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DIVISION OF THE
STATE GEOLOGICAL SURVEY
M. M. LEIGHTON, *Chief*
URBANA

REPORT OF INVESTIGATIONS—NO. 119

KING OIL FIELD
JEFFERSON COUNTY, ILLINOIS

BY

STEWART H. FOLK AND DAVID H. SWANN

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KING OIL FIELD
JEFFERSON COUNTY, ILLINOIS

By

Stewart H. Folk and David H. Swann

Introduction

The discovery well of the King oil field is located on land owned by the State of Illinois, the first state-owned land in Illinois to be leased for oil and gas, and for this reason the geology of the area has been the subject of special study by the State Geological Survey. As the results of this study indicate that prospects are favorable for additional production from the field and from areas in its vicinity, it seems desirable to publish a report on the field.

The report was originally prepared by the senior author as of April 1, 1944, prior to his leave of absence to serve with the armed forces. Additional developments necessitated some revisions of the maps and of the discussion on structure, structural history, and prospects for further development. These revisions, made by the junior author, are based on data available up to May 1, 1946.

ACKNOWLEDGMENTS

The criticism and suggestions of A. H. Bell, George E. Ekblaw, L. E. Workman, Carl A. Bays and other members of the Illinois Geological Survey have been most helpful in the preparation of the report. Sample and core studies by L. E. Workman, F. E. Tippie, M. W. Pullen, E. P. DuBois, and Wayne Meents, in addition to those by the writers have been used. Samples, cores, electric logs, and other primary data were supplied by the various oil companies and operators that have been active in the area. The Texas Company supplied a large part of the information.

Location

The King field is in the southeastern part of Jefferson County, Illinois, approximately six miles southeast of the town of Mt. Vernon (see index map, fig. 1). It occupies portions of secs. 21, 27, 28, 33, and 34 of T. 3 S., R. 3 E., and a portion of sec. 3, T. 4 S., R. 3 E.

It is about 30 miles due west of the deepest part of the Illinois basin, and lies in the transition zone between western clastic facies and the eastern calcareous facies of the lower Chester formations which contain some of the principal oil-producing zones of southern Illinois. Knowledge of the conditions in this field should assist in interpreting the conditions of Chester sedimentation and help in determining the true correlations of the lower Chester strata.

History

The discovery well of the field is the Lewis Production Company, State of Illinois No. 1 in the SW. $\frac{1}{4}$, SW. $\frac{1}{4}$, SE. $\frac{1}{4}$, sec. 21, T. 3 S., R. 3 E., which was completed June 23, 1942, with an initial daily production of 153 barrels of oil and 13 barrels of water, pumping, from the Aux Vases sandstone at a depth of 2740-62 feet. It is the northernmost producing well in the field.

An earlier test on the King field structure, the Oil Inc., P. Mace No. 1, in the NE. $\frac{1}{4}$, SW. $\frac{1}{4}$, SW. $\frac{1}{4}$, sec. 34, T. 3 S., R. 3 E., drilled in 1939, was high enough structurally to have been a producing well but was a dry hole because the formations now productive in the field are not permeable enough to produce at that location. One of the best wells in the field is only one location (1320 feet) east and is structurally lower than the Oil Inc., P. Mace No. 1.

Levias (Lower O'Hara) and McClosky production were first found in the Oil Carriers, Mace No. 1, in the center NE. $\frac{1}{4}$, SE. $\frac{1}{4}$, sec. 33, T. 3 S., R. 3 E., which was completed September 15, 1942, with an ini-

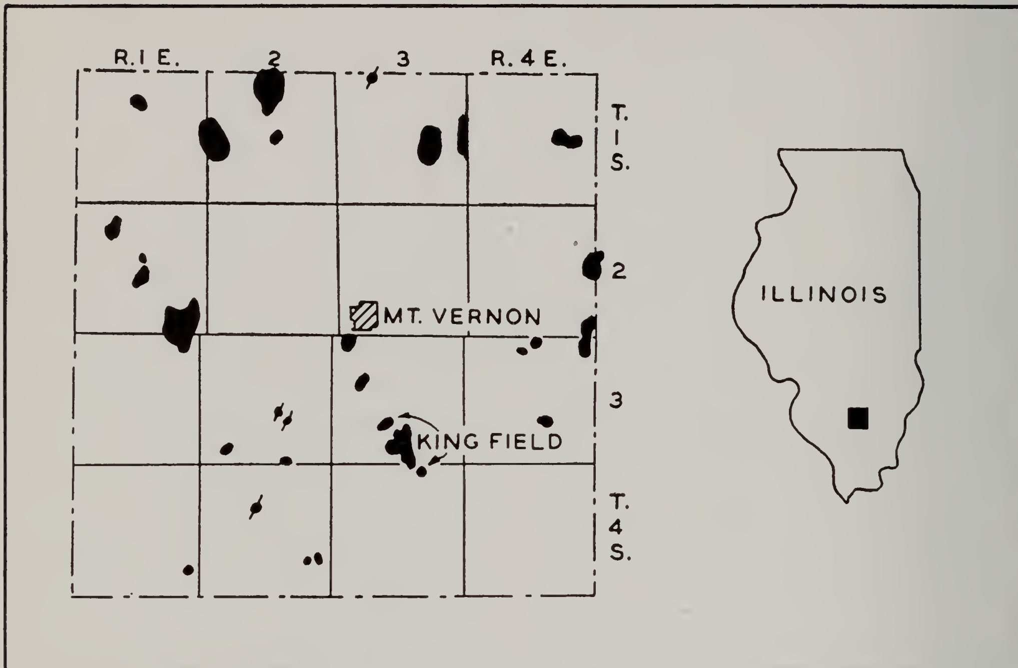

Fig. 1.—Index maps showing location of oil fields in Jefferson County and location of Jefferson County in Illinois.

tial daily production of 103 barrels of oil, pumping.

Rosiclare production was first reported in the Seaboard Oil Co., Eldridge-Whisenhunt Community No. 1, in the NE. 1/4, SE. 1/4, NE. 1/4 of sec. 3, T. 4 S., R. 3 E. The well was completed May 11, 1943, with an initial production of 53 barrels of oil and 8 barrels of water, pumping. This well is considered as being in the King field, but it probably is producing from a stratigraphic trap that is on the flank of the main King field structure.

Stratigraphy

The stratigraphic succession known in tests drilled to date in the King field is as follows:

- Pleistocene
  - Glacial drift
- Paleozoic
  - Pennsylvanian system
    - McLeansboro group
    - Carbondale group
    - Tradewater group
    - Caseyville group
  - Mississippian system
    - Chester series
      - Kinkaid formation
      - Degonia formation
      - Clore formation
      - Palestine formation
      - Menard formation
      - Waltersburg formation
      - Vienna formation
      - Tar Springs formation
      - Glen Dean formation
      - Hardinsburg formation
      - Golconda formation
      - Cypress formation
      - Paint Creek formation
      - Bethel formation
      - Renault formation
      - Aux Vases formation
    - Iowa series
      - Ste. Genevieve formation
        - Levias limestone
        - Rosiclare sandstone
        - Fredonia limestone
      - St. Louis limestone
      - Salem limestone
      - Osage group
      - Chouteau limestone
  - Devonian or Mississippian system
    - New Albany shale
  - Devonian system
    - Undifferentiated limestone and dolomite

