TPS. 24 AND 25 N., R. 8 E.

By K. C. Heald and Kirtley F. Mather.

INTRODUCTION.

The greater part of the field work in Tps. 24 and 25 N., R. 8 E. (see fig. 1), was done by K. C. Heald and K. F. Mather, assisted respectively by J. Lee Bossemeyer and M. G. Gulley, instrument men. Mr. Heald is in the main responsible for the work in the western half of T. 25 N., R. 8 E., and Mr. Mather for that in the eastern half. The areas mapped by the two geologists in T. 24 N., R. 8 E., interfinger intricately so that it is not practicable to indicate the portion worked by each man. Certain small areas in the southeast corner of this township were mapped by F. R. Clark assisted by P. V. Roundy, and in some other parts of the township J. T. Richards served as instrument man.

STRATIGRAPHY.

EXPOSED ROCKS.

The exposed rocks in these townships are all of Upper Pennsylvanian age and include sandstone, limestone, and shale with an aggregate thickness of about 500 feet. Sandstones and shales predominate, but limestone beds recur in a number of different zones between the top and bottom of the section. Certain of these beds crop out conspicuously in many different parts of the two townships. Generalized geologic sections indicating the nature of the exposed rocks and the intervals between the successive beds of sandstone and limestone are presented in figure 26. The vertical intervals vary materially from place to place, but those recorded in the sections are approximate averages for the region under discussion. In general, there is a marked convergence of the limestones above the Deer Creek limestone toward the south and, on the contrary, a marked divergence between the Lecompton and Deer Creek limestones in the same direction.

The geologic structure was determined from elevations taken on a great number of beds. Some of these beds have only a very local

development, but others may be traced for long distances. The more persistent and helpful of these key beds are described briefly below.

Okay limestone.—The Okay limestone is a thin bed, commonly inconspicuous, occurring in the lower part of the Pawhuska limestone, about 10 feet above the highest bed of the Elgin sandstone and 50

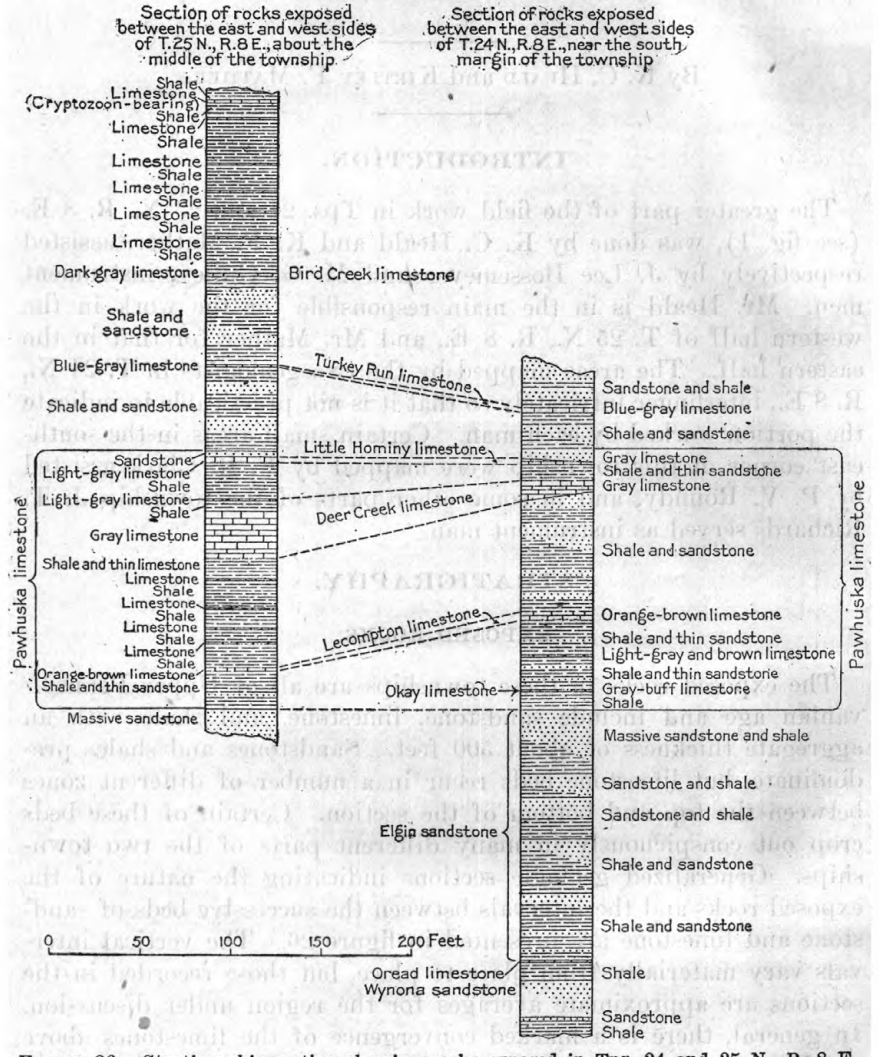


FIGURE 26.—Stratigraphic section showing rocks exposed in Tps. 24 and 25 N., R. 8 E.

to 100 feet below the Deer Creek limestone member of the Pawhuska. It was named[1] from its good exposures on and in the neighborhood of the O. K. ranch in sec. 31, T. 25 N., R. 9 E. It is probably a rather small lentil of only local importance, cropping out sporadically in different parts of T. 24 N., R. 8 E., and the neighboring townships

[1] Heald, K. C., report on T. 25 N., R. 9 E.: U. S. Geol. Survey Bull. 686–E, 1918.

toward the east and northeast. Where present it may be found easily because of its stratigraphic position with respect to the underlying massive Elgin sandstone.

The color of this limestone varies from gray to buff, with buff predominating. In most places it is characterized by a flinty hardness and an abundance of small *Fusulina*, but locally either or both of these features may be absent. Typical exposures may be observed in secs. 12 and 13, T. 24 N., R. 8 E.

Lecompton limestone.—The Lecompton limestone is a member of the Pawhuska formation, lying 30 to 60 feet below the Deer Creek limestone, which is the "Pawhuska lime" of commercial geologists. This bed is one of the most persistent of the members of the Pawhuska limestone and has been traced from the Kansas line through the Pawhuska quadrangle, through the Hominy quadrangle, where it is known to some as the "Hominy lime," and southward to the Cushing field, where it is known as the "Pawhuska lime."

It is a hard bed, which ranges from 2 to 5 feet in thickness in these townships but which is much thicker in the region to the south. In many places it forms a conspicuous outcrop and large slabs break from the ledge and litter the hill slopes. Its resistance to disintegration may lead to errors, as some of these slabs, which show little or no effect of weathering, occur on slopes or in stream beds far below the actual outcrop of the limestone.

The weathered color is commonly an orange or orange-brown, though locally it is gray. The fresh surface is lighter in color. The limestone is not markedly fossiliferous except in small areas, but almost everywhere a search will reveal small cup corals (*Lophophyllum profundum*).

The outcrops that may be seen near the east-west road in secs. 1, 2, and 3, T. 24 N., R. 8 E., are typical.

Deer Creek limestone.—The Deer Creek limestone is the most conspicuous member of the Pawhuska formation. It is about 26 feet thick in T. 25 N., R. 8 E., but becomes much thinner toward the south, where its lower beds are replaced by sandstone. The general color of the weathered surface is gray, but it shows some bands which are cinnamon-brown and blackish blue and, fortunately, are so persistent that they can be traced for considerable distances and used in mapping to determine structure. Resistance to erosion varies materially both horizontally and vertically within the member, so that the "ledge maker" is a different bed at different localities.

