the control well logs show a thin bed of black shale and coal a few feet below the calcareous zone.

In electric logs, the Mt. Carmel sandstone shows high resistivity and either high or low self-potential, varying with the salinity of the formation water (pls. 2 and 3). The sandstone is about 150 to 175 feet above the Ditney coal and West Franklin limestone, with the top 25 to 50 feet below the Reel limestone.

Shoal Creek limestone.—At present it is not possible to identify any bed in Wabash County as the Shoal Creek limestone, although it is found in other Illinois Basin counties (Sims et al., 1944; Cady et al., 1951; Harrison, 1951; Du Bois, 1951). The calcareous zone near the base of the Mt. Carmel sandstone, which may develop locally into a limestone, probably represents the Shoal Creek. No suitable reference beds are present between the Mt. Carmel sandstone and the Ditney coal bed.

Diteny coal bed.—The Ditney coal bed is best known from outcrops in Indiana. It is 14 inches thick and lies 6 feet above the West Franklin limestone at an exposure described by Malott (1948, p. 133) in the NE¼ sec. 26, T. 1 N., R. 10 W., 3 miles east of Hazelton, Ind.

This coal bed and the black shale above it are present in Wabash County, where they lie about 10 feet above the West Franklin limestone. The shale and coal have a combined thickness of about 1 to 3 feet, as estimated from control well logs. In places where the coal and shale are absent, sandstone occurs at the equivalent stratigraphic position. The Ditney is absent in at least three areas in the county (fig. 4).

The position of the Ditney coal bed is generally easily identified in cuttings from control drill holes. It is fairly definitely marked in electric log patterns by a small

high resistivity peak in the normal resistivity curve and a small reverse peak in the second resistivity curve (pls. 3 and 4). Its approximate position has also been determined by reference to the position of the West Franklin limestone in structure test borings by the Tidewater Oil Company.

West Franklin limestone.—The West Franklin limestone was named from an exposure in the river bluff at the town of West Franklin, Posey County, Ind. (Collett, 1884, p. 61-62; Schrock and Malott, 1929, p. 1301-1314). Pullen (1951, p. 71) described three benches of West Franklin

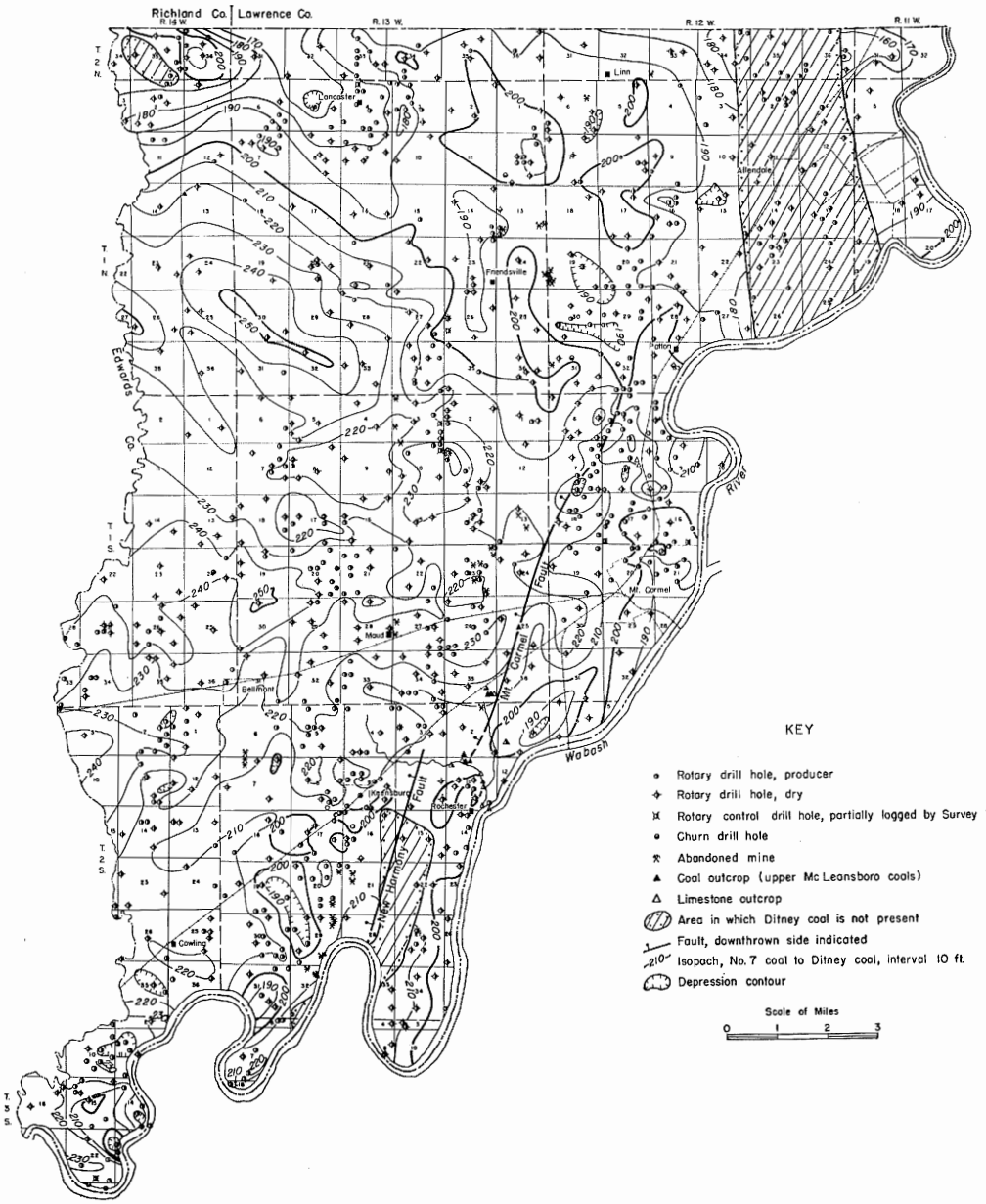

FIG. 4.—Isopach map showing interval between No. 7 and Ditney coal beds.

limestone at two exposures near Evansville, Ind.