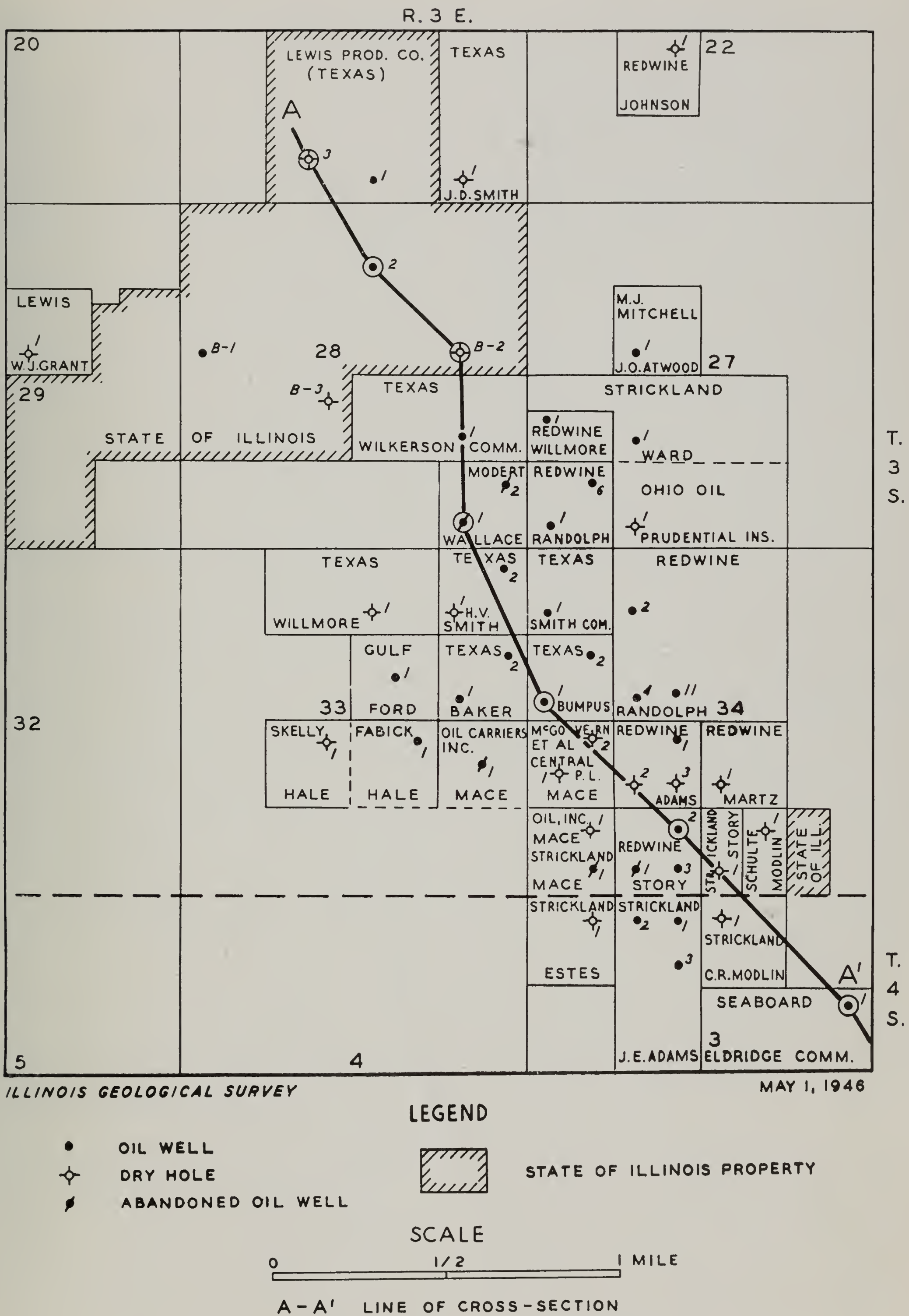

Fig. 2.—Ownership map, King oil field. Cross-section A-A[1] is shown in figure 3.

PENNSYLVANIAN SYSTEM

Except for a thin and discontinuous mantle of Pleistocene glacial drift, the surface strata in the area of the King field are Middle Pennsylvanian shales and shaly sandstones. There are almost 1800 feet of Pennsylvanian strata that belong to the McLeansboro, Carbondale, Tradewater, and Caseyville groups in the King field stratigraphic section.

The McLeansboro group, which is about 800 feet thick, includes alternating shales, siltstones, and sandstones with thin coals and underclays and a few thin beds of limestone. Most of the shales and sandstones are silty and micaceous, and some of them contain pellets or nodules of brown, dense siderite. The Shoal Creek limestone, occurring quite near the surface in this area, is a valuable horizon marker. It is light gray to light tan, very finely crystalline, and maintains a nearly uniform thickness of 14 feet.

Strata of the Carbondale group, about 300 feet thick, are similar to those in the McLeansboro, but the coal seams are thicker and more numerous. In the Carbondale group are coals No. 6 and No. 5, the most important coal seams of southern Illinois. Each is 6 feet thick in this area.

The Tradewater and Caseyville groups (the "Pottsville" of early reports) together are almost 700 feet thick. They consist largely of sandstone and siltstone with interbedded gray and black shale, and contain thin beds of coal and shaly limestone and lenses or nodules of siderite. The Tradewater and Caseyville sandstones generally are coarser and less shaly than sandstones of the McLeansboro and Carbondale groups.

MISSISSIPPIAN SYSTEM

The Pennsylvanian system is unconformably underlain by the Mississippian system, which is divided into the Chester (upper Mississippian) series and the Iowa (lower Mississippian) series.

The lithology of the lower part of the Golconda formation and the Cypress, Paint Creek, Renault, Aux Vases, and Ste. Genevieve formations is shown graphically in figure 3.

Chester series

The Chester series consists of a succession of alternating limestone-shale and sandstone-shale formations, 16 in number. Most of them, particularly the sandstone-shale units, are subject to a great deal of lateral variation. They are, in a way, transition beds, for they are intermediate in character as well as in position between the predominantly carbonate rocks of the Lower Mississippian and the predominantly clastic rocks of the Pennsylvanian system. More than 1,000 feet of Chester strata, representing every formation of the Chester series, are present in the King field.

The upper part of the Kinkaid, the uppermost formation of the Chester series, was removed by pre-Pennsylvanian erosion in this area. The part that remains, amounting to 50 feet or more in most wells, consists of shale with interbedded thin layers of limestone and siltstone and a massive bed of light brown, finely crystalline, slightly dolomitic limestone, 25 to 30 feet thick. The massive limestone, commonly known as the lower Kinkaid limestone, is prominent on both electric logs and sample-study logs, and is both persistent and nearly uniform in thickness over a large area in the Illinois basin, so it is a valuable subsurface marker. Immediately below it is a zone containing some bright red shale which helps to identify it.

Underlying the Kinkaid are the Degonia, Clore, and Palestine formations which consist largely of white fine angular sandstone and siltstone, with interbedded shales. Thin beds of light brown very finely crystalline limestone generally occur near the top and bottom of the Clore formation distinguishing it from the Degonia and Palestine, but since the limestones are very thin or absent in places, the three formations cannot always be differentiated. Their combined thickness is close to 200 feet throughout most of the field, but increases to 240 feet in wells in the southeast part.

Below the Palestine are the Menard, Waltersburg, and Vienna formations. Although the principal portion of each is readily recognized, the exact boundaries cannot be determined from well cuttings or electric logs in this area. Their total thickness is approximately 135 feet. The Menard is largely limestone, partly dolomitic and argillaceous and interbedded with shale, with a little "sugary" dolomite; it is about 50 feet thick, and is nearly uniform in lithologic character and thickness over a large area. The Waltersburg consists of shale with thin beds of siltstone or shaly sandstone. The thick permeable Waltersburg sandstone that is an important oil-producing zone in the eastern part of the Illinois basin does not extend as far west as Jefferson County. The Vienna consists of shale interbedded with thin shaly sandstones or siltstones and thin limestones. A silty to sandy, or shaly, pyritic, fossiliferous, dark brown limestone near the base of the formation is the only persistent and widely identifiable portion of the Vienna. It is only a few feet thick and consequently is not indicated on some electric logs, but it is readily recognized in most sample studies.

Beneath the Vienna is the Tar Springs formation, which is predominantly white fine angular grained sandstone with some siltstone and shale. Its thickness varies locally from 90 to 125 feet, apparently partly because of an erosional unconformity between the Tar Springs and the underlying Glen Dean formation. A lenticular sandstone at the top of the Tar Springs formation has been interpreted on some electric logs as possibly containing oil, but sample studies show that it is calcareous and not oil-bearing.

The Glen Dean formation consists of cream-colored to light brown limestone interbedded with shale. Some of the limestone is dolomitic, some beds contain oolites, and some contain chert. The basal part of the limestone is sandy in some wells, grading downward into the underlying Hardinsburg siltstone or sandstone. There appears to have been some erosion of the upper part of the formation before the deposition of the Tar Springs sandstone. Its thickness is about 50 feet in most wells, but ranges from 40 to 80 feet.

The Hardinsburg consists of shaly calcareous greenish-gray siltstone interbedded with shale. Ten to 15 feet of slightly porous sandstone occurs near its top in a few wells. Thick beds of porous sandstone occur in the Hardinsburg in the eastern part of the Illinois basin, where it is an important oil-producing formation in some fields, but it is almost entirely shale and is very thin throughout the western part of Illinois and in the northern part of the Illinois basin. In the King field the Hardinsburg formation is less than 20 feet thick in some wells but may be as much as 60 feet thick in others. The variation in thickness may be a result of either an erosional unconformity between the Hardinsburg and the underlying Golconda formation, or lateral variations in Golconda and Hardinsburg sedimentation, or both. There was pre-Hardinsburg erosion of the Golconda formation in other areas in the Illinois basin, so there might have been some here.

The Golconda formation, which consists of limestone and shale, has an average thickness of approximately 150 feet, but may be only 120 feet thick in some wells. At its top is a distinctive zone, about 20 feet thick, of variegated shales and lithographic dolomites. The main body of Golconda limestone, 80 to 120 feet thick, consists of white oolitic limestone, light tan and gray crystalline limestone and dolomitic limestone, brown shaly limestone, and interbedded shale. The lower part of the main limestone zone contains a large amount of red shale with a few thin beds or lenses of maroon colored lithographic limestone and dolomite, and at the bottom a bed of brown, buff, yellow-and-red mottled, fossiliferous coarsely crystalline limestone 4 to 12 feet thick. The "Jackson" sandstone that occurs at or near the horizon of the red mottled limestone in Indiana and eastern Illinois apparently does not extend into central and western Illinois. Below the red mottled limestone are 30 to 40 feet of gray, weak, caving shale. This shale zone is easy to locate on electric logs because the resistivity curve through it is a smooth vertical line with a value less than 5 ohm-meters. "Washouts" or over-size hole diameters resulting from caving of the shale probably are partly responsible for the low resistivity values measured through this zone. At the bottom of the Golconda formation is a bed of brown, dense to earthy limestone, 5 to 10 feet thick, commonly called the basal Golconda or "Barlow" limestone. It is one of the best subsurface markers in the Chester series, being present and easily identifiable throughout almost all of the Illinois basin, and it is a good datum for mapping structure. A structural map of the top of the basal Golconda limestone in this area was made, but it is not incorporated in this report because it closely resembles the map of the top of the Aux Vases formation (fig. 4). The top of the basal Golconda limestone is more satisfactory than its base for correlation and for use as a structural datum in the western part of the Illinois basin, because its thickness compensates somewhat for irregularities in the upper surface of the Cypress formation which underlies it; it thins, and in a few places in other fields wedges out, over bar-like sandstones at the top of the Cypress, and in some places, but not in the King field, it thickens locally to more than 50 feet, apparently where Golconda limy muds filled in depressions that existed in the Cypress surface.

