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REPORT OF INVESTIGATIONS—NO. 61

SUBSURFACE GEOLOGY OF THE CHESTER SERIES IN ILLINOIS

BY

L. E. WORKMAN

SUBSURFACE GEOLOGY OF THE IOWA (LOWER MISSISSIPPIAN) SERIES IN ILLINOIS

BY

J. NORMAN PAYNE

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SUBSURFACE GEOLOGY OF CHESTER SERIES IN ILLINOIS[1]

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ABSTRACT

The Chester series underlies most of the southern half of Illinois east of East St. Louis. Except where they have been removed by post-Chester erosion, all of the formations in the standard Chester section can be identified in the area. Producing formations are the Cypress and Bethel sandstones, both of which are in the lower part of the Chester series. The maximum known thickness is 1,450 feet at a point in the most southerly part of the area. Because of northward thinning of individual formations, the original thickness of the entire section in the northern part of the area was probably half of this. Uplift, warping, and peneplanation previous to the deposition of Pennsylvanian sediments caused truncation of the series throughout the basin and scalping of local structures. The isopach map indicates two major pre-Pennsylvanian anticlinal areas in which are located a large proportion of the Illinois oil fields, one the LaSalle anticline, and the other an uplift extending southeast from the region of Sorento.

INTRODUCTION

The Chester series occupies an area in the southern half of Illinois known as the Illinois basin. All the formations of the standard Chester section are present in the basin and have formerly had a much wider extent than at present. They are essentially parallel with no great unconformities separating them and are likewise essentially parallel with the underlying formations of the Iowa series of the Mississippian system. However, they were warped, tilted southward, and truncated previous to the deposition of Pennsylvanian strata, causing the pattern of formations shown in the accompanying areal geologic map of the Chester series below the Pennsylvanian system (Fig. 1). The stratigraphic relations of the Chester formations are shown in the geologic cross sections (Fig. 2).

[1] Read before the Association at Oklahoma City, March 24, 1939. Manuscript received, August 6, 1939.

[2] Subsurface Division, Illinois State Geological Survey.

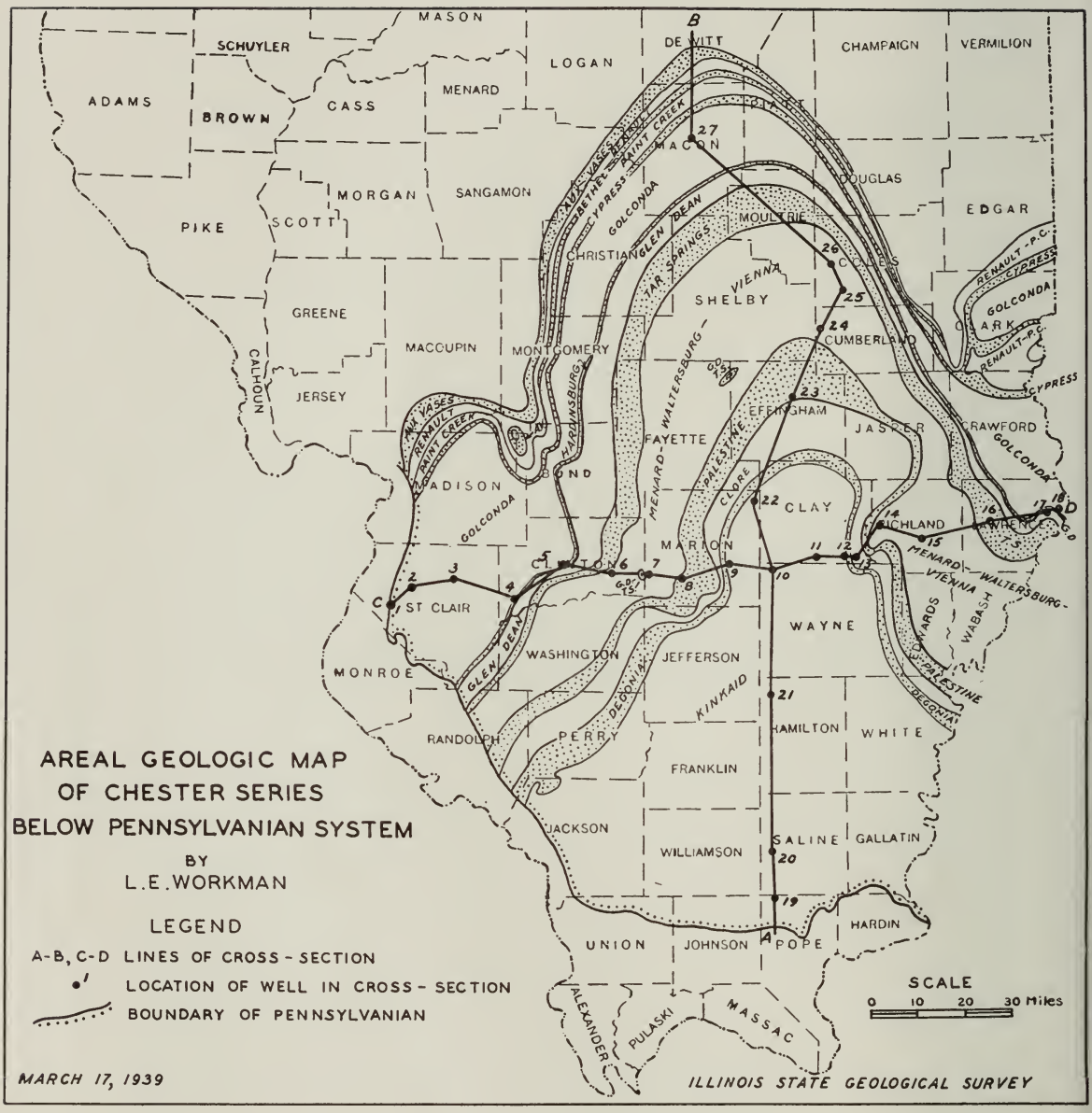


FIG. 1.—Areal geologic map of Chester series below Pennsylvanian system.

Kinkaid formation.—The Kinkaid formation is the topmost formation of the Chester series. In the Illinois basin it consists mostly of limestones and interbedded shales, but there are also some sandstone, siltstone, and chert beds. In a well in northern Pope County, in the southern part of the basin, the formation reaches its thickest development and is described as follows.

Description of Strata	*Thickness in Feet*
Limestone, mottled, very fine- to coarse-grained; some shale, dark gray	60
Shale, green and red; limestone, red and brown	15
Limestone, argillaceous, very fine-grained; shale, partly silty, gray	40
Shale, silty, grading to siltstone and sandstone	20
Limestone, argillaceous, mottled to dense, in places cherty, very fine- to coarse-grained; shale, gray to black	35
Shale, silty, dark gray to red and green; some limestone beds	15
Total	185

The limestones are more or less cherty, being especially cherty where they lie close under the Pennsylvanian strata. The strata extend laterally without important variations. The lowest limestone zone is the one encountered directly under the Pennsylvanian strata in drilling at most locations in Wayne and eastern Marion counties.

The Kinkaid formation thins northward under the erosional unconformity at the base of the Pennsylvanian system.

Degonia sandstone.—In areas of its thicker development, the Degonia sandstone is calcareous, very fine- to medium-grained, and white to light green and gray in color. As the formation becomes thinner laterally it becomes finer-grained, silty, and argillaceous and grades to carbonaceous, dark gray shale. In places it has a quartzitic appearance due to the cementing of the sand grains by silica.

The Degonia sandstone is 100–125 feet thick in Jackson County which is in the southwestern part of its area of occurrence in the Illinois basin. It thins eastward to about 50 feet in White County and northeastward to about 25 feet in northeastern Marion County.

Clore formation.—The Clore formation is variable in character. It consists of beds of buff to dark brownish gray, lithographic to coarse-grained, more or less argillaceous limestone alternating with red and green to dark gray shales, and contains also some sandstone beds. Chert, sand, oölites, and dolomite occur irregularly in the limestones. The lower limestones are more dolomitic than the upper, grading in places to dolomite.

The Clore formation ranges irregularly from 50 to 100 feet in thickness, becoming thicker toward the south.