The West Franklin limestone in the southern two-thirds of Wabash County is generally represented by two limestone beds separated by shale. Three limestone beds are locally present, as in control drill holes 120 (sec. 17, T. 1 S., R. 12 W.) and 122 (sec. 22, T. 3 S., R. 14 W.). This additional bed may be due to local thickening of a shale parting in the upper limestone bed or it may represent a lower bench of limestone present near Evansville, Ind. In the northern one-third of the county, the West Franklin zone is thinner and the lower limestone bed is not present. In control drill hole 313, sec. 4, T. 1 N., R. 13 W., siltstone is at the equivalent position.

The upper limestone bed, 3 to 16 feet thick, varies in color; the cuttings are light gray, tan, and brown. It is finely crystalline, dense, and fossiliferous. A shale parting, several inches to several feet thick, locally splits the upper limestone.

The shaly zone between the limestone beds, where two beds are present, is commonly 4 to 6 feet thick, but thicknesses varying from 2 to 18 feet have been reported. The strata are variable; they have been described as gray shale, silty gray shale, gray clay-shale, greenish-gray clay-shale, red, green, light-gray, and yellow variegated shale, and black shale.

The lower limestone bed, where two beds are present, commonly is gray, buff, or brown, finely to coarsely crystalline, and somewhat nodular and fossiliferous. It is generally less than 10 feet thick and has a maximum known thickness of 15 feet. In control drill hole 86, sec. 3, T. 1 S., R. 13 W., the limestone thought to be the lower of two benches is one foot thick and the cuttings are dark brown to black, argillaceous, carbonaceous, and fossiliferous. In the log of a diamond drill hole near Mt. Carmel reported by Worthen (1875, p. 53), the two limestone benches are separated by 3 feet 11 inches of shale.

The prominent normal resistivity peak or peaks (two such peaks are more common than one and there are three in places), are usually easily recognized in electric logs. Although the general position of the West Franklin limestone can be identified in electric logs, as stated by Pullen (1951, p. 71), it is not practical to state with certainty which bed or beds are present when only one or two are penetrated. Identification of the position of the Ditney coal bed is of some assistance in this respect because it is usually 6 to 10 feet above the upper limestone bench. A considerably larger interval might indicate absence of the upper bench.

Because the positions of the Ditney and No. 7 coal beds in Wabash County can as a rule be determined, the thickness of the lower part of the McLeansboro group is fairly accurately indicated by the interval between these two beds (fig. 4).

Strata between West Franklin limestone and No. 7 coal.—The strata between the West Franklin limestone zone and the No. 7 coal bed consist mainly of a succession of shale, siltstone, and sandstone, with a few thin coal beds accompanied by black shale, thin limestone, and underclay. This interval produces a relatively uniform low resistivity pattern on the electric logs. There are 150 to 250 feet of strata between the Ditney and No. 7 coals; the upper 25 to 35 feet represents the West Franklin limestone zone.

There are two coal seams, about 60 feet apart, in this portion of the McLeansboro group; others may be present. The upper coal is about 45 feet below the West Franklin limestone and the lower coal is normally about 90 feet above the No. 7 coal. The coal bed zones can be identified in cuttings from some control drill holes and in some electric logs of adjacent wells (pls. 3 and 4).

No. 7 coal bed.—The coal bed designated as No. 7 in Wabash County is probably the same as the Danville (No. 7) coal bed, although the correlation has not been definitely established.

The No. 7 coal bed was selected as a key bed because of the characteristic pattern

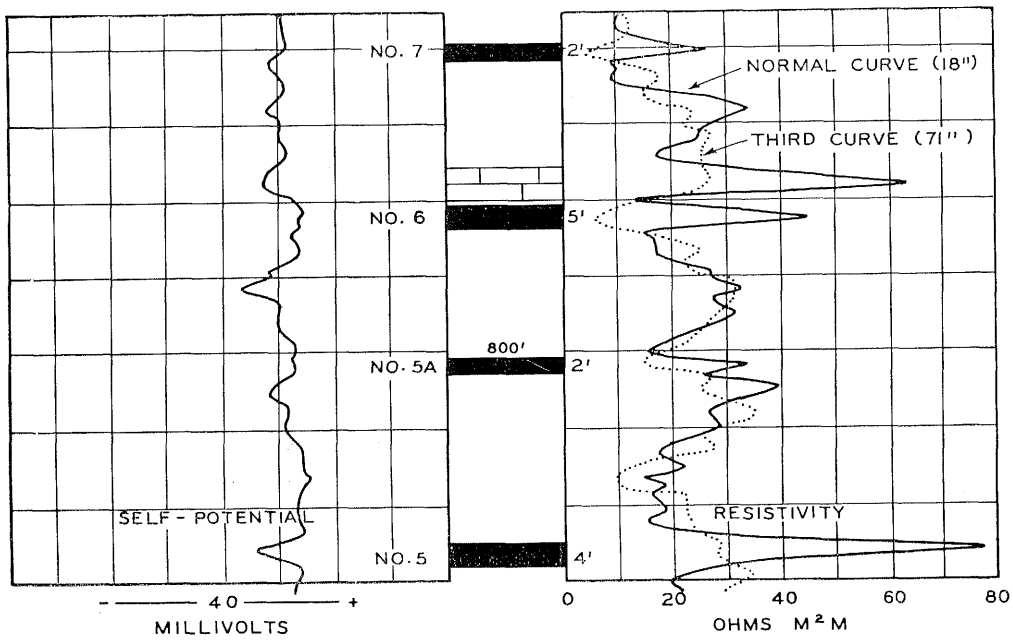

FIG. 5.—Resistivity pattern of coal beds 5, 5a, 6, and 7. From Taylor et al., 1948, Methods of subsurface study of the Pennsylvanian strata encountered in rotary-drill holes: *in* Illinois Geol. Survey Rept. Inv. 93, p. 9–21 and fig. 4.

marking its position in electric logs (fig. 5). This characteristic pattern shows a peak in the normal resistivity curve and a reverse peak in the third curve. Above these is a fairly thick section of low resistivity which is beneath the position of the West Franklin limestone zone. The No. 7 coal horizon also marks the transition to the more irregular pattern of the varied strata below, extending to the underclay limestone beneath the Herrin (No. 6) coal bed. Because the top of No. 7 coal bed can be identified in electric logs with relative certainty, it has been found to be the most useful key bed near the base of the McLeansboro group. It is of aid in delineating structural features and also in determining the position of other beds, particularly the Herrin (No. 6) and Harrisburg (No. 5) coal beds, which lie a short distance below No. 7 (pls. 3 and 4).