The Cypress formation consists of sandstone, siltstone, and shale. It varies from 100 to 170 feet in thickness in the King field, partly because of the erosional unconformity between the Cypress and the underlying Paint Creek formation, and partly because of a regional thickening to the southeast that is the result of conditions of deposition of the Cypress sediments. The Cypress formation comprises several zones that can be traced through the King field. At the top is a zone, 20 to 30 feet thick, of shale interbedded with shaly sandstone. A thin bed of sandstone that occurs locally at the very top of the formation, immediately underlying the basal Golconda limestone, contains oil but apparently is too thin and tight in wells drilled to date to afford commercial production. Below the shaly zone lies the main body of Cypress sandstone, 40 to 50 feet thick, with a few shale interbeds. Below the main sandstone is another zone of shale 20 to 30 feet thick with interbedded siltstone and shaly sandstone. At the bottom of the formation is another zone of sandstone with shale interbeds that ranges from only a few feet to as much as 80 feet in thickness. Where it is thick the underlying Paint Creek formation is unusually thin or possibly absent.

The Paint Creek formation includes limestones, shales, siltstones, and sandstones, and ranges from 40 to 70 feet in thickness. It may be absent in one or two wells because of pre-Cypress erosion. It can be divided into three more or less persistent zones. The uppermost zone consists of variegated, fossiliferous shale, and brown shaly limestone. The middle zone includes shale, calcareous siltstone or sandstone, and sandy limestone; thick beds of sandstone occur in this zone in other areas, particularly that part of Illinois to the south and east of King field. The writers agree with Dana and Scobey[1] that the Bethel sandstone of Kentucky and southeastern Illinois should be correlated with this zone rather than with the underlying "Benoist" sand. The lowest zone of the Paint Creek formation as currently defined on the western side of the Illinois basin[2] is represented in the King field by white to light brown, partially mottled pink or green, crystalline crinoidal limestone, commonly called the "Pink Crinoidal" limestone, and by variegated, fossiliferous shale with interbeds of shaly limestone, totalling 20 to 25 feet in thickness. This zone appears to be continuous with the upper Renault limestone of the subsurface of southeastern Illinois and neighboring parts of Indiana and Kentucky.[3]

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[1] Dana, P. L., and Scobey, E. H., Cross section of Chester of Illinois Basin: Bull. Amer. Assoc. Pet. Geol., vol. 25, pp. 871-882, 1941.

[2] Workman, L. E., Subsurface Geology of the Chester Series in Illinois: Illinois Geol. Survey Rept. Inv. 61, p. 217, 1940.

[3] Dana and Scobey, op. cit. Tippie, F. E., Subsurface stratigraphy of the lower Chester formations in parts of Illinois and western Kentucky: Illinois Geol. Survey, unpublished mss.

It has not been traced into the area of southwestern Illinois which includes the type localities of the Paint Creek and Renault formations. At the base of this zone in most wells in the King area is a thin bed of sandy limestone known as the "Benoist caprock" that grades downward into the "Benoist" sandstone; where the sandstone is missing this basal limestone is as much as 5 feet thick.

The "Benoist" sandstone is 30 feet thick in some wells, but grades laterally into siltstone and shale or wedges out and is missing in a few wells in the King field (fig. 3). As noted above, though the "Benoist" is currently correlated with the Bethel formation, the writers believe it is stratigraphically lower than the type Bethel sandstone and may be equivalent either to the Yankeetown chert and sandstone of the southwestern Illinois outcrop area as suggested by F. E. Tippie[4] or to sandy layers in the type Renault as would be implied by the current surface correlation of the Yankeetown with the Bethel. Unlike the overlying formations, in which the sandstone zones are thick to the east but are shaly and thin or absent to the west, the "Benoist" sandstone and the sandstones in the Renault and Aux Vases formations below it become thinner and increasingly tend to grade locally into shale and limestone in going from west to east across Illinois. Oil shows occur in the "Benoist" sandstone in the King field, but not enough oil is present for commercial production.

The Renault formation includes limestone and shale with thin beds of sandstone and siltstone. The limestone is brown, red, and gray, crystalline to lithographic, partly sandy, partly oolitic, and partly fossiliferous. Some of the oolites have red shells which serve to distinguish this zone from the overlying formations. The siltstone and sandstone generally are calcareous and pale green to white. Fine round pellets or granules of limestone occur in both sandstone and limestone. A little oil, not enough to be of commercial importance, occurs in the Renault sandstone. The formation averages about 50 feet in thickness in the King field.

[4] Op. cit.

The Aux Vases formation consists of sandstone, siltstone, shale, limestone, and all intergradations between them. It varies greatly over short distances, being principally sandstone in some wells but almost entirely limestone and shale in other wells less than 1,000 feet away. Red and green are prominent colors in all the varieties of strata. The sandstone is very fine-grained and grades into siltstone. Most of the limestones are sandy or silty and argillaceous, and contain fine round pellets or granules of limestone. Many of the limestones are oolitic, and, as in the overlying Renault formation, some of the oolites have red shells. The Aux Vases sandstone is the principal oil-producing zone in the field, but it has been found non-productive in a number of tests because of lack of permeability. The thickness of the Aux Vases formation is between 50 and 60 feet in most of the wells that have drilled through it.

The Aux Vases strata of King field are typical of the strata called Aux Vases throughout the southeastern part of Illinois, but are not at all like the Aux Vases sandstone of Missouri and western Illinois. Instead, they are similar to the Hoffner beds of southern Illinois, which are classified by Weller[5] as being uppermost Ste. Genevieve in age. Further work must be done to determine whether these so-called Aux Vases strata in the Illinois basin actually are Aux Vases, being an eastern calcareous facies of the completely clastic Aux Vases formation in western Illinois, or whether they belong in the Ste. Genevieve formation.

Iowa series

The Iowa or lower Mississippian series in the King oil field includes about 1700 feet of strata, of which the upper and

[5] Weller, J. M., and Sutton, A. H., Mississippian border of Eastern Interior basin: Bull. Am. Assoc. Pet. Geol., vol. 24, No. 5, pp. 765-858, 1940.
Weller, J. M., Geology and oil possibilities of extreme southern Illinois: Illinois Geol. Survey Rept. Inv. No. 71, 1940.

