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REPORT OF INVESTIGATIONS—NO. 135

SUBSURFACE CORRELATIONS OF LOWER CHESTER STRATA OF THE EASTERN INTERIOR BASIN

BY

DAVID H. SWANN and ELWOOD ATHERTON

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Topographic Mapping in Cooperation with the United States Geological Survey.

July 1, 1948

SUBSURFACE CORRELATIONS OF LOWER CHESTER STRATA OF THE EASTERN INTERIOR BASIN[1]

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ABSTRACT

Direct comparison of logs of closely spaced wells and their assembly into cross sections appear to demonstrate a number of inconsistencies in the nomenclature that is currently applied to the lower part of the Chester series and to the Ste. Genevieve formation in different parts of the Eastern Interior Basin. This evidence indicates that: (1) the important oil-producing "Aux Vases" sand of the central basin area is equivalent to the outcropping Rosiclare sandstone member of the Ste. Genevieve formation; (2) the "Benoist" (Yankeetown), Bethel, and Sample sandstones are successively younger rather than correlative units; (3) the Cypress sandstone of Indiana and west-central Kentucky is younger than the Cypress of Illinois; (4) certain continuous limestone units can be traced between the various areas (the Beech Creek or "Barlow" limestone lies above the Illinois Cypress but beneath the Indiana Cypress); (5) the Downeys Bluff limestone, for a long time considered a part of the Renault formation because it lies below the Bethel sandstone, is in reality the basal Paint Creek limestone above the Yankeetown and is correlated with the upper portion of the Paoli limestone of Indiana; (6) the Levias limestone and part of the Shetlerville (Renault) together form a continuous limestone sequence which overlies both the "Aux Vases" of the basin and the Rosiclare sandstone of the outcrop area in southeastern Illinois.

INTRODUCTION

The intensive drilling program that began in 1937 when oil was discovered in the deeper part of the Eastern Interior Basin has produced a wealth of stratigraphic data on the Mississippian formations above the St. Louis limestone. Almost all locations within the Illinois Basin proper (the deepest part of the Eastern Interior Basin) are within 2 miles of wells or tests for which good stratigraphic records are available. Thus a re-examination of the long-range correlations made at the beginning of the basin oil development appears in order.

The fund of information on the variation in stratigraphy indicated by subsurface records provides material not only for subsurface correlation but also for a new attack on the perplexing problems of outcrop correlation around the border of the basin area.

This paper records the stratigraphic columns in current use in different parts of the Eastern Interior Basin for the Mississippian strata between the St. Louis formation of the Meramec group and the Hardinsburg sandstone of the Homberg (middle Chester) group. Correlation between the several areas is indicated by a chart (fig. 1). The chart is substantiated by the cross sections (figs. 3–6) whose locations are shown on the index map (fig. 2). The conclusions are similar to those of Dana and Scobey (1941) but are here presented in greater detail.

Although this report indicates the need for a revision of the standard classification of the lower part of the Chester series, this revision is not attempted here. It is postponed, awaiting clarification of several problems involving the correlation of formations defined in the southwestern Illinois and Missouri outcrop area with the units which can be traced throughout the rest of the basin.

CORRELATION CHART

The left-hand column of the correlation chart (fig. 1) has been slightly modified since the Chester rocks in south-

[1] Published by permission of the Chief, Illinois Geological Survey, Urbana, Illinois. Manuscript received May 20, 1948.

western Illinois were described by S. Weller (1913, p. 120); its present form is that used by Cooper (1941, p. 7). The formation boundaries as originally given by Weller are in current use and appear to be applied consistently throughout the outcrop area, which extends along the Mississippi River for 85 miles below St. Louis. This area is west of the limits of the index map (fig. 2).

The second column gives the usage applied by members of the Illinois Basin Oil Scouts Association in the Louden, Salem, Boyd, and Woodlawn oil fields of south-central Illinois and in the area west of these fields. Boyd (fig. 2) is near the eastern edge of the area in which this nomenclature is consistently used.

The third column shows the nomenclature applied by the geologists of oil companies operating in the lower portion of the drainage basin of the Wabash River in Illinois and Indiana. Maunie and New Haven, Illinois, are in this area (fig. 2).

The fourth column of figure 1 shows the names applied in the fluorspar area of Hardin County, Illinois, and adjacent parts of Illinois and Kentucky by S. Weller (1920*b*, pl. 1), as modified by J. M. Weller and Sutton (1940, p. 766), and Atherton (1948, p. 129). Golconda, Illinois, is in this region (fig. 2).

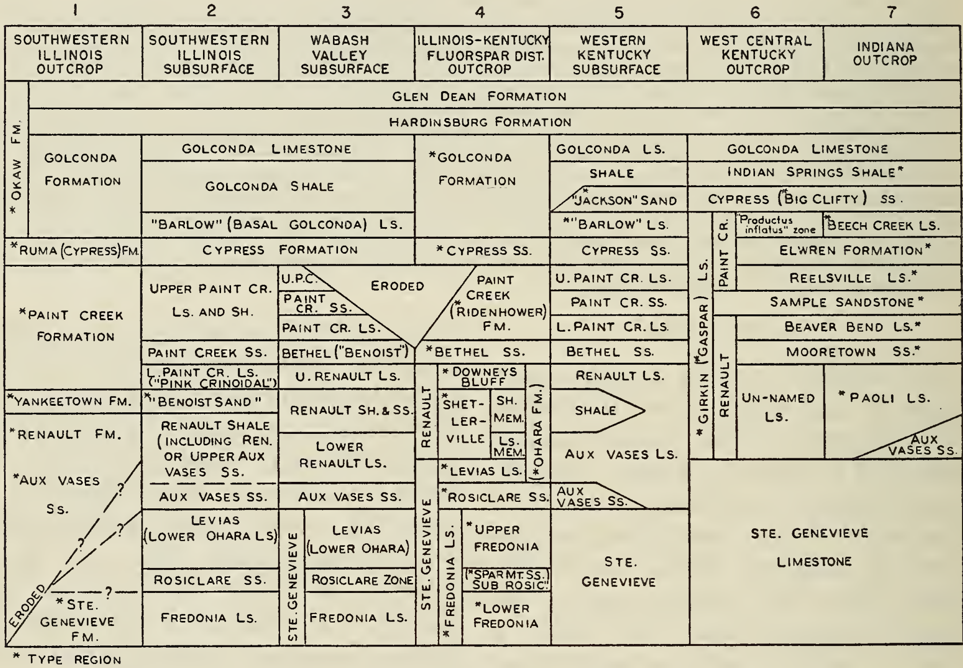


FIG. 1.—Correlation of middle Chester, lower Chester, and Genevieve strata in Eastern Interior Basin

The names currently applied in oil fields in Henderson and Daviess counties, Kentucky, are indicated in the fifth column of figure 1. Poole oil field (fig. 2) is near the heart of this area.

The sixth column is the outcrop section in west-central Kentucky given by Stouder (1941, p. 25), and the last column is the outcrop section in Indiana given by Malott (1931, p. 222 and 1946, pp. 322–326). Leavenworth, Indiana (fig.

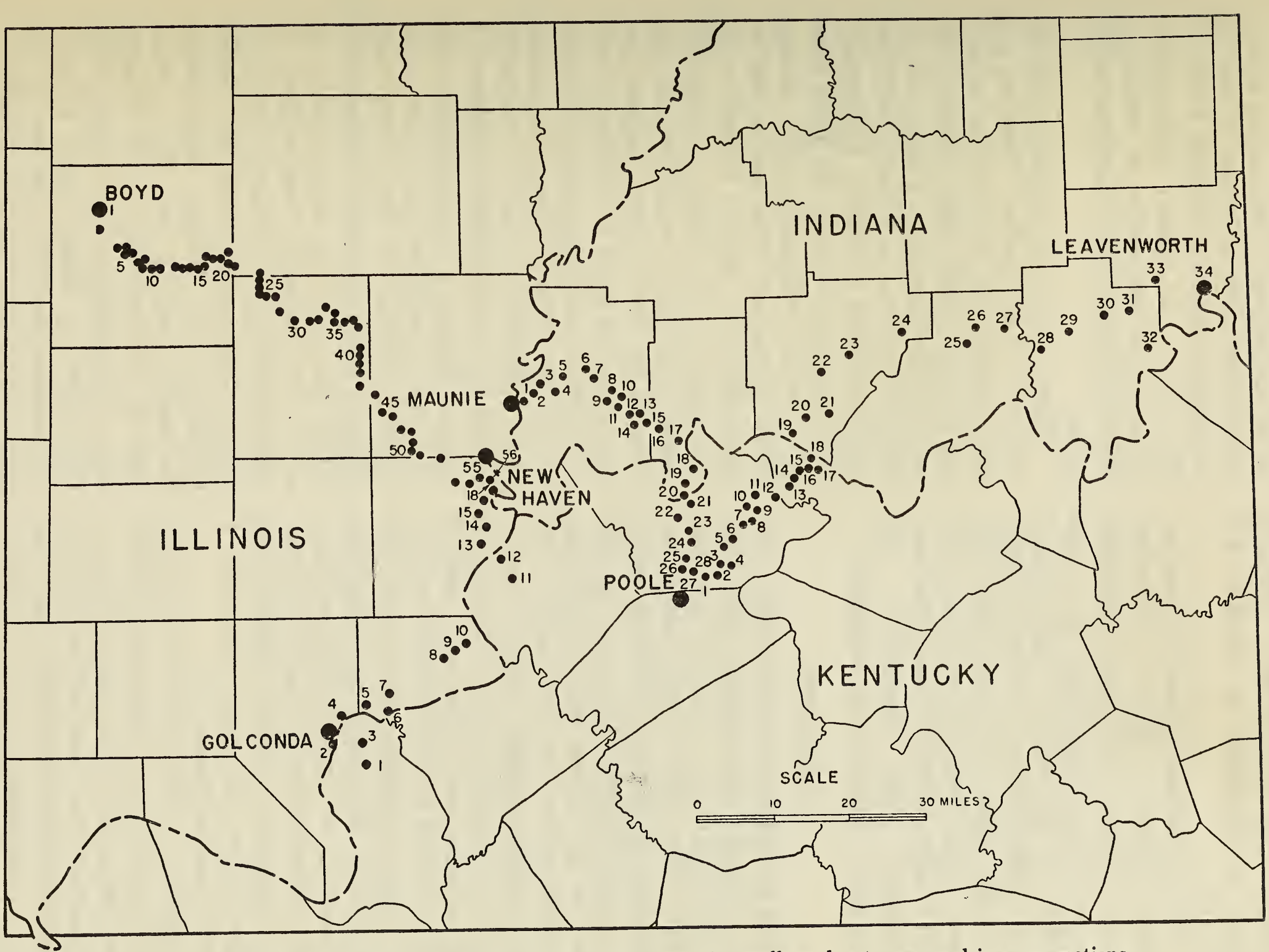


FIG. 2.—Index map of part of Eastern Interior Basin, showing wells and outcrops used in cross sections

2), lies in the outcrop belt of southern Indiana and west-central Kentucky which is described by Malott and Stouder.

