T. 29 N., RS. 11 AND 12 E.

By MARCUS I. GOLDMAN.

INTRODUCTION.

The geologic work on most of T. 29 N., Rs. 11 and 12 E. (see fig. 1), was done between the beginning of October, 1917, and the end of February, 1918, by the writer, assisted for a short time by Frank Reeves, under the general direction of K. C. Heald, who helped especially in working out the structure in some of the areas where it is more difficult to unravel. Mr. Heald himself mapped the area in the northwestern part of T. 29 N., R. 12 E., as shown on Plate XLIX. The instrument work was done by Elton Rhine and Mary Ware Goldman and for a few days by Frank Reeves.

T. 29 N., R. 11 E., is rather open and rolling except in its northwestern part, which is marked by sandstone escarpments, where higher sandstones come in. As the surface rises in the northern part of T. 29 N., R. 12 E., it becomes rough and more wooded, but the southern part of that township, separated from the northern part by a pronounced escarpment, capped by the Cheshewalla sandstone, is also open and rolling. The proposed line of the Atchison, Topeka & Santa Fe Railway from Pawhuska, Okla., to Caney, Kans., lies just south of these townships, passing through the extreme southeast corner of T. 29 N., R. 12 E.

STRATIGRAPHY.

ROCKS EXPOSED.

The rocks exposed in T. 29 N., R. 12 E., are predominantly shales, but there are a few sandstone beds present and a very minor amount of limestone. The stratigraphic relations of these rocks are shown graphically in figure 46, and the characteristic features of the beds which were most useful in mapping the structure of the townships are briefly described below.

Jonesburg sandstone.—The Jonesburg sandstone is a persistent bed which forms the rim of many of the minor ridges and plateaus in the northwestern part of this area. It is named for its conspicuous exposure on the top of the ridge west of the town of Jonesburg, Chautauqua County, Kans., a short distance to the north of T. 29 N.,

R. 11 E. Its topographic position in this area makes it seem probable that it is the lowest bed of the "Chautauqua sandstone" of Adams.[1] Its physical appearance is not sufficiently characteristic to permit it to be distinguished by this criterion from other sandstones in this area. It can, however, be recognized by its relation to a thin sandstone about 12 feet above it, which generally exhibits fossil imprints, mainly pelecypods and gastropods, among which the strongly ornamented *Astartella* can frequently be observed. Very rarely the fossils of the overlying sandstone appear in the upper part of the Jonesburg sandstone itself, and near the extreme northwest edge of the township surfaces covered with impressions of *Fusulina* were found. In places the top of the Jonesburg sandstone shows a heavy stain of red to yellow ocher, and the tops of the main beds display beautifully preserved linear ripple marks and current marks. However, these same markings have also been observed in other sandstones in the townships discussed in this report, so although they are of local assistance they can not be used as definite criteria for the recognition of this sandstone. Like all the other sandstones of the area, the Jonesburg is of variable thickness. In most localities it is evidently at least 5 to 10 feet thick, but locally, as in the NW. ¼ sec. 17, T. 29 N., R. 11 E., it is 75 feet or more thick.

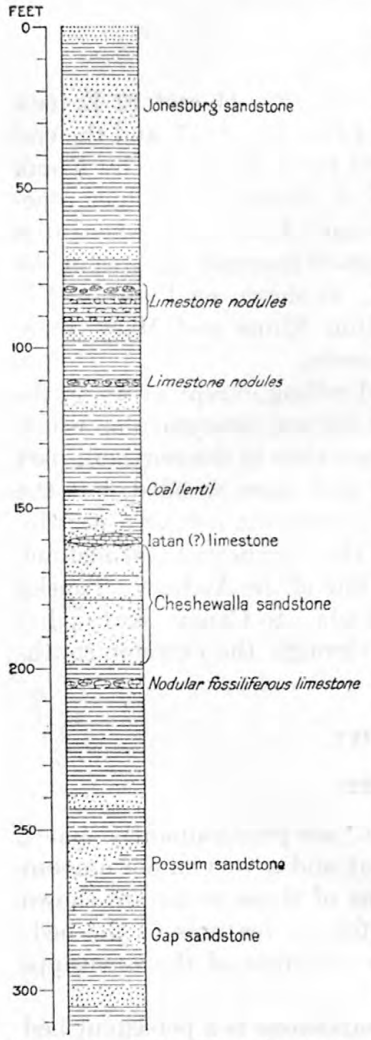

FIGURE 46.—Stratigraphic section showing rocks exposed in T. 29 N., Rs. 11 and 12 E.