Throughout the greater part of T. 25 N., R. 8 E., a brown band, 3 or 4 feet thick, near the top of the Deer Creek limestone, proved especially helpful in the detailed mapping. At many places also the very top of the member, which is dark blackish blue and has a peculiar velvety-smooth appearance, was used. Elsewhere a thin bed of

gray limestone about 7 feet above the massive ledge proved the most reliable stratum.

As this limestone is traced southward into T. 24 N., R. 8 E., the brown band becomes extremely irregular, the black bed disappears, the interval immediately below the thin upper bed becomes more and more calcareous, and the lower beds change somewhat abruptly into sandstone diagonally across the member from the base upward. South of Little Hominy Creek, therefore, the outcrop of the Deer Creek limestone indicated on the map (Pl. XXIV) is that of a bed at a horizon 7 feet higher than that represented farther north.

Little Hominy limestone.—The Little Hominy limestone is a bed 3 to 15 feet thick lying between 12 and 30 feet above the Deer Creek member of the Pawhuska limestone. It is persistent and conspicuous in T. 27 N., R. 8 E., where it maintains a constant position 30 feet above the Deer Creek limestone, but its outcrop is found to become intermittent and variable when traced southward into T. 25 N., R. 8 E.; about midway of that township it begins to converge toward the lower limestone, and in the southwest quarter of T. 24 N., R. 8 E., where its rare outcrops are last observed, the two limestone beds are only 12 feet apart.

Typically the Little Hominy limestone is light gray on the weathered surface, somewhat darker where freshly broken, and very coarsely crystalline. In many places the uppermost 3 to 6 inches of this member consists of very impure conglomeratic limestone containing many shell fragments. At certain localities well-preserved *Fusulina*, brachiopods, gastropods, and other organisms are present, but at most places good fossils are lacking.

In the southern half of T. 25 N., R. 8 E., and wherever observed in T. 24 N., R. 8 E., this limestone is unusually sandy, containing from 20 to 30 per cent of clear, glistening quartz grains. In places this proportion is greatly exceeded, and it is impossible to separate the limestone from the overlying massive sandstone, a bed which, in the absence of the Little Hominy limestone, has proved very serviceable in detailed mapping. It is probable that the abrupt disappearance of this limestone at many localities is due to its transition from a sandy lime into a calcareous sandstone that is indistinguishable from the overlying sands.

Good exposures may be observed on the west slope of the southward-trending valley in the SW. ¼ sec. 30, T. 25 N., R. 8 E., and south of Hominy Creek in the SE. ¼ sec. 30, T. 24 N., R. 8 E. The bed is named from its outcrops on Little Hominy Creek in the southwestern part of T. 25 N., R. 8 E. This member is probably the equivalent of either the Howard or the Topeka limestone of Kansas.

Turkey Run limestone.—From 40 to 90 feet above the Deer Creek member of the Pawhuska limestone is a dark-gray limestone, 1 to 3 feet thick, to which the name Turkey Run limestone is here applied because of its excellent exposures near the head of Turkey Run, in secs. 9, 16, and 17, T. 24 N., R. 8 E. As in the case of the Little Hominy limestone the interval between this bed and the underlying limestone is greatest in the northern part of T. 25 N., R. 8 E., and least near the south margin of T. 24 N., R. 8 E.

This limestone is fine grained, thin bedded, hard, and brittle and weathers into smoothly rounded slabs a few inches in length. The weathered surface is generally light gray with many curving traceries and irregular patterns of darker gray or yellowish brown, due to the fragments of brachiopod and gastropod shells, the margins of which are thus etched by weathering. On fresh fracture the color is a much darker bluish gray, at some localities almost black. Well-preserved fosils are extremely rare; in fact, it may most readily be distinguished from the lithologically similar limestone 60 feet higher in the section by the absence of the brachiopod species commonly found in the higher bed.

Bird Creek limestone.—The next limestone above the Turkey Run bed, just referred to, has been named the Bird Creek limestone, for there are many good outcrops along the headwaters and main branches of Bird Creek in the townships immediately north of those now under consideration. The exposures along the south side of South Bird Creek in secs. 28 and 29, T. 26 N., R. 8 E., are typical of its development there. In the SE. ¼ sec. 4, T. 25 N., R. 8 E., it is crossed by the Fairfax road, and in T. 24 N., R. 8 E., it may be seen to good advantage along the northwest-southeast road in sec. 8.

Near the north margin of T. 25 N., R. 8 E., the Bird Creek limestone is 50 feet above the Turkey Run limestone; 6 miles farther south the interval has increased to 72 feet. The two beds are very similar in general appearance, but the upper one is slightly darker than the lower and contains fewer fossil fragments. On the other hand, the Bird Creek limestone carries many more complete fossil shells and is indeed characterized by the presence of the brachiopod *Enteletes hemiplicata* at nearly every outcrop. Another method of distinguishing between the two beds depends upon the presence of a thin soft limestone, crowded with *Fusulina*, about 18 or 20 feet above the Bird Creek limestone.

UNEXPOSED ROCKS.

The unexposed rocks of Pennsylvanian age are of the same general type as those that appear at the surface. Sandstone and shale form about 90 per cent of the total above what is known to the

drillers as the Big lime (probably the Pawnee limestone of the Kansas section). Below that horizon there is comparatively little sandstone, but there are massive beds of limestone and thick series of shale. (See Pl. XXVI.)

Many of the sandstones in the upper part of the section contain water, even in areas of pronounced anticlinal structure, and in some of the synclines they yield enormous quantities of either salt or fresh water. Most of these water-bearing sands seem to be lenticular, for not all the wells, even those that are closely spaced, get the water at the same horizon. One of these sands, which in most localities appears to be heavily charged with salt water, is very persistent and will probably be encountered in many of the wells drilled in these townships. Its top is between 480 and 560 feet below the horizon of the Lecompton limestone.

Either oil or gas has been found in more than a dozen distinct beds in the different wells which have been drilled in these townships. Most of these beds contained only "showings" which were not large enough to be commercially important, although they indicate the possibility of obtaining oil from the beds in which they were found, but at least four zones have been proved to contain sufficient oil or gas to justify the expense of drilling and equipping wells. The uppermost of these zones is about 1,200 feet below the Lecompton limestone; in the oil field in the southeast corner of T. 24 N., R. 8 E., where it is known as the Layton sand, it has thus far been reported to yield only small volumes of gas and oil. The Big lime lies 500 or 600 feet lower, and in two or three of the wells in the field mentioned above it has contributed a little gas and oil to the total production. More important is a sand about 25 feet thick known as the Peru sand which lies immediately below the Big lime; this is the "little pay" in a few of the oil wells. The Fort Scott limestone ("Oswego lime") is about 2,000 feet below the Lecompton limestone and in some places is immediately overlain by a thin oil-bearing bed known as the Wheeler sand. This zone is penetrated at a depth of about 1,750 feet in the wells in the southeast corner of T. 24 N., R. 8 E., and from it the majority of the wells in that field get their oil. About 300 feet below these beds is a sand about 15 feet thick which lies immediately on or a very short distance above the "Mississippi lime" and yields both oil and gas in favored localities. This sand is known as the Bartlesville sand in the oil field mentioned above and has yielded good returns in several of the wells there.

Besides the oil and gas bearing formations mentioned above, there are unquestionably deeper sands 200 feet or more below any which have been reached by drilling operations in these two townships.