The correlations between the first and second columns of figure 1—the southwestern Illinois outcrop and subsurface areas—are not represented by a cross section. As indicated by Tippie (1943), these correlations are commonly accepted in this region. They are further discussed in the stratigraphic section of this report under "Beech Creek limestone," "Downeys Bluff limestone," and " 'Benoist' (Yankeetown) sandstone."

CROSS SECTIONS

The geologic cross sections (figs. 3–6) pass through wells nowhere more than 11 miles apart and averaging less than 2 miles apart. Most sections were compiled from electric logs. Although only a few major lithologic types can be indicated on the figures, minor distinctions in lithology were used throughout the study to guard against errors in correlation between adjacent wells. The original cross sections were drawn on a vertical scale of 20 feet to 1 inch. Twelve to fourteen different physical types of rock were classified by their electrical characteristics, and the electric-log interpretations were checked by sample studies wherever there appeared to be any possibility of miscorrelation. All cross sections have a vertical exaggeration of 211.

Figures 3, 4, and 5 have been prepared by using the base of the Downeys Bluff limestone as the datum plane. Figure 3 substantiates the correlations indicated between the second and third columns of figure 1 and shows that the "Benoist" (Yankeetown) and the Bethel sandstones are not continuous. Figure 4 shows that the terminology used for the lower part of the stratigraphic section in the Wabash Valley oil fields is a full sedimentary cycle lower than that applied to the same beds in the outcrop area of southeastern Illinois. Figure 5 carries the correlation from the Wabash Valley to the heart of the western Kentucky oil fields across the barrier of continuous Bethel-Sample-Cypress sandstone deposition.

Figure 6 has been prepared with the Beech Creek or "Barlow" limestone as a datum plane. This has been done because the Downeys Bluff, which is readily distinguishable throughout Illinois and the adjacent portions of Indiana and Kentucky, becomes difficult to differentiate from the other beds of the Paoli limestone as the Indiana-Kentucky outcrop belt is approached. This cross section extends from the western Kentucky oil-field district to the Indiana outcrop belt, substantiating the correlations indicated between the fifth column and the last two columns of figure 1. The Beech Creek or "Barlow" limestone is shown to underlie the Big Clifty or Cypress sandstone of the Indiana section and to overlie the Illinois Cypress. The Bethel sandstone of western Kentucky is equivalent to the Mooretown sandstone rather than to the Sample sandstone of the outcrop belt. Figure 6 shows the entire Chester series rather than just the lower portion, as seen in the preceding cross sections. It indicates clearly the character of the pre-Pennsylvanian surface and the regular thinning of most Chester units toward the eastern outcrop belt. The correlations of the upper part of the Chester series demonstrated here agree with those given by Malott (1931, p. 222). The Indiana names for this part of the section have been virtually abandoned in favor of their western correlatives.

The logs of fluorspar tests[2] in Living-

[2] H. H. Cronk, superintendent of the Rosiclare Lead and Fluorspar Mining Company, and P. L. Richards, superintendent of the Inland Steel Com-

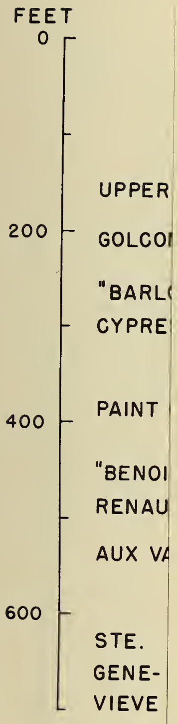


FIG. 3.—Cross sec

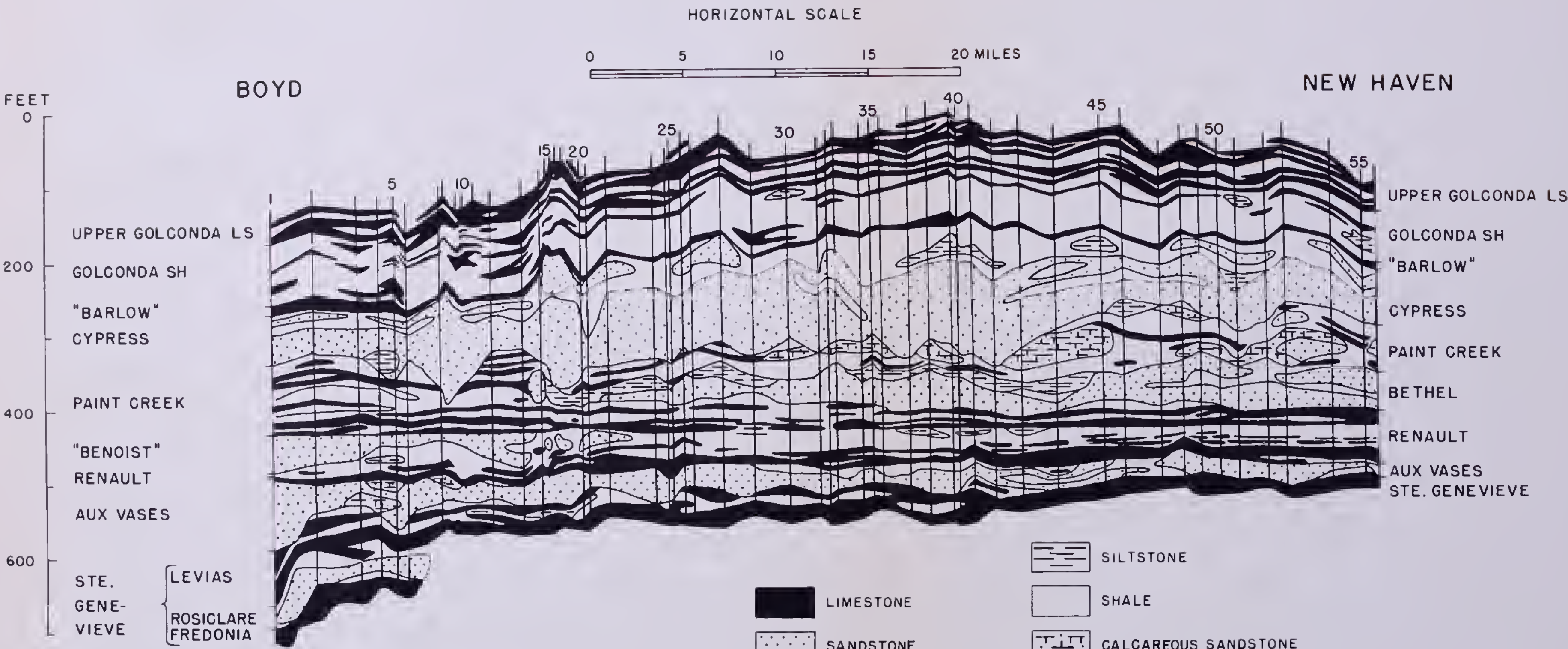


Fig. 3.—Cross section of lower Chester strata between oil fields of southwestern Illinois near Boyd and Wabash Valley oil fields near New Haven, Illinois (see fig. 1, cols. 2 and 3). Well lines omitted in congested portions

