STATE OF ILLINOIS
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DEPARTMENT OF REGISTRATION AND EDUCATION
VERA M. BINKS, *Director*

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

REPORT OF INVESTIGATIONS 193

SUBSURFACE GEOLOGY AND COAL RESOURCES OF THE PENNSYLVANIAN SYSTEM IN CRAWFORD AND LAWRENCE COUNTIES, ILLINOIS

BY

PAUL EDWIN POTTER

PRINTED BY AUTHORITY OF THE STATE OF ILLINOIS

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SUBSURFACE GEOLOGY AND COAL RESOURCES OF THE PENNSYLVANIAN SYSTEM IN CRAWFORD AND LAWRENCE COUNTIES, ILLINOIS

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ABSTRACT

Crawford and Lawrence counties, located on the southeastern border of Illinois, include portions of three regionally prominent structural elements: the Illinois Basin to the west, a shelf area to the east, and the southern termination of the LaSalle anticlinal belt. Distribution and structure of the coal beds and other associated Pennsylvanian sediments in the two counties were studied. Outcrops are few and subsurface data from oil test wells were the primary source of information. Economically and stratigraphically important coal and limestone horizons are described briefly and identified in cross sections. Paleogeology, isopach, and structure maps are included.

Total coal reserves in the two counties are estimated at 5,356,851,000 tons, of which one quarter are classed as *proved* and *probable* reserves. An isopach map shows the uniformity of the interval containing the coals of greatest potential economic value.

INTRODUCTION

Crawford and Lawrence counties lie on the eastern edge of the Illinois Basin (fig. 1). This report presents the results of a subsurface study made to determine distribution and structure of the coal beds and other associated Pennsylvanian sediments in the counties. Because outcrops are few, primary reliance was placed on subsurface data from oil test wells. Over 1500 electric, gamma-ray, and drillers' logs were studied. Electric and radioactivity log interpretation was facilitated by use of 14 control drill holes for which sample studies had been made by members of the Coal Division of the Illinois State Geological Survey. The studies were based on rotary drill hole cuttings using five-foot samples collected in the field and one-foot drilling time. Estimates of coal thickness are based largely on oil test data and must be considered with due reserve.

Previous studies covering aspects of the Pennsylvanian geology of Crawford and Lawrence counties have been published by Worthen (1875, p. 22 and 37), Rich (1916), Mylius (1923, p. 18-20, 34-37, and 45; 1927, p. 83 and 93), and Newton and Weller (1937). Unpublished studies in the files of the Survey include manuscripts and maps prepared by D. J. Fisher and Elwood Atherton. Studies of the Pennsylvanian geology of adjacent Wabash, Richland, and Jasper counties, Ill., have been made by Cady et al. (1955), Siever and Cady (1951), and Williams and Rolley (1955). Weir (1952) has made a similar study of Sullivan County, Ind.

It is a pleasure to acknowledge the assistance provided by other Survey members. The geologic criticism of A. H. Bell, Arthur Bevan, M. E. Hopkins, Raymond Siever, J. A. Simon, D. H. Swann, and H. B. Willman were especially helpful.

GENERAL GEOLOGIC DESCRIPTION

The LaSalle anticlinal belt passes through Crawford and Lawrence counties. West of the anticlinal belt, Pennsylvanian sediments thicken rapidly; east of it, Pennsylvanian sediments are thinner and lie on a shelf. The southernmost tip of the Marshall-Sidell syncline (Mylius, 1927, plate 1) extends into north-central and northeastern Crawford County. Pennsylvanian thickness ranges from 600 feet to over 2150 feet. Pennsylvanian sediments, unconformably