The highest of these deep-lying sands has been proved to contain both oil and gas in other parts of the Osage Reservation, and it seems practically certain that future deep drilling in these townships will result in obtaining a good yield from one or more of these lower beds.

GEOLOGIC STRUCTURE.

GENERAL STRUCTURE.

The structure in Tps. 24 and 25 N., R. 8 E. (see Pls. XXIV, XXV), is complicated. In general there is a regional downward tilt of the beds in a direction a little north of west, so that any definite bed is about 200 feet higher at the east margin of the area than it is at the west, but this regional tilt is so greatly obscured by the manner in which the beds are folded and faulted that it is not in the least prominent.

A very conspicuous structural feature is a shallow syncline extending in a nearly straight line for 11 miles from sec. 31, T. 24 N., R. 8 E., in a direction 15° east of north to sec. 10, T. 25 N., R. 8 E. The floor and flanks of this syncline are crossed by no less than 16 faults, all striking between N. 10° W. and N. 32° W. and nearly all with the upthrow on the northeast side of the fault plane. As a consequence of this fault-shattered trough at right angles to the regional tilt of the beds, there is a series of minor anticlines and domes on each side of the syncline and roughly parallel to it. These folds will be described in detail, beginning with the southernmost one of the western series, proceeding northward and then southward along the east side of the syncline. (See fig. 27.)

Equally as remarkable as the structural trough just described is an anticlinal fold which covers a large part of T. 24 N., R. 8 E., and which extends into T. 23 N. on the south and into R. 9 E. on the east. It is shaped like the letter **V**, with the point of the letter near the north quarter corner of sec. 16, T. 24 N., R. 8 E., and with one limb trending southeastward to secs. 15, 14, and 13 and into T. 24 N., R. 9 E. Between the sides of the **V** there is a broad and very pronounced syncline, a part of which is now occupied by the valley of Little Hominy Creek and most of which was probably at one time occupied by one of the major streams that drain the region. This large syncline is particularly remarkable because it opens toward the southeast, whereas most of the synclines in the Osage Reservation have their heads to the east and open toward the west. Along the axis of the large anticlinal fold there are four minor anticlines separated by structural saddles. In the detailed discussion which follows the major fold is considered as a unit and is described separately.