Limestone nodules in shale.—A series of layers of limestone nodules was observed in several places from 65 to 100 feet below the top of the Jonesburg sandstone (the upper layer of limestone nodules in fig. 46). These limestone nodules are associated with abundant marine fossils of many kinds, among which Bryozoa are the most easily distinguishable. The nodules are distributed through a layer of about 11 feet in the shale, but the largest ones, averaging some 4 to 5 inches in diameter, occur near the top of

[1] Kansas Univ. Geol. Survey, vol. 3, pp. 58, 59, 1898; vol. 9, p. 107, 1908.

the layer. At approximately the same horizon some white to yellow vesicular calcareous material is in many places disseminated through the shale. This is undoubtedly the product of concentration of limy material in the shale by surface waters, so that it does not represent a definite horizon, but it may be easily confused with scattered nodules of limestone, weathered out of the shale. The layer of limestone nodules was used only in working out the complicated structure along the fault in sec. 16, T. 29 N., R. 11 E. Limestone nodules at a lower horizon were found in sec. 31 near the west edge of T. 29 N., R. 11 E., and are said to be represented by a more persistent limestone farther west. Between these limy series and the Jonesburg sandstone is shale with some lenticular bodies of sandstone.

Iatan (?) limestone.—The Iatan (?) limestone, which lies from 100 to 180 feet below the top of the Jonesburg sandstone, is an impure limestone, in some places as much as 7 feet thick and in others represented merely by impressions of fossils on the upper surface of the underlying sandstone. It seems very probable that this is the continuation of the "Kickapoo limestone" of Kansas (now considered as unquestionably the same as the Iatan limestone of Missouri), though unfortunately the "Kickapoo limestone" is not shown on any of the available maps of that part of Kansas which is just north of T. 29 N., R. 11 E. However, the outcrop of this limestone at the Kansas boundary of the township is intermediate in position between the outcrops of the Oread and Stanton and Plattsburg limestones, and the general description given in the Kansas report conforms to what is found in T. 29 N., R. 11 E., in Oklahoma. The Kansas report[1] describes the limestone as "found in places here and there"; correlates it with the "lenticular limestone of Willow Creek described by Schrader," notes its frequent variations in thickness, and says that "in some places it is scarcely recognizable." This variation in thickness is characteristic of the Iatan(?) limestone in the townships under discussion. It is probably best developed in sec. 16, T. 29 N., R. 11 E., but it is also prominent in the southeastern part of sec. 22 and the northwestern part of sec. 27, T. 29 N., R. 11 E. In the southwest corner of sec. 34, T. 29 N., R. 11 E., it attains a thickness of 7 to 8 feet, the greatest thickness noted in this area. Over most of the rest of the area it is represented only by shell impressions in sandstone, but near the middle of the boundary between secs. 25 and 26, T. 29 N., R. 11 E., it appears in an isolated lens about 5 feet thick and 100 feet long. In T. 29 N., R. 12 E., it has been noted only near the west edge, but fossils in the upper part of the underlying sandstone are persistent throughout the township.

[1] Kansas Univ. Geol. Survey, vol. 9, p. 106, 1908.

Fusulina is the most characteristic and easily recognizable fossil in the limestone throughout this area. It is least conspicuous in sec. 16, T. 29 N., R. 11 E., where the limestone consists more predominantly of other shells, including brachiopods and corals. Along Skull Creek *Fusulina* practically makes up the limestone and is abundant in the basal 3 or 4 feet of the overlying sandstone.

Cheshewalla sandstone.—The Cheshewalla sandstone, named by Winchester and Heald,[1] from Cheshewalla Creek, in T. 25 N., R. 10 E., immediately underlies the Iatan(?) limestone. It is very similar in general appearance and composition to the other sandstones in this region, being composed of very fine, moderately well rounded translucent grains of quartz cemented with varying degrees of firmness into beds which are in some places thick and massive and in others finger out into thin flagstones, with intervening lentils of shale. The upper portion of this sandstone is commonly fossiliferous, pelecypods and gastropods being particularly abundant. The fossils are largely confined to the thin flaky beds, but here and there imprints of *Fusulina* and other forms are found in the upper surface of the more massive members. The thickness of the bed varies from place to place. The maximum thickness is probably more than 50 feet, but in some parts of T. 29 N., R. 12 E., the bed is less than 20 feet thick. In T. 29 N., R. 12 E., occur a number of more or less distinct heavy benches from 2 or 3 to 10 feet thick, separated from the main overlying sandstone by thin layers of shale. These benches are particularly numerous and heavy along the sides of the Coon Creek valley, in the northern part of the township.

Possum sandstone.—The Possum sandstone is the first sandstone of prominence below the Cheshewalla sandstone in T. 29 N., R. 11 E. Between it and the Cheshewalla is a shale member usually 75 to 100 feet thick. This shale member contains a number of lenticular sandstones which occupy about 50 feet of the interval, but none of these could be traced for any appreciable distance. The Possum sandstone is therefore equivalent to a part of the Revard sandstone,[2] probably lying at or being near the top of that sandstone.