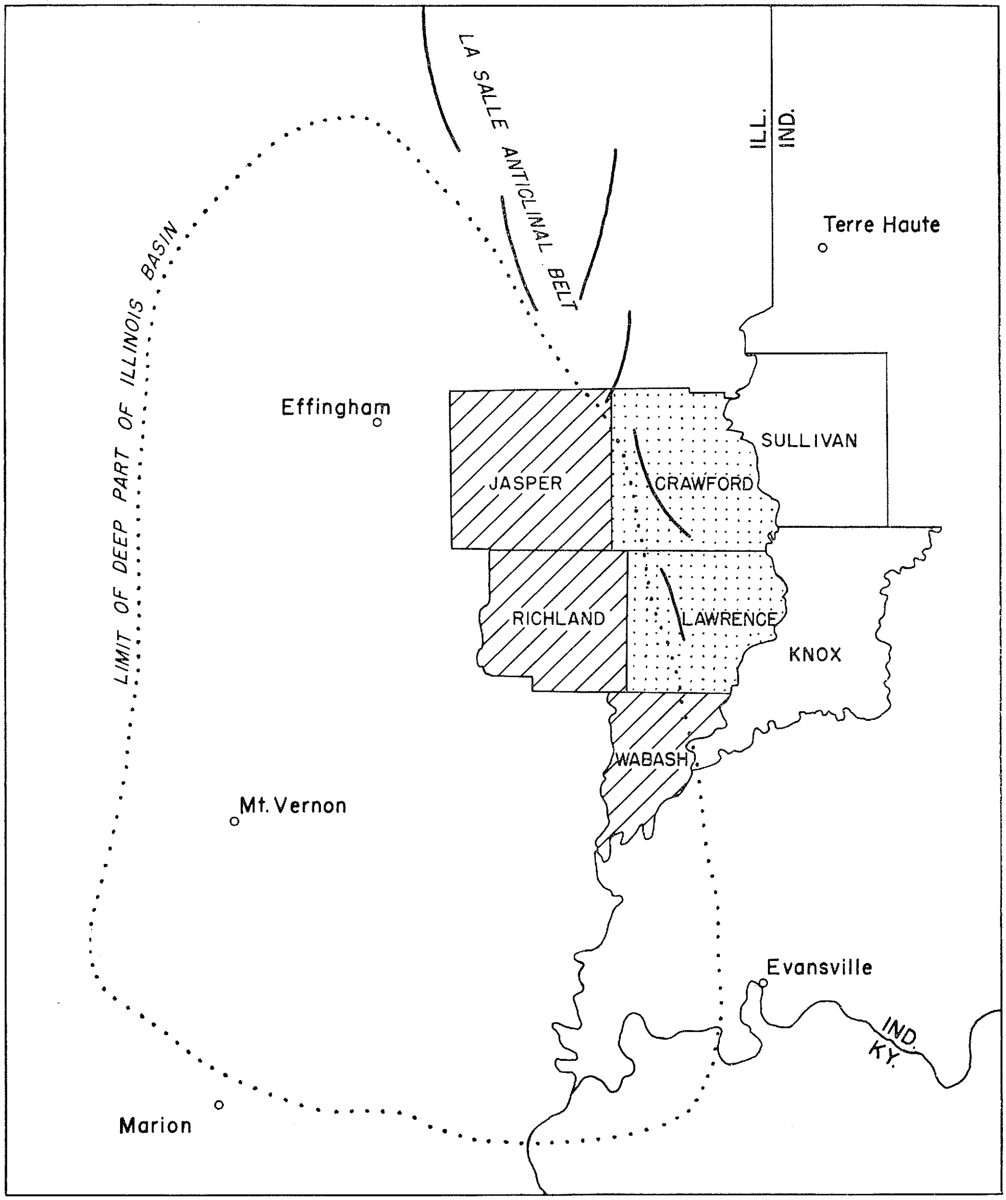

FIG. 1.—Index map of area covered by this report. Dotted area shows counties studied; diagonal lines indicate adjacent Illinois counties investigated previously.

overlying the Mississippian, have been divided into four groups: Caseyville, Tradewater, Carbondale, and McLeansboro (Weller, 1940, p. 36, footnote 13). A generalized stratigraphic section of the Pennsylvanian sediments in the two counties is shown in figure 2.

PRE-PENNSYLVANIAN GEOLOGY

Pre-Pennsylvanian areal geology of Crawford and Lawrence counties and isopachs of the combined Caseyville and Tradewater are shown on figures 3a and 3b. Because it is easily identified and widely developed, the top of coal No. 2 near the base of the Carbondale was used as the top of the Tradewater.

The paleogeology maps (figs. 3a and 3b) were made more objective by mapping appropriate combinations of the Mississippian formations. Subsurface recognition of the Mississippian-Pennsylvanian unconformity was especially difficult when electric logs were used to distinguish between Mississippian and Pennsylvanian sandstones. Thus in south-central Lawrence County, where the massive Mississippian Tar Springs sandstone lies at or near the unconformity, accuracy of the isopached interval may be no more than ±10 percent. In contrast, in most other areas isopach accuracy probably averages 2 to 3 percent. Although the base of the Pennsylvanian generally is clearly defined throughout Crawford County, the limited number of wells drilled to the Mississippian permits interpretations other than those presented here.

As has long been recognized and described in detail elsewhere (Siever, 1951; Wanless, 1955, p. 1764-1768; Potter and Siever, in press), basal Pennsylvanian sedimentation in the Illinois Basin followed a long interval of erosion that produced: 1) a regional basin-wide erosional pattern, 2) locally more extensive erosion over active late Mississippian–early Pennsylvanian structures, and 3) an integrated system of entrenched channels commonly from 100 to 200 feet deep. In Crawford and Lawrence counties, differential erosion related to the differential subsidence between the Illinois Basin and the shelf area to the east is the most prominent of these effects.

Mississippian sediments exposed at the beginning of Pennsylvanian deposition range from Menard (Chester series), and probably higher in southwestern Lawrence County, to as low as Ste. Genevieve (Lower Mississippian) in northern Crawford County (figs. 3a and 3b). A maximum truncation of 550 feet is indicated but may be slightly less because of possible thinning of Chester sediments to the north. Most of this truncation resulted from differential uplift and erosion of the area prior to basal Pennsylvanian sedimentation. As suggested by the paleogeology maps (figs. 3a and 3b), the Illinois Basin west of the LaSalle anticlinal belt was less rejuvenated than the shelf area to the east.

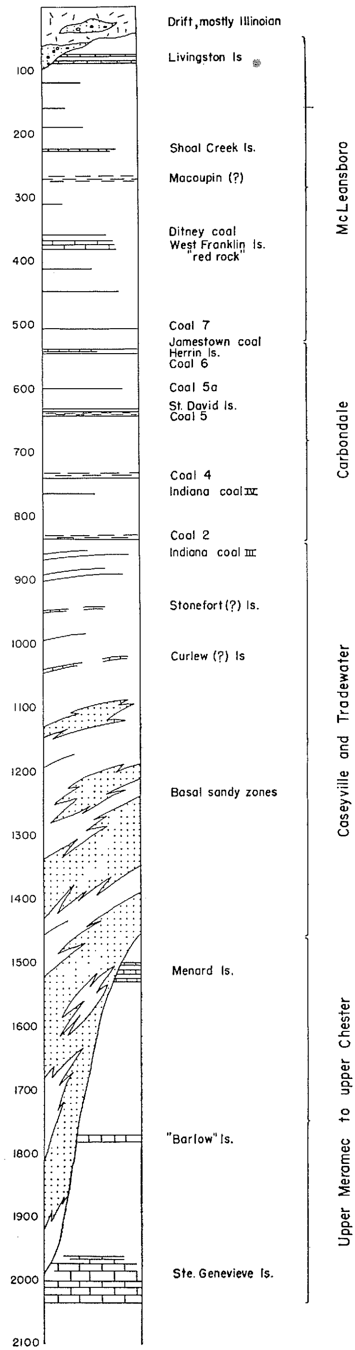

FIG. 2.—Diagrammatic Pennsylvanian stratigraphic section for Crawford and Lawrence counties.