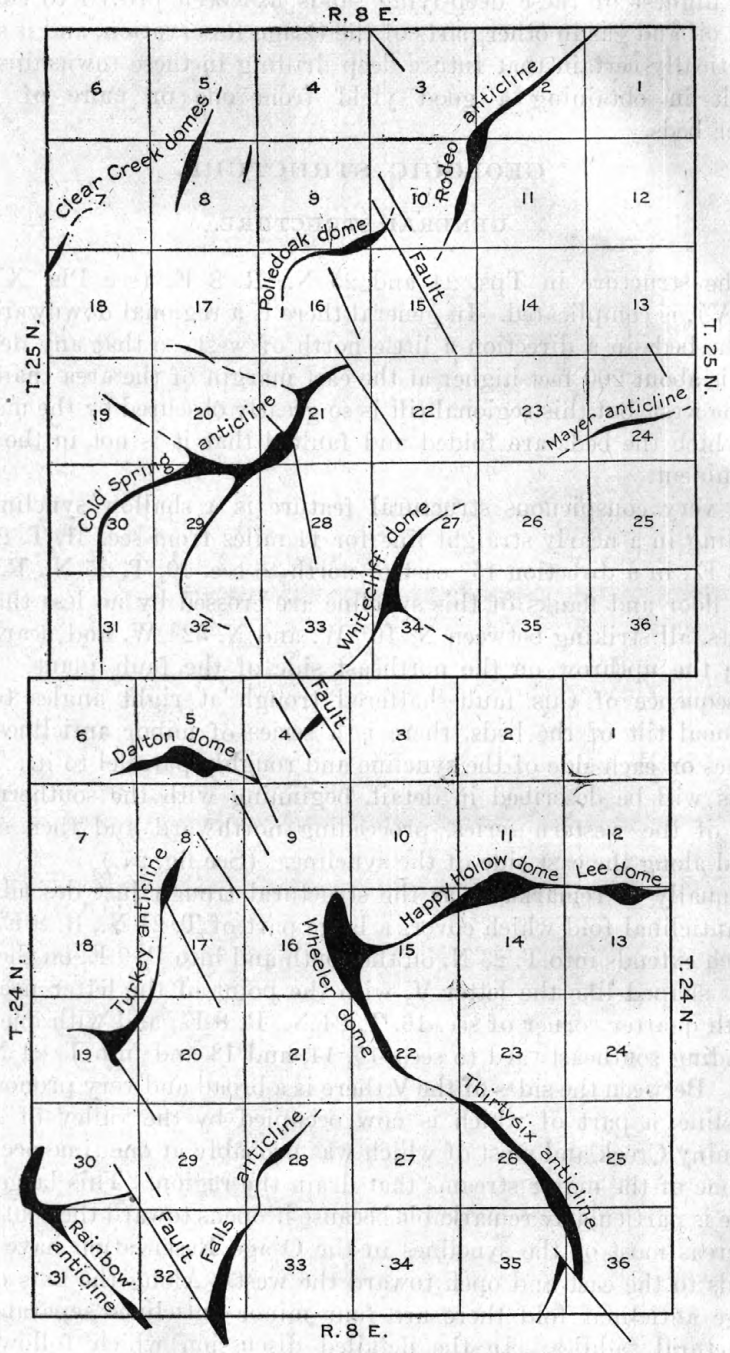
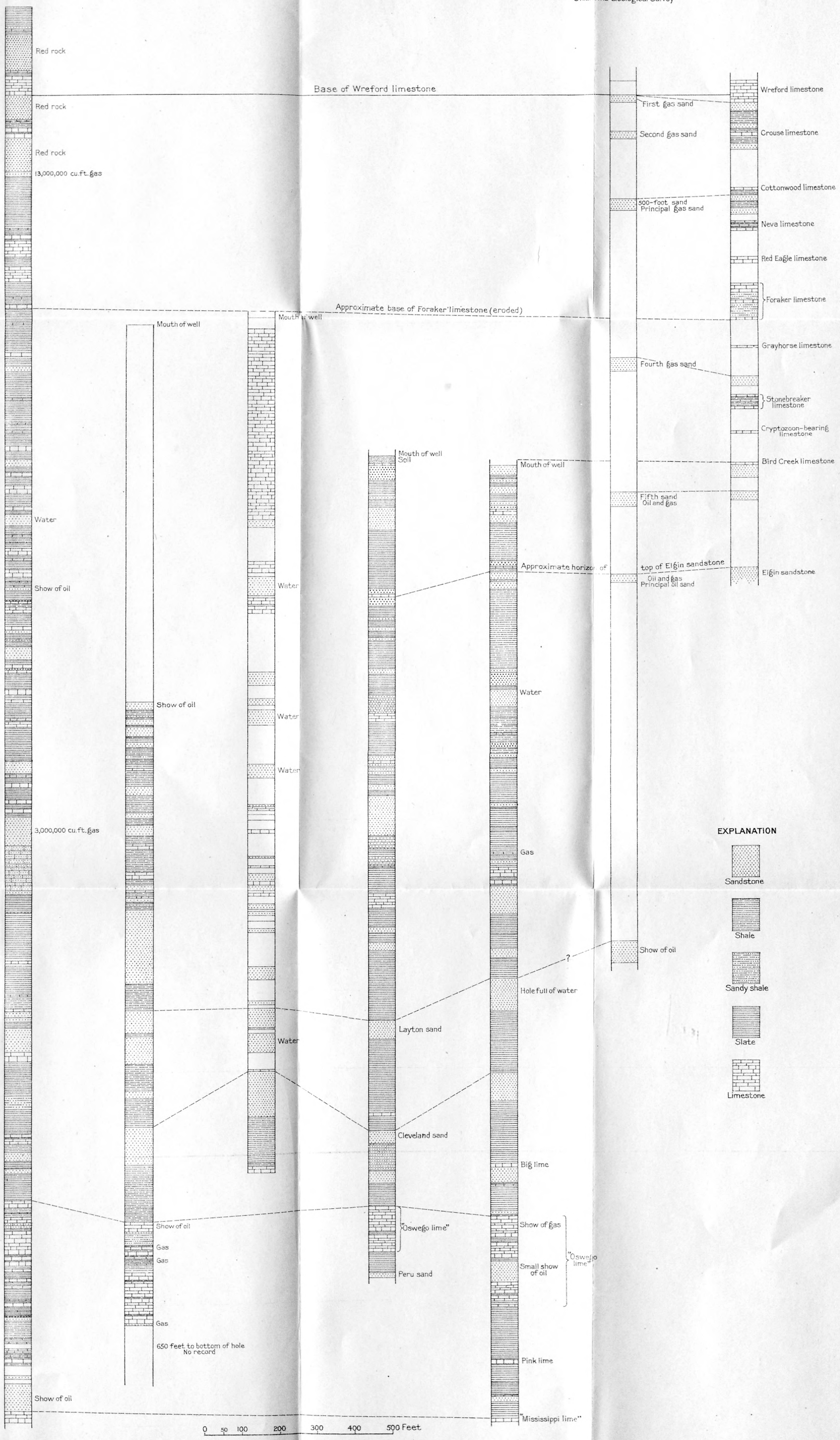
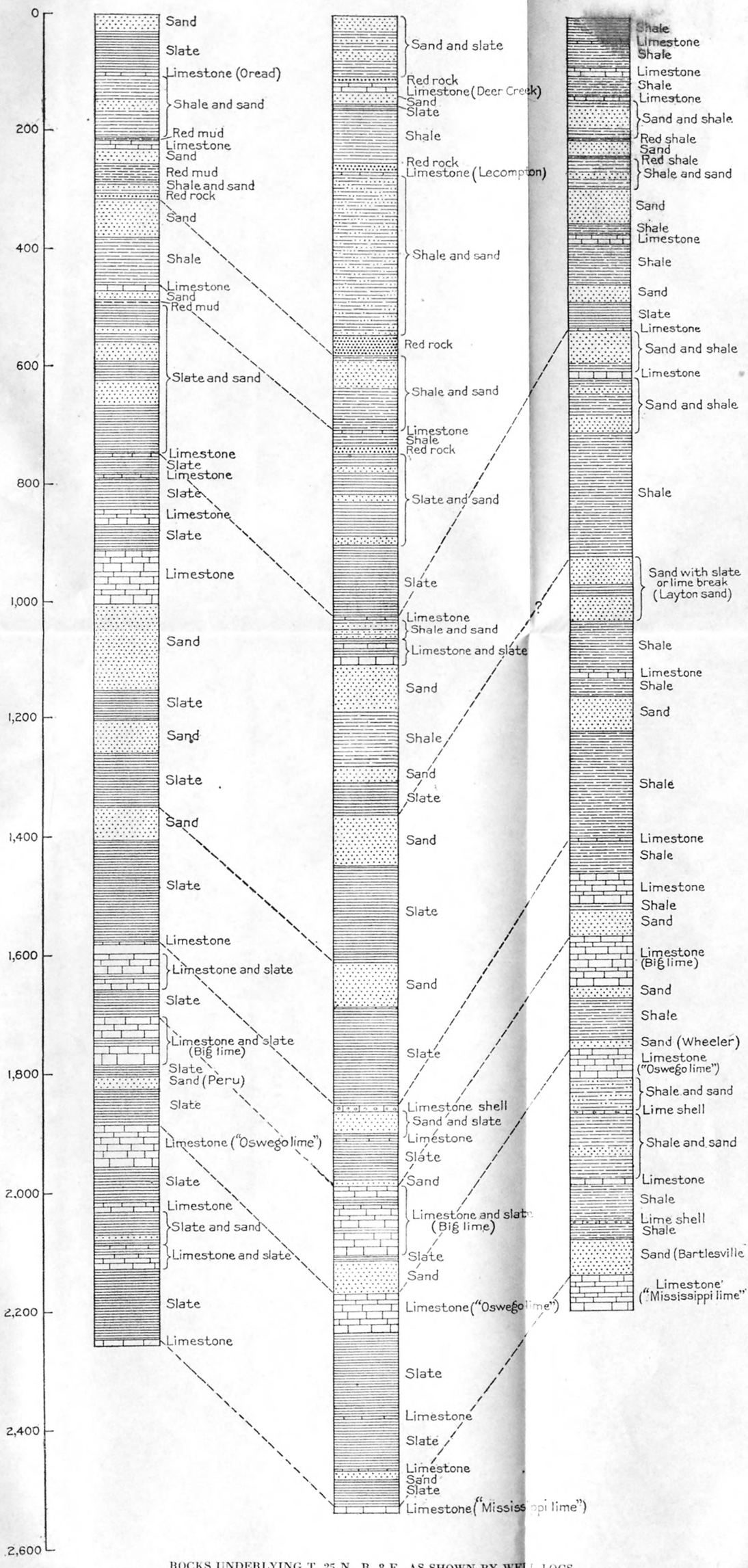


FIGURE 27.—Sketch showing approximate positions of the axes of anticlinal folds in Tps. 24 and 25 N., R. 8 E.



SECTIONS SHOWING DRILLER'S INTERPRETATIONS OF UNEXPOSED ROCKS IN OR ADJACENT TO WESTERN OSAGE COUNTY, THEIR RELATIONS TO THE EXPOSED ROCKS, AND THE PROBABLE CORRELATIONS OF THE SANDS



ROCKS UNDERLYING T. 25 N., R. 8 E., AS SHOWN BY WELL LOGS.

ANTICLINES AND DOMES.

RAINBOW ANTICLINE.[1]

The axis of the Rainbow anticline trends northwest across the center of sec. 31, T. 24 N., R. 8 E., athwart the syncline referred to above, which divides the anticline into two distinct parts. The southeastern part continues to rise toward the southeast as the anticlinal axis passes out of the area under discussion into sec. 5, T. 23 N., R. 8 E.

The northwestern portion of the Rainbow anticline is a broad, low dome covering parts of secs. 25 and 36, T. 24 N., R. 7 E., and of secs. 30 and 31, T. 24 N., R. 8 E. The summit of the dome is in sec. 25, and only the eastern and northeastern flanks lie within the townships which are the subject of this report. The closure is less than 20 feet. No tests have been drilled on this fold, but from the presence of the rich oil field 3½ miles southeast of it the inference is justifiable that oil and gas bearing sands are present at this locality. To judge from the general shape and size of the dome, however, it does not appear probable that wells drilled in it will yield nearly so much oil as has been produced from the wells in the more pronounced dome of this neighboring field.