Palestine sandstone.—The Palestine sandstone is generally calcareous, light gray to white, and very fine- to fine-grained. It contains

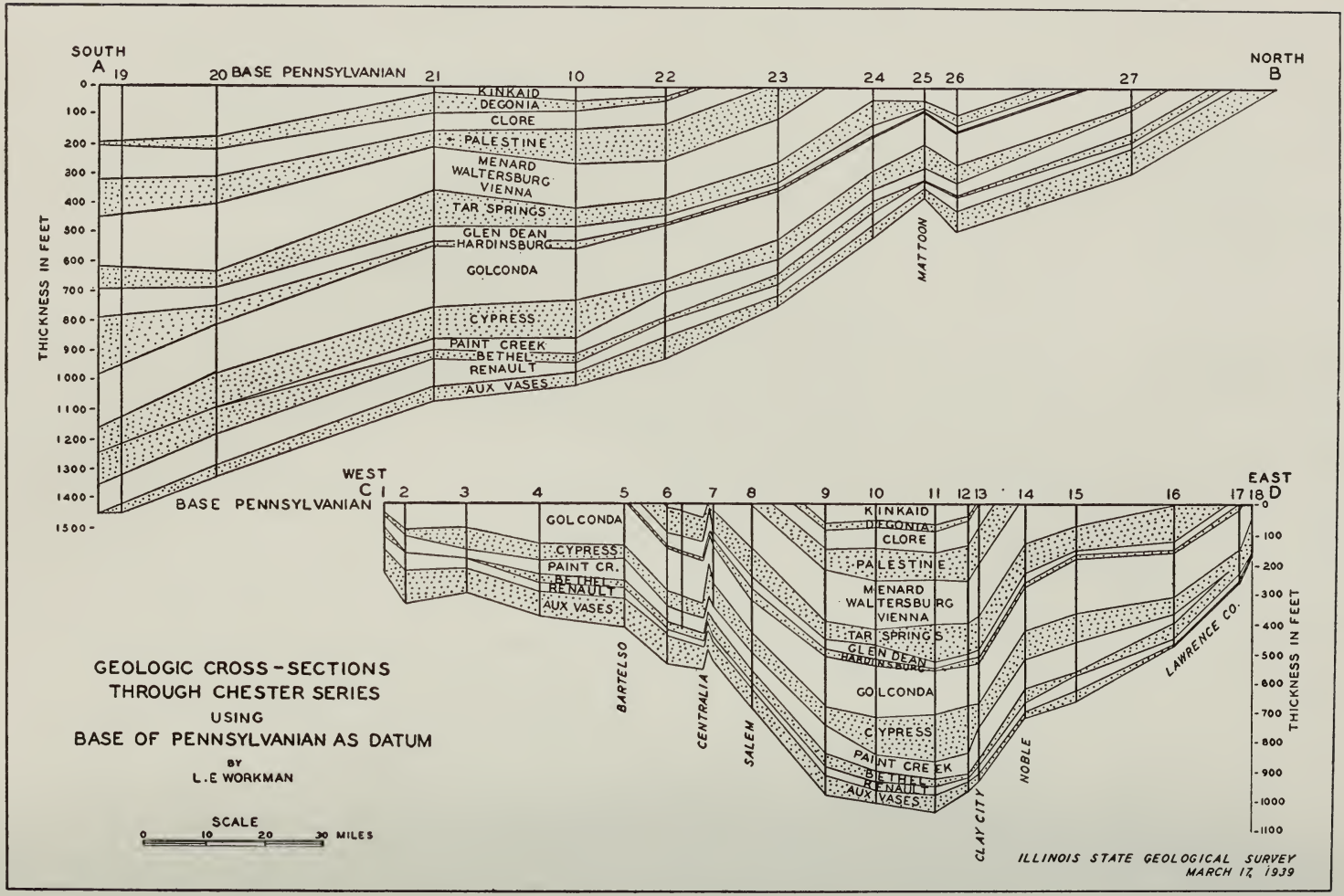


FIG. 2.—Geologic cross sections through Chester series on base of Pennsylvanian system as datum.

dark gray, carbonaceous, silty partings and some interbedded dark gray, silty to sandy, carbonaceous shale. The contact with the overlying Clore is in some places difficult to distinguish because of the presence in both formations of this type of dark carbonaceous shale.

The sandstone averages 40 feet in thickness in the western part of the Illinois basin, in Washington and Jackson counties, and it thickens eastward to 100 and 120 feet in the eastern part. Unlike most of the other Chester formations, the Palestine sandstone does not thin northward, being nearly as thick in Effingham County as in Gallatin County.

Menard formation.—The Menard formation is best developed in the southwestern part of the basin, in Jackson, Randolph, and Perry counties, where it may be divided into five zones: three zones of shale at the top, middle, and bottom with two alternating zones of limestone. These divisions of the Menard, however, may be observed elsewhere throughout its area in the basin. The limestone zones are 20–50 feet thick. The limestones are buff to brown and dark brownish gray, more or less argillaceous, and very fine- to coarse-grained in texture. Partly oölitic, speckled, light to dark gray and brownish limestone, similar to limestones of the Glen Dean and upper Golconda formations, are present in the Menard. Chert is irregularly present. The lower limestone zone is characterized by dolomitic limestone and a few beds of true dolomite. Some shale is interbedded with the limestone, and here and there, especially in the lower limestone zone, increases in proportion so as to constitute a considerable part of the zone. The three shale zones consist mostly of brown to dark gray calcareous shale but contain also some interbedded limestone. Red and green shales occur sporadically in each of the three zones.

The Menard formation is 125 to 135 feet thick in the southern part of its area, in Jackson to Pope counties, and thins northward to 70 or 80 feet.

Waltersburg sandstone.—The Waltersburg formation is best developed in the eastern part of the basin from Wabash to Pope counties where it consists of light greenish gray to white, very fine- to fine-grained sandstone. Westward it is more shaly, grading to greenish to gray shaly sandstone and siltstone, and in many places appearing quartzitic.

In the southeastern part of the basin the Waltersburg formation is 35–50 feet thick. It thins northwestward to 10 feet or less, and in places it is difficult to identify it in the well cuttings.

Vienna formation.—The Vienna formation is variable in character. In its typical development it consists of dark brown to brownish

gray limestone which is more common near the top of the formation, grading to a predominance of shale at the base. The limestone grades in texture from lithographic to coarsely crinoidal, is ordinarily dolomitic, and is commonly siliceous to cherty. Most of the shales are brown and dark gray to black, but red and green shales are present. The darker shales commonly contain siderite concretions and are more or less silty and carbonaceous. The more calcareous phases of the Vienna are in the south, but northward the formation becomes silty and sandy and some thin sandstones occur. A sandy limestone is common in the base of the formation in Marion and Fayette counties.

The Vienna formation ranges irregularly in thickness from 40 to 80 feet. It is thinnest in the southwest in western Jackson County where it is only 15 feet thick.

Tar Springs sandstone.—The Tar Springs is white to light gray, very fine- to fine-grained, calcareous sandstone. It contains carbonaceous material on bedding and laminae surfaces. In places the grains reach medium sizes. In the southeastern part of its area, from Williamson and Pope to Richland and Edwards counties, and also in scattered occurrences elsewhere, the Tar Springs is made up of three zones consisting of an upper and lower sandstone zone and a middle shaly zone containing dark gray, sandy, carbonaceous shale. In a few wells in Williamson, Pope, and Edwards counties this zone contains a thin coal overlain by green, smooth shale.

The Tar Springs ranges in thickness from 60 to 100 feet in most of its area of occurrence in Illinois. It is thinnest in the area extending west from Clinton to northwest Jackson County where it is only 40–30 feet thick. Along the eastern border from Cumberland to Gallatin counties it averages 100 feet in thickness.

Glen Dean formation.—A number of wells in Jackson and Randolph counties, where the Glen Dean formation is developed to its greatest thickness, show the following succession of strata in the formation.

	Thickness in Feet
Shale, red, green, and gray, partly calcareous, silty to smooth; a few limestone lenses	5–25
Limestone, slightly cherty, oölitic, light brown and gray speckled, coarse-grained, fossiliferous	30
Shale, calcareous, gray	0–10
Limestone, argillaceous, partly oölitic, speckled, coarse-grained	25
Limestone, cherty, speckled, coarse-grained	10
Shale, red and green, smooth	5

These various members have not yet been traced eastward in the

Illinois basin but the general characters of the formation remain the same. The formation is typically coarse-grained, crinoidal, oölitic, speckled brownish gray limestone containing variable amounts of chert and dolomite. There is a minor amount of interbedded calcareous and dolomitic dark gray shale, although in a few localities the limestone content decreases so as to be only a minor proportion or even disappears. Red and green shales are rare in the Glen Dean, and where found occur only at the top or bottom, more commonly at the bottom.

The Glen Dean formation is 80–90 feet thick along the southwestern and southern border of its area in Illinois. In an area extending northward from Johnson County through the center of Williamson, Franklin, and Jefferson counties it thins northward from about 90 feet to only 70 feet. On the west and east in the same latitude it is about 65–40 feet thick. This area of thick Glen Dean is just east of the Du Quoin anticline and may indicate some differential anticlinal and synclinal movement during the deposition of the Glen Dean sediments.

Hardinsburg sandstone.—The Hardinsburg sandstone in its areas of thicker development is calcareous, white to gray, very fine- to fine-grained, and friable. Where it is thin it is ordinarily calcareous, more or less argillaceous, light to medium gray and green, compact, and grades to green and gray siltstone, in many places appearing quartzitic.

The Hardinsburg is thickest in Johnson, Pope, and Hardin counties where it is generally more than 100 feet thick and reaches a known thickness of 170 feet in northern Pope County. It thins in a short distance northward to 60 or 65 feet in southern Williamson, Saline, and Gallatin counties. In a wide area north of this and southeast of a line extending from Lawrence County to the middle of Jackson County, it is about 60 feet thick. Northwest of this line the formation is generally 30 feet or less in thickness and it thins and almost disappears in the vicinity of its present northwest, north, and northeast borders. In a local area extending in a southwest direction from central Wabash to central White counties, on the east side of the basin, the Hardinsburg is only 20–25 feet thick, whereas on the west, in White and Edwards counties, thicknesses range from 65 to 90 feet and on the east, along the eastern borders of Wabash and Lawrence counties, they are about 90 feet.

Golconda formation.—The Golconda formation may be divided into five distinct zones which are persistent throughout the basin. A generalized section follows.