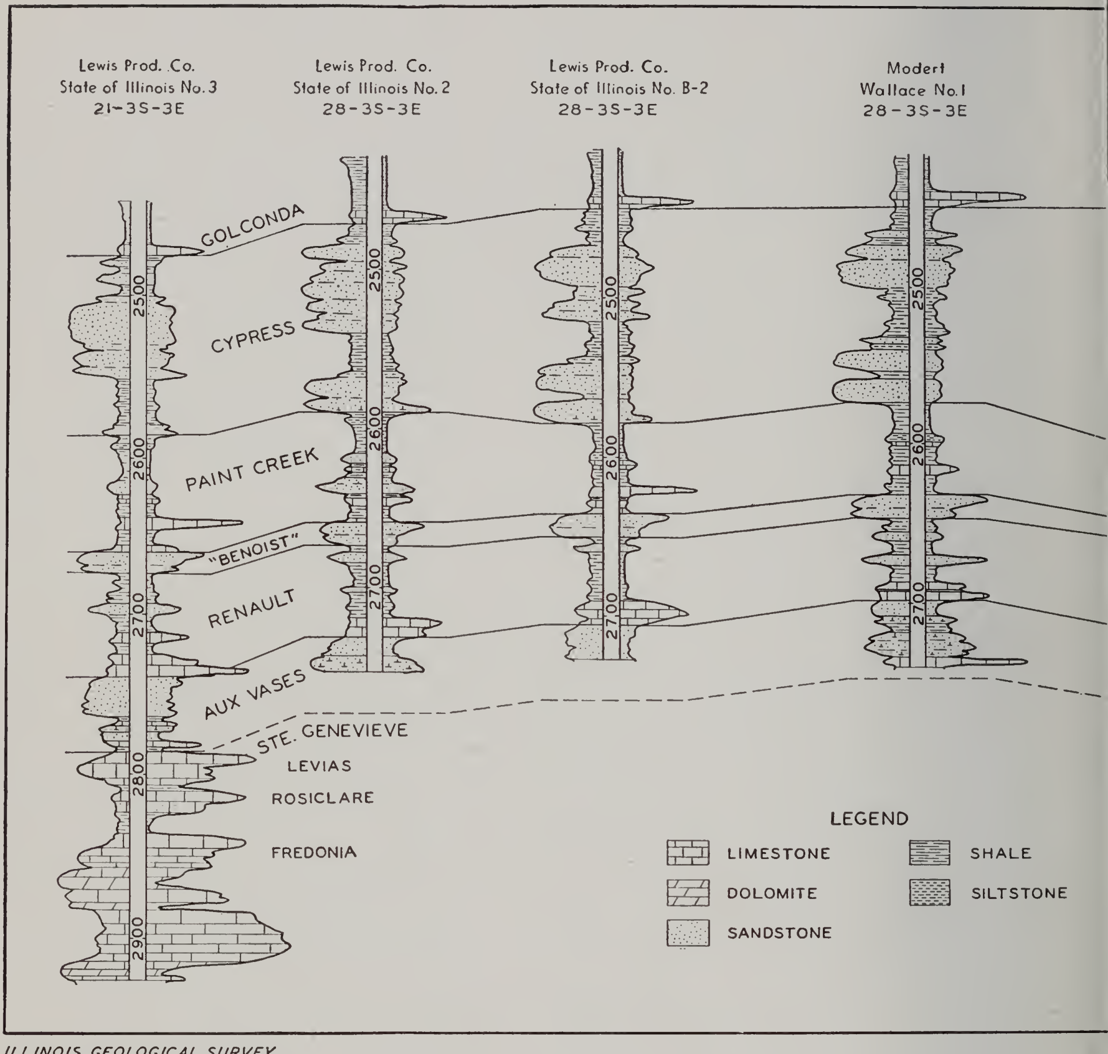
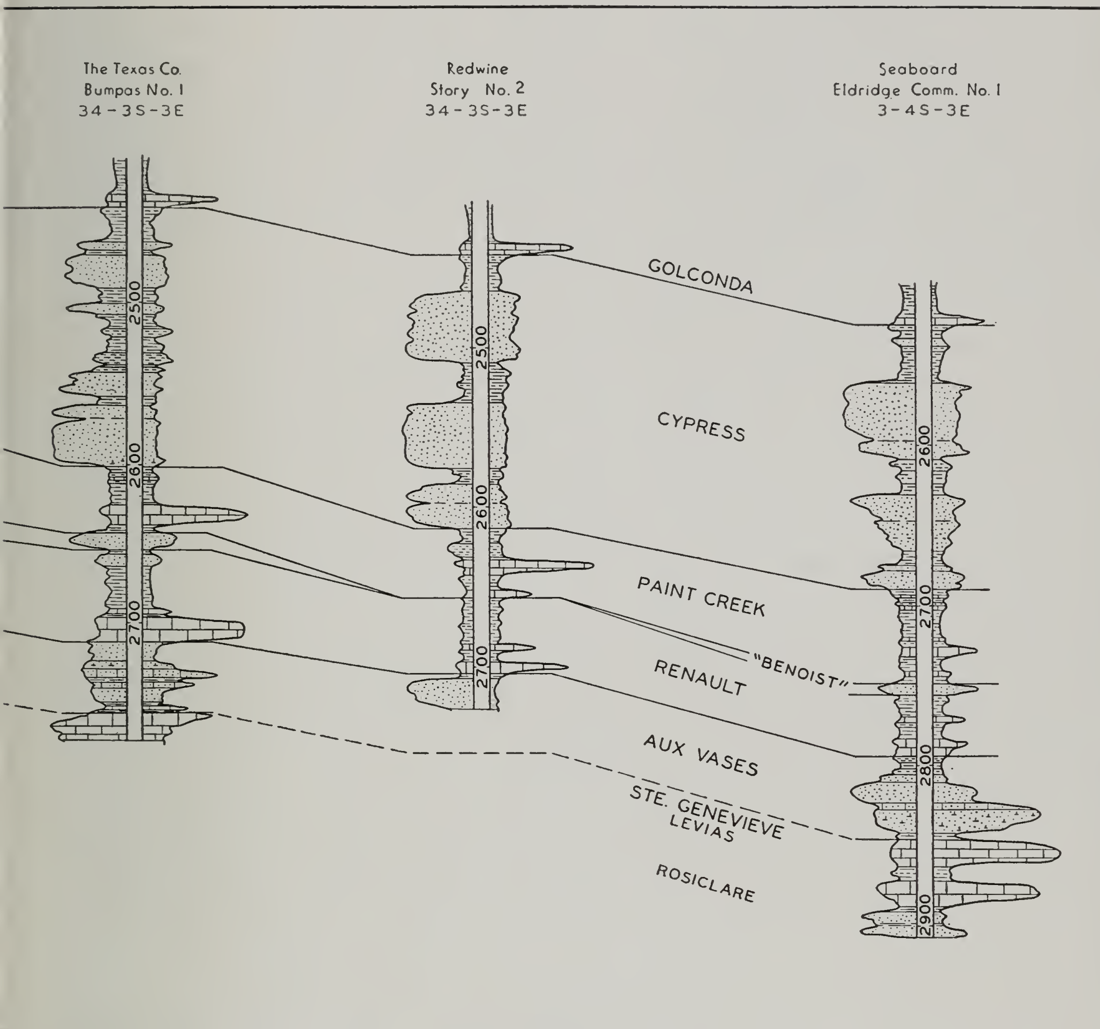


Fig. 3.—Northwest-southeast electric log cross-section of King oil field, from lower part of G



nda formation down into the Ste. Genevieve formation. For line of cross-section see figure 2.

greater portion is largely limestone and the lower portion, less than 400 feet thick, is chiefly shale. The following formations, listed in descending order, are represented: Ste. Genevieve, St. Louis, and Salem limestones, undifferentiated limestone, shale and siltstone of the Osage group, Chouteau limestone, and New Albany shale. The formational boundaries and the correlations of some of the formations are somewhat uncertain, as is the case in most subsurface work dealing with this series.

Three members of the Ste. Genevieve formation are recognized. They are, in descending order, the Levias (Lower O'Hara) limestone, Rosiclare sandstone, and Fredonia limestone. The Levias is 15 to 30 feet thick; its upper part is slightly glauconitic crystalline limestone with a little dolomite or dolomitic limestone, and its lower part is light tan and gray oolitic limestone that contains a few quartz sand grains with secondarily developed crystal faces. The Rosiclare consists of sandstone, sandy and oolitic limestone, and shale. Fine round granules of limestone are common in both sandstone and limestone, and the sandstone grades laterally into limestone. The thickness of the Rosiclare is difficult to determine, for beds of Rosiclare-like sandstone and sandy limestone occur in the Fredonia, but it ranges from 40 to 60 feet. The Fredonia consists of limestone and silty dolomite. Most of the Fredonia limestones are white to cream-colored and oolitic, the oolites generally being larger than those in the overlying and underlying strata. Porous oolitic zones are called "McClosky." Some of the limestones are crystalline to dense, some are dolomitic, some cherty, and some sandy. A sandy limestone commonly occurs at the base of the Fredonia. Beds of cream-colored to gray silty dolomite with finely sugary to earthy texture occur throughout the Fredonia. The Fredonia is approximately 150 feet thick.

The St. Louis formation consists of light brown crystalline to dense limestone, most of it cherty and some of it dolomitic, interbedded with light gray and cream-colored silty dolomite with earthy texture. It contains a few veins and thin beds of colorless anhydrite. Its lower part is brown, mottled with gray, fossiliferous, silty, argillaceous, dolomitic limestone, with finely crystalline to finely granular texture. It is about 250 feet thick.

The Salem limestone is for the most part an aggregate of small oolites, limestone granules, foraminifera and ostracode tests and the fragmental remains of other fossils, and contains many minute pore spaces. There are some beds of medium to coarsely crystalline limestone. It is prevailingly light tan to brown and gray in color. Some of the limestone is dolomitic. Argillaceous limestone beds grading to dark brown shale beds are irregularly present. The formation is about 300 feet thick.

Below the Salem limestone are about 800 feet of strata that are collectively assigned to the Osage group and are equivalent in age to the Warsaw, Keokuk, Burlington, and Fern Glen of the type Mississippian section. The upper 300 feet consists of light gray to brown limestone containing some dark gray shale. The limestone contains numerous bryozoa and fragments of crinoids and other fossils and most of it is porous. Some beds contain scattered very fine pellets of pale green clay and some beds are oolitic. Below this fossiliferous limestone is about 300 feet of dark brown and brownish-gray, cherty dolomitic limestone and dolomite interbedded with dark gray shale and siltstone. The chert is fossiliferous, dark blue and brown, and semi-vitreous. The limestone and dolomite are partly argillaceous and become increasingly argillaceous downward, and grade downward into about 200 feet of silty shales with interbedded shaly siltstones typical of the Borden group of Indiana.

The Chouteau limestone is 10 feet thick. It is brownish-gray, sublithographic, dolomitic and argillaceous, and slightly fossiliferous. There are a few feet of soft gray shale immediately above it. No other definitely Kinderhook strata are known in the area.