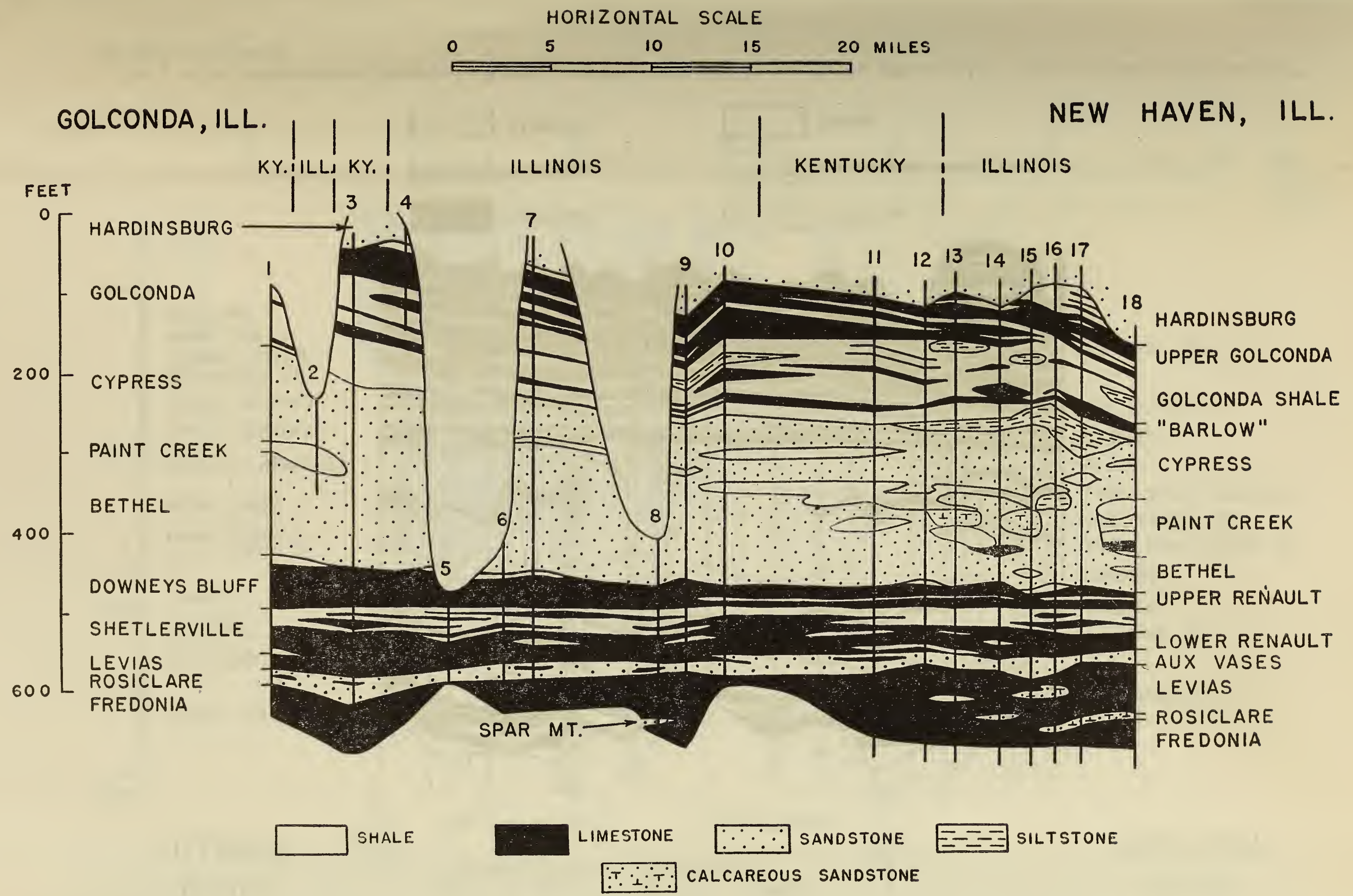


Fig. 4.—Cross section of lower Chester strata between outcrops in the Illinois-Kentucky fluorspar district near Golconda and the Wabash Valley oil fields near New Haven, Illinois (see fig. 1, cols. 4 and 3).

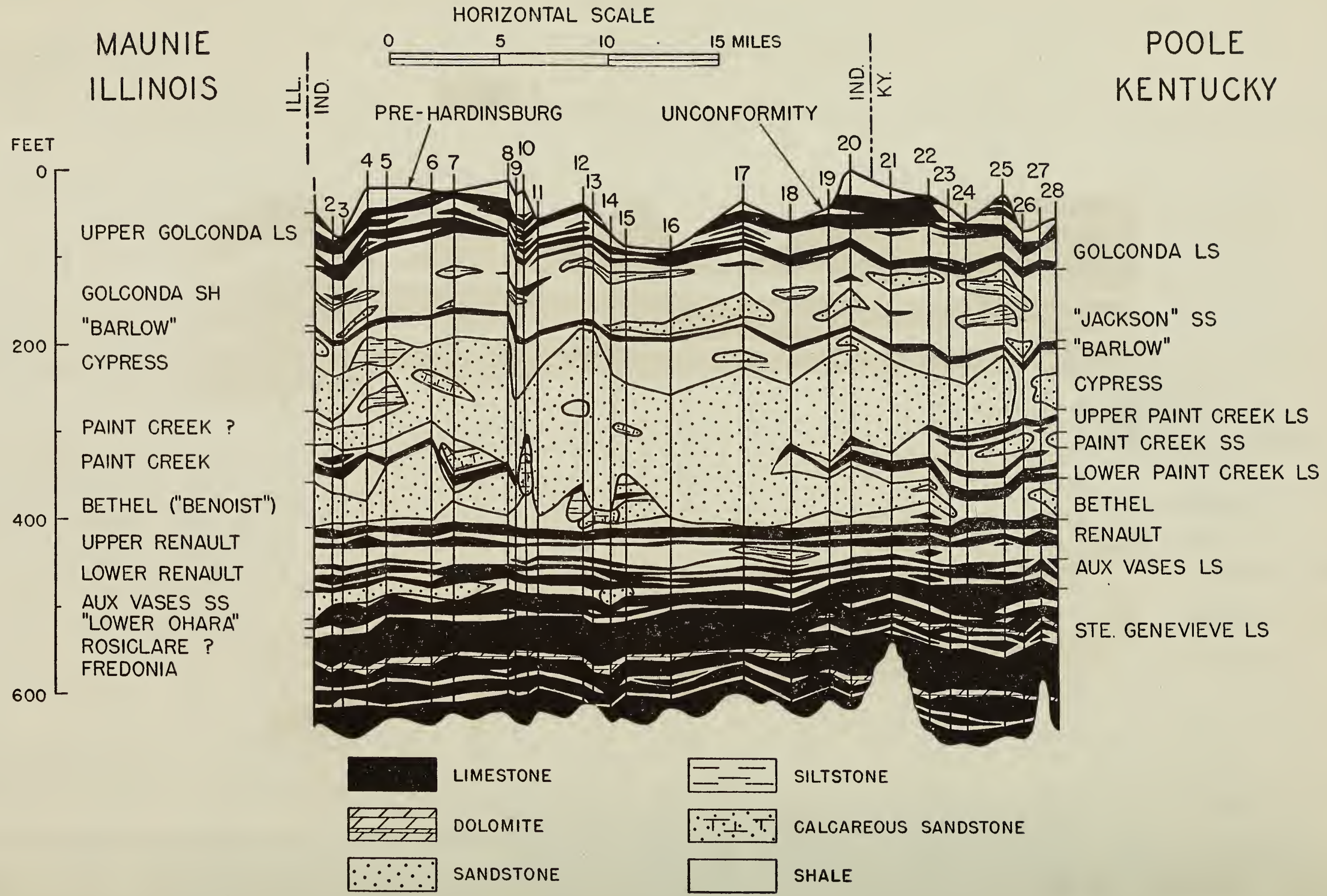
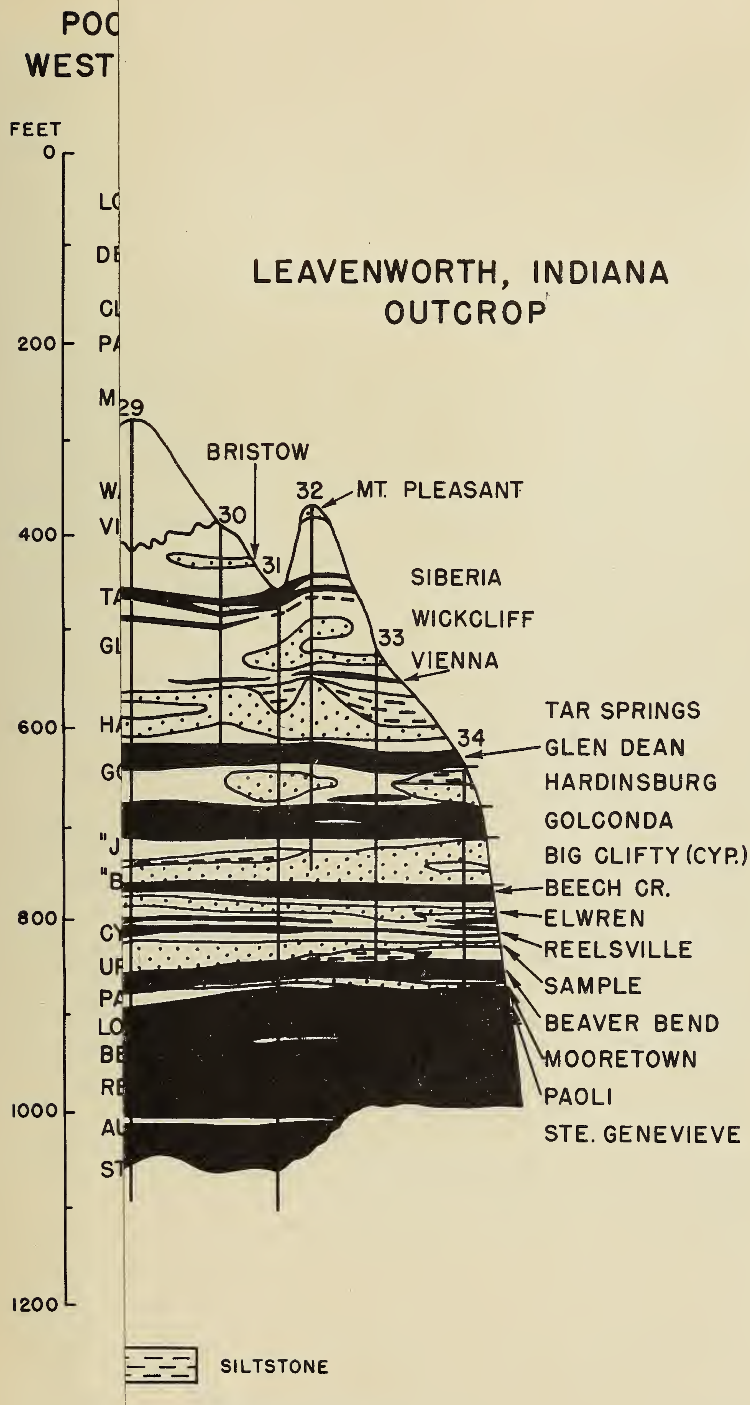


FIG. 5.—Cross section of lower Chester strata between the Wabash Valley oil fields near Maunie, Illinois, and the western Kentucky oil fields near Poole (see fig. 1, cols. 3 and 5).