Bankstone Fork limestone.—The interval between the No. 7 and Herrin (No. 6) coal beds is 25 to 40 feet in the southern two-thirds of the county; it is almost twice this in the northern third. The strata lying between the two coal beds in the southern part of the county include the Bankston Fork and Herrin limestones. In the northern third of the county, the intervening beds consist of silty shale, siltstone, and sandstone, with limestone less important.

The Bankston Fork limestone is commonly very dense and is light cream or light gray to buff. It becomes somewhat nodular toward the top, where it resembles an underclay limestone, and toward the base tends to become sandy and grade into sandstone. The lower part of the limestone is fossiliferous and contains fusulinids very similar to those found in the Herrin limestone (Dunbar and Henbest, 1943, p. 25). Drill cuttings indicate that within a distance of a quarter of a mile its thickness decreases from between 4 and 5 feet to 1 foot. Recognition of the Bankston Fork

limestone in many electric logs is uncertain, so it is possible that this limestone (like the Herrin) is discontinuous, at least as a high resistive bed.

Jamestown limestone and coal bed.—In southern Illinois, a limestone very similar to, but commonly thinner than, the Herrin limestone generally lies a few feet above it. This is the Jamestown limestone, present in southern Illinois and western Kentucky. It is lithologically so similar to the Herrin that differentiation by study of well cuttings is not practical. The Jamestown limestone is generally more fossiliferous than the Herrin; it contains large brachipods and some fusulinids. The irregularity of the Jamestown limestone is caused partly by the irregular occurrence, distribution, and thickness of the Anvil Rock sandstone, which lies between the Bankston Fork and Jamestown limestones. In places the Anvil Rock sandstone was deposited in an erosional channel that extends through the Jamestown limestone and may extend into or through the Herrin limestone and coal bed (see log of drill hole 313, pl. 3).

The Jamestown coal occurs between the Jamestown and Herrin limestones in southern Illinois (Bell, Ball, and McCabe, 1931), but is rarely more than a few inches thick. Its correlative, the No. 12 coal bed in western Kentucky, although commonly thin, is several feet thick in places and has been mined. Coal and a thin layer of underclay, with a combined thickness usually less than one or two feet, intervenes between the Jamestown and Herrin limestones.

It is not known whether the Jamestown coal bed attains a workable thickness in Wabash County. Locally the Jamestown coal bed may thicken; such thickening would complicate recognition of the No. 6 coal horizon.

Carbondale Group

The Carbondale group in Wabash County includes strata from the top of the Herrin limestone to the base of the Palzo sandstone, which underlies the "No. 2" coal bed (fig. 3). The group has an average thickness of about 350 feet. The Carbondale strata in Wabash County are known only from subsurface data.

Herrin limestone.—In Wabash County, as elsewhere, the thickness of this limestone varies. It is rarely more than 6 feet thick, and variations of from 1 to 4 feet may take place within a few hundred feet or less. As described from drill cuttings, the Herrin limestone is light gray, brownish gray, or dark brown, finely granular, and contains marine fossil fragments. It generally occurs in a fairly massive bench, but in places there are argillaceous layers with irregular nodular masses of limestone, which give the rock a somewhat slabby structure.

The interval from the Herrin limestone to the No. 7 coal is about 20 to 30 feet in the southern two-thirds of the county and about 50 to 60 feet north of T. 1 S. and west of R. 12 W. The Herrin limestone is not present everywhere, particularly in the northern part of the county, where there is a greater thickness of silty shale, siltstone, and sandstone between the two coal beds.

In some places the normal resistivity curve of the Herrin limestone and coal combine to form a single peak; elsewhere, presumably where shale intervenes, two peaks occur (fig. 5). In electric logs that show only one peak, it is generally impossible to tell whether the peak represents both the limestone and coal or only one of the members. Therefore, the Herrin limestone and No. 6 coal bed are not fully satisfactory as key beds for structural delineation; however, in combination they answer this purpose, making it possible in most cases to estimate the position of the coal. It is sometimes difficult to distinguish between the Herrin and Jamestown beds.

Herrin (No. 6) coal bed.—The Herrin (No. 6) coal bed is economically the most important in the State; the bed called No. 6 in Wabash County is thought to be the same as the bed extensively mined in southern Illinois.