The best location for a test well on the northwestern portion of the Rainbow anticline is a little west of the center of the SE. ¼ sec. 25, T. 24 N., R. 7 E. A well drilled there should strike the "Oswego lime" between 2,100 and 2,200 feet below the surface, and the "Mississippi lime" about 375 feet deeper. It should be drilled to a depth of at least 3,000 feet to be an adequate test. Within R. 8 E. the best location for testing this structure would be at the middle of the west side of sec. 30, T. 24 N. Conditions favoring the accumulation of oil and gas are present throughout the greater part of the W. ½ NW. ¼ and the SW. ¼ sec. 30 and the NW. ¼ sec. 31, T. 24 N., R. 8 E.

TURKEY ANTICLINE.

The axis of the Turkey anticline is sigmoidal and extends from a point near the center of sec. 19 across the NW. ¼ sec. 20 and through the W. ½ sec. 17 and dies out against the southern flank of the Dalton dome, near the center of sec. 8, T. 24 N., R. 8 E. The crest of the anticline is modified by two domelike bulges, each with a closure of little more than 10 feet and each pierced by a fault extended from the axis of the syncline toward the east. Neither has been tested.

[1] In the preceding chapter of this volume (Bull. 686–L) the Rainbow anticline is described in the text (p. 145) as the South Hominy Creek anticline. In the same chapter the name of the North Hominy Creek anticline was, through an oversight, omitted from the map (Pl. XXIII).

The south dome is broad and flat, embracing less than half a square mile, although the accumulation of oil and gas may be influenced by it over a much larger area. The broad, flat terrace underlying all of sec. 18 may be of considerable economic importance, though wells with only a moderate yield are all that can be expected even in its most favorable part. Good places for test wells may be found near the center of the NW. ¼ sec. 20, a little south of the center of the NE. ¼ sec. 19, or in the extreme southwest corner of sec. 17. If the first of these localities is chosen and the well is drilled in the creek bottom it should encounter the Big lime at a depth between 1,800 and 1,850 feet, the Oswego lime somewhere near 2,000 feet, and the Mississippi lime between 2,300 and 2,400 feet.

The north dome on the Turkey anticline covers a much smaller area, centering about a point 1,700 feet east of the northwest corner of sec. 17. This feature might better be described as a warped terrace on the south flank of the Dalton dome. Its importance as a reservoir of hydrocarbons is probably very slight in comparison with that of the larger and higher dome to the north. No prospecting for oil or gas should be attempted there unless the Dalton dome should prove to inclose a productive pool.

DALTON DOME.

The Dalton dome is a much more pronounced uplift than any of those described above, both as regards area and closure. The lowest closed contour embraces an area of nearly a square mile in the southern and western parts of sec. 5, the SE. ¼ sec. 6, the NE. ¼ sec. 7, and along the north side of sec. 8, T. 24 N., R. 8 E. The closure is about 30 feet. The crown of the dome is centered near the middle of the east line of the SW. ¼ sec. 5; there is a secondary bulge in the SE. ¼ SE. ¼ sec. 6.

The size and shape of this dome and the area of gathering ground from which oil may have migrated to form a pool beneath it appear favorable for the development of wells with at least moderate yield. The presence of a dry hole squarely on top of the smaller bulge near the southeast corner of sec. 6 is therefore very much of a disappointment. This well, which was drilled in the spring of 1918, reached a depth of 2,529 feet without encountering more than small "showings" of oil and gas. At the horizon of the Layton sand, as that name is applied in the oil field in the southeast corner of the township, only large volumes of water were encountered. A light show of oil is reported from a sand 250 feet lower; and a limestone penetrated at 1,985 feet, reported as the "Oswego lime," but in reality the Big lime, yielded a "small show" of gas. A short distance below this limestone is a sand—the equivalent of the Wheeler sand of the oil field 6 miles to the southeast—from which a "small show" of oil

was obtained. The Fort Scott ("Oswego") limestone carried no oil. At the horizon of the Bartlesville sand 15 feet of "broken sand" which did not show any sign of oil or gas was encountered. The "Mississippi lime," which gave a "very small show" of gas, was penetrated for only 10 feet. The rocks reported by the driller as having been penetrated are shown graphically in Plate XXVI.

Before condemning the Dalton dome, or even before concluding that the sands above the "Mississippi lime" will not yield oil or gas in commercial quantities within its area, at least one other test hole should be drilled. It should be located on the higher and larger bulge in the SW. ¼ sec. 5. The Big lime should be reached here at a depth of about 1,950 feet, the "Oswego lime" at about 2,120 to 2,150 feet, and the "Mississippi lime" at nearly 2,500 feet. The hole should be continued to about 3,100 feet in order to give an adequate test. It is greatly to be regretted that the hole in sec. 6 was not drilled deep enough into the "Mississippi lime" to reach the beds 130 feet and more below its top, which have been proved to yield commercial quantities of oil and gas elsewhere in the Osage Reservation.

COLD SPRING ANTICLINE.

The sinuous crest of the Cold Spring anticline stretches from the NE. ¼ sec. 6, T. 24 N., R. 8 E., northward across secs. 31 and 30, T. 25 N., R. 8 E., bends eastward along the north side of sec. 29 and reaches its highest altitude in the SW. ¼ sec. 21. There it is sheared downward by a crooked fault that extends across it and the adjacent syncline in secs. 28 and 21, but the anticlinal fold continues northeastward nearly to the north line of sec. 21, where it terminates against another but much smaller fault. (See fig. 27.) A branch from this main crest extends southward from the center of sec. 29 to the center of sec. 32; another trends westward from the southern part of sec. 20 to the center of sec. 19; and a third minor flexure crosses the NE. ¼ sec. 20 to the SW. ¼ sec. 17. About 2¼ square miles is included within the lowest closed contour on this anticline, but nearly one-fifth of the township is underlain by beds having the favorable structure pertaining to it. The closure is about 90 feet, but the area from which oil and gas may be drawn probably extends west of the lowest closed contour. The size, shape, and relation to drainage area of the Cold Spring anticline indicate that it is one of the most favorable uplifts for the localization of an oil and gas pool in the region under discussion, and it is difficult to see how the fault which crosses it can materially improve or impair its capacity as a reservoir of hydrocarbons. Unless there is an utter absence of suitably porous strata, or of a source for oil and gas, beneath this anticline, it should yield many wells of moderate production and a few of large flow. Structure favorable for oil accumulation is found in all

of sec. 21 except the SE. ¼ and the far northwest corner, all of sec. 20 except the NE. ¼, the SW. ¼ sec. 17, nearly all of secs. 19, 30, and 31, all but the southeast corner of sec. 29, and the northwest corner of sec. 28.

This anticline has not been drilled, although three holes have been sunk in its immediate vicinity. The dry hole in the southeast corner of sec. 16 is exactly in the bottom of the synclinal saddle between the Cold Spring anticline and the Polledoak dome. Its record, as preserved in the archives of the Osage Indian Agency, shows 200 feet of "sand and water" at a depth of 950 feet, immediately below a limestone which was incorrectly identified as the Big lime. This sand probably represents the Layton sand of the oil field in the southeast corner of T. 24 N., R. 8 E. A 55-foot sand was penetrated at a depth of 1,405 feet. Between a limestone series at 1,670 to 1,680 feet, which doubtless represents the Big lime, and the Fort Scott ("Oswego") limestone there is reported to be 65 feet of "slate." Below the Fort Scott limestone only "slate and shells" are recorded until the "Mississippi lime" is reached at 2,284 feet. It was penetrated for only 7 feet. This record is a very poor one, and the information it gives can not be accepted without question. There must be some doubt about the absence of sands between the Fort Scott and the "Mississippi lime." Another well drilled since the completion of the field work on which this report is based is situated on the southwest flank of the Whitecliff dome, in the southeast corner of sec. 33. Gas was encountered in this well at a little more than 1,000 feet below the surface, and oil in commercial quantities was obtained from a 21-foot sand at 1,890 feet. This sand would correspond to either the Peru or Wheeler sand of the drillers, and its presence here lends support to the hope that it is also present beneath the Cold Spring anticline. The third well near this anticline is that, already referred to, which punctures the secondary bulge on the crest of the Dalton dome in sec. 6, T. 24 N., R. 8 E.