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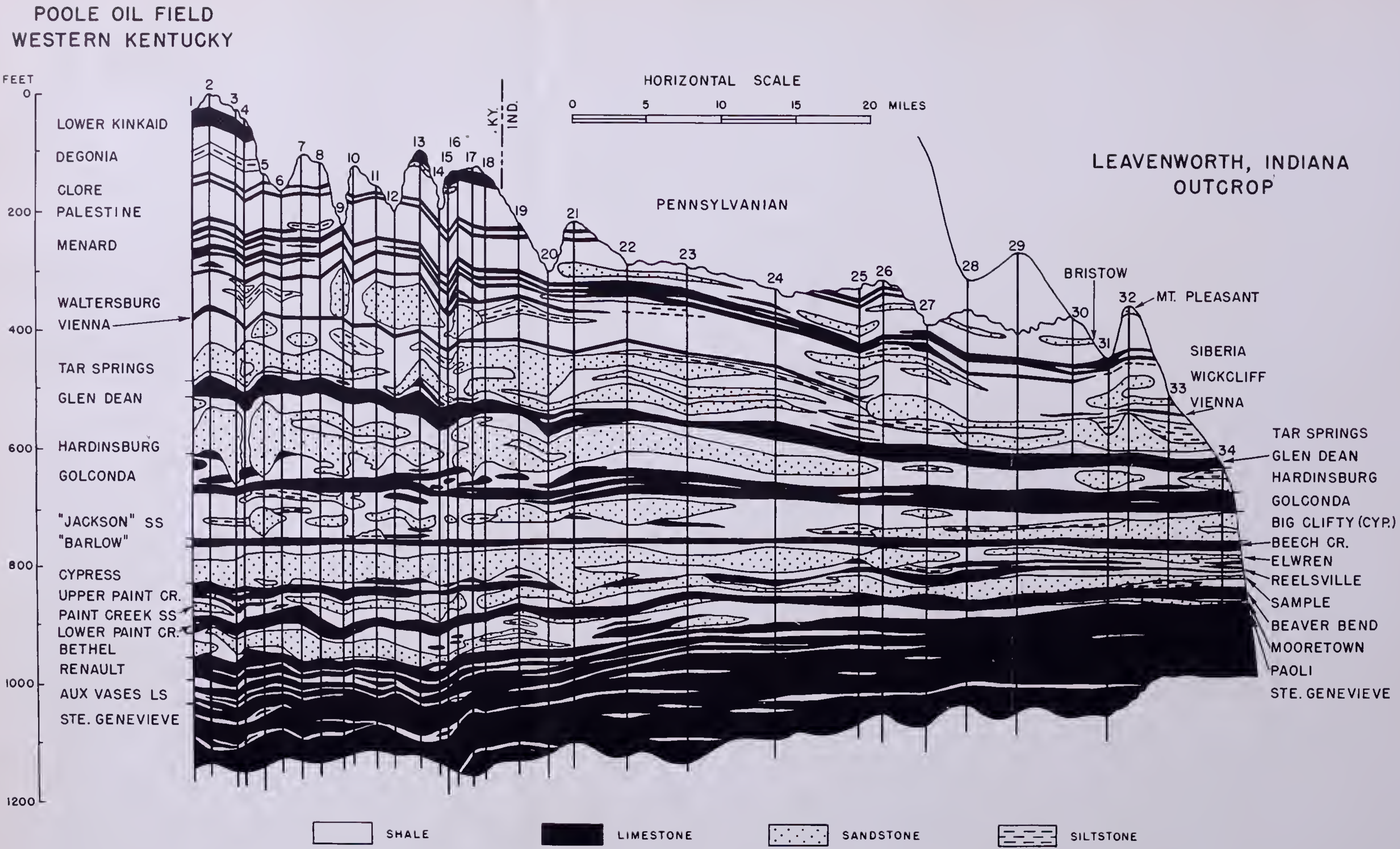

FIG. 6.—Cross section of Chester strata between western Kentucky oil fields near Poole and the Indiana-Kentucky outcrop belt at Leavenworth, Indiana (see fig. 1, cols. 5 and 7)

ston County, Kentucky, and Hardin County, Illinois, used in figure 4 are based on descriptions by Gill Montgomery of the Minerva Oil Company and by several members of the Illinois Geological Survey. Section 2 of figure 4 is that given by S. Weller (1920, p. 168); section 4 of this figure was measured by L. E. Workman and published by Atherton (1948, p. 128); sections 5 and 6 have been described in several publications on the stratigraphy of the fluorspar district; and log 8 was used by Tippie (1945, p. 1657). Logs 28 and 29 in figure 6 are given by Logan (1931, pp. 461, 466). Section 30 in figure 6 is from Malott (1925, p. 125). Sections 32, 33, and 34 were measured by Swann.[3] All other logs used in the cross sections are sample studies by Atherton, electric logs interpreted by Swann, or composite sample and electric logs.

STRATIGRAPHY

Inasmuch as there is general agreement in the correlation and nomenclature used within the Eastern Interior Basin for units above the Golconda formation, the uppermost formation which is considered here is the Hardinsburg sandstone which overlies the Golconda. Stratigraphic units are described in descending order. No attempt is made to place the units in formations, groups, or series, and the text headings are not intended to imply stratigraphic rank.

HARDINSBURG SANDSTONE

The Hardinsburg sandstone has its maximum development in an area extending from Hamilton and Lawrence counties, Illinois, on the northwest to the outcrop belt through Crittenden and Christian counties, Kentucky, on the south, and to Daviess County, Kentucky, on the east. In this area it lies unconformably on the Golconda formation. Local relief of the pre-Hardinsburg surface is as much as 60 feet in a few localities; channels 10–30 feet deep are quite common (figs. 4, 5, and 6). These narrow channels may be traced for only short distances and appear to die out at either end and do not seem to be connected into valley systems. The thickest known section of Hardinsburg (more than 200 feet) includes about 50 feet of sandstone filling such a channel. Within its region of greatest development the formation is typically 50–70 feet thick; but at a few localities in this same area only 20 feet of gray and varicolored shale with silty laminae separate the massive Glen Dean and Golconda limestones.

Most of the Hardinsburg formation consists of very fine and fine angular light-gray sandstone, greenish siltstone, and gray to black shale. These rocks are present in varying proportions and different successions in localities within a few hundred feet of each other. In the region of its maximum thickness the sandstone is separated from the overlying Glen Dean limestone at almost all localities by a few feet of greenish to dark-gray shale. This shale above the Hardinsburg and below the massive limestone beds of the Glen Dean becomes varicolored and contains dolomite and limestone lenticles as it is traced away from the region of thick Hardinsburg. Within the general region of thick Hardinsburg there are many disconnected areas in which soft gray and greenish shales as much as 30 feet thick, containing occasional red streaks and brown sublithographic dolomite lenses, lie between undisputed Hardinsburg sand-

pany, Fluorspar Division, kindly released the information on which composite log 7 in fig. 4 is based. J. H. Steinmesh, president of Minerva Oil Company, kindly released logs 1, 3, 9, and 10 of fig. 4.

[3] Field notes, 1947.

stone and massive Golconda limestone (figs. 4, 5, and 6). To the west, north, and northeast this shale becomes more persistent and includes more dolomite and more red, green, and purplish shales. In these peripheral areas this lower shale is overlain in apparent conformity by the feather edge of the typical Hardinsburg sandstone-siltstone–dark-shale unit. In the parts of the Illinois Basin farthest from the Hardinsburg center, the sandy facies is not developed and the massive Glen Dean and Golconda limestones are separated by only 12–40 feet of varicolored shales containing dolomite and occasional limestone lenses. The sandstone-siltstone–dark-shale unit extends to the outcrop along the southern and eastern margins of the basin, but, in general, only varicolored shale is present at the western, northern, and northeastern borders.

The general practice among oil companies is to place the boundaries of the Hardinsburg formation at the base of the massive Glen Dean limestone and at the top of massive thick-bedded, light-colored oölitic or crystalline limestone of Golconda age, thus including the varicolored shales and brownish dolomites as well as the sandy phase in the Hardinsburg formation (Dana and Scobey, 1941, p. 876). The formation boundaries as thus designated are probably contemporaneous over most or all of the basin and follow horizons which can be identified consistently both in the area of maximum development where channel cutouts occur and in the peripheral areas of apparent conformity. If this practice is followed, the episode or episodes of channel-cutting are placed in the middle rather than at the beginning of Hardinsburg time, since it is apparent that the unconformable surface lies above both the shale-and-dolomite facies and the massive Golconda limestone.

If the name "Hardinsburg" is restricted to the sandy facies (and this has historical precedence), the time of channel-cutting is placed at or near the beginning of Hardinsburg time, and the formation name is limited to genetically related lithologies. Varicolored shale above the sandy phase of the Hardinsburg was originally placed in the Glen Dean formation (Butts, 1917, p. 97). Because it weathers readily, the shale beneath the Hardinsburg sandstone rarely crops out; sandy strata have been reported to rest directly on massive Golconda limestone wherever the contact is visible. The Illinois Geological Survey places this lower shale-and-dolomite zone in the Golconda formation (Workman, 1940, p. 816; Folk and Swann, 1946, p. 11), though it is recognized that the boundaries of the sandstone facies to which the name "Hardinsburg" is thus restricted may not be contemporaneous throughout the basin.

The Hardinsburg has been described in detail because it presents a number of features common to the lower sandstone units in the Chester and the Ste. Genevieve strata. In the lower beds these features are in part obscured and there are disagreements concerning correlation, whereas in the Hardinsburg there is no correlation problem. In those areas in which the Chester sandstones are coarsest and thickest, they rest on conspicuous surfaces of unconformity which are clean and not deeply weathered and in which valley systems have not been noted. Surrounding these areas are belts in which the sandstones are thinner and finer and lie with apparent conformity between shale beds, many of which are in part red, green, and purple. Still farther from the areas of maximum thickness, the sandstones are replaced entirely by shales, which may be fossiliferous and contain limestone or dolomite beds.

GOLCONDA FORMATION, UPPER SHALE AND LIMESTONE

At the top of the Golconda formation is the unnamed, gray, green, and red shale interbedded with thin lithographic dolomite, which has been described in the preceding section.