Description	Thickness in Feet
Shale, red, green, and dark gray, partly calcareous; interbedded with dolomite, argillaceous, lithographic, red, brown, and green, grading to limestone	0–40
Limestone, oölitic, speckled white to brownish and dark gray, coarse-grained, partly dolomitic, in places cherty; partings of dark gray shale increasing downward	30–55
Shale, calcareous, red, green, brown, gray; some limestone, argillaceous, very fine-grained to coarsely crinoidal, gray, green, and red; zone becomes sandy eastward, grading to siltstone and sandstone in lower part, known as "gas sand" in Lawrence County	20–35
Limestone, more or less argillaceous and dolomitic, partly oölitic, speckled brownish gray, very fine- to coarse-grained; interbedded shale, dolomitic, dark brownish gray, contains pink bryozoa in the top layer; lithographic limestone at base in western part of area; zone becomes sandy eastward.	30–60
Shale, calcareous, green and red, containing some lenses argillaceous limestone, zone increasingly sandy eastward	5–40

The lithographic character of the vari-colored dolomite occurring in the upper shale zone is unique. The oölitic speckled limestones of the Golconda are similar to the limestone typical of the Glen Dean formation. The contact of the Golconda and the underlying Cypress is gradational. However, the base of the dominantly calcareous shale and limestone is usually considered the base of the Golconda.

The Golconda formation is 100–120 feet thick in the northwest, north, and northeast part and 140–180 feet thick along the southern part of its area of occurrence in Illinois. Like the Glen Dean, the Golconda is relatively thin along a belt extending through the middle of Fayette County southward along the general region of the Du Quoin anticline, along which belt several important oil fields are aligned. On the other hand the formation reaches its greatest thickness of 270 feet in the area directly east of this belt in eastern Jefferson County.

Cypress sandstone.—The Cypress sandstone is calcareous, light gray to white, very fine- to fine-grained and friable with a thin shaly to silty zone at the top in most of its section throughout the basin. However, the whole formation grades laterally into shaly sandstone, especially where the formation is thin. As previously noted, it is difficult to determine its contact with the overlying Golconda, partly due to the downward-increasing sandiness of the basal Golconda red and green shales, and also partly because of the tendency of these shales to cave and mask the true character of the samples. Ordinarily the top of the Cypress is marked by bright green quartzitic siltstone, though such a siltstone is found in some places above the base of the Golconda. Two thin coals, each only a few inches thick, are found in some places in the upper part of the Cypress in the Clay, Richland, and Wayne counties region. The Cypress is unconformable on the Paint Creek formation below.

The thickness of the Cypress sandstone ranges irregularly in the basin between 20 and 60 feet. However, thicknesses of 140 feet or more are attained in an area near the oil fields of Clay, Richland, and Wayne counties, whereas the thicknesses in the surrounding areas are less than 100 feet. Likewise in an area comprising eastern Perry and Jackson and western Franklin and Williamson counties, thicknesses of 100–140 feet are attained. In some localities, as in Fayette County, it is reported that no Cypress is encountered, but it is likely that at such places the sandstone is shaly and, possibly, grades to shale.

Paint Creek formation.—The Paint Creek formation consists of alternating vari-colored shales and limestones, with some sandstone beds. The contact of the overlying Cypress sandstone on the Paint Creek is sharp in most places. The shales are generally calcareous and brightly colored with various shades of red, green, brown, and gray. The limestones are also variable in color, being light to dark gray and brown with some pink to red. In texture they range from lithographic to coarsely crinoidal, and they are more or less argillaceous, sandy, oölitic, and fossiliferous. In the western part of the basin a prominent marker of the base of the formation is a brightly speckled, red, green, brown, and gray coarsely crinoidal limestone. Sandstone beds are more prominent in the eastern part of the basin, and in White and Gallatin counties the formation is divided into three members, consisting of upper and lower shale and limestones and a middle sandstone.

The Paint Creek formation is 100 feet or more thick along the western border of its area and eastward from Perry and Jackson to White and Gallatin counties. Northward it thins to an average of about 60 feet in Clay and Richland counties and to about 40 feet in Lawrence County. South of the broad area of 100-foot thickness the formation thins within a short distance to 20 feet and in places disappears entirely.

Bethel sandstone.—The Bethel sandstone, locally called the "Benoist sand," is white to gray and light green and very fine- to fine-grained, having partings here and there containing flakes of carbonaceous material and a little mica. Limestone and shale pebbles are commonly present near the base. Where the formation is thin it is shaly.

The thickness of the Bethel sandstone averages about 25 feet but ranges from 15 to 50 feet in most of its area of occurrence in the basin. In places it is less than 10 feet thick. In most of the southern counties of the area, however, the thickness increases irregularly southward so that it is more than 80 feet in certain areas.

Renault formation.—The Renault formation is composed of a wide variety of sediments. Where it is thickest in the deepest part of the basin it consists mostly of limestone with minor amounts of interbedded shale and a few thin beds of sandstone. Where it is thinner the formation becomes increasingly shaly and sandy. The limestones are generally more or less argillaceous and vary in texture from very fine- to coarse-grained. Oölitic rock is common, ordinarily being brownish gray and speckled, but in places forming beds of pure light gray limestone similar to the typical "McClosky" oölite of the Ste. Genevieve formation. Cherty and sandy limestones are present irregularly in the formation. Speckled pink, green, and light gray crinoidal limestone containing pink and bluish white chert replacements occurs in the lower part of the formation in some areas. The shales are generally calcareous and dark brown to dark gray, but red and green shales are common, being somewhat less brilliant in color than the Paint Creek shales. The sandstones are lenticular and more or less argillaceous. Breccias and conglomeratic zones are not uncommon in the Renault formation.

The Renault formation has its maximum thickness of about 100 feet in a north-south belt about two counties wide in the deepest part of the Illinois basin, extending from Pope County to Edwards County. Away from this area the formation ranges in thickness from 10 to 50 feet.

Aux Vases sandstone.[3]—The Aux Vases sandstone is calcareous, very fine- to fine-grained, and greenish gray to gray and pink. It contains numerous gray, pink, and yellow oölites, and hematite is commonly present. In diamond-drill cores it is observed to contain limestone pebbles in zones anywhere from top to bottom. In about the middle of the formation a sandy oölitic limestone is persistent through the central and eastern part of the basin. In places the sandstone grades to dark gray sandy shale and green argillaceous siltstone. Lenses of brown dolomite occur irregularly in the lower part of the formation.

The Aux Vases sandstone becomes thickest toward the southwest, being 125–150 feet thick in Randolph, Perry, and Jackson counties.

[3] It is not certain that all of these strata belong to the Aux Vases formation. Part of them may be the equivalent of the Hoffner member of the Ste. Genevieve formation which crops out in Union County. However, in view of the impossibility of differentiating the two formations in subsurface studies at this time, the general practice of designating all of them as Aux Vases is provisionally continued. The Hoffner beds are described by F. F. Krey, "Geology and Mineral Resources of the Dongola Quadrangle," *Illinois Geol. Survey unpublished manuscript*, and by J. Marvin Weller and A. H. Sutton, "Mississippian Border of the Interior Basin," *Bull. Amer. Assoc. Petrol. Geol., unpublished manuscript.*

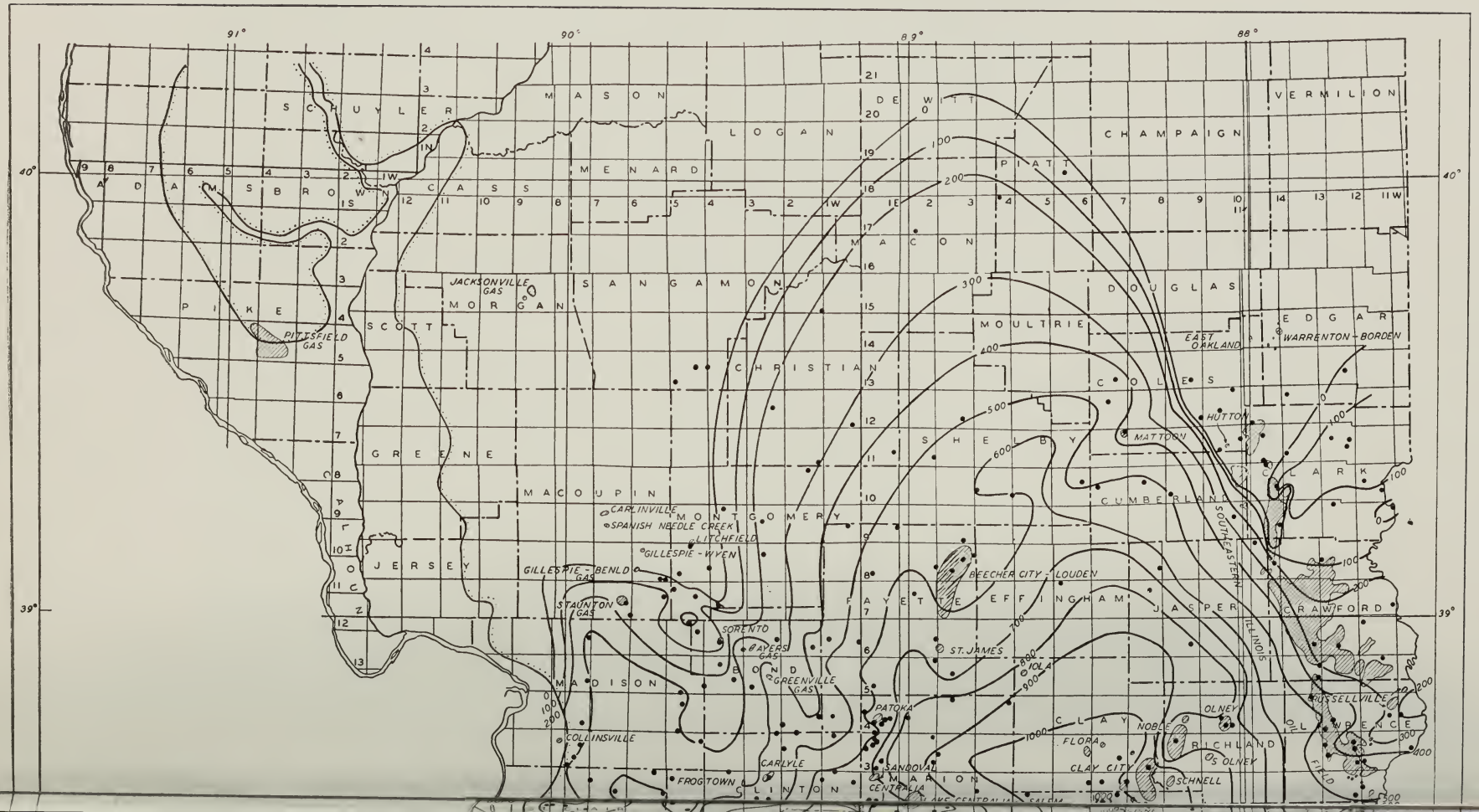
Northward along the western border of the Aux Vases area and in an area extending somewhat south of east through the north half of Bond and the southern part of Fayette to the northeastern part of Marion County, it is generally 100 feet or more thick. The formation thins eastward to about 10 feet along the eastern edge of the Aux Vases area, disappearing entirely in some localities.