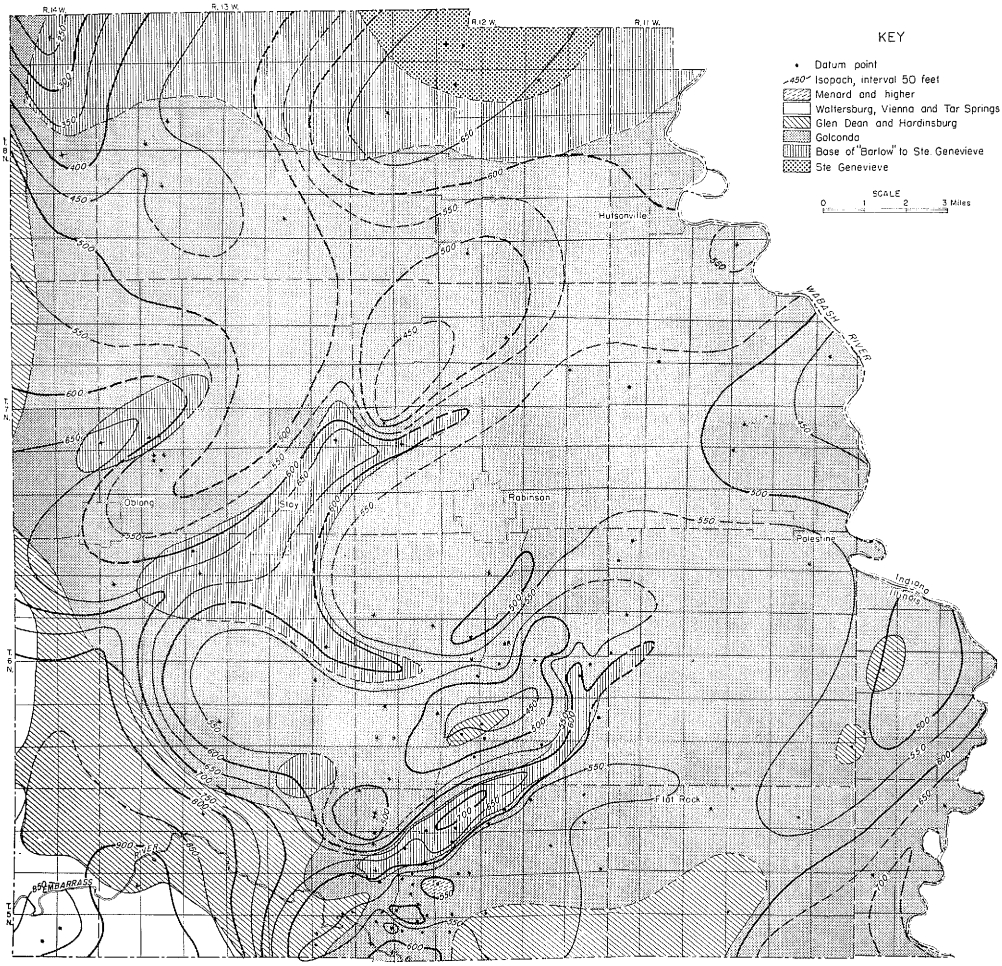

FIG. 3a.—Paleogeology map showing pre-Pennsylvanian areal geology and isopach of interval from coal No. 2 to Mississippian-Pennsylvanian unconformity in Crawford County.

The wells in Crawford County indicate the character of several entrenched channels. These channels are 100 to 250 feet deep, generally less than 2 to 3 miles wide, and trend southwestward where most clearly defined, as in T. 5 N., R. 12 W., and T. 6 N., R. 12 W. The latter channel appears to turn southward along much of the Lawrence-Richland county line. The general south-southwest orientation of these channels accords well with the regional southwest orientation of the channels of the Mississippian-Pennsylvanian unconformity in the Eastern Interior region that were mapped in outcrop by Weller (1923) and Malott (1930), and in subsurface by Siever (1951) and Wanless (1955, p. 1764-1766). In Crawford County these channels were superimposed across the LaSalle anticlinal belt.

As reflected by the Caseyville-Tradewater isopach maps (figs. 3a and 3b) local relief was small in all but channeled areas and the area along the eastern portion of the Menard subsurface.

PENNSYLVANIAN SYSTEM

Caseyville and Tradewater Groups

Subsurface electric log distinction between Caseyville and Tradewater groups is not practical in these counties.