Underlying the unnamed shale unit, or in direct contact with the Hardinsburg sandstone, where the shale has been removed by pre-Hardinsburg erosion, is a prominent limestone, generally called "the Golconda lime" and more specifically described as "the massive upper Golconda limestone" by petroleum geologists. It is equivalent to the entire Golconda formation as recognized in the outcrops of Indiana and west-central Kentucky but to only a part of the formation as recognized in the type area in southern Illinois and in western Kentucky. White, light-gray, and light-tan crystalline or crinoidal limestone and dolomitic limestone, gray to tan oölitic limestone, and gray shaly limestone predominate. Oölitic beds are common in the western part and cherty limestones in the eastern part of the basin. In some localities this member is nearly all limestone, but within a short distance it may grade to 50 per cent or more gray shale. It is 40–50 feet thick in the south-central part of the basin, and it thins slightly but retains its essential limestone character to the eastern and western outcrops. It thins markedly toward the north and becomes very shaly, so that, at its northernmost subsurface occurrences, it can hardly be distinguished from the underlying Indian Springs shale.

INDIAN SPRINGS SHALE

Underlying the massive upper Golconda limestone in the central parts of the Eastern Interior Basin is a third member of the Golconda, a shale 60–100 feet thick, containing minor amounts of limestone, siltstone, and sandstone. The unit is commonly known only as "the Golconda shale," but a representative of the upper part has been named the "Indian Springs shale." The most common rock in this unit is a weak gray shale which weathers readily to a light-colored or olive mud in outcrops and which caves badly in well borings. Red shale is common toward the top of this zone. Siltstones occur at several levels in southernmost Illinois but farther north are confined to the middle and lower portions. They do not occur in western Illinois. Several types of limestone occur in thin beds or lenses that increase in number and importance from eastern to western Illinois. In the west a 5–15-foot bed of red and yellow mottled, fossiliferous, crystalline limestone is a persistent marker near the middle of the member. The upper portion of this shale becomes so limy at the western edge of the Illinois Basin that its contact with the overlying limestone member is obscure.

In Indiana and Kentucky there is very little limestone in this shale unit, and the lower part is replaced by the sandstone known locally as "Jackson" in the subsurface and "Cypress" on the outcrop, described below as the "Big Clifty sandstone." The upper portion of the shale unit extends over the Big Clifty to the Indiana outcrop belt, where it has been named the "Indian Springs shale" by Malott and Thompson (1920, p. 521).

BIG CLIFTY SANDSTONE

Sandstone lenses occur sporadically in the lower part of the Golconda (Indian Springs) shale as far west as Marion County, Illinois, 60 miles from the Wabash River. The lenses are rather uncommon in Illinois, but eastward they are more abundant and coalesce into a continuous sandstone unit which apparently has its maximum thickness in a belt extending through eastern Gibson County, Indiana, and Daviess County, Kentucky. There are places in this area at which the sandstone is more than 100 feet thick and lies on an unconformable surface which cuts into and even through the Beech Creek limestone. This is the most continuous and most prominent sandstone in the lower and middle Chester of the Indiana and central Kentucky outcrop belt. Its maximum outcrop thickness, 55–70 feet, is in Hardin, Breckinridge, and Grayson counties, Kentucky, where it caps the Dripping Springs escarpment (Stouder, 1941, p. 48). The name "Big Clifty" was applied to this sandstone in this area by Norwood (1876, p. 369). The name has been little used because this prominent sandstone has generally been considered equivalent to the Cypress sandstone, which had been previously named in southern Illinois. Northeast of a line extending approximately from Shawneetown, Illinois, through Dixon and Greenville, Kentucky, the Big Clifty is separated from the true Cypress by a sheet of Beech Creek ("Barlow") limestone, continuous except for very narrow channels from which it was removed by pre–Big Clifty erosion. Southwest of this line along the outcrop belt through Christian and Caldwell counties, Kentucky, the Big Clifty may lie directly on the true Cypress. It seems likely that even in this area there may be scattered remnants of the Beech Creek separating the two sandstones, as was suggested by Ulrich (1917, p. 94).

BEECH CREEK ("BARLOW") LIMESTONE

A thin, but widespread and readily recognized, limestone is the basal unit of the Golconda formation and has been named the "Barlow" line in the subsurface section of Kentucky. It is a dark-brown to dark-gray limestone which in many localities is mottled. Scattered sand grains and very dark-colored limestone granules are common; in some localities there are true oölites. The limestone is commonly very fossiliferous. It contains a diverse fauna in which small brachiopods and mollusks predominate. Polished sections of cores show numerous small gastropods, but the compact matrix makes the fauna difficult to identify. Other types of limestone may be a associated with the dark-colored dense bed, in most cases overlying it.

The "Barlow" line extends across the basin from east to west, appearing in the lower part of the Okaw limestone in southwestern Illinois and as the Beech Creek limestone of Indiana. Unlike other Chester limestones, it thickens consistently toward the north. In the lower Wabash Valley its thickness averages about 8 feet, but it is 20–30 feet thick in the northernmost parts of the basin, where it is by far the most prominent Chester limestone.

The "Barlow" thins southward until it cannot be recognized in many wells in southern Webster and Hopkins counties, Kentucky, or in Saline, Williamson, and even Franklin counties, Illinois. It is present in possibly half the diamond-drill cores from the Illinois-Kentucky fluorspar district as described by trained geologists familiar with its appearance. It is seldom noted in other types of subsurface records from this area and has not been recognized in the poorly exposed outcrops of the lower Golconda shales. In the diamond-drill core used for log 1 of figure 4 it is represented by less than 3 feet of dark, very shaly limestone.

The light-colored, coarsely crystalline limestone containing large crinoid stems which forms approximately the upper three-fourths of the Beech Creek limestone of Indiana can be traced for some distance as the upper portion of the "Barlow," but it is much less persistent than the dark-brown basal portion.

The base of the "Barlow" is the most widely used horizon for contour maps of Illinois Basin areas. It is now generally considered the base of the Golconda formation.

CYPRESS SANDSTONE

The Cypress sandstone has its greatest thickness in the south-central part of the Illinois Basin, where it may be more than 200 feet thick. Because in this area it rests on other similar sandstones, its true thickness may never be known. It is predominantly white fine- to medium-grained sandstone and gray siltstone and shale. One or two thin coal beds occur sporadically near the top of the formation. Lateral changes from sandstone to shale are very common. The top part, 30–50 feet thick, is commonly more shaly than the lower part of the formation, but beds of sand may occur at any position up to the very top. A zone of red and green shale and green siltstone occurs at the top of the Cypress throughout a wide belt surrounding the region of greatest thickness. Along the extreme eastern and western borders of the basin the entire unit may be replaced with varicolored shale. Although the uppermost shale zone has been placed in the Golconda formation (Brokaw, 1916, pl. 1; Workman, 1940, p. 216), the current tendency is to include it with the Cypress, as it is commonly interbedded with thin sandstone beds. The varicolored shales equivalent to the true Cypress have been named "Ruma" (S. Weller, 1913, p. 126) in southwestern Illinois and "Elwren" (Malott, 1919, p. 11) in Indiana. The Cypress rests unconformably on lower formations, except possibly in the most northern and eastern parts of the basin.

PAINT CREEK (RIDENHOWER) FORMATION

Approximately midway between the persistent Beech Creek ("Barlow") limestone and the equally persistent Downeys Bluff limestone, there occurs a discontinuous zone which is composed of diverse rock types and has a maximum thickness of 100 feet. This zone has been described as three formations—the Reelsville limestone, Sample sandstone, and Beaver Bend limestone in Indiana (Malott, 1919, pp. 9–11); as a single formation—the Ridenhower shale in southeastern Illinois (Butts, 1917, p. 73); and as part of the Paint Creek formation in southwestern Illinois. Although single units within this zone may be traced a number of miles, it is difficult to characterize the zone as a whole. Several factors have shared in producing the complex stratigraphy of this zone. Pre-Cypress erosion removed the zone entirely in some localities and reduced its thickness in many areas. The Cypress sediments deposited on the eroded surface are, in some places, similar to the beds removed. There is at least one pronounced unconformity within the zone. Rapid lateral and vertical changes in deposition can be demonstrated in a number of single outcrops.

There is a belt 10–20 miles wide extending north-northeast from the vicinity of Marion and Uniontown, Kentucky, toward Washington, Indiana, in which the entire column between the "Barlow" and the Downeys Bluff is occupied by sandstone (fig. 5). It is probable that the Indiana classification of three units can be followed rather consistently between the east side of this belt and the region in south-central Kentucky where all clastics disappear from the section. Available data from the belt of thick sandstone do not show any clear break between the pre-Cypress unconformity and the base of the Bethel, so it is not certain that both Bethel and Sample sandstones are present, although this seems probable. It also is not evident whether the Beaver Bend and Reelsville limestones were deposited and later eroded from this area or were never deposited here.

In the subsurface section of Illinois west of the continuous sandstone belt, the application of a threefold division of the Paint Creek above the Bethel is much more difficult than in Kentucky and Indiana. The division is suggested in some logs shown in figure 3. Certain geologists who have studied intensively the area north of logs 30–50 of this section recognize beneath the pre-Cypress unconformity a "gray limestone" (Reelsville?) which has generally been removed by erosion, a shale and micaceous sandstone zone (Sample?), a "yellow limestone" (Beaver Bend?), a blastoidal shale, and the Bethel. The unconformity cuts across all these strata, so that the Cypress may rest directly on the Bethel. The writers are unable to distinguish these zones in their work in Lawrence and Edwards counties, Illinois; therefore, they recognize only a single zone, which consists primarily of dark greenish-gray shale with variable proportions of fine-grained calcareous sandstone and sandy fossiliferous, partly oölitic limestone. In western Illinois this zone becomes more calcareous and is represented in the Paint Creek outcrop belt by as much as 50 feet of limestone.