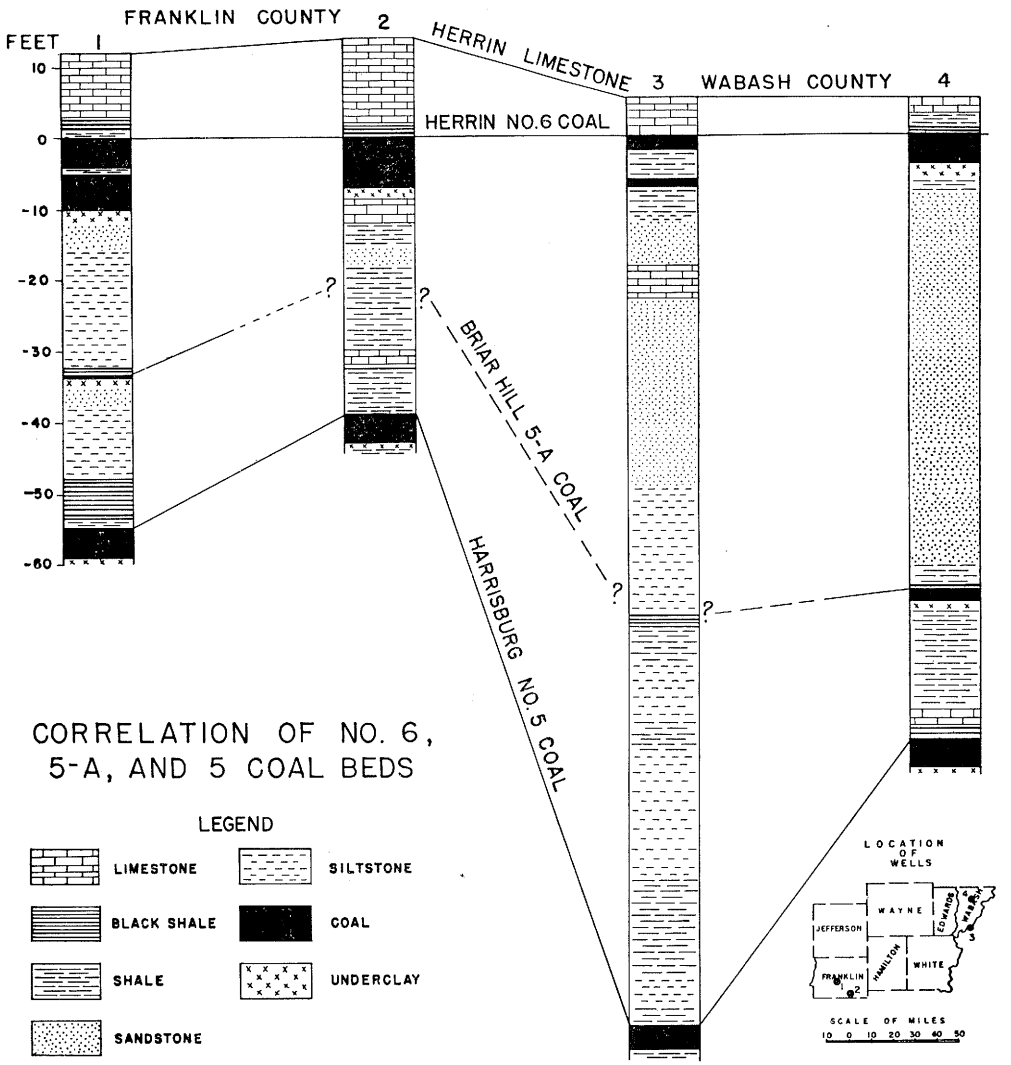

FIG. 6.—Correlation of coal beds with the aid of spores from rotary drill samples. From Kosanke, R. M., 1950, Pennsylvanian spores of Illinois and their use in correlation: Illinois Geol. Survey Bull. 74, fig. 6, p. 77.

As noted previously, the No. 6 coal bed is often difficult to identify in electric logs because of its relationship to the overlying beds. In some places it appears to be absent, as in the northern one-third of the county (pl. 1).

Kosanke (1950, p. 77) has presented a correlation chart (fig. 6) in which the succession in the upper part of the Carbondale group in Franklin and Wabash counties is compared. Fossil spore evidence identifies the No. 6 and No. 5 beds when correlation based only on stratigraphic succession may have been inconclusive.

Estimates of No. 6 coal thickness from 13 control holes in Wabash County and immediately adjacent areas indicate a range of 12 inches to 5 feet. These represent the most reliable records of coal thickness in the county, and, in general, indicate that the thickness of the No. 6 coal varies considerably. Coal test drilling will be required to determine the thickness.

Harrisburg (No. 5) coal bed.—In Wabash County, the Harrisburg (No. 5) coal bed ranges from 1 to 5 feet thick. It seems probable that the No. 5 coal is as thick as, and somewhat more continuous in minable thickness than, the No. 6 coal bed. The interval between the two coal beds in 11 control drill holes is between 80 and 125 feet, but in electric logs of other holes the interval is between 90 and 110 feet.

The strata between the No. 6 and No. 5 coal beds consist predominantly of shale and sandstone. Fairly thick sandstone makes up most of the succession in some places, but shale generally predominates. A nodular underclay limestone 2 to 5 feet thick is generally found a few feet below the No. 6. A thin but persistent coal bed is commonly present 15 to 25 feet above the No. 5. In control drill holes 120, 122, and 258, a thin limestone was formed above this thin coal bed. It is assumed, because of its persistence and relative position, that this intermediate bed represents the No. 5A coal bed. Another thin coal bed appears in places, 40 to 50 feet above the No. 5 coal. In drill holes where this bed is present, correlations are made with less assurance. The No. 5 coal bed is overlain by a layer of black slatey shale 2 to 4 feet thick. Logs of control drill holes 36, 99, 119, and 313 reported a limestone about 2 feet thick above the black shale.

The electric log pattern of the upper 100 to 125 feet of the Carbondale group to a zone below the position of the No. 5 coal bed is sufficiently uniform and characteristic that both the No. 5 and No. 5A coal beds can be traced fairly well throughout the county.

No. 4 coal bed.—The No. 4 coal bed lies about 80 to 100 feet below the No. 5 coal bed, in a series of shales and sandstones. It is not known to be of workable thickness (28 inches) and is generally less than 1 foot thick. The No. 4 coal underlies a black shale 1 to 3 feet thick. A limestone 1 to 4 feet thick locally overlies or occurs in the black shale. This limestone is probably the cause of the upper peak in the normal resistivity curve in this stratigraphic zone. In control drill holes 36, 86, 119, and 313, the limestone cuttings were described as light gray to buff, finely crystalline, fossiliferous, and somewhat nodular. In diamond drill holes outside Wabash County, this limestone commonly has been described as dark gray to black and nonfossiliferous. The characteristic electric log pattern facilitates identification of this zone (pls. 3 and 4). The No. 4 coal bed has been correlated with the No. IV-A coal of Indiana (Weller and Wanless, 1939, p. 1390).

"No. 2" coal bed.—The coal bed designated as "No. 2" lies about 75 to 90 feet below the No. 4 coal bed. It has been noted in a considerable number of drill holes in Wabash County. The identification of this bed is tentative; it is called "No. 2" because it appears to lie at the same position as a thin coal bed found in drill holes in Franklin County from which Kosanke (1950, p. 70) identified fossil spores typical of the LaSalle (No. 2) coal bed of northern Illinois. This coal is probably less than 24 inches thick over most of the county.