Test wells should be sunk at a number of points on the Cold Spring anticline. One should be drilled about 500 feet east and 200 feet north from the southwest corner of sec. 21, squarely on top of the highest point of the fold, where the Big lime may be expected at a depth of about 1,800 feet, the "Oswego lime" at approximately 2,050 feet, and the "Mississippi lime" between 2,400 and 2,500 feet. A good place for a second test is in the SE. ¼ NW. ¼ sec. 21, where the limestones just named should be encountered at depths 75 to 100 feet less than in the first test suggested. A third suggested location is in the SW. ¼ NE. ¼ sec. 19, where depths to the limestones should be about 50 feet greater than in the first test suggested. Still another hole, to complete the thorough testing of this anticline, might be sunk near the center of sec. 29.

POLLEDOAK DOME.

The apex of the Polledoak dome is near the southeast corner of sec. 9, T. 25 N., R. 8 E., and the area embraced within the fold covers approximately 1 square mile, including the N. ½ sec. 16, the SE. ¼ sec. 9, and parts of the SW. ¼ sec. 10 and the NW. ¼ sec. 15. It is difficult to estimate the amount of closure with accuracy. If the long fault that traverses the whole of sec. 15 effectually seals the northeast side of the fold, the closure is about 40 feet, and nearly a half section is included within the lowest closed contour. If this fault does not continue to the oil or gas bearing strata which may be below the surface here, the closure is less than 20 feet and less than a quarter section is included within the lowest closed contour. In either event, the dome is well worth a test, for the dry hole in the syncline to the south, referred to in a preceding paragraph, is no criterion of conditions within the area of this dome.

It is quite likely that at least a moderate yield will be obtained within the area covered by the Polledoak dome. The structure is well defined, the closure is fair in amount, and the area available for drainage into the dome is extensive. The best place for a test well is on the crown of the dome in the SE. ¼ SE. ¼ sec. 9. A well on the table-land there should strike the Big lime at a depth between 1,750 and 1,800 feet, the "Oswego lime" about 250 feet lower, and the "Mississippi lime" between 2,350 and 2,400 feet.

CLEAR CREEK DOMES.

The Clear Creek domes are three small bulges on the surface of a broad terrace which extends from the NE. ¼ sec. 13, T. 25 N., R. 7 E., to the NE. ¼ sec. 5, T. 25 N., R. 8 E. It is possible that the entire area between the 540 and 580 foot contours in this corner of T. 25 N., R. 8 E., may prove to be underlain by gas or oil in commercial quantities, although no wells of more than moderate yield should be expected. The three small domes, however, extend much greater promise than the portions of the terrace beyond their limits. Each has a closure of 10 to 20 feet, and the middle one of the three covers an area of about half a square mile. In view of the magnitude of its drainage area to the west, this largest one of the Clear Creek domes is well worthy of a test, although the results of the test can not be forecast until the Coldspring anticline and the Polledoak dome have been drilled. The test well might be located in the Clear Creek bottoms about 1,700 feet east of the west line and 1,500 feet south of the north line of sec. 8. The Big lime probably lies about 1,800 feet below the surface at that point.

RODEO ANTICLINE.

Stretching northeastward from the NE. ¼ sec. 15, T. 25 N., R. 8 E., is a broad, low fold—the Rodeo anticline. Nearly 2 square miles in secs. 1, 2, 3, 10, 11, 14, and 15, T. 25 N., R. 8 E., fall within the lowest closed contour on this fold, although the closure is only 30 feet. Two small bulges centering in the NE. ¼ and the SE. ¼ sec. 10 rise above the generally flat summit of this anticline. Structurally it is well adapted for the localization of an oil or gas pool, although its gentle slopes may mean that only moderate yield would be obtained from its wells. The drainage area is less than might be desired. Even though the faults which graze the anticline on the southwest should prove ineffectual as a barrier to the migration of oil and gas, the source of supply from that direction is to some extent cut off by the domes and anticlines just beyond, so that the Rodeo anticline could receive the drainage up the general western dip of the region only through a narrow belt in the N. ½ sec. 10 and the S. ½ sec. 3.

Little light can at present be shed upon the question of the presence or absence of suitable strata which might serve as reservoirs of oil and gas below this anticline and without which the favorable structure will be of no avail. The anticline has not been drilled and none of the closely adjacent folds have been tested. A good place for a test well is probably in the NE. ¼ NE. ¼ sec. 10 about 1,000 feet west of the east line of the section; a second location is near the center of the NW. ¼ NE. ¼ sec. 15. At the location in sec. 10 the Big lime should be struck at a depth of 1,725 feet, the Fort Scott limestone between 1,950 and 2,000 feet, and the "Mississippi lime" between 2,300 and 2,350 feet. The well in sec. 15 would reach the same horizons at depths only slightly less.

MAYER ANTICLINE.

The Mayer anticline is a short fold extending westward across the S. ½ sec. 24, T. 25 N., R. 8 E., into the SE. ¼ sec. 23. There is no closure; the fold is outlined by strong north, west, and south dips, but no east dip occurs. This anticline is therefore of trivial importance in comparison with the other favorable folds here described. Moreover, it is so hedged in by synclinal troughs that the gathering ground from which oil or gas might migrate into it is very small.

Two holes, both dry, are reported to have been drilled on the flanks of this fold. The locations of these wells as shown on the map are only approximate, for neither was found in the course of the field work on which this map is based. No log of the northern well is available, and that of the southern one merely records the presence

of sand at 1,656 feet and the total depth of the hole as 1,956 feet. This depth would probably carry the hole only a short distance below the Fort Scott ("Oswego") limestone.

Unless good yields should be obtained on the neighboring anticlinal folds, it would not seem advisable to make further tests on the Mayer anticline. Should such a test prove advisable a good location for it is 1,000 feet north of the south line and 1,000 feet west of the east line of sec. 23, on the plunging tip of the anticline. The well here should reach the Big lime at a depth between 1,600 and 1,700 feet, the Fort Scott ("Oswego") limestone 250 to 300 feet deeper, and the "Mississippi lime" between 2,200 and 2,300 feet.

WHITECLIFF DOME.

The prominent, well-defined dome in the middle of the southern part of T. 25 N., R. 8 E., may be referred to as the Whitecliff dome because of the conspicuous cliffs of light-gray Little Hominy and Deer Creek limestone which nearly surround it. The apex of the dome is in the NW. ¼ sec. 34, and large parts of secs. 33, 28, and 27 lie on its flanks or summit. The closure is about 40 feet, and approximately three-fourths of a square mile lies within the lowest closed contour. Should it prove that the structure of this dome has served to localize an oil or gas pool, it may be expected that the productive area will cover the W. ½ sec. 34, much of sec. 27, the southeast corner of sec. 28, and the eastern part of sec. 33. It may also extend into the NE. ¼ sec. 3, T. 24 N., R. 8 E.