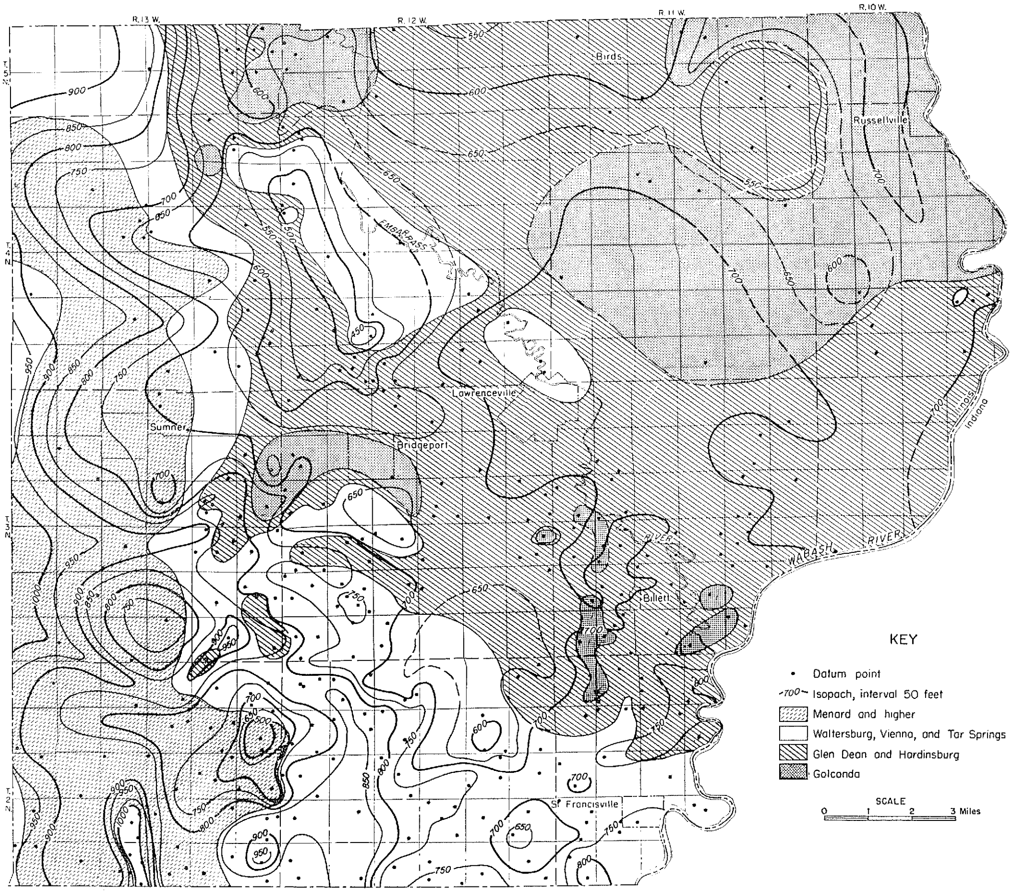

FIG. 3b.—Paleogeology map showing pre-Pennsylvanian areal geology and isopach of interval from coal No. 2 to Mississippian-Pennsylvanian unconformity in Lawrence County.

The combined thickness of the Caseyville and Tradewater groups ranges from less than 250 feet over the LaSalle anticline (northwestern Crawford County) to more than 1000 feet in the Illinois Basin (southwestern Lawrence County). East of the LaSalle anticlinal belt, the thickness on the shelf area is generally between 550 and 700 feet.

The lower portion of the Caseyville-Tradewater interval is characterized by a dominance of sandstones, a few thin (generally less than 24 inches thick) coal beds of limited lateral extent, and rare thin limestones. Sandstone distribution is notably irregular. Individual sandstones, often exceeding 200 feet in thickness, have limited lateral persistence. Transition from sandstone to shale or an interbedded sand-shale association is common within the space of a mile. As indicated by the restricted lateral persistence of most Lower Pennsylvanian lithologies, deposition was the response to rapidly shifting loci of sedimentation. The variability shown in plate 1 is not appreciably greater than that shown in cross sections with one-mile spacing. In channeled areas the proportion of sandstones generally is greater.

Oil field usage has introduced the names Bridgeport and Buchanan (Blatchley, 1913, p. 15), Biehl and Jordan (Moulton, 1925, p. 9-10; Bell, 1934, p. 11), and Robinson (Blatchley, 1913, p. 97-99) for the oil-bearing sands of the sandy zones of the Caseyville and Tradewater groups. Detailed cross sections indicate that individual sandstones of the basal sandy zones rarely are traceable over more than a few square miles. Hence these terms have no precise stratigraphic significance.

The higher portion of the Caseyville-Tradewater groups has appreciably less sandstone, a dominance of siltstone and shale, several poorly developed discontinuous limestones, and an increasing abundance of thicker, more-widespread coal beds than does the lower part.

Curlew (?) limestone.—This limestone, the probable equivalent of the Curlew limestone (Butts, 1925, p. 44-45), is generally 180 to 220 feet below coal No. 2, is commonly 2 to 4 feet thick, and varies from light gray to buff. It has been identified in less than one well in four. In Richland County (Siever and Cady, 1951, p. 120 and 122) and Wabash County (Cady et al., 1955) it has been identified tentatively.

Stonefort (?) limestone.—The limestone generally 100 to 130 feet below coal No. 2 tentatively is considered equivalent to the Stonefort limestone (Henbest, 1928). It is poorly developed, locally sandy, light gray to buff, and rarely more than 4 feet thick. Siever and Cady (1951, p. 119-120 and 122) have tentatively identified the Stonefort limestone in Richland County, as have Cady et al. (1955) in Wabash County.

Dekoven (?), Davis (?), and Indiana III coals.—The large number of thin coals and their undetermined lateral extent in an interval from 10 to 60 feet below coal No. 2 combine to obscure the stratigraphic relationships of the Dekoven, Davis, and Indiana III coals in Crawford and Lawrence counties and to complicate identification of the Tradewater-Carbondale boundary.

The probable position of the Dekoven and Davis coals in Crawford and Lawrence counties is below Indiana coal III. The coals considered equivalent to Dekoven and Davis coal beds generally are 10 to 20 feet apart and 30 to 60 feet below coal No. 2. Coal Division control wells generally indicate a thickness of less than 2 feet for each coal. Both coals have been tentatively identified in Richland County (Siever and Cady, 1951, p. 119-120 and 122) and Wabash County (Cady et al., 1955).

Indiana coal III has been identified in Lawrence County but is better developed in Crawford County (pl. 2). It is generally 20 to 30 feet, occasionally as much as 40 feet, below coal No. 2, and is often split. Although thicknesses of as much as 90 inches have been reported in rotary cuttings, thicknesses of 30 to 40 inches probably are more typical. Incomplete paleobotanical evidence (R. M. Kosanke, personal communication) suggests a Tradewater age. This coal is well developed in Jasper County, Ill. (Williams and Rolley, 1955, fig. 5), and in Sullivan County, Ind. (Weir, 1952).