Palzo sandstone.—The base of the Carbondale group is defined as the base of the Palzo sandstone (Weller, 1940), a prominent bed in southern Illinois (Pullen, 1944, p. 80). It is not continuous, is locally massive, and in some places seems to have the characteristics of a channel-fill deposit. In Wabash County, cuttings from control drill holes indicate that the sandstone changes laterally into siltstone, carbonaceous shale, or clay shale.

Tradewater and Caseyville Groups

The Tradewater and Caseyville groups represent the lower part of the Pennsylvanian system in Illinois. In Wabash County the interval between the "No. 2" coal bed and the base of the Pennsylvanian system varies from less than 650 feet in the northeastern part of the county to as much as 1150 feet a few miles to the southwest (Siever, 1951, p. 554-555, 559-565).

As Siever pointed out, the surface upon which the Pennsylvanian strata were deposited was characterized by considerable topographic irregularity. This is partly the reason for the very irregular thickness and lithology of the Caseyville. Variations in thickness of the interval from the "No. 2" coal bed to the base of the Pennsylvanian system are thought to indicate variations in the thickness of the Caseyville group rather than of the overlying Tradewater group.

It is impossible to differentiate the Tradewater and Caseyville groups in Wabash County with the information now available. Only four control drill holes—121, 258, 313, and 314—were logged to the base or within a few feet of the base of the Pennsylvanian system. The boundary between the two groups was not recognized in any of these drill holes.

Within the Tradewater and Caseyville groups there are no beds sufficiently continuous and well marked in electric logs to serve as key beds; however, the more prominent beds will be discussed briefly.

Dekoven and Davis coal beds.—The Dekoven and Davis coal beds have been mined in Saline and Gallatin counties and in western Kentucky (Butts, 1925, p. 64). They extend eastward into Williamson County.

In Wabash County, coal beds several feet in thickness, 800 to 1200 feet deep, have been found in several control drill holes at the estimated position of the Dekoven and Davis coal beds. One or both of these beds may be fairly continuous in Wabash County. The possible discontinuity of the Dekoven bed is believed to be primarily the result of erosion shortly after its deposition, the lower part of the Palzo sandstone occupying the channel thus formed. The Davis coal is thought to be the bed most commonly shown in electric logs and cuttings from drill holes. Control wells indicate a thickness of 12 to 60 inches for the Davis coal bed.

In general the interval between the No. 5 and Davis coal beds appears to be between 240 and 290 feet. This interval is about the same as that separating the coal beds in Saline and Gallatin counties (Cady, 1919, p. 18).

A discontinuous limestone, 3 to 6 feet thick, has been reported about 60 to 80 feet below the top of the Tradewater group in control drill holes 164, 313, and 314. The cuttings consist of light- to brownish-gray limestone, locally sandy and nodular. This limestone is tentatively called the *Stonefort* as its position is similar to that of the Stonefort limestone of Williamson County (Henbest, 1928). In Williamson County this limestone is associated with a thin bed of coal (Stonefort coal) about 5 feet below it, and a somewhat thicker bed, the Bald Hill coal, about 30 feet lower.

In Gallatin and Saline counties, a second discontinuous limestone, the Curlew limestone (Butts, 1925, p. 64), lies 80 to 100 feet below the Stonefort. It is medium gray, nodular, fossiliferous, argillaceous, and is locally represented in outcrop by a bed of fossiliferous weathered chert. A thin coal bed is reported a few feet below the limestone. One or two control drill holes in Wabash County penetrated a limestone, 160 to 180 feet below the Davis coal bed, which may be the equivalent of the Curlew; however, this horizon is not generally recognized in electric logs.

STRUCTURE

Wabash County is situated on the southeastern flank of the Illinois Basin. The westward regional dip of the strata is interrupted by faults and folds, trending roughly north and south. Most oil pools in the county have been discovered on structure reflected in Pennsylvanian strata.

The delineation of structure of the Pennsylvanian strata is shown on the structure maps of No. 7 coal bed (pl. 2) and No. 6 coal bed (pl. 1). It is believed that the map of No. 7 coal bed is more representative of the Pennsylvanian structure than structure shown on maps of other key horizons because of the relatively greater ac-

curacy with which it has been identified in electric logs.

Faults.—Two faults, the Mt. Carmel and the New Harmony, which are more-or-less continuous, run roughly SSW on the eastern side of the county. They appear to be high-angle normal faults with the upthrown sides on the east. It may be that each represents a zone of faulting rather than a displacement along a single fault plane. The Mt. Carmel fault, to the north, is believed to extend from sec. 32, T. 1 N., R. 12 W., to sec. 2, T. 2 S., R. 13 W. This fault zone is cut by the following drill holes:

County 328, sec 32, T. 1 N., R. 12 W.; displacement about 40 feet in the Mississippian (Chester).