Although the Whitecliff dome leaves little to be desired so far as size and shape are concerned, its relations to the general structure of the whole region are not so favorable for the accumulation of a large pool of oil or gas as might be wished. As it stands on the east side of the long, shallow, fault-shattered syncline which traverses the west side of the township, it may, to a large extent, be cut off from any supply of hydrocarbons that may have moved up the regional dip from the west. This condition will probably result in wells of moderate production, with the possible exception of such as are drilled close to the crown of the dome.

Since the completion of the field work on which this report is based a well has been drilled in the southeast corner of sec. 33, on the southwestern flank of this dome. The well log is not now available, but it is known that oil in commercial quantities was struck in a 21-foot sand at a depth of 1,890 feet. This sand is presumably either the Peru or the Wheeler sand of the oil fields to the east and south. The inference is that wells with greater yield may be obtained in the higher parts of the dome and that either gas wells or fairly large oil wells may be expected in the northwest corner of sec. 34

and the immediately adjacent territory. In estimating the value of the output which may be expected from this dome, the possible presence of the Bartlesville sand and of oil-bearing beds in the "Mississippi lime" below the sand whose presence has been demonstrated by the well just mentioned should be taken into consideration.

The very apex of the Whitecliff dome should be penetrated by a well sunk at a point 1,000 feet east of the west line and an equal distance south of the north line of sec. 34. This well would probably reach the Big lime at a depth of about 1,750 feet, the Fort Scott ("Oswego" limestone 250 or 275 feet deeper, and the "Mississippi lime" at about 2,400 feet.

LEE DOME.

The Lee dome is the easternmost of the separate domes on the axis of a large anticlinal fold which occupies most of the eastern part of T. 24 N., R. 8 E. It is a small rounded swelling, in which the rocks bow upward very gently, and stands on the line between secs. 12 and 13. The closure is but 10 feet, and the area included within the lowest closed contour is only about 80 acres. On the north and south sides of the dome the rocks dip steeply for a long distance into the synclines which border the big anticlinal fold, but on the east and west flanks of the dome the beds lie almost flat.

No drilling has been done on or near the Lee dome, so any guess as to the conditions which underlie it must be based on evidence offered by wells at some distance and is accordingly liable to considerable inaccuracy. To judge from the conditions of the oil field in T. 24 N., R. 8 E., which is about 3 miles south of the Lee dome, the beds most likely to contain oil are moderately shallow sands associated with the Big lime and the Fort Scott ("Oswego") limestone, which are known as the Peru sand and the Wheeler sand in the oil field referred to above. Although the Bartlesville sand may possibly be present in the Lee dome, it is probably either entirely absent or is very thin and can not be expected to be very productive. There is also a possibility that beds in the "Mississippi lime" carry oil and gas at this locality, and any development work that is done on the Lee dome should be thorough enough to determine the nature and oil content of the beds which lie for about 300 feet below the top of the "Mississippi lime."

The structural conditions at the Lee dome would not be considered exceptionally good were it not that this dome is only a part of a very strongly developed anticline which has probably induced the formation of oil pools at any point under its axis where there is appreciable secondary doming.

A good location for a test well is believed to be just east of the quarter corner between secs. 12 and 13. A well located here should

strike the Big lime at a depth of about 1,700 feet, the Fort Scott limestone at about 1,900 feet, and the "Mississippi lime" at about 2,300 feet.

HAPPY HOLLOW DOME.

The Happy Hollow dome is a low fold whose crown lies between Happy Hollow and Little Hominy Creek. The highest point on the fold is a little south of the quarter corner between secs. 11 and 14, and from this point the rocks slope gently to the east and to the west until the dip is reversed on the structural saddles that separate the Happy Hollow dome from the Lee dome on the east and from the Wheeler dome on the west. To the north and the south the dip steepens a short distance from the crown of the dome and the beds descend steeply into the large synclines which limit the fold in these directions.

No drilling has been done on the Happy Hollow dome, and as it is 3 miles from any extensive developments, it is not possible to say definitely what oil-bearing beds may underlie its surface. The nearest producting well is on the Wheeler dome, almost 2 miles west of the center of the crown of the Happy Hollow dome, where a single well has been drilled to the horizon of the "Oswego" lime. Several gas sands and at least one oil sand were struck above the Big lime, from which the principal yield comes. On the Whitecliff anticline, about 3 miles north of the Happy Hollow dome, a single well has been drilled; this well found enough oil at the general horizon of the Fort Scott ("Oswego") limestone to make about a 5-barrel well.

The data given above and the conditions in the oil fields in the southeastern part of T. 24 N., R. 8 E. (see p. 167 and Pl. XXIV), indicate that the beds which are most likely to contain gas and oil below the Happy Hollow dome are those which are closely associated with the Big lime and with the Fort Scott ("Oswego") limestone. There is a chance of obtaining some oil from the Bartlesville sand, but the prospects of any great yield from this sand do not look particularly good. There is a very fair possibility that the "Mississippi lime" will prove to contain both oil and gas, and it should be tested thoroughly beneath this dome.

Good locations for testing the Happy Hollow dome are in the bottom of the valley of Little Hominy Creek near the center of the NW. ¼ NW. ¼ sec. 14 and near the center of the NE. ¼ NE. ¼ sec. 14. A well at the first location should encounter the oil and gas bearing beds of the field in sec. 36 at a depth not more than 100 feet greater than in that field. (See Pl. XXIV.) A well at the second location will find these same beds at slightly greater depth.

WHEELER DOME.

The Wheeler dome lies at the tip or point of the V formed by the large anticline in the eastern part of T. 24 N., R. 8 E. The crown of the dome is just west of the quarter corner between secs. 15 and 16, and the lowest closed contour incloses much of the W. ½ sec. 15 and the E. ½ sec. 16. From the crown of the fold the beds dip gently to the east and the south until they reach the axes of the structural saddles in secs. 15 and 22, which separate the Wheeler dome from the Happy Hollow dome on the east and from the Thirty-six anticline on the south. To the north and west the beds plunge toward the bottoms of the major synclines that limit the large anticlinal fold of which the Wheeler dome is but a part. The closure on the Wheeler dome is only about 20 feet, but it seems improbable that the importance of the dome as a source of oil and gas can be judged by this small measurement. When the field work in T. 24 N., R. 8 E., was completed no drilling had been done on the Wheeler dome, but since that time a well in the SW. ¼ sec. 15, a short distance from the crown of the fold, has been drilled to a depth of 1,933 feet, where it was stopped in the Fort Scott ("Oswego") limestone. This well passed through several gas-bearing sands and one oil-bearing sand in the upper 1,000 feet and obtained a heavy flow of gas from the upper part of the Big lime. The total flow is reported to be 12,000,000 cubic feet a day. The well passed through 12 feet of sand just below the Big lime, but no yield is reported from it. The "Oswego" lime was penetrated 12 feet and is gas bearing.

It has been demonstrated that gas-bearing sands underlie the Wheeler dome, and it is very probable that wells bored farther down from the crown of the dome than the well which is giving the present gas yield will find oil as well as gas in some of these sands. This belief is encouraged by conditions in the field about 3 miles southeast of the Wheeler dome, where the shallow sands in some of the wells carry little but gas, whereas in others only a short distance away they yield large volumes of oil.

Besides the prospects of obtaining oil and gas from the shallow sands there is a possibility that the Bartlesville sand underlies this dome and carries oil. In the field just mentioned the Bartlesville sand has been a disappointment, for it is much thinner than it is in the more productive portions of the Osage Reservation and has contributed a comparatively small amount of oil to the total output of the field. On the other hand, a "pay" sand which is either at the horizon of the Bartlesville or only a little lower has yielded tremendous volumes of oil in secs. 8 and 9, T. 23 N., R. 8 E., only about 5 miles south of the Wheeler dome. Accordingly it must be recognized that there is a strong possibility that some beds at the general horizon

of the Bartlesville will be found extremely productive under this entire area.