BETHEL SANDSTONE

The Bethel sandstone has its greatest thickness east of the area of maximum Cypress sandstone, locally measuring 100 feet or more. It contains some quartz-pebble conglomerate, but the formation usually consists of more or less calcareous light-gray, very fine to fine-grained sandstone with some medium-grained sandstone. Dark-gray to green shale containing laminae of siltstone is quite common. The type locality near Marion, Crittenden County, Kentucky, is probably within the belt of continuous Bethel-Cypress or Bethel-Sample-Cypress sandstone described above (Butts, 1917, p. 63; 1929, p. 46).

To the north and west of the area of maximum thickness the formation becomes thinner, more shaly, more calcareous, and fossiliferous. The writers know of only a single outcrop of the Bethel in southwestern Illinois. It is a calcareous fossiliferous sandstone a few feet above the deep-red nonlaminated shale member of the Paint Creek formation in the NE. corner of the SE.$\frac{1}{4}$ and NE.$\frac{1}{4}$ of Sec. 23, T. 5 S., R. 9 W., about 2 miles east of Prairie du Rocher, Randolph County. This locality was noted by Stuart Weller in his report on the "Geology of Parts of Monroe and Randolph Counties."[4] In the rest of the southwestern Illinois outcrop area the position of the Bethel is occupied by varicolored calcareous shales that in some localities are highly fossiliferous.

The sandstone phase of the Bethel continues to the eastern outcrop, where it is known as the "Mooretown sandstone" (Cumings, 1922, p. 515) and includes thin but persistent coal streaks overlain by a few feet of dark-gray shale. The "limestone" indicated in the Bethel position in log 22 of figure 6 is probably calcareous sandstone; several sandstones in this well had abnormally high apparent resistivity, and samples were not available for comparison. As is true with most Chester sandstone units, the Bethel is recognized by its relation to the as-

[4] Illinois Geological Survey, unpublished manuscript.

sociated limestone beds rather than by any inherent characteristics.

DOWNEYS BLUFF LIMESTONE

A persistent limestone which is useful in correlating lower Chester beds has been named the "Downeys Bluff" by F. E. Tippie (Atherton, 1948, p. 129). The type locality is in the Ohio River bluff at Rosiclare, where the limestone underlies the Bethel sandstone and overlies the Shetlerville limestone and shale. In southwestern Illinois these beds consist of bluish calcareous shales with platy, fine-grained limestone layers lying between the deep-red nonlaminated shale member of the Paint Creek and the Yankeetown chert. This zone was described by S. Weller (1913, p. 125; 1920*a*, p. 294) as the basal member of the Paint Creek formation. Two other kinds of rock are found in this zone in the western outcrop belt. One is a yellowish, crystalline, crinoidal limestone. The other is a characteristic light-gray, coarsely crystalline, fossiliferous, and somewhat sandy limestone in which numerous blastoid and crinoid plates are in part replaced by a bright-pink or salmon-colored chert. Replacement of colored crinoid plates by pink or red chert is not known in other lower Chester formations. The gray limestone with pink chert fossils can be seen in the outcrops along a branch of Carr Creek in the NE.¼, Sec. 33, T. 1 S., R. 10 W., about 2 miles south of Columbia, Monroe County, Illinois. It is recognized throughout the subsurface section of southwestern and south-central Illinois, and the entire Downeys Bluff is known by the informal name "Pink Crinoidal" throughout Illinois. In eastern Illinois the bulk of the Downeys Bluff is a light-brown to gray crinoidal limestone, the upper part cherty and the lower part slightly sandy. Pink to red chert is reported in some wells in eastern Illinois and even in Indiana (Dana and Scobey, 1941, p. 879). Throughout most of eastern Illinois and western Kentucky and Indiana the Downeys Bluff may be recognized by a very characteristic double-peaked resistivity curve on the electric log. The saddle has been interpreted in figures 5 and 6 as a thin shale, although it may be an argillaceous limestone. The Downeys Bluff is represented in the Indiana outcrop by the upper part of the Paoli limestone.

"BENOIST" (YANKEETOWN) SANDSTONE

All the sandstones considered so far are prominent beds in the eastern or south-central parts of the Eastern Interior Basin; on the southwestern Illinois outcrop they are represented by, at most, a few feet of impure sandstone. In contrast, Chester and Ste. Genevieve sandstones below the Downeys Bluff limestone (with a possible minor exception) are best displayed near the western margin of the basin.

The uppermost of these western sandstones has been named the "Benoist" sandstone in Sandoval oil field, Marion County, Illinois, about 15 miles north of Boyd. The stratigraphic section at Sandoval is very similar to that shown in figure 3, log 1. In this area the "Benoist" is separated from the "Pink Crinoidal" or Downeys Bluff limestone by a very few feet of green shale. Continuous cores show that immediately above or interbedded in the top foot or two of the "Benoist" are thin beds (nodules?) of a brown siliceous limestone, which grades into, or is replaced by, chert. Westward this zone at the top of the "Benoist" can be traced into at least some of the outcrops of the Yankeetown chert (Tippie, 1943, p. 141). Swann agrees with Weller and Sutton (1940, p. 826, ftn. 19) that the Yankeetown includes residual chert from several horizons, and therefore he hesitates to apply the outcrop term to the sandstone. The "Benoist" is typically 40–60 feet thick where best developed, but it rests directly on continuous Renault or Aux Vases sandstone in many localities where its true thickness cannot be determined.

Eastward from its area of maximum thickness the "Benoist" thins rapidly, and in easternmost Illinois it consists only of about 20 feet of dark-gray, green, and red shale, in the upper part of which occur lenses of calcareous light-gray, red, or greenish fine-grained sandstone or siltstone. The lower part of this shale is interbedded with layers of brownish-gray argillaceous, fossiliferous limestone and grades downward into the main body of Shetlerville limestone. The entire sequence was named the "Shetlerville formation" by S. Weller (1920*a*, p. 290), and the shale and the sandstone are now called "Middle Renault" by most operators in the Wabash Valley oil fields. East of the Wabash the sandstone is absent. Its position is indicated by 2–3 feet of fossiliferous shale near the middle of the Paoli limestone at the more northern of the Indiana outcrops; but even this shale is lacking in the southernmost Indiana and Kentucky occurrences of the Paoli.

SHETLERVILLE LIMESTONE

The lower portion of the Shetlerville formation is predominantly limestone, grayish-brown in color, oölitic, fossiliferous, argillaceous, and in many places sandy. Oölites with dark centers are common; and red, pink, olive, and yellow oölites occur. The Shetlerville in Illinois is quite impure, as is indicated by the insoluble residues described by Tippie (1944, p. 157); but it apparently becomes purer in Indiana and Kentucky, where it forms the lower portion of the Paoli limestone. It makes up the bulk of the "Lower Renault" limestone of the oil fields in the deeper part of the basin.

LEVIAS LIMESTONE

The Levias limestone of the fluorspar district is a high-purity oölitic or crinoidal limestone containing coarse pink crinoid fragments and, at its base, minor amounts of sand. It may be traced northward from the outcrop to Lawrence County, Illinois, as a thin, light-gray or pink oölite at the base of the "Lower Renault" (Shetlerville) limestone. It is not known to be more than 15 feet thick in the subsurface of the basin and is absent from many localities. As this bed contains columnals of *Platycrinus penicillus* in the outcrop area, it is placed in the Ste. Genevieve formation. However, it overlies a continuous sandstone horizon which can be traced north and west to a point where nearly 200 feet of sandstone and shale are present beneath what appears to be the position of the type Levias (figs. 3 and 4).

ROSICLARE ("BASIN AUX VASES") SANDSTONE

The Rosiclare sandstone of the fluorspar outcrop district of southeastern Illinois and western Kentucky is an extremely fine-grained sandstone which approaches siltstone in grain size. It continues to the north with similar lithology and is productive in many oil fields in Hamilton, Wayne, and White counties in southeastern Illinois, where it is called the "Aux Vases" sandstone. It is sometimes distinguished from the coarser-grained sandstones of western Illinois by the title "basin Aux Vases." Because of its fine grain size and resultant high connate water retention, it is characterized by abnormally low electrical resistivity

TABLE 1

Wells Used in Cross Section between Boyd Oil Field, Jefferson County Illinois, and the Vicinity of New Haven in the Wabash Valley (Fig. 3)