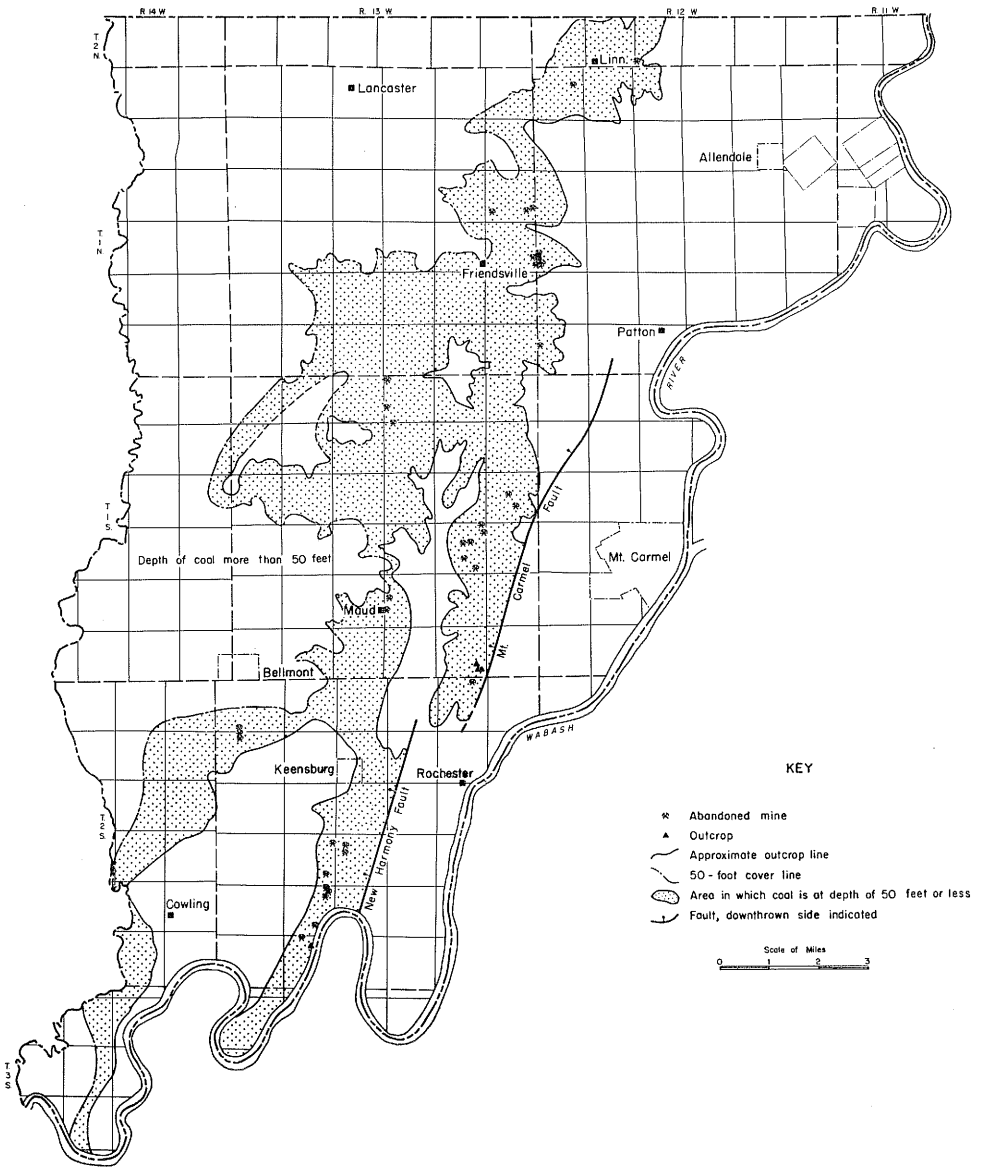

FIG. 7.—Map of Friendsville coal bed showing outcrops, mines, and area suitable for prospecting for strippable coal.

County 359, sec. 5, T. 1 S., R. 12 W.; displacement about 50 feet below the No. 4 coal bed.

County 454, about cen. SW¼ sec. 5, T. 1 S., R. 12 W.; displacement about 40 feet between Mt. Carmel sandstone and No. 7 coal.

County 456, sec. 5, T. 1 S., R. 12 W.; displacement about 40 feet; No. 7 coal bed not present.

County 459, sec. 5, T. 1 S., R. 12 W.; displacement about 20 feet between No. 6 and No. 5 coal beds.

The New Harmony fault enters the county from the south in sec. 28, T. 2 S., R. 13 W., and extends into sec. 3, T. 2 S., R. 13 W. The fault surface is not known to be cut by drill holes in Wabash County, but a drill hole crosses it a short distance to the south, in the elongated horseshoe bend of the Wabash River in Indiana (SE cor. NW¼ NE¼ sec. 8, T. 3 S., R. 13 W., Lacy-Heston #2).

The positions of the two faults are indicated on the structure maps (pls. 1 and 2).

FRIENDSVILLE COAL

Distribution.—Abandoned mines are located in a narrow belt, a mile or two wide, extending from the vicinity of Rochester northward to the vicinity of Friendsville. In general this belt indicates the approximate extent and distribution of the area in which the coal is not more than 50 to 60 feet deep. The belt is by no means sharply marked because (1) the coal bed is concealed by unconsolidated deposits, such as glacial drift and alluvium, except at one or two places, (2) the surface is uneven, and (3) the direction and amount of dip of the Pennsylvanian strata, including the coal bed, is irregular.

In figure 7 a line represents the approximate position of the outcrop of the coal bed beneath the drift. Stippling shows the approximate area in which stripping possibilities may exist with less than 50 feet of overburden. Depth, thickness, character of the coal, and character of the overburden will have to be determined by drilling. Availability of any tract for strip mining is determined to a considerable extent by the distribution of active oil pools. No systematic shallow drilling for coal is known to have been carried on in the county. It is probable that more interest will develop in the shallow coal resources after exhaustion of oil pools.

Minable coal reserves in Illinois were considered in a recent Survey publication (Cady and others, 1952). A summary of reserve estimates from this publication for the Friendsville coal is contained in table 4.

Chemical characteristics.—The chemical characteristics of the Friendsville coal are known from analyses and tests made on 13 samples of various kinds (tables 1 and 2).

Samples 1, 2, and 10 are the only ones that seem to have moisture content percentages that compare with the actual moisture of the bed (approximately 14 percent). Samples 3, 4, and 13 probably dried out somewhat before analysis. Other samples are not representative of the bed as a whole and were essentially in an air-dried condition. In general Illinois coals with a rank index between 123 and 125 have a moisture content of 13 to 14 percent (Cady, 1935, p. 314-326; Cady, 1948, p. 60-70).

The sulfur content of the coal is somewhat lower than in other Illinois coals, which average about 3 percent. Low-sulfur coals in Illinois contains 1.5 percent or less sulfur.

The ash softening temperature varies greatly among the samples tested, although the face samples (Nos. 1 and 2) and the sample for stoker test (No. 13) show somewhat higher values than northern Illinois coals of the same rank. The tests for softening temperature made on blocks of coal cut from various parts of the bed at the Hillcrest mine and samples from two other localities (Nos. 5-9, 11, and 12) show a wide range for initial deformation, softening temperature, and fluid temperature. The ash-fusion values indicated for samples 1, 2, and 13 probably fairly closely approximate characteristic values for the Friendsville coal in Wabash County.