Below the Bartlesville sand is the "Mississippi lime," which has not been really tested by any wells in this general region. However, it is known to carry both oil and gas under favorable anticlinal folds in other parts of the Osage Reservation, and there is good reason to hope that it will prove to be similarly productive below the Wheeler dome.

Good locations for further testing of the Wheeler dome are the center of the SE. ¼ SE. ¼ sec. 16, the center of sec. 16, and the extreme southeast corner of sec. 9. It will also probably be well to test the lower part of the dome by drilling near the center of sec. 22. At these locations the oil and gas bearing beds should lie about 200 feet farther below the surface than they do in sec. 36. (See Pl. XXIV.) Drilling should be continued in these wells until they have penetrated the "Mississippi lime" about 300 feet, unless they find "pay" at less depth. This will call for a total depth of not less than 2,700 feet. There is every reason to believe that the anticlinal structure is more pronounced in the "Mississippi lime" than it is on the surface, and the oil-bearing possibilities of this deep lime should be thoroughly demonstrated.

THIRTY-SIX ANTICLINE.

The Thirty-six anticline is the largest of the separate folds that lie along the axis of the big V-shaped anticline in the eastern part of T. 24 N., R. 8 E. The axis of the Thirty-six anticline runs from a point about 1,000 feet west of the quarter corner between secs. 22 and 23 southeastward through the southwest corner of sec. 23 and the center of sec. 26 and along the west side of sec. 36, where it terminates abruptly against a fault with a throw of about 50 feet which cuts squarely across the anticline. On the south end of this anticline an extensive oil and gas field has been developed; wells with an initial daily production as great as 4,000,000 cubic feet of gas and 400 barrels of oil have been reported, although the average is much less. The fields extend far down the east flank of the anticline toward the syncline that borders the fold on the east. As noted in a preceding paragraph of this report (p. 154), the oil and gas are obtained largely from the Wheeler sand and the "Oswego" lime, reached at a depth between 1,700 and 1,800 feet, but the Peru sand, a little higher in the section, and the Bartlesville sand, reached at a depth of about 2,050 feet, also give fair yields. It is reported that wells drilled since the completion of the field work for this report have obtained very good yields from sands that lie above the Peru sand, but no information concerning the exact position of these sands

in the stratigraphic section or the initial production of the wells is available. So far as can be learned no wells have been drilled deeper than 50 feet into the "Mississippi lime," which is not a sufficient depth to test this formation adequately. It is very important that wells be drilled at least 300 feet into the lime below the Thirty-six anticline, as this formation has yielded large volumes of both oil and gas elsewhere in the Osage Reservation, and there are few localities where the geologic structure appears better suited to have brought about an accumulation of oil and gas than under the Thirty-six anticline. The exact effect which the large fault that cuts the beds on the Thirty-six anticline has had upon the oil and gas-bearing strata has not been determined. Thus far no wells with large production have been completed west of the fault, but it can not be said definitely that the fault is the cause of the small yield.

The Thirty-six anticline should be developed by extending the present field to the north and west; it is probably also justifiable to drill a few test wells beyond the productive area. Good locations for these wells are the center of sec. 26, the extreme northwest corner of sec. 26, and the center of the SW. ¼ SE. ¼ sec. 35. At all these locations the beds which are productive in the developed field lie at slightly greater depths below the surface than in the wells that have already been drilled.

FALLS ANTICLINE.

The Falls anticline is a small fold extending from the SE. ¼ sec. 32, T. 24 N., R. 8 E., in a direction a little east of north to the SE. ¼ sec. 21, where it merges with the Little Hominy anticline. Beneath the bed of Hominy Creek the anticlinal fold is crossed by a synclinal saddle which divides it into two parts, each of which is in reality a long, narrow terrace or "nose" extending outward from the lower flanks of a large anticlinal uplift. The northern part of the Falls anticline is a low terrace projected far southward from the side of the Little Hominy anticline and bears a small bulge with a closure of about 10 feet on the outer end of the "step." The southern part of the Falls anticline bears a similar though somewhat more remote relation to the anticlinal fold on which lies the "Osage-Hominy oil field," in and near sec. 9, T. 23 N., R. 8 E.

Neither portion of this fold has been drilled, and no tests should be made here until the location of the oil pools in the adjacent, more pronounced uplifts have been fairly well outlined. Structural conditions beneath the areas included within the 740-foot contour (Pl. XXIV), in secs. 28, 32, and 33, are unquestionably favorable for the accumulation of oil and gas, but only wells of small yield should be expected there. The available gathering ground is small,

and the capacity of the fold at best is slight. Good localities for testing its possibilities will be found in the SW. ¼ NE. ¼ sec. 32 and about 300 feet east of the west quarter corner of sec. 28.

Attention may be directed in this connection to the similar warped terrace underlying the SE. ¼ sec. 34. In spite of its unfavorable situation with respect to the probable directions of underground migration of oil and gas, it may possibly have determined the location of a small pool.

UNFAVORABLE AREAS.

It is evident from the foregoing descriptions of anticlinal folds in Tps. 24 and 25 N., R. 8 E., that the greater part of this area lies in a zone of marked deformation. Either the rocks have been subjected to unusual deformational stresses or they have been of less than average competence to resist stresses. In either event it can scarcely be doubted that crustal movements have been localized here for a long time, probably dating from a period preceding that during which the rocks now exposed at the surface were laid down. It should not be forgotten that deposition has been far from continuous in this region; that a break in sedimentation of continent-wide extent occurred after the deposition of the "Mississippi lime" and before that of the "Oswego lime." This break was occasioned or accompanied by notable crustal movements. Accordingly there may well be in the lower strata beneath these townships many wrinkles which do not appear in the exposed formations. General experience in the Osage Reservation in particular seems to indicate that zones of marked deformation are very likely to contain pools of oil and gas, which disregard to some extent the minor structural features apparent in the surface rocks. Accordingly there are few localities in such a zone which are unworthy of a test by drilling.

Certain districts in these two townships, however, appear so unfavorable to oil or gas accumulation that it seems wise to avoid them. Although it is possible that oil and gas may be present beneath these areas, it is most unlikely that commercial production will ever be attained in them. They should be left undrilled until the remainder of the townships has been explored, and even then they should be tested only if the conditions in some adjoining area indicate that they contain the extension of a previously discovered pool.

Among these unfavorable districts is the syncline embraced between the arms of the Little Hominy anticline (Happy Hollow and Lee domes and Thirty-six anticline) in T. 24 N., R. 8 E.; most of the N. ½ sec. 25, the SW. ¼ sec. 24, and the N. ½ sec. 23 lie on the floor or lower slopes of that syncline and should be avoided.

The E. ½ sec. 33, T. 24 N., R. 8 E., bears an analogous relation to the synclinal basin east of the Falls anticline. The SW. ¼ sec. 19, the NW. ¼ sec. 9, all of secs. 1 and 2, and all except the northern margin of sec. 3, T. 24 N., R. 8 E., appear distinctly unpromising. In T. 25 N., R. 8 E., the synclinal basins beneath secs. 12 and 13, the E. ½ secs. 11 and 14, and secs. 25, 26, 35, and 36 place those districts in the same category. The E. ½ sec. 32 and the SW. ¼ sec. 28 should likewise be avoided.