Carbondale Group

The base of the Carbondale is defined as the base of the Palzo sandstone (Wanless, unpublished manuscript). Coal No. 2 was used as the best mappable unit approaching this contact, and general thickness of the Carbondale group ranges from 220 to 260 feet. In extreme northwestern Crawford County, directly over the LaSalle anticline, the thickness is approximately 185 feet. Siltstone and shale are dominant. Sandstones are mainly restricted to the lower portion of the group, especially between coals No. 2 and 4. In Crawford and Lawrence counties, as in most other parts of the Illinois Basin, the Carbondale group contains the thickest and most widespread coal beds. Many lithologic units have wide lateral persistence.

Coal No. 2 (Indiana IIIa).—Coal No. 2 is one of the most distinctive and widespread horizons on both electric (pl. 1) and gamma-ray (pl. 2) logs. It has been recognized in all adjacent counties investigated. Coal No. 2 rarely is thicker than 24 inches. The overlying black shale is persistent and prominently expressed on gamma-ray logs (pl. 2).

Coal No. "2a" (Indiana IV).—Coal No. "2a" is commonly a thin coal and is not always present. It is generally 15 to 60 feet below coal No. 4.

Coal No. 4 (Indiana IVa).—Coal No. 4 is easily recognized in electric logs. Rotary well cuttings indicate that it is a thin coal, thicknesses of 12 to 24 inches probably being most typical. The overlying black shale (1 to 4 feet thick) is very persistent and easily recognized on gamma-ray logs (pl. 2). The overlying limestone rarely is more than 2 feet thick and is present in less than 1 out of 5 control wells. Coal No. 4 has been recognized in all adjacent Illinois counties investigated.

Harrisburg (No. 5) coal (Indiana V).—The No. 5 coal is distributed widely (pls. 1 and 2). Control wells indicate a thickness ranging from 28 to 72 inches although limited data suggest that thicknesses between 36 to 42 inches probably are most common. The overlying black shale (1 to 5 feet thick) is present nearly everywhere and is easily identified on gamma-ray logs (pl. 2). The overlying St. David limestone is present in 80 percent of the control wells, and is generally between 1 and 3 feet thick. Coal No. 5 has been recognized in all adjacent counties investigated.

Coal No. 5a.—Coal No. 5a is a thin coal bed 10 to 20 feet above coal No. 5. It probably rarely exceeds 10 inches in thickness and is sometimes absent. Coal No. 5a has been recognized in all adjacent Illinois counties investigated.

Herrin No. 6 coal.—Coal No. 6 is a persistent coal bed. It has a reported thickness ranging from 28 to more than 72 inches, but a thickness of 30 to 40 inches is probably more typical. It is not always possible to distinguish it from the overlying Herrin limestone on electric logs (pl. 1). No major cut-outs of coal No. 6 were noted in Crawford and Lawrence counties such as were reported in other counties. The Herrin limestone does not appear to be as widespread in these counties as in other parts of southern Illinois. The low gamma-ray intensity of the coal No. 6–Herrin limestone–Jamestown interval is distinctive (pl. 2). Coal No. 6 has been recognized in all adjacent counties investigated.

Jamestown (?) coal.—This coal, which rarely is more than 3 to 4 feet above coal No. 6, may be the equivalent of the Jamestown coal (Bell et al., 1931, p. 3). Its electric-log separation from coal No. 6 is generally uncertain, making thickness estimates unreliable. Although local thicknesses of about 48 inches have been reported, it appears to be much thinner in most parts of the two counties. The Jamestown coal has been recognized in Richland County (Siever and Cady, 1951, p. 115-116), Jasper County (Williams and Rolley, 1955), and Wabash County (Cady et al., 1955).

McLeansboro Group

The base of the McLeansboro group is defined as the base of the Anvil Rock sandstone (Wanless, unpublished manuscript). In western Lawrence County the maximum thickness of the McLeansboro group is approximately 750 feet; over the LaSalle anticline in northwestern Crawford County it is less than 175 feet. Most of this thinning is the result of post-Pennsylvanian pre-Pleistocene erosion. Shale and siltstone remain the dominant lithologies; coal beds are thin and probably have less lateral persistence than those of the Carbondale group. The McLeansboro contains the thickest and most widespread limestones. Sandstones appear to constitute a smaller proportion of the section than they do in the Caseyville and Tradewater groups.

Coal No. 7 (Indiana VII).—The No. 7 coal is persistent and can be identified on most electric logs (pls. 1 and 2). Although the maximum reported thickness is 54 inches, thicknesses of 30 to 40 inches are probably more typical of prominently developed areas, and it is commonly much thinner. No. 7 coal has been recognized in all adjacent counties investigated.

West Franklin limestone and Ditney coal.—The West Franklin limestone is easily recognized on electric and gamma-ray logs (pls. 1 and 2). Total limestone thickness for all benches (as many as three are present) generally is 10 to 15 feet. The West Franklin limestone is locally inter-