TABLE 1.—ANALYSES OF COAL FROM FRIENDSVILLE BED, WABASH COUNTY

Sample No.	*Laboratory No.*	*Laboratory*	*Date*	*Condition**	*Moisture*	*Vol. matter*	*Fixed carbon*	*Ash*	*H*	*C*	*N*	*O*	*S*	*B.t.u.***
1 . . .	C–2680	Ill. Geol. Survey . .	11/42	1	13.2	31.9	42.5	12.4					2.65	10,603
				2		36.8	48.9	14.3					3.06	12,217
				3		42.9	57.1						3.56	14,252
				4	15.5	35.1	49.4							12,296
				5		41.5	58.5							14,557
2 . . .	C–2724	Ill. Geol. Survey . .	11/42	1	14.2	36.5	38.2	11.1	5.91	59.62	1.37	20.22	1.79	10,691
				2		42.5	44.6	12.9	5.06	69.48	1.60	8.84	2.09	12,458
				3		48.8	51.2		5.81	79.80	1.84	10.15	2.40	14,309
				4	16.3	40.1	43.6							12,181
				5		47.8	52.2							14,547
3 . . .	16055	U. of Ill.	4/28	1	9.70	36.31	37.97	16.02					2.32	10,436
				2		40.21	42.05	17.74					2.57	11,612
				3		48.90	51.10						3.12	14,116
				4	11.91	41.88	46.21							12,736
				5		47.54	52.46							14,548
4 . . .		U. of Ill.	4/28	1	9.20	41.10	41.42	8.28					1.80	11,672
				2		45.26	45.62	9.12					1.99	12,855
				3		49.80	50.20							14,145
				4										
				5										
13 . . .	C–2932	Ill. Geol. Survey . .	10/43	1	10.6	34.0	34.6	20.8	5.16	54.45	1.39	15.42	2.77	9,655
				2		38.1	38.6	23.3	4.46	60.87	1.55	6.76	3.09	10,794
				3		49.6	50.4		5.81	79.33	2.02	8.81	4.03	14,067
				4	13.9	41.1	45.0							12,518
				5		47.9	52.1							14,547

Sample No.	*Sulfate sulfur*	*Pyritic sulfur*	*Organic sulfur*	*Total sulfur*
1	0.08	1.56	1.13	2.77
2	0.09	1.75	1.25	3.09
3	0.12	2.28	1.63	4.03

*1) As received, 2) moisture-free, 3) ash- and moisture-free, 4) moist mineral-matter-free, 5) dry mineral-matter-free.
**Rank index; nearest hundred B.t.u. on moist mineral-matter-free basis (12,296—rank index=123).

TABLE 2.—RESULTS OF MISCELLANEOUS TESTS ON FRIENDSVILLE COAL, WABASH COUNTY*
(Other than analyses)

Sample No.	Laboratory No.	Date	Moisture (as rec'd)	Ash		Ash fusion temperature (°F)		
				As received	Moisture-free	Init. def.	Softening	Fluid
1	C–2680	1942	13.2 (note sample 10)	12.4	14.3	2158	2170	2466
2	C–2724	1943	14.2	11.1	12.9	2240	2294	2562
5	C–2682	1942	5.3	12.5	13.2	2231	2316	2671
6	C–2683	1942	5.3	16.2	17.1	2103	2180	2255
7	C–2685	1942	8.8	14.5	15.9	2566	2648	2729
8	C–2684	1942	6.2	17.0	18.1	2195	2348	2674
9	C–2686	1942	4.5	21.7	22.7	2168	2304	2597
10	C–2680	1942	14.0 (air dried 2.9%)					
11	C–2687	1942	5.3	8.4	8.9	1960	2043	2224
12	C–2681	1942	4.2	16.6	17.3	2729	2794**	2862**
13	C–2932	1943	10.6	20.8	23.3	2065	2113	2618

Sample 13

British Standards coking index – 2

Giesler plasticity	(10–15–43)	(10–16–43)
Softening temp. (0.5 div./min.)	321° C.	326° C.
Fusion temp. (5.0 div./min.)	366° C.	372° C.
Maximum fluidity temp.	374° C.	377° C.
Solidification temp.	435° C.	435° C.
Maximum fluidity (div./min.)	6.8 div./min.	6.6 div./min.

*Tests made by Analytical Division, Geochemistry Section, Illinois State Geological Survey.
**One determination only for each value.

In general, no definite cause for variation in the fusibility of Illinois coal ash is known. The softening temperature of the ash seems to have no consistent relationship to the rank of the coal or pyritic sulfur content, although there is thought to be a tendency for coal with high sulfur content to have a lower ash softening temperature than coals with low sulfur content. Such a rule, however, actually has little value for specific cases (Cady, 1935, p. 330-343; Cady, 1948, p. 75-77).

According to O. W. Rees (personal communication), ignitability or reactivity of the Friendsville coal is about average for Illinois coals.

Special tests were applied to sample 13 to determine the effect of heat upon the physical state of the coal. The results are given in table 2 under the heading "Giesseler Plasticity." The Friendsville coal shows very consistent plasticity values for all samples, both before and after cleaning; the values are similar to those obtained for most Illinois coals tested (Helfinstine and Boley, 1946, p. 59; Helfinstine, 1951, p. 44). The British swelling index of 2 for the Friendsville coal is low among Illinois coals, for which the values vary between 2 and 7.5 (Helfinstine and Boley, 1946, p. 59). The characteristics of the Friendsville coal when used in a domestic-type underfeed stoker have been invetigated by Helfinstine and Boley (1946).

MINABLE COAL RESERVES

Estimates of the minable coal reserves of Wabash County were included in a recent Survey publication by Cady and others (1952). *Minable coal* was defined in this publication as coal 28 inches or more thick. No limit was placed on depth to coal as no coal in Illinois is sufficiently deep to be technically unminable. Coals under oil fields were considered unminable. The basis of classification of coal reserves is summarized in table 3 (Cady and others, 1952, table 1, p. 17).