Index No.	State, County (Illinois)	Operator	No. and Farm	Spot or Footage	Sec., T., R.
1	Jefferson	D. Schwab *et al.*	1 Hutchings-Haldorson	NE. SE. NW.	36-1S.-1E.
2	Jefferson	T. B. Dirickson	1 Miller	NE. NE. NE.	18-2S.-2E.
3	Jefferson	E. J. Ruwaldt	1 W. J. Hynes	NW. SW. NW.	28-2S.-2E.
4	Jefferson	A. W. Gerson	1 W. B. Horton	SE. SE. NW.	27-2S.-2E.
5	Jefferson	Magnolia Pet. Co.	1 Bullock Unit	NW. NW. SE.	34-2S.-2E.
6	Jefferson	H. H. Wegener	1 Grant Comm.	W. NW. SE.	35-2S.-2E.
7	Jefferson	N. Redwine	2 Howard-Casey	SE. NE.	6-3S.-3E.
8	Jefferson	N. Redwine	1 K. Gee	NE. SW. SE.	6-3S.-3E.
9	Jefferson	Magnolia Pet. Co.	1 Badgett	NE. NW. SE.	7-3S.-3E.
10	Jefferson	Magnolia Pet. Co.	1 Daniels Unit	SW. SW. SW.	8-3S.-3E.
11	Jefferson	W. I. Lewis	1 Schul	SE. SE. NW.	9-3S.-3E.
12	Jefferson	Texas Co.	1 N. Cowger	NW. NW. NW.	11-3S.-3E.
13	Jefferson	J. V. Canterbury	1 L. S. Kent	NW. NE. SE.	12-3S.-3E.
14	Jefferson	Canterbury & Gill	1 R. Ross	SE. SE. SE.	7-3S.-4E.
15	Jefferson	Phillips-Gussman	1 R. E. Sheppard	C. SE. SE.	8-3S.-4E.
16	Jefferson	B. Martin *et al.*	1 Rittermeyer	SE. SW. NE.	9-3S.-4E.
17	Jefferson	C. E. Brehm	1 Burnett-Shelton Comm.	SE. SW. SW.	3-3S.-4E.
18	Jefferson	Gulf Refining Co.	1 Homer	SW. SE. NW.	3-3S.-4E.
19	Jefferson	Kewanee Oil & Gas	2 Derringer	N. NE. SE.	2-3S.-4E.
20	Jefferson	Tidewater Assoc. Oil Co.	"B"-1 Newton Investment Co.	N. NE. SW.	1-3S.-4E.
21	Jefferson	Magnolia Pet. Co.	1 F. R. Johnson	N. NE. SE.	1-3S.-4E.
22	Wayne	Lario Oil & Gas	1 R. Dodge	E. NE. NE.	7-3S.-5E.
23	Wayne	C. Crosby & Witt	1 Murphy	E. SW. NE.	15-3S.-5E.
24	Hamilton	Seaboard	1 G. Knapp	N. SW. SW.	22-3S.-5E.
25	Hamilton	Seaboard	2 D. Garrison	N. SW. NW.	27-3S.-5E.
26	Hamilton	Gulf Refining Co.	1 F. Zellers	SE. NW. SE.	27-3S.-5E.
27	Hamilton	Exchange Oil Co.	"A"-1 E. Silliman	SW. NW. NW.	35-3S.-5E.
28	Hamilton	Oil Carriers	1 T. Rose	SW. NE. SE.	36-3S.-5E.
29	Hamilton	Magnolia Pet. Co.	"A"-1 Kaufman	SE. SE. NW.	7-4S.-6E.
30	Hamilton	Magnolia Pet. Co.	1 Haas (Heil)	NW. NW. SW.	16-4S.-6E.
31	Hamilton	Oil Management *et al.*	1 Leach & Gilpin	C. SW. NE.	14-4S.-6E.
32	Hamilton	Phillips Pet. Co.	1 Holla	NW. NW. NE.	13-4S.-6E.
33	Hamilton	Phillips Pet. Co.	1 Wilma	SE. SW. NW.	7-4S.-7E.
34	Hamilton	Texas Co.	3 Flannigan	NE. SE. SW.	17-4S.-7E.
35	Hamilton	Texas Co.	2 Minton Comm.	SW. NE. NE.	20-4S.-7E.
36	Hamilton	Texas Co.	3 S. Minton	NE. NW. SW.	21-4S.-7E.
37	Hamilton	Oldfield & Spires	2 York	NE. SE. SE.	22-4S.-7E.
38	Hamilton	Oil Management *et al.*	1 J. Keith	NW. NW. SE.	26-4S.-7E.
39	Hamilton	Kingwood Oil Co.	1 Swadier	NE. NW. SE.	2-5S.-7E.
40	Hamilton	Kingwood Oil Co.	1 McGuire	W. SW. NW.	11-5S.-7E.
41	Hamilton	Lomelino & Williamson	1 Biggerstaff	NE. SE. NW.	14-5S.-7E.
42	Hamilton	T. Harvey	1 Wilson	NE. SE. SW.	23-5S.-7E.
43	Hamilton	B. M. Heath	1 Klemm Heirs	C. NE. SE.	35-5S.-7E.
44	White	National Assoc. Pet. Co.	1 A. Dalby	SE. SW. NE.	6-6S.-8E.
45	White	Gossett & Swensen	1 Justice	SE. NW. NE.	20-6S.-8E.
46	White	Luttrell	1 T. Aud	NE. NE. SE.	21-6S.-8E.
47	White	J. Reznik	1 Mills	NE. SW. NW.	35-6S.-8E.
48	White	Sinclair-Wyoming	1 A. Cobbell	SW. SW. SW.	36-6S.-8E.
49	White	Gulf Refining Co.	1 J. Moore	SW. SW. NW.	12-7S.-8E.
50	White	Kingwood Oil Co.	1 P. Martin	NW. SW. NE.	13-7S.-8E.
51	White	Sinclair-Wyoming Oil Co.	1 C. E. Wilson	SW. NE. SE.	18-7S.-9E.
52	Gallatin	Skelly *et al.*	1 H. H. Hale	NE. NE. NE.	21-7S.-9E.
53	Gallatin	Murphy Oil *et al.*	1 Spence	N. NE. NW.	33-7S.-9E.
54	Gallatin	N. V. Duncan	1 Greer	SE. SE. SE.	35-7S.-9E.
55	Gallatin	R. L. Kinkaid	1 A. B. Schmidt	NE. NE. NW.	33-7S.-10E.
56	Gallatin	Hageman & Pond	1 Stofleth-Cokes	NE. NE. NW.	34-7S.-10E.

for Illinois Basin sandstones. This electrical characteristic is indicated both on logs run in the basin and on a log run on a typical fluorspar exploration hole in Hardin County, Illinois. The sandstone is calcareous and variable in color; red sandstone is common where the formation is not productive, but the productive sand is very light colored, nearly white.

The Rosiclare shows considerable lateral changes within a very short distance and includes numerous lithologic types —siltstone, shale, sandy limestone, and dolomite—in addition to sandstone. Some sandstone beds contain very small, light-brown, round limestone grains and grade laterally to sandy oölitic limestone. Hematite-ringed oölites are characteristic of the zone, and a basal detrital conglomerate is present at many points. The Rosiclare ("basin Aux Vases") sandstone of southeastern Illinois appears, at least superficially, to grade imperceptibly into the thicker and coarser Aux Vases sandstone of the oil fields on the western flank of the basin, as is indicated by figure 3. The possibility of a transgressive overlap of western coarse-grained Aux Vases sandstone on eastern fine-grained "basin Aux Vases" is recognized; but the evidence supporting this interpretation is not conclusive, and further study is necessary.

TABLE 2

WELLS AND OUTCROPS USED IN CROSS SECTION FROM GOLCONDA, ILLINOIS TO NEW HAVEN, ILLINOIS (FIG. 4)

Index No.	State and County	Operator	No. and Farm	Spot or Footage	Sec., T., R.
1.....	Ky., Livingston	Minerva Oil Co.	DD 1 Robinson	7,200 WL., 10,550 NL. quad.	7-J-14
2.....	Ill., Pope	Outcrop at Golconda		SE. NW.	30-13S.-7E.
3.....	Ky., Livingston	Minerva Oil Co.	2 O. Morton	5,150 WL., 7,550 SL. quad.	17-K-14
4.....	Ill., Pope	Outcrop at Rock Quarry School		SE.	5-13S.-7E.
5.....	Ill., Hardin	Outcrop at Shetlerville		NE. SW.	35-12S.-7E.
6.....	Ill., Hardin	Outcrop at Downeys Bluff (Rosiclare)		NW. SE.	5-13S.-8E.
7.....	Ill., Hardin	Rosiclare Lead & Fluorspar Mining Co.	Ac 2 Fee	SE. SE. NW.	32-12S.-8E.
		Hillside Fluorspar Mines	107-D Fee	NW. NW. SE.	29-12S.-8E.
8.....	Ill., Hardin	Victory Fluorspar	126 Fee	NE. SE.	33-11S.-9E.
9.....	Ill., Hardin	Minerva Oil Co.	1 C. M. Austin	SW. SW. NE.	26-11S.-9E.
10.....	Ill., Hardin	Minerva Oil Co.	7 U.S. Forest Service	SE. NE. SE.	24-11S.-9E.
		Minerva Oil Co.	7 Milligan	CW. line, NW. NE. SW.	19-11S.-9E.
11.....	Ky., Union	H. H. Weinert	1 Union Trust Co.	N.½ N.½ N.½	22-O-18
12.....	Ky., Union	Sohio Prod. Co. *et al.*	2 Boswell	SE.	14-O-18
13.....	Ill., Gallatin	Cherry & Kidd	1 Gray	NE. NE. SE.	15-9S.-10E.
14.....	Ill., Gallatin	Sinclair-Wyoming	1 E. Hines	SE. SE. NW.	3-9S.-10E.
15.....	Ill., Gallatin	Sohio Prod. Co.	2 Nat. Resources	SW. SW. SW.	28-8S.-10E.
16.....	Ill., Gallatin	Carter	2 Jordan	NE. SE. NE.	21-8S.-10E.
17.....	Ill., Gallatin	Cherry & Kidd	12 Kerwin	SW. SW. SW.	11-8S.-10E.
18.....	Ill., Gallatin	Hagemann & Pond	1 Stofleth-Cokes	NE. NE. NW.	34-7S.-10E.

FREDONIA LIMESTONE

The Fredonia limestone of the fluorspar district includes beds equivalent to the entire sequence called "Ste. Genevieve" in the eastern Illinois oil fields (fig. 4). The Fredonia is mainly limestone, oölitic, slightly sandy, light-gray, buff, or brown, and medium to coarse textured. Porous oölitic zones are known as "McClosky," although the upper two such zones are designated the "Lower O'Hara pay" and the "Rosiclare pay" by many geologists in the eastern Illinois oil fields. Many beds may be traced accurately over short distances, but long-range correlations within the mass of limestone are very difficult because of rapid lateral variation and the recurrence of similar lithologic types at different levels in the section.