ISOPACH MAP

Much of the oil produced in Illinois has come from the lower part of the Chester series below the top of the Cypress sandstone and from the upper part of the underlying Ste. Genevieve formation. Widespread uplift, deformation, and erosion previous to Pennsylvanian deposition established certain structural trends which seem to have been influential in the accumulation of oil in most of the Illinois fields. The isopach map (Fig. 3) shows the thickness of the Chester series from its top at the contact of the overlying Pennsylvanian system to the base of the Aux Vases sandstone.

Two major anticlinal belts were produced: (1) on the east the LaSalle anticline, which extends south-southeast along the eastern boundary of the Illinois basin, and (2) on the west, a southeastward anticlinal belt which extends along a line through Carlinville and Centralia, reaching into the middle of the Illinois basin, which is here designated as the Carlinville-Centralia anticlinal belt. The two anticlinal belts may be visualized as uplifts extending southeastward into that larger basin of Chester sediments which reaches from the Ozarks of Missouri to the Cincinnati arch of Indiana.

The LaSalle anticline is responsible for the formation of the major features of the old southeastern oil fields of Illinois. It is an asymmetrical fold having a gentle northeast dip and a sharp dip of 1,000–1,500 feet in a distance of a mile or two on the southwest. The uplift and subsequent erosion caused the Chester series to be entirely removed in a v-shaped area north of the northwest corner of Crawford County. From Douglas County southeast into Crawford County the sharply upturned edges of the Chester series were truncated along the steep edge of the anticline, as indicated by the closely spaced isopachs. Southeastward, however, the sharp west dip of the anticline, although present in the structure, is not revealed in the isopachs. In contrast, the isopachs spread apart as the result of erosion after broad domal uplift. This is interpreted as indicating that the development of the sharp westward dip was a progressively southward movement, and that the dome from Crawford to Wabash counties was covered and protected by Pennsylvanian sediments by the time the development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CUMBERLAND
GREENE
MACOUPIN
CARLINVILLE
SPANISH NEEDLE CREEK
LITCHFIELD
MONTGOMERY
GILLESPIE-WYEN
GILLESPIE-BENLD
BEECHER CITY-LOUDEN
SOUTHEASTERN ILLINOIS OIL FIELD
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STAUNTON GAS
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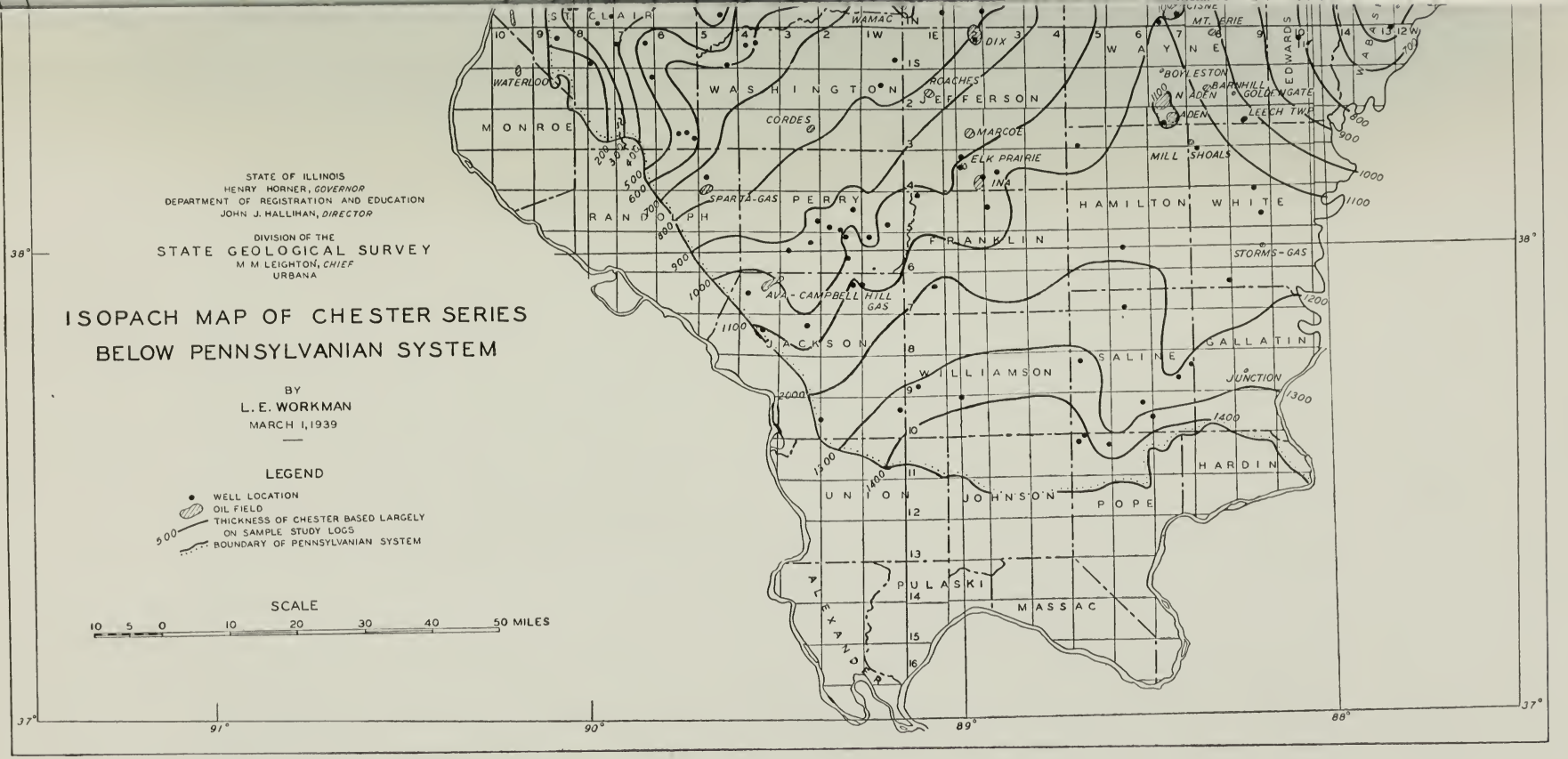

FIG. 3.—Isopach map of Chester series below Pennsylvanian system.

of the sharp westward dip had proceeded southward as far as northern Crawford County.

A pre-Pennsylvanian syncline extends northeast across the LaSalle anticline in central and northeast Clark County, and parallel with this in Crawford County is an anticline where Chester sediments are thin or have been entirely removed. It is possible that additional data may reveal this anticline to have a direction in line with the Clay City and Noble fields.

A minor anticlinal axis southwest through Lawrence County is also shown. Numerous evidences of southwest cross-folds and related phenomena along the LaSalle anticline should be significant in the study of structural trends on the anticline and in the basin.

Pre-Pennsylvanian movements were an important factor in the formation of structures in the Richland, Clay, and Wayne counties area, evidenced by thinning of the Chester series and erosion of the upper Chester formations.

The Carlinville-Centralia anticlinal belt has been of great importance to the accumulation of oil and gas in Macoupin, Bond, Clinton, and Marion counties. Most of the fields in the central and western parts of the Illinois basin, with the exception of the Louden-Beecher City field, lie in this belt. The uplift caused a v-shaped indentation of the western border of the Chester similar to that produced by the LaSalle anticline. The regional uplift seems to consist of two or three parallel lines of relatively thinner Chester series trending southeastward.