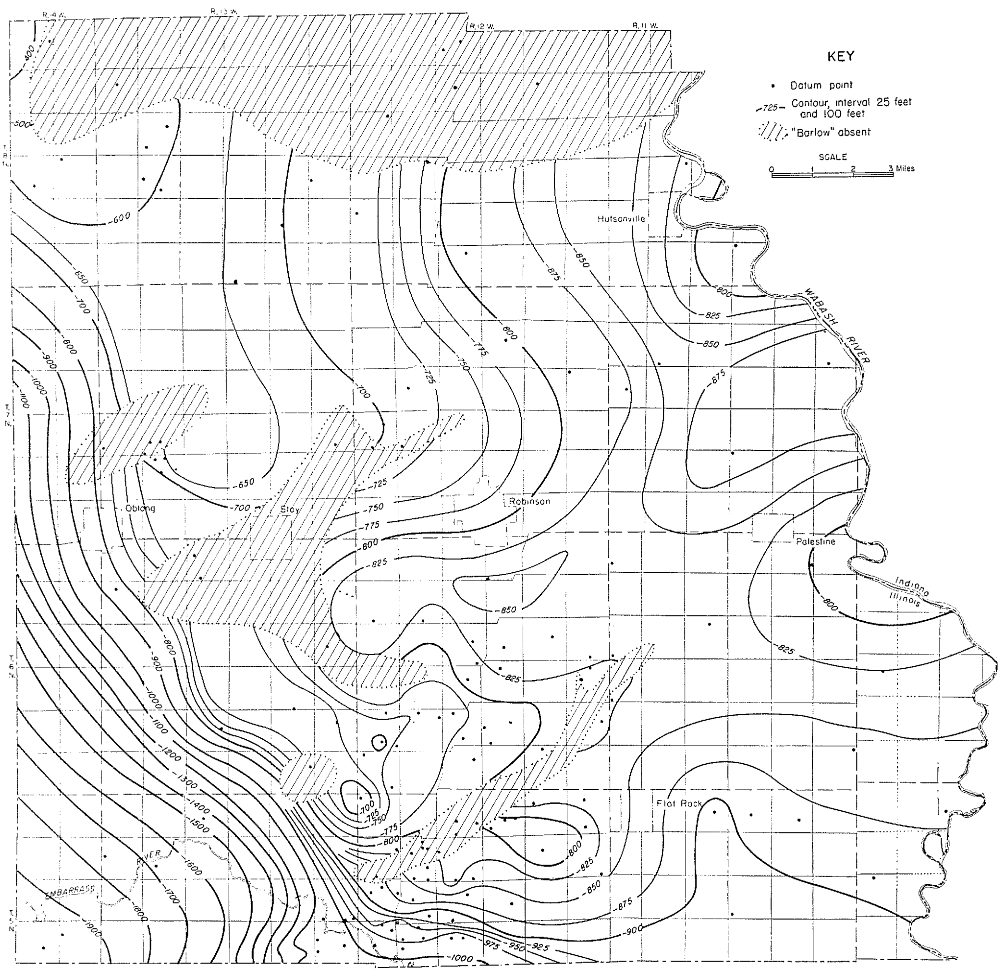

FIG. 4a.—Structure map of the base of the Mississippian "Barlow" (Golconda) limestone in Crawford County.

stratified with, and generally overlies, a variegated red, yellow, and greenish shale ("red rock" of drillers' logs). The West Franklin limestone zone is absent in large portions of Crawford County, having been eroded by an overlying sandstone. The West Franklin limestone has been recognized in Richland County (Siever and Cady, 1951, p. 111-114), Jasper County (Williams and Rolley, 1955), and Wabash County (Cady et al., 1955). The Ditney coal is thin (generally less than 10 inches) to absent. It lies 5 to 15 feet above the West Franklin limestone.

Macoupin (?) black shale and coal.—As shown on plate 2, a shale with an appreciable gamma-ray intensity lies 70 to 90 feet above the West Franklin limestone and 20 to 30 feet below the Shoal Creek limestone. This unit is stratigraphically in about the same position as the black shale that overlies the Macoupin coal (Wanless, 1939, p. 93) of western Illinois 20 to 40 feet below the Shoal Creek limestone.

Shoal Creek limestone.—The Shoal Creek limestone is commonly 130 to 150 feet above the West Franklin limestone and may be up to 10 feet thick. It is poorly developed throughout most of Crawford and Lawrence counties (pls. 1 and 2) either because of erosion by the overlying Mt. Carmel sandstone or lack of deposition.