DEVONIAN OR MISSISSIPPIAN SYSTEM

The New Albany shale includes 80 feet of dark brown, platy, firm shale containing numerous spore-like bodies underlain by 30 feet of gray and green shale that unconformably overlies Devonian strata. The New Albany shale has been referred variously to either one or both of the Devonian and Mississippian systems.

DEVONIAN SYSTEM

Nearly half of the Devonian system, 270 feet of strata, have been penetrated by one test in the King oil field. At the top of the system is a light brown to gray fossiliferous cherty partly shaly, partly oolitic limestone, which overlies or is interbedded with dark brown argillaceous dolomite of finely crystalline to earthy texture and containing large spores. These beds are approximately 50 feet thick, probably represent the Lingle formation. Similar strata at the same stratigraphic position in the Salem field are known to pass laterally into shales. The shaly and variable character of the strata at the top of the Devonian has been responsible for some difficulty in picking the top of the Devonian in both sample study and electric logs, and may be responsible for some of the difficulty experienced in picking the top of the Devonian from seismograph records.

Below the dark shaly limestone and dolomite there are 220 feet of white to light brown crystalline limestone, partly dolomitic, partly cherty, and partly sandy. These strata probably belong to the Grand Tower, Clear Creek, and Backbone formations. The vuggy, sugary dolomite and sandstone zone that was the prolific Devonian pay in the Salem and Centralia fields does not occur in this area.

There probably are several hundred more feet of Devonian limestone and dolomite that have not been penetrated. Below the Devonian there probably are 500 feet or more of Silurian limestone, and 1200 feet or more of Upper and Middle Ordovician strata, comprising 200 feet of Maquoketa shale, 900 feet of Kimmswick ("Trenton"), Plattin, and Joachim limestone, with interbeds of dolomite, shale, sandstone, and anhydrite, and 100 feet of St. Peter sandstone. No reliable estimate of the thickness of the lower Ordovician and Cambrian strata that lie below the St. Peter can be made, but they probably are more than 5,000 feet thick and consist largely of dolomite and sandstone. Thus there probably are at least 7,000 feet of sedimentary strata that have not been penetrated as yet, which would bring the total thickness of sedimentary strata in the King field close to 12,000 feet.

Structure

The structure of the Aux Vases, the principal producing formation in the King field, is that of an irregularly shaped dome on a prominent anticlinal nose that plunges to the southeast in the direction of the regional dip (see fig. 4). The dome is roughly elliptical in plan and is creased with a few shallow troughs; its principal axis extends northwest-southeast, parallel to the axis of the nose on which it lies. The highest part of the structure is in the SE. $\frac{1}{4}$, SE. $\frac{1}{4}$, sec. 28. A subsidiary crest lies near the center of the NE. $\frac{1}{4}$ of sec. 33.

There appear to be two spurs extending, one west and northwest from the main part of the structure into the center of sec. 29, and the other north and northeast into sec. 22. It is possible that either or both of these high areas may be separate closed structures isolated from the main dome by shallow saddles, but the conservative interpretation of contouring them as spurs has been followed in figure 4. In addition, the area between the King field and the southern pool of the Mt. Vernon field, including most of secs. 21 and 17, the northeastern part of sec. 20 and the southwestern part of sec. 16 seems to be structurally high, and the King pools and southern Mt. Vernon pool may prove to be located on the same structural feature or group of closely related structural features and be portions of one large oil field. This situation is tentatively suggested in figure 8.

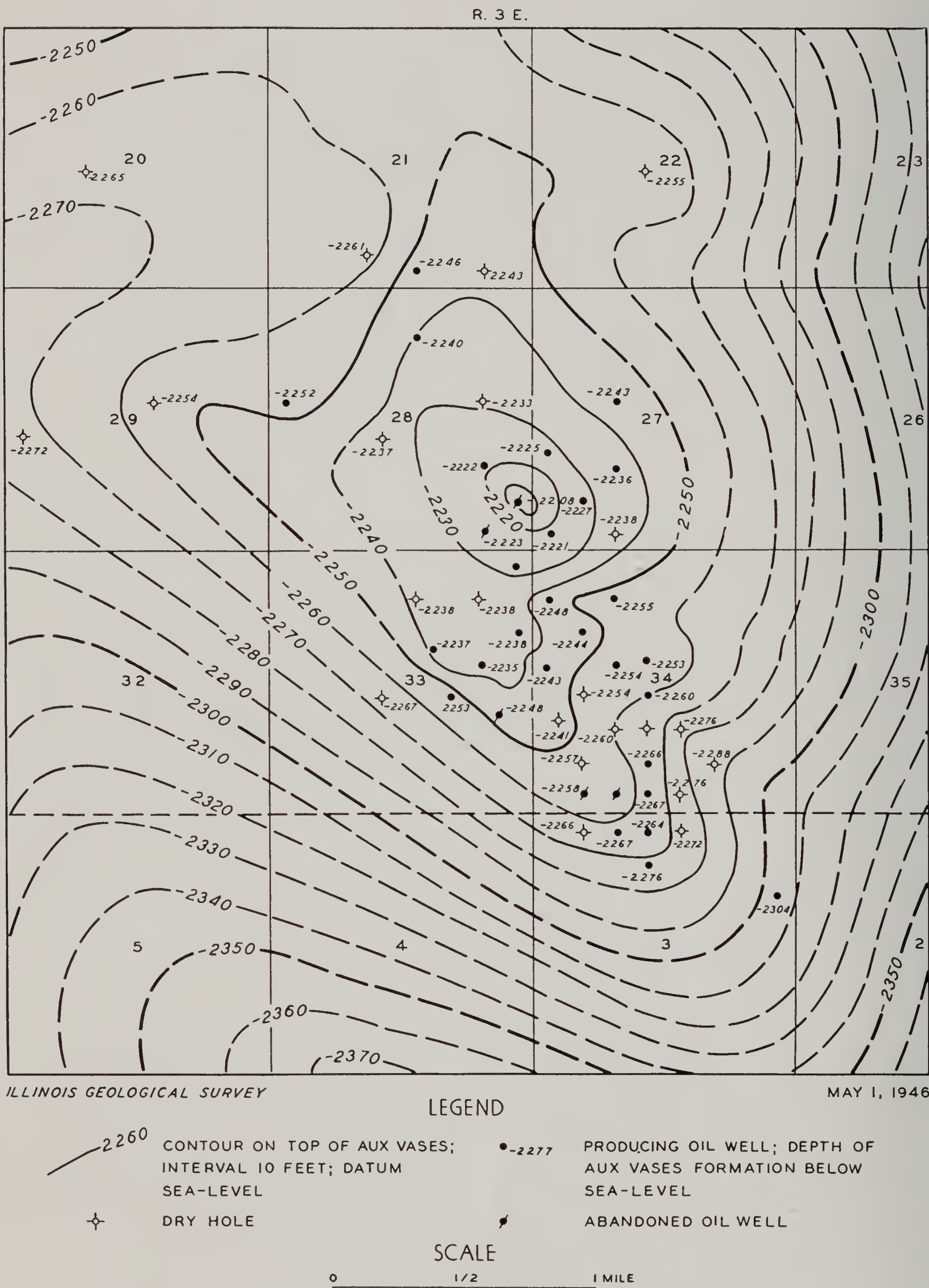


Fig. 4.—Structure of the Aux Vases formation, King field.

There is also the possibility of a separate closure at the southeast end of the King field, where the Seaboard Oil Co., Eldridge Community No. 1, sec. 3, T. 4 S., R. 3 E., produces oil from the Rosiclare sandstone at an elevation considerably lower than that of water-bearing Rosiclare in tests located in the main part of the field. However, the Rosiclare production in the F. L. Strickland, J. E. Adams No. 1, in the same section but definitely on the King structure, makes it seem more likely that the Rosiclare production in both wells is from a stratigraphic trap with a lithologic barrier rather than a structural barrier separating it from the main dome.

The structures of the other Mississippian formations are in general similar to that of the Aux Vases, but in detail differ slightly because of the lateral variations in thickness of the individual formations. For example, the subsidiary crest in sec. 33 is more pronounced in structure maps contoured on the top of the basal Golconda limestone because the Cypress sandstone which underlies the Golconda is thicker there than in other parts of the King field.

The King oil field structure is in alignment with and is probably part of the Carlinville-Centralia anticline belt pointed out by Workman and Payne.[6] Although the field is in this northwest-southeast belt of relatively thin Mississippian strata, the isopach map (fig. 7) indicates little, if any, local thinning of the formations of the Chester series over the field. The erratic variations in thickness which are indicated seem to be located at random with respect to the structural features and to be a result of local stratigraphic variations chiefly in the Chester sand bodies. When looked at broadly there may be a slight systematic displacement of the isopach lines to the southeast over the pool indicating a thinning, but this thinning is less than the variations caused by sedimentational irregularities.

[6] Workman, L. E., Subsurface geology of the Chester series in Illinois; and Payne, J. Norman, Subsurface geology of the Iowa (Lower Mississippian) series in Illinois: Illinois Geol. Survey Rept. Inv. No. 61, 1940.