Of course, an isopach map of the Chester series does not give the whole structural history responsible for the accumulation of oil in this belt. Evidently cross-folds, produced either during the pre-Pennsylvanian period of diastrophism, or during or after Pennsylvanian time, formed local traps on the relatively broad folds. Thus the local structures forming the numerous oil and gas fields along the Carlinville-Centralia anticlinal belt do not show elongation along the direction of the belt but rather appear as domes or short anticlines, which are elongate in other directions.

The isopach map indicates that the Louden-Beecher City field was formed, at least in part, during the period of pre-Pennsylvanian diastrophism. This field has an arcuate form and seems to connect with the field south of Mattoon.

The map also suggests a northeast-southwest trending fold in southeastern Illinois extending through Saline County. Oil showings have been reported in the Tar Springs sandstone in wildcat wells of this general area, and a field is being opened up along the intersection

of this line with the Wabash River, taking oil from the McClosky limestone.

These features resulting from pre-Pennsylvanian diastrophism are also brought out in the pre-Pennsylvanian pattern of the formations of the Chester series in the areal geologic map (Fig. 1).

CROSS SECTIONS

Two geologic cross sections through the Chester series (Fig. 2), on the base of the Pennsylvanian as datum, are drawn along the lines *AB* and *CD* shown on the areal geologic map. The data used in these sections are almost exclusively from sample studies.

The north-south section, *AB*, is located as closely as possible to the middle of the Illinois basin, thus showing the thickest sediments. The greatest known thickness of Chester strata in Illinois is 1,450 feet at the location of well No. 19. The individual formations in general increase in thickness toward the basin. The thickness of that part of the Chester series below the base of the Palestine sandstone at a point between wells 23 and 24 is about 625 feet, whereas at well 19 the thickness of the same part of the Chester is 1,015 feet, showing a proportionate increase of 6:10.

The Mattoon structure is peculiar in that all Chester formations except the Cypress sandstone thin over the structure. This is not generally true of other structures in the line of the cross sections. It indicates that the area south of Mattoon had been a positive area of relative uplift through most of the time of the deposition of the Chester formations involved (Fig. 1). Inasmuch as this structure is considered to be aligned with the Louden-Beecher City structure, as indicated in the isopach map, it will be interesting to observe if these conditions continue into the latter field.

The west-east section, *CD*, shows the effect of the Carlinville-Centralia anticlinal belt on the west and the combined effect of the Clay City-Noble uplift and the LaSalle anticline on the east. The names of important producing fields are shown. Although the Centralia structure is the only local fold shown in this cross section, it is believed that, with sufficient data, other fields will show similar local uplifts.

The crest of the LaSalle anticline extends approximately through the location of well No. 16 in a line almost at right angles to the line of section *CD*. The section shows no effect of the sharp descent of 1,000 to 1,500 feet along the west limb of the anticline, but it does show the effect of the broad uplift. Here, also, there is some thinning of beds below the Cypress sandstone, but this may be natural thinning

toward the eastern borders of the Chester basin rather than the effect of any differential uplift along the anticline in early Chester time.

CONCLUSION

In conclusion it may be stated that the further study of the Chester series by isolating it in the foregoing manner from the effects of later Pennsylvanian structural movements should yield information of economic value to the oil industry. Likewise, significant trends are likely to be revealed by a study to locate more definitely the positive areas of relatively less depression during deposition.

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SUBSURFACE GEOLOGY OF IOWA (LOWER MISSISSIPPIAN) SERIES IN ILLINOIS[1]

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ABSTRACT

The Iowa, or lower Mississippian, series consists of the formations belonging to the Kinderhook, Osage, and Meramec groups. The Kinderhook group is made up almost entirely of shales with one or two thin limestones near the top. The Osage group is composed dominantly of silty shale and siltstone throughout the Illinois basin except in the extreme western and northwestern parts where the group can be separated into the typical Fern Glen, Burlington, Keokuk, and Warsaw formations. The Meramec group, consisting of the Salem, St. Louis, and Ste. Genevieve formations, is composed almost entirely of limestone and dolomite which lend themselves readily to separation by means of insoluble residues. The Iowa series reaches a maximum thickness of 2,000 feet in Gallatin County. This is probably due to thickening of the individual formations. Local variations in the thickness of the series and beveling of upper Iowa strata in Bond and Clark counties indicate some pre-Chester folding.

The strata beneath the Chester series and above the Devonian limestone in the southern Illinois basin have become of considerable importance to the oil geologist since the drilling of a producing well in the Devonian at Sandoval. The definite separation of the Ste. Genevieve, St. Louis, and Salem formations will probably depend to a large extent on the use of insoluble residues; nevertheless, there are strata that appear to be distinctive without the study of insoluble residues and they may be used for correlation purposes.

Ste. Genevieve formation.—The Ste. Genevieve formation (Fig. 1) consists, in descending order, of the Levias, Rosiclare, and Fredonia members. Its approximate boundaries in the Illinois basin are shown on the isopach map of the Iowa series (Fig. 3). Its total thickness is generally 165–175 feet, reaching a maximum of 200 feet in Jefferson, Franklin, and Pope counties. The formation generally thins toward the edges of the basin.

Levias member (6, p. 439).[3]—The Levias member consists partly of oölitic limestones and partly of fossiliferous shales. The insoluble residues are characterized by clay chips, white sugary chert, pink chert, and buff-colored finely botryoidal chert. The contact of the

[1] Read before the Association at Oklahoma City, March 24, 1939. Manuscript received, August 6, 1939.

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[3] The name Levias has been adopted by the Illinois State Geological Survey to replace the older and more confusing name—"Lower O'Hara."
Numbers in parentheses refer to bibliography at end of article.

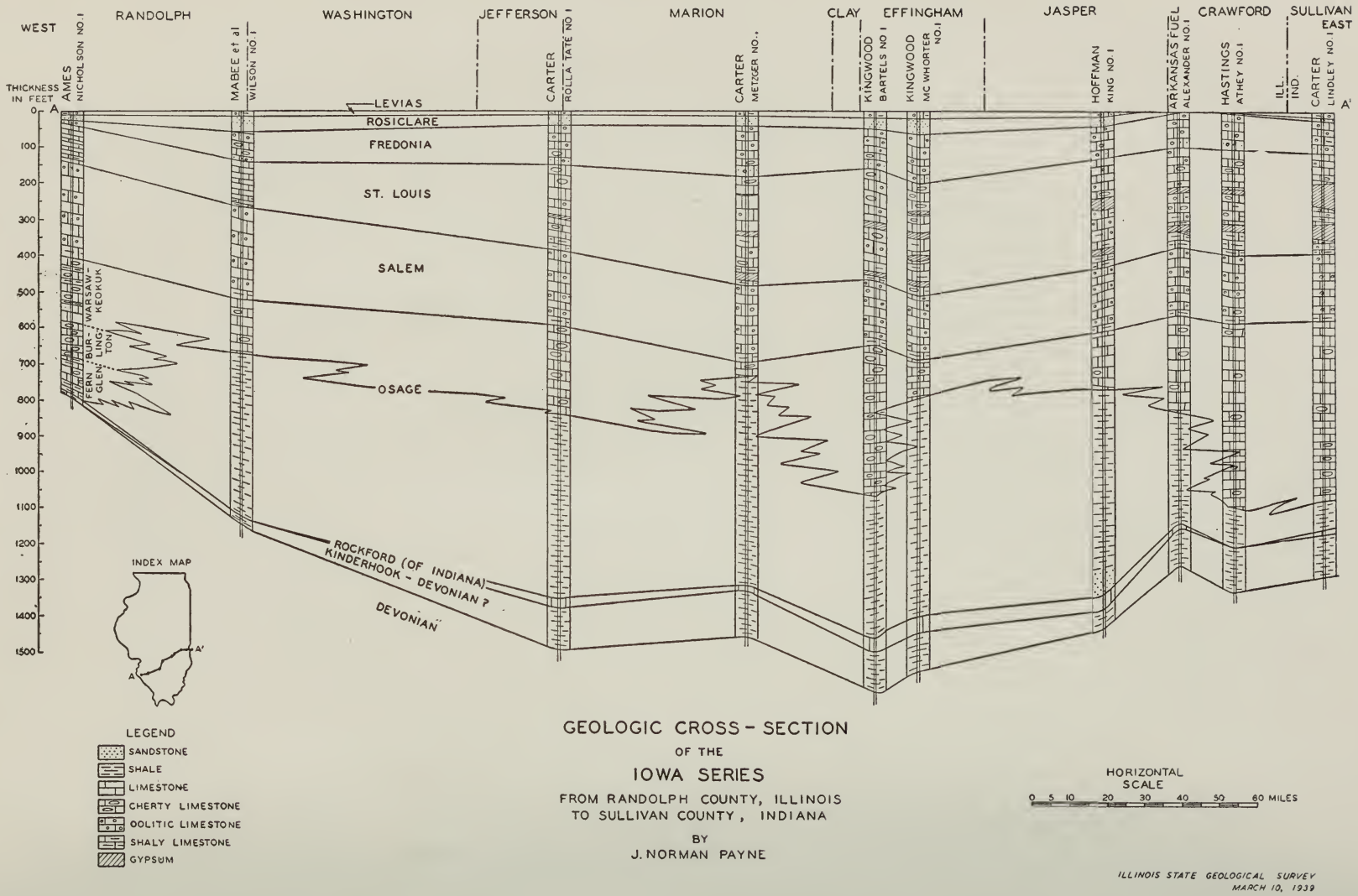


FIG. 1.—Geologic cross section of the Iowa series from Randolph County, Illinois, to Sullivan County, Indiana.