In Wabash County, reserves were estimated for the Friendsville, No. 6, and No. 5 coal beds (table 4). Although the Davis coal bed is believed to be of minable thickness in the county, there is not enough information available to estimate its reserves.

It should be noted that none of the reserves are considered to be in the *proved* class and that only the Friendsville has reserves in the *probable* class. The two *indicated* classes are based on relatively inadequate data owing to the lack of coal test drilling and mining operations (except for Friendsville).

Although deep coals in Wabash County must be considered ultimate reserves, it is probable that thicker and shallower seams in other areas of the State will be mined before those in this county. Commercial development of the Friendsville coal may be more imminent. Future test drilling for coal will alter and improve the reliability of reserve estimates.

TABLE 3.—SUMMARY OF CLASSIFICATIONS FOR COAL RESERVES INVENTORY*

Class	*Maximum distance from datum points***	*Accepted datum points*
I-A Proved	½ mile	Mined-out areas Diamond drill holes Outcrops
I-B Probable	2 miles	All points of Class I-A and coal-test churn drill holes
II-A Strongly indicated	4 miles	All points of Classes I-A and I-B, churn drill holes drilled for oil or water with unusually good records, and control rotary drill holes
II-B Weakly indicated	Indefinite	All points used in higher categories and knowledge of geologic probability based on available information

* *After* Cady and others, 1952, p. 17, table 1.
**Distances modified in practice by geological considerations.

TABULATIONS

Drill hole, outcrop, and mine data used in compiling the maps for this report are recorded on International Business Machine punched cards. Approximately one-half, or 1889, of nearly 3400 records of drill holes in Wabash County were selected for control. They show location, type (drill hole, mine, or outcrop), map number (county number), company and farm names and numbers, surface elevation, and depth and elevation of the principal key beds. The map numbers of the datum points appear on the No. 6 coal structure map. The tabulated lists are on open file at the Geological Survey.

TABLE 4.—RESOURCES OF WABASH COUNTY: FOUR CATEGORIES OF RESERVES*
(In thousands of tons)

Coal Bed Average thickness, inches	*I-A Proved*	*I-B Probable*	*II-A Strongly indicated*	*II-B Weakly indicated*	*Total*
WABASH COUNTY					
Friendsville					
28	—	17,681	70,018	5,388	93,087
35	—	6,768	—	—	6,768
Total, coal bed	—	24,449	70,018	5,388	99,855
Herrin (No. 6)					
28	—	—	24,900	11,325	36,225
35	—	—	539,683	—	539,683
Total, coal bed	—	—	564,583	11,325	575,908
Harrisburg (No. 5)					
28	—	—	214,134	12,267	226,401
35	—	—	286,663	—	286,663
Total, coal bed	—	—	500,797	12,267	513,063
Total, county	—	24,449	1,135,397	28,980	1,188,826

**After* Cady and others, 1952, p. 132.

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APPENDIX

DESCRIPTION OF SAMPLES

1. Collected in Hillcrest mine, NE¼ NE¼ sec. 29, T. 2 S., R 13 W., Wabash County, about 500 feet north-northwest of slope entrance November 7, 1942, by J. M. Schopf. Cut from fresh face; gross weight 50 pounds; taken from mine in sealed steel sample can; crushed and quartered in laboratory; thickness where sampled 46 inches, nothing excluded; air dry loss 9.5%.
2. Collected in Hillcrest mine about 100 feet from sample 1, January 16, 1943, by G. M. Wilson. Cut from fresh face; gross weight 50 pounds; taken from mine in sealed steel sample can; crushed and qaurtered in laboratory; thickness where sampled 40½ inches, nothing excluded; air dry loss 9.0%.
3. Collected in Kolb mine, SW¼ sec. 23, T. 1 S., R. 13 W., Wabash County, March 1928, by Evan Bennett. Face channel sample; thickness not reported.
4. Collected at Black Diamond mine, cen. NE¼ sec. 23, T. 1 S., R. 13 W., Wabash County, 1928, by Richard Corden, mine operator. About 22 lbs. of hand-picked lump coal. Coal has calcite facings and clay partings in a few places near middle of seam which probably were partially excluded from the sample.
5. Collected at Hillcrest mine by J. M. Schopf same time as sample 1. Consists of cuts from a specimen block of top coal about 9 inches thick.
6. Collected at Hillcrest mine by J. M. Schopf same time as sample 1. Consists of cuts from a specimen block of middle coal about 8 inches thick.
7. Collected at Hillcrest mine by J. M. Schopf same time as sample 1. Consists of cuts from a specimen block of bottom coal about 8 inches thick.
8. Collected at Hillcrest mine by J. M. Schopf same time as, and a short distance from, sample 1. Consists of cuts from a block of moderately impure coal 4 inches from the basal part of the seam. Some coal of this quality is rejected by hand picking in usual mining procedure.
9. Collected at Hillcrest mine by J. M. Schopf same time as, and a short distance from, sample 1. Consists of cuts from a block of impure "jack coal" from basal 4 inches of bed; this impure coal is usually rejected.
10. Collected at Hillcrest mine by J. M. Schopf at the same time as sample 1. Consists of about 3 lbs. of small lumps of coal taken across a fresh face and sealed immediately in a tight friction-top metal container; to be used as a check on moisture of face sample.
11. Collected from outcrop south of Sugar Creek school near cen. SE¼ sec. 35, T. 1 S., R. 13 W., Wabash County, by J. M. Schopf, 1942.
12. Collected at Maud Station mine SW¼ SW¼ NW¼ sec. 27, T. 1 S., R. 13 W., Wabash County, by J. M. Schopf, 1942. Consisted of small hand-specimen of top coal supplied by the owner.
13. Screenings obtained at Mt. Carmel by R. J. Helfinstine and C. C. Boley in October 1943 from a bin in the home of one of the operators; said to be coal from the Hillcrest mine; sample used in stoker tests after crushing to ½ inch and screening to eliminate minus 8-mesh coal.

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