Figure 6 is an isopach map of the interval between the base of the lower Kinkaid limestone at the top of the Chester series and the top of the Shoal Creek limestone in the McLeansboro group, the highest easily recognized bed in the Pennsylvanian of this area. It is, thus, essentially a map of the thickness of the bulk of Pennsylvanian strata in the area. It indicates a distinct thinning of Pennsylvanian strata over the pool with isopach lines systematically displaced approximately 3 miles to the southeast as they cross the pool area, corresponding to a deficiency of approximately 50 feet. Superposed on this reduced interval are the results of sedimentational variations in the Pennsylvanian formations which, however, are much smaller than the thinning apparently due to structure.

Although the regional dip of the upper Pennsylvanian strata is to the northeast, transverse to the regional dip and roughly parallel to the regional strike of the Mississippian strata, the structure of the Shoal Creek limestone in the upper part of the Pennsylvanian of this area reflects quite well the structure of the Mississippian formations in the King field (fig. 5), but the dips are much less, because of the thinning of Pennsylvanian strata noted in the preceding paragraph. The Shoal Creek limestone is easily identified in both sample study and electric logs, it is persistent and maintains a uniform thickness over a large area, it is less than 400 feet below the surface throughout T. 3 S., R. 3 E., and the townships to the south and west, and it is overlain only by shales and sandstones which are easily drilled; it should therefore be a good key bed to use for shallow structural testing in this area.

There is both northeast-southwest and northwest-southeast structural grain in this area. The Mississippian strata, dipping toward the southeast, have a northeast-southwest regional strike but lie in folds whose major axes extend northwest-southeast, with a resultant drapery-like structural pattern. King field is apparently situated on one of the northwest-southeast anticlinal trends, the Carlinville-Centralia

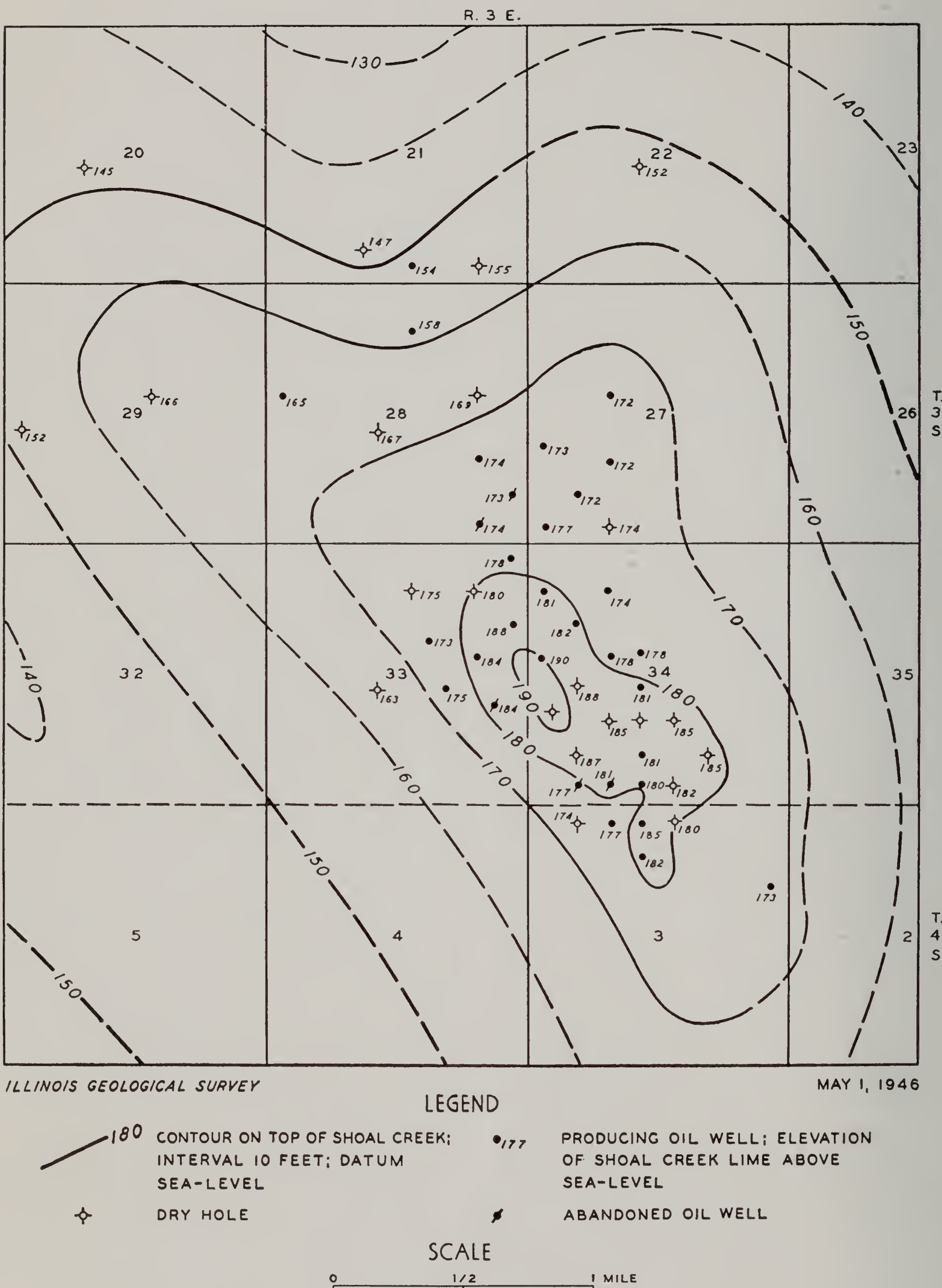
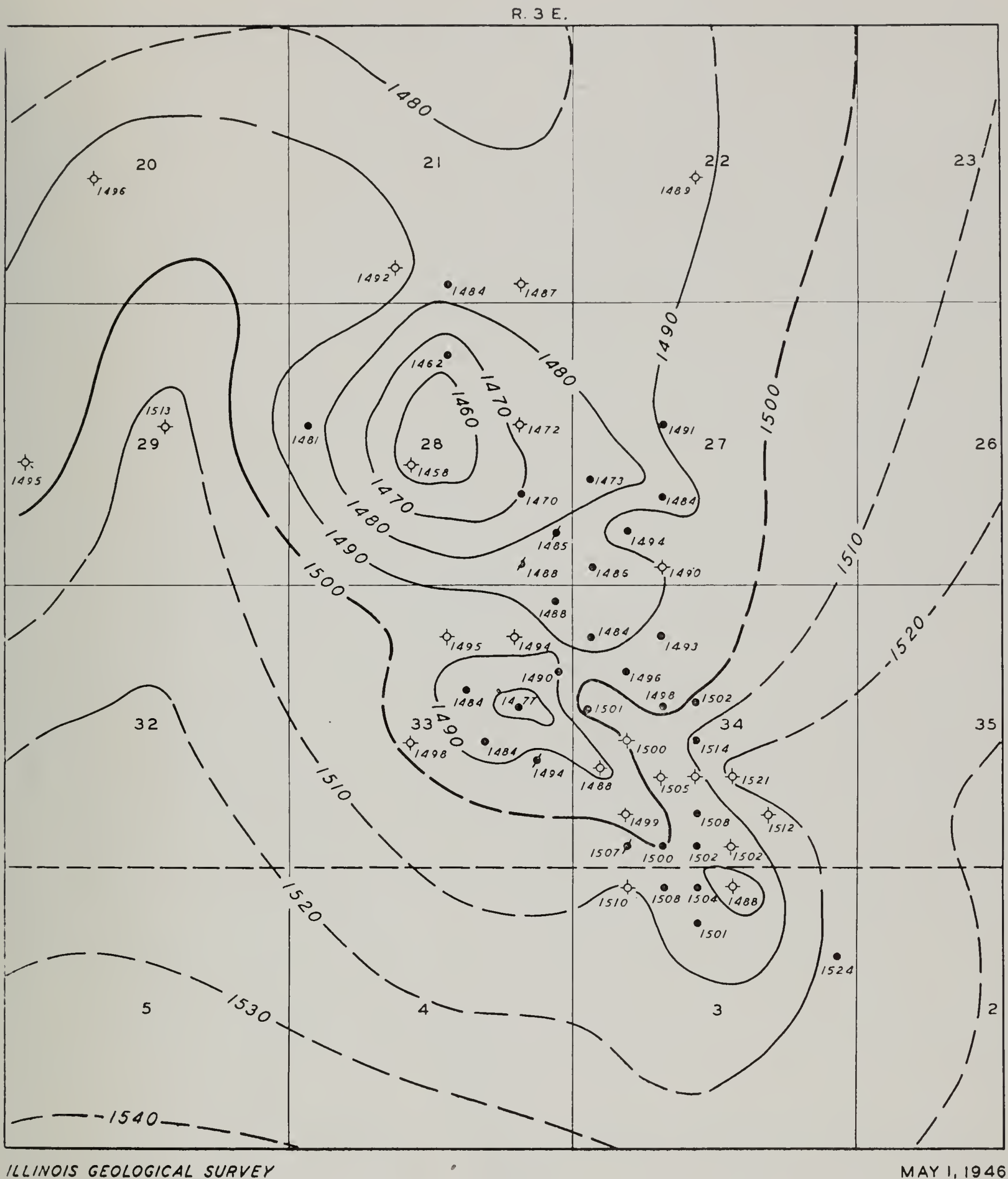


Fig. 5.—Structure of Shoal Creek limestone, King field.