TABLE I

LITHOLOGIC DESCRIPTIONS AND THICKNESSES OF STRATIGRAPHIC UNITS OF IOWA (LOWER MISSISSIPPIAN) SERIES (EXCEPT KINDERHOOK GROUP) IN VARIOUS PARTS OF ILLINOIS BASIN

Stratigraphic Unit		*Southern Illinois Basin Franklin, Williamson, Southern Jefferson, Saline, Gallatin, Hamilton, and White Counties*		*Central Illinois Basin Fayette, Marion, Northern Jefferson, Clay, Richland, Wayne, Edwards, Effingham, and Jasper Counties*		*Southeastern Illinois Fields Clark, Crawford, and Lawrence Counties*	
		Thickness (Feet)	*Lithology*	*Thickness (Feet)*	*Lithology*	*Thickness (Feet)*	*Lithology*
Ste. Genevieve formation	Levias member	25–70	Limestone, oölitic, light gray to brown, finely to coarsely granular containing some pink and yellow grains; some limestone, brownish gray, very fine-grained and dense; subordinate amounts of greenish black shale and brown dolomites. Some oil showings	20–30	Upper part shale, greenish black, platy, interbedded with limestone, brownish gray to brown, finely to coarsely granular, and dolomite, brown; lower part limestone, partly oölitic, brown to gray, fossiliferous, with some fine-grained beds and some shale layers; basal beds sandy	15–25	Limestone, light gray to light buff, very fine-grained to sublithographic, red and green spots; shale, green, gray, and red
	Rosiclare member	20–80	Sandstone, calcareous, oölitic, light greenish gray, finely granular; limestone, sandy, oölitic, brownish gray, locally containing red oölites; shale, black, green, and red; erratic lenses of limestone breccia. Oil showings, some production	15–50	Sandstone, calcareous, oölitic, greenish gray, fine-grained, grading to siltstones, shales, and sandy, oölitic limestone; erratic lenses of limestone conglomerate, and breccia	10–40	Sandstone, calcareous, partly oölitic, green to gray, fine-grained; some limestone, sandy, oölitic, brownish gray; shale, sandy, green and gray
	Fredonia member	105–175	Limestone, oölitic, light gray to light brown, finely to coarsely granular; some lithographic beds and dolomites; some lenses of chert, bluish gray, translucent. Producing zones	20–150	Same as in southern Illinois basin. Important producing zones	100–175	Limestone, oölitic, light gray and brown, with dense, sandy, and dolomitic beds; distinct dolomite horizons at or near top and near middle. Important producing zones

TABLE I—*Continued*

Stratigraphic Unit	*Southern Illinois Basin Franklin, Williamson, Southern Jefferson, Saline, Gallatin, Hamilton, and White Counties*		*Central Illinois Basin Fayette, Marion, Northern Jefferson, Clay, Richland, Wayne, Edwards, Effingham, and Jasper Counties*		*Southeastern Illinois Fields Clark, Crawford, and Lawrence Counties*	
	Thickness (Feet)	*Lithology*	*Thickness (Feet)*	*Lithology*	*Thickness (Feet)*	*Lithology*
St. Louis limestone	150–300	Upper half limestone, dolomitic, partly cherty, oölitic, brownish gray, finely granular; lower half limestone, dolomitic, partly argillaceous, cherty, dark brown to gray, finely granular, with abundant dolomite and some gypsum beds. One producing zone	250–500	Same as in southern Illinois basin with two distinct gypsum horizons in lower part. Producing zones	250–350	Same as in central Illinois basin. Producing zones
Salem limestone	200–300	Limestone, dolomitic, slightly cherty, brown and gray, mottled, coarse-grained, with abundant *Endothyra* and *Ostracoda;* a few beds of finer-grained limestones, dolomites, and shales. Oil and gas showings reported	175–220	Same as in southern Illinois basin, but practically entire formation made up of oölitic limestone with abundant *Endothyra*. Oil showing reported in Edwards County	140–200	Same as in central Illinois basin. Producing zones
Osage group	750–1,000	Varying thicknesses of limestone, light gray to light buff, coarse-grained, very fossiliferous; grading down to limestone, silty, brown, interbedded with shales, siltstones, and sandstones	600–1,000	Same as in southern Illinois basin	600–900	Same as in southern Illinois basin. Production from "Carper sand" in Clark County

Levias member with the overlying Aux Vases formation of the Chester series is not sharp and at some places appears gradational. The Levias member grades imperceptibly into the subjacent Rosiclare member.

The Levias member varies somewhat in thickness but is present in the greater part of the Illinois basin. Its average thickness is about 20 feet but 50 feet was penetrated in the Ohio Oil Company's Perry Hancock well No. 1, Sec. 4, T. 13 S., R. 5 E., in northwestern Pope County.

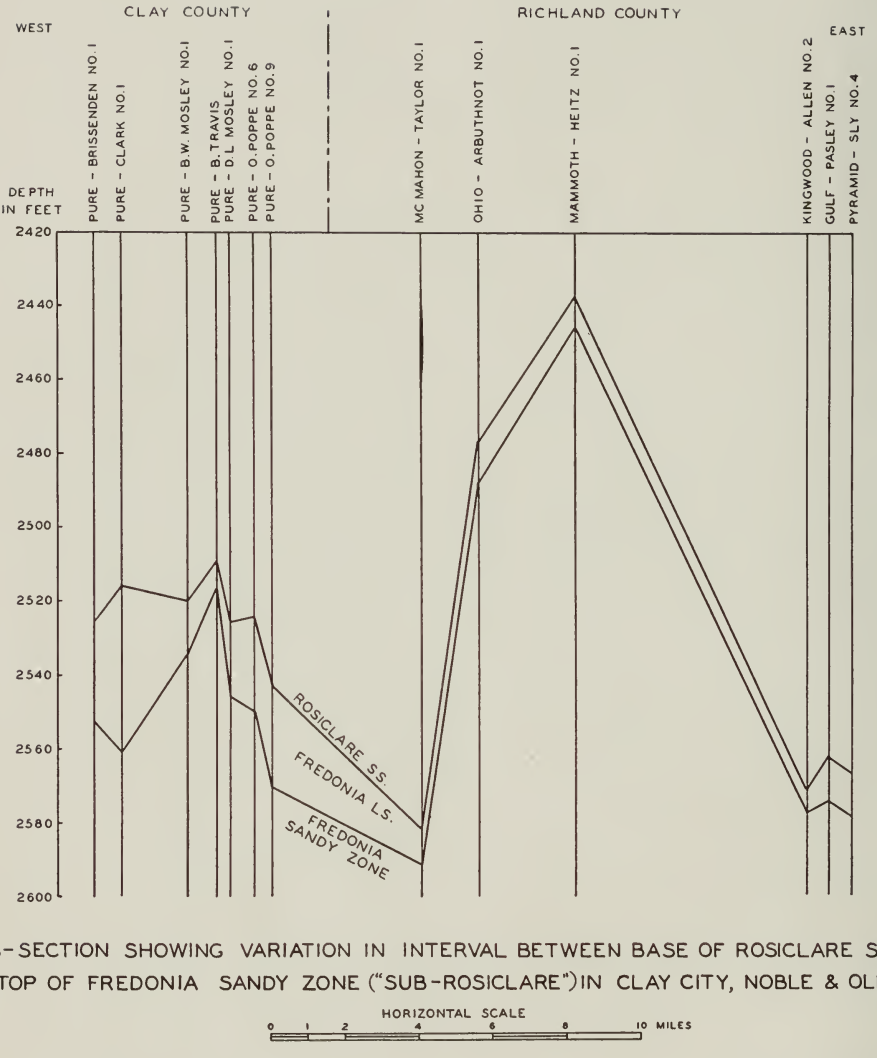
Rosiclare member.—The Rosiclare member varies lithologically but is dominantly sandstone containing lenses of shale, sandy limestone, and limestone breccia. Small rounded chert grains are plentiful in the insoluble residues from the basal part of the member. Sand showing more or less regeneration is the dominant residue.

The thickness of the Rosiclare member varies considerably within short distances but is generally 25–30 feet. As much as 75 feet has been penetrated in wells in Jefferson and Franklin counties.

No evidence of unconformity has been recognized beneath the Rosiclare sandstone where it crops out in southern Illinois and western Kentucky but an unconformity may occur at this position northward in the basin. This is suggested by: (1) considerable variation in the interval between the base of the Rosiclare and the top of a distinctive sandy zone in the Fredonia in the Clay City-Noble area (Fig. 2), (2) rapid increase and decrease in the thickness of the Rosiclare member, (3) a very sharp decrease in the amount of residues from basal Rosiclare beds as compared with upper Fredonia beds, (4) an apparent overlap of lower Fredonia beds by the Rosiclare along the margins of the basin, and (5) areas of channel-like thinning of the Fredonia in southwestern Illinois.

Fredonia member.—The Fredonia member is composed mostly of oölitic limestones but contains numerous beds of fine-grained limestones, dolomitic limestones, and dolomites and some shale beds.