Livingston limestone.—The Livingston

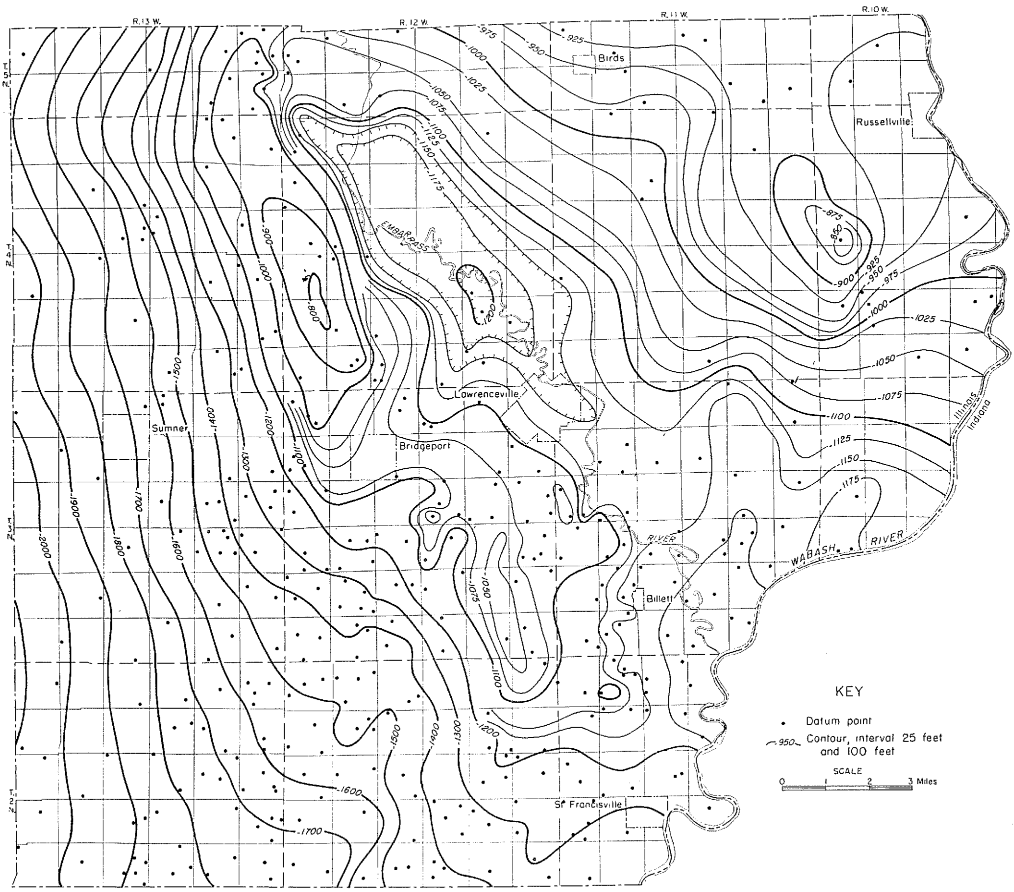

FIG. 4b.—Structure map of the base of the Mississippian "Barlow" (Golconda) limestone in Lawrence County.

limestone is well developed and commonly consists of two benches separated by 15 to 20 feet of shale. Total limestone thickness is approximately 15 to 20 feet. Post-Pennsylvanian erosion has restricted it to northern Crawford County. It has a characteristic gamma-ray intensity (pl. 2). Detailed cross sections prepared by the writer from the type locality of the Millersville in Christian County, Ill. (Taylor and Cady, 1944, p. 22), show the Millersville to be the same limestone as the Livingston. The Millersville limestone has been recognized in Jasper County (Williams and Rolley, 1955).

STRUCTURE

Structure maps were made for the base of the "Barlow" limestone (figs. 4a and 4b) and for coals No. 5 and 6 (pls. 3 and 4). Allowing for the smaller number of wells drilled to the "Barlow" limestone, all these maps show essentially the same structural features. The most prominent feature is the south-southeast trending LaSalle anticlinal belt. It is essentially continuous in most of Crawford County with only minor sags, has a prominent sag and offset along the Crawford-Lawrence county line, and becomes progressively less clearly defined in central and southern Lawrence County. Although high-angle normal faults may be associated at depth with some of the sharper folds of the anticlinal belt, none were observed at the "Barlow" and higher horizons. Faults in other parts of the counties were not observed. The southernmost portion of the Marshall-Sidell syncline of Clark and

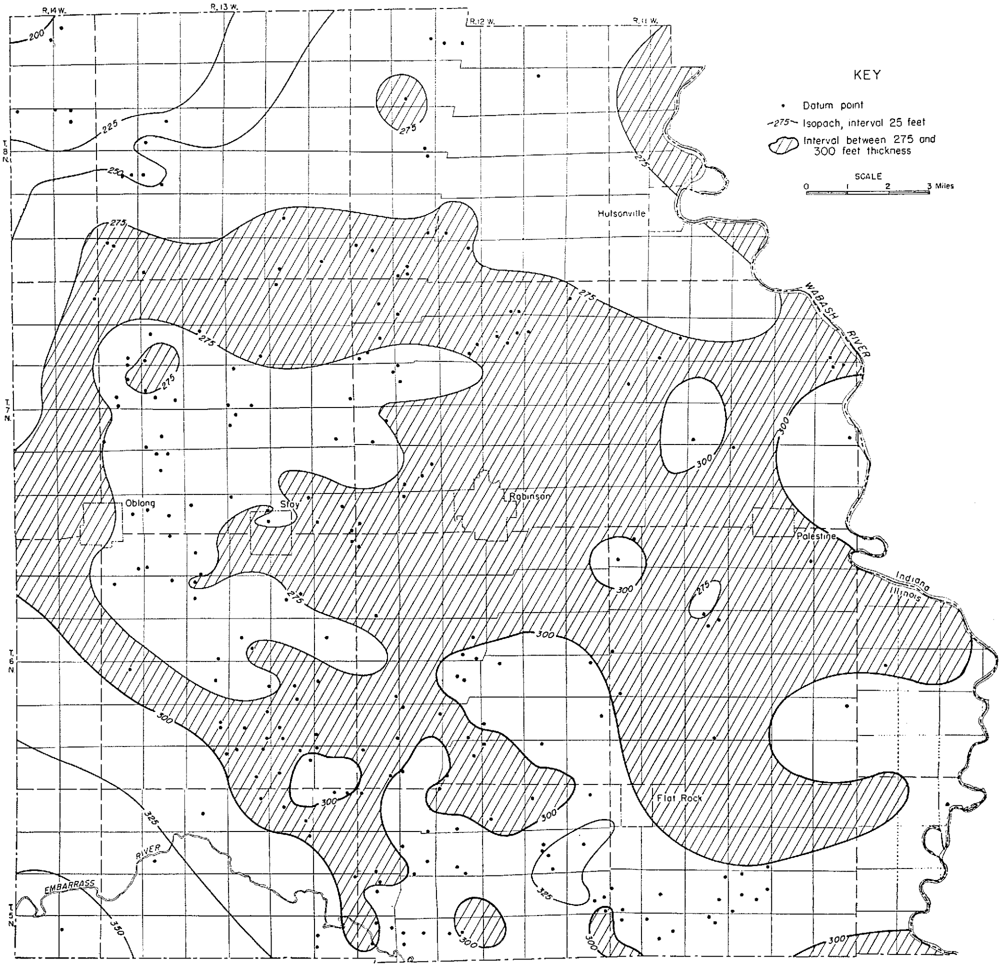

FIG. 5a.—Isopach of interval between coal No. 2 and coal No. 7 in Crawford County. Note minor thinning over LaSalle anticline in northwestern part of the county and compare with figures 3a and 5b.

Edgar counties (Mylius, 1927, pl. 1) is reflected on all the structure maps in extreme north-central Crawford County.