LEGEND

1510 ISOPACH; INTERVAL 10 FEET

ABANDONED OIL WELL

DRY HOLE

1462 PRODUCING OIL WELL; THICKNESS OF STRATA BETWEEN TOP OF SHOAL CREEK LIMESTONE AND BASE OF LOWER KINKAID LIMESTONE.

SCALE

0 1/2 1 MILE

FIG. 6.—Isopach map of interval between top of Shoal Creek limestone in upper part of Pennsylvanian system and base of lower Kinkaid limestone at top of Mississippian system in King field.

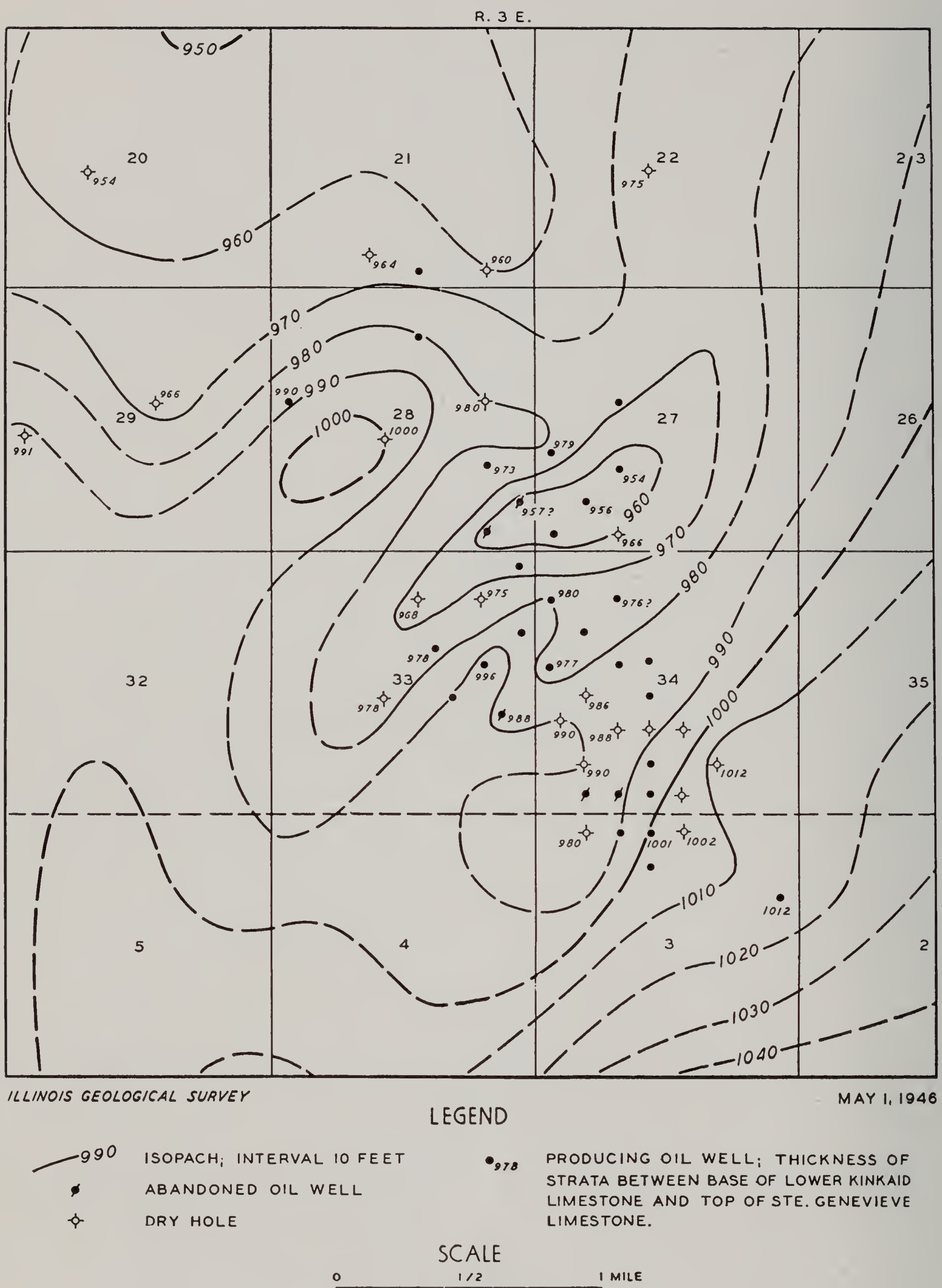


Fig. 7.—Isopach map of Chester series below the lower Kinkaid limestone in King field.

belt, which is paralleled at a short distance to the west by a similar anticlinal belt on which are situated the Irvington-Roaches-Woodlawn group of pools, and at a considerable distance to the east by the LaSalle anticlinal belt.

The northeast-southwest grain is much less well developed in this part of Jefferson County. Although it should be most easily recognized on structural maps on Pennsylvanian horizons whose regional strike is northwest-southeast at approximately right angles to it, there is some evidence that it antedates Pennsylvanian deposition and thus is poorly indicated by Pennsylvanian horizons. It is suggested by the noses extending into secs. 22 and 29, T. 3 S., R. 3 E., which may well indicate the position of a structural high of this trend crossing the King field axis. In other parts of the Illinois basin this trend is well delineated by the group of major pools which lie along such axes as the Salem-Louden, Clay City, and Wabash River anticlinal belts, all of which extend northeast-southwest.

Structural History

The Carlinville-Centralia anticlinal belt to which the King pool seems related has relatively thin Mississippian strata,[7] and must have existed before Mississippian times. In the King area there was little or no erosion of the Lower Mississippian strata preceding Chester deposition, and the Devonian system seems to be virtually complete, so any appreciable pre-Chester folding probably occurred before Devonian time. The northwest-southeast orientation of the King field anticline and Carlinville-Centralia anticlinal belt, along which the Mississippian strata are relatively thin, is transverse to both initial and present regional strike of the Mississippian system, and may reflect the trend of some middle or early Paleozoic or pre-Cambrian "high."

Following the deposition of the Mississippian system, the edges of the Illinois basin were upwarped and the whole basin was subjected to erosion. The chief structural deformation in this area at the end of the Mississippian period was a tilting to the southeast, but at this time or during the deposition of the older part of the Pennsylvanian sediments, the King field anticline was definitely formed as a structure of relatively low relief. This is indicated by the decreased thickness of Pennsylvanian sediments over the anticlinal area as shown in figure 5. However, the erosion of Chester strata from the field area is not marked, although elsewhere in Illinois there was considerable deformation and great thicknesses of strata were removed by erosion at this time.

At the close of the Pennsylvanian period or later, the edges of the basin were again upwarped and the strata were folded and subjected to erosion. It was probably at this time that the strata in southwestern Illinois were tilted to the northeast and the King field anticline received its greatest amount of folding, and was brought to its present form. This tilting and folding probably accompanied the pronounced upwarping of the southern end of the Illinois basin that shifted the deepest part of the basin from the region southeast of the King field where it had been throughout the Mississippian and Pennsylvanian periods, to its present location in northwestern White County, almost due east of the King field.

Oil Producing Zones

There are at present four producing zones in the King field: the Aux Vases sandstone, the oolitic portion of the Levias limestone, the Rosiclare sandstone, and the McClosky oolite of the Fredonia limestone (fig. 3). On May 1, 1946, 27 of the 32 wells completed in the field were still producing, some of them from two or more zones. The Aux Vases was productive in all but one of the wells, the Levias in 6, the Rosiclare in 2, and the McClosky in 2. The number of wells producing from some of the zones in the Ste. Genevieve formation may be greater than that reported here because of unreported work-overs and deepenings since the wells were first completed.

[7] Workman, L. E., Op. cit.; Payne, J. Norman, Op. cit.

Great variation in the productivity of each zone in different wells occurs because of lateral variations in lithology and permeability. The Aux Vases and Rosiclare change from porous sandstone to dense sandy limestone, and the Levias and McClosky change from porous to tight limestone within the distances between wells. Lack of permeability has been responsible for a large number of dry holes within the boundaries of the field. Of the first 49 tests drilled in the field, 17, or more than one-third were dry holes, and the production of several more was so small that they scarcely merit being called wells.

An attempt was made to ascertain the relationship, if any, between sand conditions —especially porosity and permeability—and structure, so that future development might be better directed. Unfortunately no conclusions could be drawn from the data available. Core analyses are too few, and electric logs do not afford accurate evaluation of the properties in question for strata so variable in composition as those in the Aux Vases and Ste. Genevieve formations. The best wells, having the most productive Aux Vases sand bodies, are located on the flanks rather than on the crest of the structure but there also are dry holes, due to poor sand conditions, on the flanks of the structure close to the good wells.