The McClosky oil-producing zone in the Fredonia member is porous, oölitic limestone with more or less crystalline calcite in the interstices. The porosity of, and to some extent the production from, the McClosky "sand" depends on the amount of interstitial calcite. This type of rock is found at several horizons through the Ste. Genevieve formation and may be oil-stained whether it occurs at the top or bottom. In the Clay City, Noble, and Olney areas the highly productive zones are generally within 25 or 30 feet of the top of the Fredonia member but some production has been obtained as deep as 100 feet in the limestone. In southern Jefferson County production has been obtained as much as 50 feet below the top of the Fredonia.



CROSS-SECTION SHOWING VARIATION IN INTERVAL BETWEEN BASE OF ROSICLARE SANDSTONE AND TOP OF FREDONIA SANDY ZONE ("SUB-ROSICLARE") IN CLAY CITY, NOBLE & OLNEY FIELDS

HORIZONTAL SCALE
0 1 2 4 6 8 10 MILES

ILLINOIS STATE GEOLOGICAL SURVEY
MARCH 10, 1939

FIG. 2.—Cross section showing variation in interval between base of Rosiclare sandstone and top of Fredonia sandy zone ("Sub-Rosiclare") in Clay City, Noble, and Olney fields.

In the Lake Centralia-Salem area the large production from the Ste. Genevieve formation will probably come from the upper 30 feet of the Fredonia member, which is for the most part typical McClosky that has undergone varying degrees of dolomitization. From these data it appears that a thorough test of the Ste. Genevieve formation can not be said to have been made until the well has been drilled completely through it.

Certain dolomites or highly dolomitic horizons in the Fredonia member seem to be reliable correlation beds. The first of these, a dolomite at or near the top, is restricted to the southeastern fields; the second, extending over most of the basin, occurs 40–50 feet below the first zone and about 70 feet above the base of the formation.

The insoluble residues from the Fredonia member are made up of a relatively small proportion of chert, which is rounded to botryoidal, dense to sugary or chalky, vitreous, and translucent, and in general a relatively high proportion of very fine to coarse regenerated sand. Fragments of siliceous foraminifera are rather common. In the lower 15–20 feet of the formation there is a general increase in the proportional amount and coarseness of sand and of rounded pebble-like grains of white to dark gray chert. The Fredonia is ordinarily 130–140 feet thick in the central part of the basin and thins west and northwest.

St. Louis formation.—The St. Louis formation is composed chiefly of fine-grained dolomitic and cherty limestones, with some oölitic, argillaceous, and sandy beds. Two widespread gypsum horizons occur in the lower part of the formation, the tops being respectively about 175 feet and about 50 feet above the base. The basal part of the St. Louis formation is commonly marked by argillaceous and silty limestone and dolomite.

Some beds in the St. Louis formation merit attention in prospecting for oil. The upper part of the limestone, where overlain by Pennsylvanian or Chester formations, may be porous enough as a result of weathering to be oil-producing (4, pp. 145–50). In the southeastern fields the formation, notably the upper part, contains porous petroliferous dolomites. In several wells in Jefferson and Franklin counties a porous limestone zone is present about 100 feet below the top of the formation. One well is producing from this zone.

The residues from the upper 30–40 feet of the St. Louis formation differ from those of the Ste. Genevieve in consisting of much white to buff, chalky to dense, angular, doloclastic chert. Silt, fine sand, clay chips, and white siliceous foraminifera are also common.

The maximum thickness of St. Louis formation thus far penetrated

in drilling is in northern Edwards County where it is 500 feet thick. In general the formation thins westward (Fig. 1).

Salem formation.—The Salem formation is an oölitic, very fossiliferous, mottled limestone having a characteristic chalky appearance. In several areas the rock has been found to have porous zones. The base of the formation is commonly marked by silty, argillaceous dolomite. The limestone ordinarily has a small percentage of insoluble residues typically consisting of (1) brown, glistening, sugary, crystalline silica or chert, (2) white, porous, chalky, dull chert, (3) porous, brown clay flakes, and (4) varying small amounts of very fine to medium sand.

In the Westfield pool of Clark County some oil production is believed to come from the Salem (4, pp. 125, 145). Gas with a little oil has been produced from the limestone in the Jacksonville gas field in Morgan County (1, pp. 3, 7). Showings of oil have been reported from the Salem in wells elsewhere in the basin.

In the north part of southern Illinois the average thickness of the Salem is approximately 130 feet, but southward the formation thickens. The cross section (Fig. 1) shows a thickening from Sullivan County, Indiana, southwestward to Randolph County, Illinois. The maximum thickness thus far penetrated in drilling is 300 feet in Howard Forester's Forester No. 1 well, SW. $\frac{1}{4}$, NW. $\frac{1}{4}$ of Sec. 5, T. 6 S., R. 1 W., Perry County.

OSAGE GROUP

In most of the Illinois basin the Osage group is similar to the Borden group of Indiana (5), consisting of silty shales, siltstones, and sandstones with lenses of limestone, but along the western and northwestern borders of the basin the rocks are like the standard Mississippi Valley section of Fern Glen, Burlington, Keokuk, and Warsaw formations, which are dominantly cherty limestones. Some of the limestones of the siltstone facies are reef-like in character, being composed mostly of bryozoan and crinoid remains.

A widespread occurrence of oil-producing zones in the Osage is very doubtful. Although some of the reef-like bryozoan limestone has good porosity, the rock is so erratic that its occurrence on structure is highly speculative. However, the sandstone which occurs near the base of the Osage in certain areas may be productive if it occurs on structure.

In Clark County there is a producing sandstone known as the "Carper sand," which has been reported as being in the Kinderhook (3, p. 2, and 4, pp. 39, 150), but careful review of all logs in the vicinity

of the Carper farm, Sec. 30, T. 10 N., R. 13 W., and a comparison with sample study logs also in the area reveals the fact that the "Carper sand" is basal Osage. The sandstone is similar to, and grades imperceptibly into, the Osage above. The "Carper sand" is extensive in the southeastern part of the basin but is variable in thickness.

KINDERHOOK GROUP

Below the base of the "Carper sand" there is 5–20 feet of green, structureless shale which belongs to the Kinderhook group. Beneath the shale is a lithographic limestone similar in lithology and stratigraphic position to the Rockford formation of Indiana (2, pp. 486, 487). This limestone is a good correlation bed throughout most of southern Illinois. It is about 30 feet thick in the central part of the basin and thins east and west (Fig. 1). The Rockford limestone is underlain by black to dark brown *Sporangites*-bearing shale which averages about 100 feet in thickness. A calcareous sandstone containing phosphatic nodules occurs locally at the base of the shale and above the Devonian limestones.