Figures 5a and 5b show the isopach of the interval between coals No. 2 and 7. This interval closely approximates the thickness of the Carbondale group. The over-all uniformity of the No. 2 to No. 7 coal isopach contrasts sharply with variation shown by the combined Caseyville-Tradewater isopach. Whereas the latter reflects primarily unequal subsidence between the Illinois Basin and the eastern shelf area, the No. 2 to No. 7 coal isopach indicates that this inequality became negligible over large areas of both counties dur-

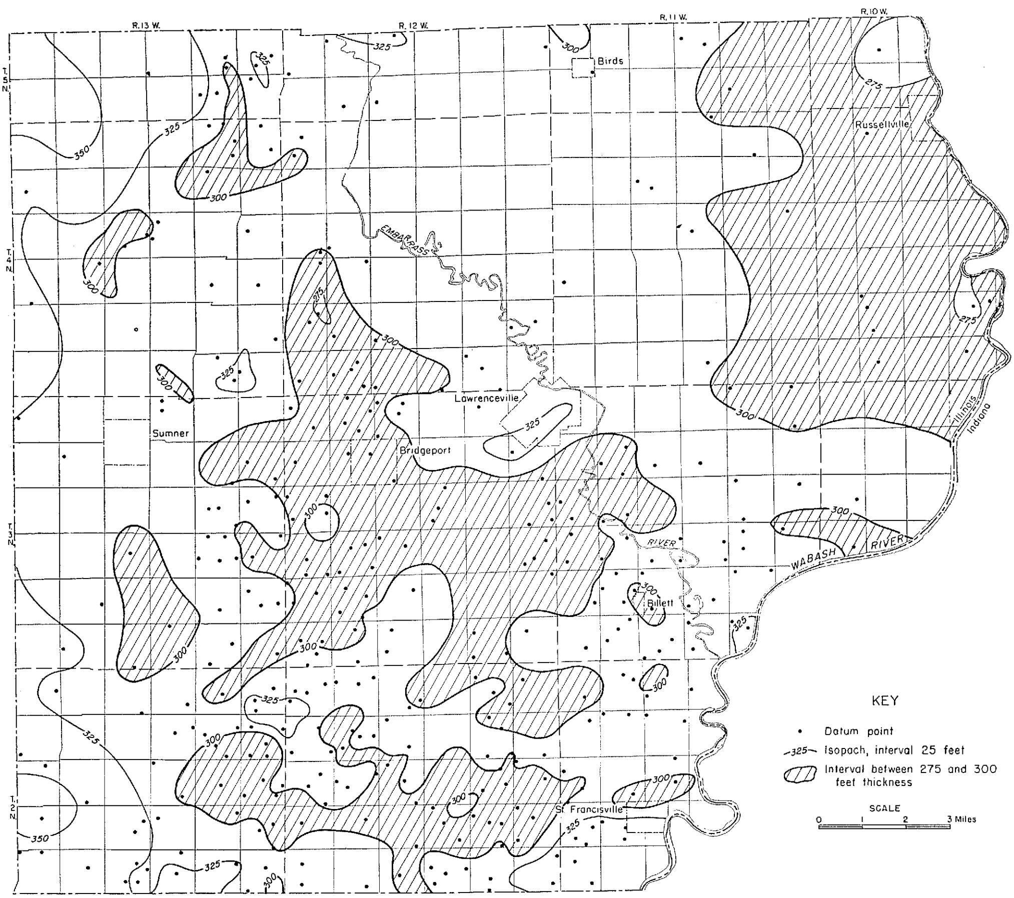

FIG. 5b.—Isopach of interval between coal No. 2 and coal No. 7 in Lawrence County. Note general county-wide uniformity of thickness, and compare with figures 3b and 5a.

ing Carbondale deposition. In extreme northwestern Crawford County there is some thinning of the interval over the La-Salle anticline, indicating a continued, although relatively minor, activity of that portion of the anticlinal belt. For the Mc-Leansboro, numerous cross sections indicate that differential subsidence between the Illinois Basin and the eastern shelf area was comparable to that of the No. 2 and No. 7 coal interval. Thus, beginning in the later portion of Tradewater time, the activity of the LaSalle anticlinal belt in Crawford and Lawrence counties declined, as did differential subsidence between the Illinois Basin and the shelf area to the east.

TABLE 1.—ESTIMATED COAL RESERVES IN CRAWFORD AND LAWRENCE COUNTIES*
(thousands of tons)

	Proved**	Probable**	Strongly indicated**	Weakly indicated**	Total
Crawford County	40,877	401,752	1,524,693	438,599	2,405,921
Lawrence County	156,469	737,175	1,629,124	428,163	2,950,930
Total	197,346	1,138,927	3,153,817	866,762	5,356,851

* Summary of total reserves for coal beds No. 7, Jamestown, No. 6, No. 5, Indiana IV, and Indiana III as listed in Cady, 1953, p. 102 and 116.
** As defined by Cady, 1953, p. 17, table 1.

COAL RESOURCES

Estimates of minable coal reserves of Crawford and Lawrence counties were made by Cady and others (1953, p. 102 and 116). Only coal seams 28 inches or more thick were considered as minable coal, and coal under oil pool areas was not classified. Table 1 gives a brief summary of classified reserves.

No major coal mines have operated in either Crawford or Lawrence counties or in the adjacent Illinois counties of Wabash, Richland, Jasper, and Clark. However, in Sullivan County, Ind., both strip and underground mines have produced from Indiana coals III, IV, V, VI, and VII. In Knox County, Ind., the principal coals mined have been Indiana IV, V, and VI coals (Charles Weir, personal communication).

Because the LaSalle anticlinal belt passes through Crawford and Lawrence counties, the coal beds have, in comparison to many other Illinois counties, greater-than-average dips (pls. 3 and 4). West of the anticlinal belt, dips commonly range from 50 to 100 feet per mile with local extremes of 200 feet per mile. East of the anticlinal belt, dips are between 30 and 70 feet per mile.

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