The wells with the greatest initial production and the greatest accumulative production to date are located southeast of the structural crests. Production occurs much lower at the southeastern edge of the field where wells which produce oil from the Aux Vases are at least 20 feet structurally lower than wells containing water in the Aux Vases at the northwestern edge of the field. The occurrence of oil at structurally lower positions to the southeast is probably due to the relatively impermeable shale and sandy limestone belts of Aux Vases which separate the permeable productive areas. Thus, the field as a whole can be thought of as a number of separate Aux Vases pools with the oil-water contact being considerably lower in the more southeasterly of them, or the field can be considered as having a sloping oil-water contact. This latter interpretation has been followed on figure 8 where the top of the Aux Vases formation in the area considered structurally high enough for Aux Vases production ranges from 2278 feet below sea-level at the southeastern extremity to about 2250 feet below sea-level at the north.

Potential Producing Zones

Oil shows occur in some wells in several formations above the present producing zones. Shows have been noted in the uppermost body of Cypress sandstone, in the "Benoist" sandstone, and in a thin sandstone in the Renault formation. Some of the shows have been cored, but no tests of any of them have been reported. Probably none of them will prove to be of commercial value in the present area of the field, but any or all of them may be productive in the area northwest of the field if that area is as high structurally as it appears to be.

There are a number of prospects for deeper production. Various tests drilled in Jefferson County have found oil shows in the St. Louis, Salem, and Warsaw limestones, all in the Lower Mississippian, and in the Devonian limestone. In view of the production from the first three named in other areas, any production from them here probably would be less than 200 or 300 barrels of oil per day. Any production from the Devonian likewise probably would not be more than a few hundred barrels of oil per day, for the prolific Devonian pay of the Salem and Centralia oil fields apparently is not present in this area.

In the one test in the King field, the Nash Redwine, Prudential Insurance Co. No. 1, in the SW. $\frac{1}{4}$, SE. $\frac{1}{4}$, SW. $\frac{1}{4}$, sec. 27, T. 3 S., R. 3 E., that was drilled through the Mississippian system and into the Devonian, no oil shows were reported below the Ste. Genevieve, and the test was abandoned. It does not, however, condemn the Lower Mississippian and Devonian possibilities of the whole field for it was located on the flank of the structure.

There are a number of potential producing zones in deeper strata—in the lower part

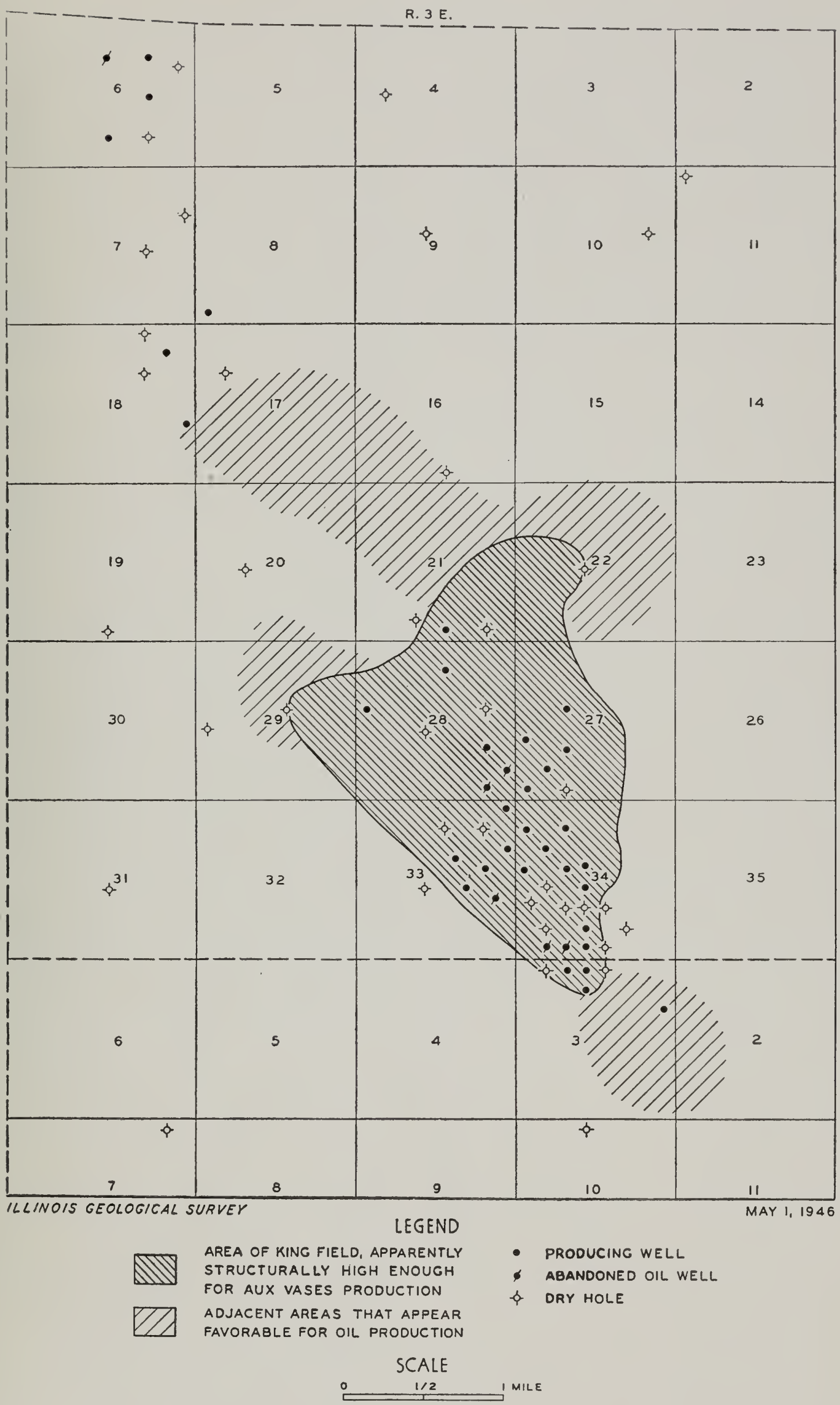


FIG. 8.—Areas apparently structurally favorable for oil production in region of the King oil field.

of the Devonian and in the Silurian, Ordovician, and Cambrian systems—that never have been tested in the King field or in Jefferson County. There remain perhaps as much as 10,000 feet of sedimentary strata that have some possibility of containing oil.

If the northwest-southeast Carlinville-Centralia anticlinal belt, of which the King field anticline seems to be a part, does reflect deep structure, as suggested in the discussion of structure, conditions would be distinctly favorable for the occurrence of oil in the deep-lying strata.

Prospects for Additional Wells in Present Producing Zones

There is an area of approximately 2100 acres on the King field structure that appears structurally high enough for production from the Aux Vases sandstone (fig. 8). As noted in the discussion on producing zones, this area is bounded by approximately the –2278 contour on the top of the Aux Vases formation at the southern end of the field and the –2250 contour on the north. Some 47 tests have been drilled within or at the borders of this area. Of these 31 were completed as wells in the Aux Vases sandstone and have proved that approximately 650 of the 2100 acres are underlain by more or less permeable sand. The 16 dry holes have directly condemned about 450 acres, leaving approximately 1,000 acres in which Aux Vases production might be found if permeable sandstones are present.

If the present ratio of productive to nonproductive acreage should hold, only about 60 percent of the undrilled area would be productive and less than half could support wells that would pay for themselves.

No reliable estimate of the potential producing acreage of the Ste. Genevieve formation can be made but it seems evident that the productive area will be less than that of the Aux Vases sandstone. The position of the oil-water contact in each zone of the Ste. Genevieve varies a great deal from place to place in the King field, probably because of the lenticular nature of the producing zones. It does seem that Levias and McClosky production may be obtained at a number of additional locations on the higher part of the structure if permeable zones are present. Any test that proves to be dry in the Aux Vases certainly should be drilled deep enough to thoroughly test the Ste. Genevieve, spacing regulations permitting. Some wells have been completed in both Aux Vases and Ste. Genevieve formations; other wells producing only from the Aux Vases might be deepened and converted into multi-zone wells with resultant increases in production.

Possibilities for Extension to King Field

Four areas adjacent to the King field appear to have possibilities for oil production. The largest of these is the saddle extending from the northern part of the King field in sec. 21 through the corners of secs. 20 and 16 and S. $\frac{1}{2}$ of sec. 17 to the southern pool of Mt. Vernon field in sec. 18 (fig. 8). It is at least possible that there may be a closure at some point within this area which, according to our present knowledge, appears structurally high. Should there be any considerable amount of structural closure in this area it is possible that Cypress and "Benoist," as well as Aux Vases and Ste. Genevieve production might be developed.

The features in secs. 29 and 22 that have been interpreted as spurs from the main structure (see fig. 4) may instead be separate structures such as small domes or anticlines. If the latter should be the case in either area, further production might well be expected.

The regional dip of the Mississippian formations to the southeast has seemingly caused the greatest amount of migration into the King pool area from this direction. As any such migration would be channeled along the nose upon which King field is located, it would be expected that the area of this nose in secs. 2 and 3, T. 4 S., R. 3 E., would be favorable places for oil accumulation, both in small closures and in stratigraphic or lithologic traps. The Rosiclare sandstone production in the Seaboard Oil Company, Eldridge Community No. 1 and in the Strickland, J. E. Adams No. 1 appears to be trapped stratigraphically and further examples may be discovered by future exploration in the western part of sec. 2 and in sec. 3, T. 4 S., R. 3 E.

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