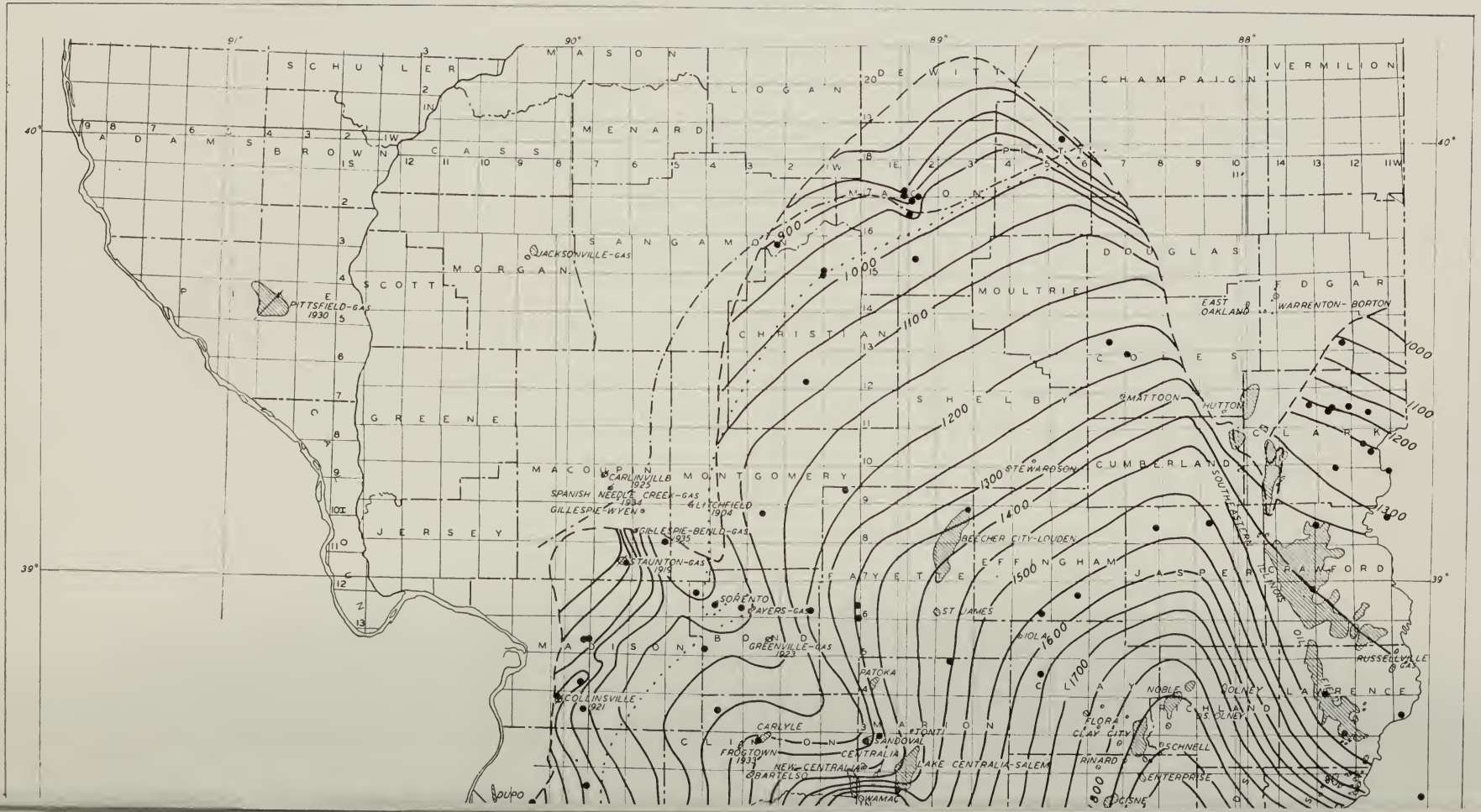
THICKNESS OF IOWA SERIES

In the aggregate the Iowa series thickens eastward and southward to a maximum of about 2,000 feet in Gallatin County (Fig. 3). Two prominent structures are revealed by thinning of the series on the structures—the LaSalle anticline in the east and the Carlinville-Centralia anticlinal belt in the west.

The thinning and complete removal of the Iowa series on the more northern parts of the LaSalle anticline is probably due to erosion prior to the deposition of the Pennsylvanian strata. Farther south in the area covered by Chester formations, the structure shows no effect on the thickness of the Iowa series.

The Carlinville-Centralia anticlinal belt extending through southeastern Macoupin and central Bond counties may be due to a structure of pre-Chester age. The greatest decrease in thickness of the Iowa series over this area amounts to about 175 feet, of which a maximum of only 70 feet can be attributed to thinning of the Ste. Genevieve formation. Likewise there is thinning of other Iowa formations. It is believed, therefore, that this belt was a positive area in pre-Chester time.

Minor structures that seem to have been formed prior to Chester deposition are found at Collinsville, Decatur, and in eastern Clark County. These areas of relatively thin Iowa series seem to be due to removal of upper Iowa beds of either Ste. Genevieve or St. Louis age.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MASON
LOGAN
DE WITT
CHAMPAIGN
VERMILION
ADAMS
BROWN
CASS
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SANGAMON
MORGAN
SCOTT
PIKE
GREENE
MACOUPIN
MONTGOMERY
CHRISTIAN
MOULTRIE
DOUGLAS
EDGAR
CLARK
COLES
SHELBY
CUMBERLAND
JERSEY
MADISON
BOND
FAYETTE
EFFINGHAM
JASPER
CRAWFORD
CLAY
RICHLAND
CLINTON
MARION
CLAY
NOBLE
OLNEY
LAWRENCE
JACKSONVILLE-GAS
PITTSFIELD-GAS 1930
CARLINVILLE 1925
SPANISH NEEDLE CREEK-GAS 1934
GILLESPIE-WYEN
GLUTCHFIELD 1904
GILLESPIE-BENLD-GAS 1935
STAUNTON-GAS 1915
SORENTO
SAYERS-GAS
GREENVILLE-GAS 1923
COLLINSVILLE 1921
PATOKA
CARLYLE
FROGTOWN 1933
NEW CENTRALIA
BARTELSO
SANDOVAL
CENTRALIA
LAKE CENTRALIA-SALEM
WAMAC
ST JAMES
BEECHER CITY-LOUDEN
STEWARDSON
MATTOON
HUTTON
EAST OAKLAND
WARRENTON-BORTON
SOUTH EASTERN ILLINOIS
FLORA
CLAY CITY
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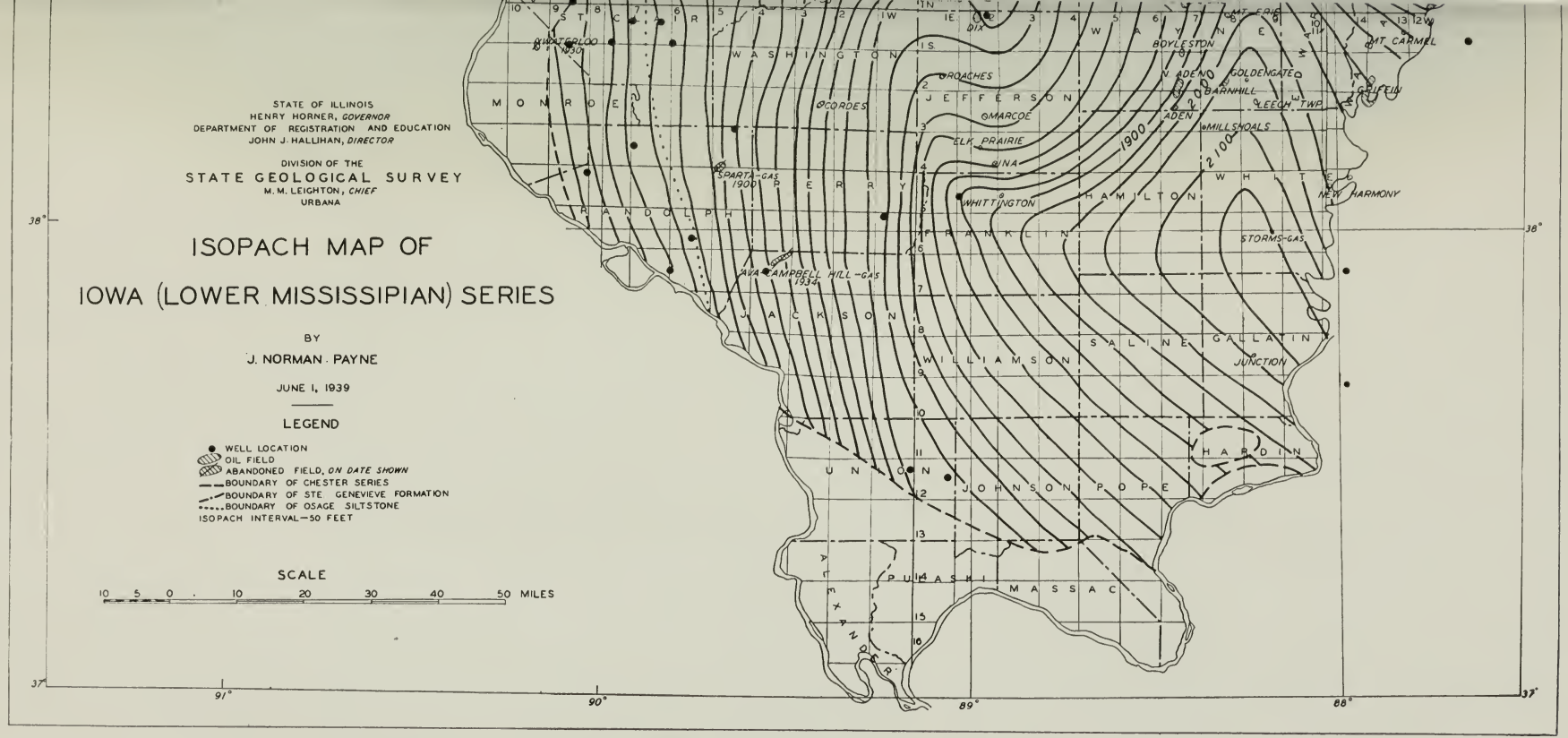

FIG. 3.—Isopach map of Iowa (lower Mississippian) series.

It is to be expected that other folds were formed in the basin prior to Chester time and it may be that pronounced structures, such as the Clay City, Noble, Louden-Beecher City, and Salem-Lake Centralia upfolds, may be reflected in the thinning of the lower Mississippian strata.

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DISCUSSION

Lynn K. Lee, The Pure Oil Company, Olney, Illinois (discussion received, August 28, 1939).—Mr. Payne is to be commended on his paper dealing with the Iowa series in Illinois. His work on insoluble residues, in addition to conventional lithologic studies, may well serve as a basis for the subsurface correlations of this section. Such correlations have heretofore been hazy due to the lack of concrete published material on the subject. His interpretation of the Osage group as being a contrasting lithologic phase of the Fern Glen, Burlington, Keokuk, and Warsaw formations of the Mississippi Valley is a logical one.

The placing of an unconformity at the base of the Rosiclare is a controversial point, which Mr. Payne recognizes as such. The writer is of the opinion that no unconformity exists at this contact, and that the evidence as given for this can more satisfactorily be explained by lateral variations of the lithologic units. Such variations are conspicuous in all three divisions of the Ste. Genevieve. The shales of the "Lower O'Hara" (Levias) vary considerably in thickness, yet the total thickness of this member remains fairly constant. The Rosiclare member in the Cisne, Clay City, and Noble areas varies in texture from very fine, sandy, limestone to medium-grained, calcareous cemented sandstone, containing large, rounded, frosted quartz grains. The beds of oölitic limestone, dolomites, and sandy zones of the Fredonia vary in thickness just as much in the middle of the formation as near the top. Since there is no suggestion of an unconformity within the Fredonia, I see no reason why the same stratigraphic condition at the top of the formation should be construed as indicating that one exists at that point.