Sandy zones occur at many horizons and may grade laterally into sandstone. One such sandy zone has been named the "Spar Mountain sandstone" by Tippie (1945, p. 1658) at a locality about 1 mile

TABLE 3

WELLS USED IN CROSS SECTION FROM VICINITY OF MAUNIE, ILLINOIS, TO POOLE OIL-FIELD AREA, HENDERSON CO., KY. (FIG. 5)

Index No.	State and County	Operator	No. and Farm	Spot or Footage	Sec., T., R.,
1...	Ind., Posey	Gulf Refining Co.	1 Aldrich Community	SE. NE. NE.	8-6S.-14W.
2...	Ind., Posey	Paul Maier	1 Aldrich	C. NE. NE.	4-6S.-14W.
3...	Ind., Posey	Morgenstern Oil Co., Inc.	1 Mentzer	NW. SW. NE.	34-5S.-14W.
4...	Ind., Posey	Justrite Drilling Co.	1 French	CW.$\frac{1}{2}$ W.$\frac{1}{2}$ W.$\frac{1}{2}$	1-6S.-14W.
5...	Ind., Posey	B. M. Heath	1 Noble Utley	SE. NE. SW.	30-5S.-13W.
6...	Ind., Posey	Milton A. Lobree C. E. O'Neal *et al.*	1 W. Jackson	NW. NW. NW.	27-5S.-13W.
7...	Ind., Posey	Paul Rossi	1 Kincheloe & Williams	NE. NE. NW.	35-5S.-13W.
8...	Ind., Posey	Gulf Refining Co.	3 Lang	SE. NE. SE.	6-6S.-12W.
9...	Ind., Posey	Nelson Development Co.	1 Horstman	NE. SE. NE.	7-6S.-12W.
10...	Ind., Posey	Gulf Refining Co.	1 Reineke	NE. SE. NW.	8-6S.-12W.
11...	Ind., Posey	L. E. Butzman *et al.*	1 B. R. Juncker	NW. NW. NW.	9-6S.-12W.
12...	Ind., Posey	S. C. Yingling	1 Eckhoff	SE. NW. SE.	21-6S.-12W.
13...	Ind., Posey	Ward-Larson	1 Eickhoff-Wolf	SW. NE. SW.	22-6S.-12W.
14...	Ind., Posey	Fleming & A. K. Swann	1 John Hartmann	NW. NW. SE.	27-6S.-12W.
15...	Ind., Posey	E. T. Wix	1 E. Miller	NW. SE. SW.	26-6S.-12W.
16...	Ind., Vanderburg	Justrite Drilling Co.	1 Miller	N.$\frac{1}{2}$ SE. NW.	31-6S.-11W.
17...	Ind., Vanderburg	Roy Lee, Trustee	1 Oakland City College	E.$\frac{1}{2}$ SE. SW.	3-7S.-11W.
18...	Ind., Vanderburg	Sun Oil Co.	1 Adcock Unit	NE. SE. SE.	23-7S.-11W.
19...	Ind., Vanderburg	C. E. O'Neal & Co.	1 Kuester	NE. SW. NE.	3-8S.-11W.
20...	Ind., Vanderburg	Calvert-Willis & Delta	1 Simmons	NW. NW. SE.	10-8S.-11W.
21...	Ky., Henderson	Basin Drilling Co.	5 Carl Smith	8,890' NL., 9,810' EL. quad.	8-P-23
22...	Ky., Henderson	Sohio Producing Co.	1 Bartley	6,900' SL., 7,950' WL. of quad.	17-P-23
23...	Ky., Henderson	Herndon Drilling Co.	1 Barrett	2,900' SL., 11,250' EL. quad.	23-P-23
24...	Ky., Henderson	Carter Oil Co.	1 Ben Rudy	4,500' NL., 11,250' WL. quad.	3-O-23
25...	Ky., Henderson	W. F. Bilsky	1 F. P. Royster	13,600' SL., 12,300' EL. quad.	13-O-23
26...	Ky., Henderson	Sohio Producing Co. & W. E. Hupp	1 Minton	6,800' SL., 7,500' WL. quad.	17-O-23
27...	Ky., Henderson	Carter Oil Co.	6 S. T. Denton	1,290' SL., 5,670' EL. quad.	22-O-23
28...	Ky., Henderson	Sohio Producing Co.	1 O. Royster 95A.	3,150' SL., 400' WL. quad.	25-O-24

south of the well illustrated in log 8 in figure 4. The sequence of minor lithologic types above the sandstone at this point is very similar to that above the "Rosiclare" in certain of the southeasternmost Illinois oil fields. In other areas different sand zones appear more prominent, and it is probable that different zones are called "Rosiclare" in different parts of the basin. Sandstones are much more common to the west, and in certain areas as many as three thick "Rosiclare" sandstones can be recognized, reaching 100 feet in total thickness. One moderately thick sandstone is indicated at the western edge of figure 3.

LOCATIONS USED IN CROSS SECTIONS

Locations in Illinois (see tables 1, 2) and Indiana (tables 2–4) are described by the United States Land Office system of sections, townships, and ranges. Locations in Kentucky (see tables 3, 4) are given in the co-ordinate system for Kentucky originated by the Carter Oil Company about 1937 and now in common use by the oil industry. In this sytem, 5′ quadrangles are lettered in alphabetical order north from latitude 36°30′ and are numbered consecutively east from longitude 89°30′. Each 5′ quadrangle is thus indicated by a letter analogous to the township and a number analogous to the range of the standard system. Each of these quadrangles is subdivided into twenty-five 1′ rectangles which are called "sections" and approximate the mile-square Land Office sections in area but not in shape. The northeastern section in each quadrangle is numbered 1

TABLE 4

WELLS AND OUTCROPS USED IN CROSS SECTION FROM POOLE OIL-FIELD AREA HENDERSON CO., KY., TO LEAVENWORTH, CRAWFORD CO. INDIANA (FIG. 6)

Index No.	State and County	Operator	No. and Farm	Spot or Footage	Sec., T., R.
1....	Ky., Henderson	Sohio Producing Co.	1 O. Royster 95A.	3,150 SL., 400 WL. quad.	25-O-24
2....	Ky., Henderson	Cherry & Kidd	1-A L. Eakins	300 EL., 200 NL. sec.	4-N-24
3....	Ky., Henderson	Cherry & Kidd	1 T. J. Pritchett	1,050 EL., 2,950 SL. sec.	19-O-24
4....	Ky., Henderson	Sohio Producing Co.	1 H. J. Knight	8,400 SL., 550 EL. quad.	20-O-24
5....	Ky., Henderson	Ryan Oil Co.	1 V. Crafton	3,700 SL., 1,600 EL. sec.	9-O-24
6....	Ky., Henderson	National Assoc. Pet. Co.	1 Williams	3,300 NL., 4,470 EL. sec.	1-O-24
7....	Ky., Henderson	Carter Oil Co.	1 H. P. Barrett	5,880 SL., 4,650 WL. quad.	25-P-25
8....	Ky., Henderson	Kingwood Oil Co.	1 Jones	7,380 WL., 6,900 SL. quad.	17-P-25
9....	Ky., Henderson	Reznik	1 Moss	1,750 WL., 1,900 SL. sec.	7-P-25
10....	Ky., Henderson	Sinclair Prairie Oil Co.	1 Hatchett	12,500 NL., 9,550 EL. quad.	12-P-25
11....	Ky., Henderson	J. H. Williams	1 J. L. Overby	8,000 EL., 700 NL. quad.	2-P-25
12....	Ky., Henderson	McCummings Oil Co.	1 E. Allen	1,950 SL., 2,300 WL. sec.	5-P-26
13....	Ky., Henderson	Kentucky Producers Corp.	1 O. Breitschere	10,250 EL., 100 SL. quad.	23-Q-26
14....	Ky., Henderson	Coaster Co.	1 Haynes	5,600 EL., 5,950 SL. quad.	22-Q-26
15....	Ky., Henderson	Farmer & Chenault	1 R. E. Dunbar	9,260 SL., 3,240 EL. quad.	20-Q-26
16....	Ky., Henderson	Farmer & Chenault	1 M. Bruck	12,950 SL., 1,850 WL. quad.	15-Q-27
17....	Ky., Daviess	Sohio & Hupp Pet.	3 Reno Heirs	2,750 NL., 800 EL. sec.	14-Q-27
18....	Ky., Henderson	Farmer & Chenault	1 Bower & Heppler	4,400 WL., 9,600 NL. quad.	6-Q-27
19....	Ind., Warrick	W. Chenault	1 Turner	Approx. C. SW. SE.	36-6S.-9W.
20....	Ind., Warrick	Ohio Oil Co.	1 R. Jones	NE. NE. SW.	20-6S.-8W.
21....	Ind., Warrick	Eureka Oil Co.	1 T. H. Helms	SW. SW. NW.	23-6S.-8W.
22....	Ind., Warrick	Sunlight Coal Co.	1 Hart	SE. SE. NW.	27-5S.-8W.
23....	Ind., Warrick	Cherry & Kidd (Ashland Oil)	1 Verona Coal Co.	SW. SE. SW.	8-5S.-7W.
24....	Ind., Warrick	L. T. Phillips	2 T. S. Phillips	NE. NE. SW.	32-4S.-6W.
25....	Ind., Spencer	Texas Co.	1 Hanning	SW. SW. NE.	2-5S.-5W.
26....	Ind., Spencer	Texas Co.	1 Gogel	SE. NW. SW.	25-4S.-5W.
27....	Ind., Spencer	Ohio Oil Co.	1 Holtzman	NE. SE. SE.	28-4S.-4W.
28....	Ind., Perry	Ohio Oil Co.	1 W. Epple	NE. NE. NE.	8-5S.-3W.
29....	Ind., Perry	Ohio Oil Co.	1 J. C. Harbaville	NE. SE. NW.	36-4S.-3W.
30....	Ind., Perry	Outcrop at Branchville		SW.¼	13-4S.-2W.
31....	Ind., Perry	Sun Oil Co.	1 Gibson	SE. SE.	17-4S.-1W.
32....	Ind., Perry	Outcrop at Courcier Hill			10 & 11, 5S., 1W.
33....	Ind., Crawford	Outcrop at Sulphur		SW.¼	31-3S.-1E.
34....	Ind., Crawford	Outcrop at Leavenworth		E.½	6-4S.-2E.

and the northwestern 5. Six is immediately south of 5, and 10 is south of 1. The southeastern section is 21 and the southwestern is 25.

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