In the western part of its area the Possum sandstone is a soft massive bed, the freshly broken surface of which shows some discontinuous bedding lines and is generally covered with rusty or blackish specks as much as an eighth of an inch in diameter. To the east in sec. 32, T. 29 N., R. 12 E., the bed thins abruptly, changes to a hard, platy, greenish limy or sideritic sandstone only a few inches thick, and within a few feet disappears entirely. This accounts for the fact that the line on Plate XLIX indicating the outcrop in that section does not close. Similar greenish sideritic material was found

[1] Winchester, D. E., and Heald, K. C., U. S. Geol. Survey Bull. 686–G, p. 61, 1918.
[2] U. S. Geol. Survey Bull. 686–G, pp. 61–63, 1918; Bull. 686–I, p. 94, 1918.

overlying the Possum sandstone at several places, and about 1,000 feet south of the southwest corner of T. 29 N., R. 12 E., about 1 foot of this material is overlain by a few inches of nodular limestone made up mainly of fossils, including many brachiopods and large crinoid stems.

The Possum sandstone is named from the occurrence as a prominent ledge along the sides of Opossum Creek in the southeast corner of T. 29 N., R. 11 E.

Gap sandstone.—The Gap sandstone is named from its occurrence at the top of Gap Ridge, in the southeast corner of the area mapped. The gap, locally known as Osage Gap, through which pass a high road and the branch of the Atchison, Topeka & Santa Fe Railway between Pawhuska, Okla., and Caney, Kans., cuts through this ridge just east of the southeast corner of T. 29 N., R. 12 E., as shown on the map. In its exposure at the gap the sandstone is 10 feet or less thick, but it thickens to the north, where it forms the surface of most of the Ramsey anticline. This sandstone, like the Possum sandstone, is equivalent to a part of the Revard sandstone of neighboring townships. Like most of the other sandstones in this part of the section, it is very lenticular. It was not recognized to the west across the valley of Coon Creek, in sec. 32, T. 29 N., R. 12 E., and it can be seen to pinch out within half a mile to the south of the gap, in and just east of the northeast corner of T. 28 N., R. 12 E.

ROCKS NOT EXPOSED.

Inspection of the map (Pl. XLIX) shows that except in the small field in the north-central part of T. 29 N., R. 11 E., and in the northwestern part of sec. 17 of the same township, drilling in the area under discussion is very small in amount and widely scattered. So far as known only eight wells in T. 29 N., R. 11 E., and three in T. 29 N., R. 12 E., have reached the "Mississippi lime." Of several of these wells the record is very incomplete, in some logs only the "Mississippi lime" being recorded. Those having more complete records all started within a few feet of the top of the Cheshewalla sandstone. Below are given the average approximate distances below the top of that sandstone of the principal strata encountered:

Approximate distances below top of Cheshewalla sandstone of principal strata encountered in wells in T. 29 N., Rs. 11 and 12 E.

	Feet.
Sand with a little gas and some water	250–350
Gas and water sand	550
Red or Stray sand (so-called "Peru" sand of some drillers)	900–1,000
Big lime, sometimes with a strong flow of gas (20–90 feet thick, average about 50 feet)	1,000–1,050
"Oswego lime" with interbedded black shale (about 75–125 feet thick)	1,310
"Mississippi lime" (greatest thickness penetrated 123 feet)	1,650–1,780

A number of these deep wells obtained considerable gas and a showing of oil in the "Mississippi lime," but the available records report a workable yield of oil from only one, the 225-barrel well at the south edge of the SW. ¼ sec. 31.

Most of the oil and gas produced in the area appears to come from a sand called by the drillers the "Peru" sand, although it does not coincide with the true Peru sand. It lies at an average distance of 950 feet below the top of the Cheshewalla sandstone, ranging from about 900 feet to a little over 1,000 feet, but usually between 950 and 1,000. Its thickness seems to be about 45 feet. It does not appear to be recorded in any of the wells drilled to the "Mississippi lime," unless it is represented by 45 feet of water-bearing "lime" found at a depth of about 935 feet below the Cheshewalla sandstone in a well in sec. 30, T. 29 N., R. 12 E., and 4 feet of "lime" at a depth of 910 feet below the Cheshewalla in a well in the NE. ¼ sec. 20, T. 29 N., R. 11 E. The true Peru sand lies below the Big lime, but the Big lime, so far as noted, is never recorded above the so-called "Peru" sand. Probably this "Peru" sand occupies approximately the same horizon as the No. 7 sand, from which oil is obtained in T. 29 N., R. 10 E.[1] It is probably the equivalent of the Red or Stray sand, which is one of the important producing sands in Chautauqua County, Kans.[2] The logs of three of the wells that go down to the "Mississippi lime" in T. 29 N., Rs. 11 and 12 E., record a sand about 20 feet thick which is believed to be the true Peru sand. They all agree in placing it at a depth of about 1,230 feet below the Cheshewalla sandstone and not more than 10 feet below a heavy lime which in one of these logs is called the Big lime. This lime overlying the true Peru sand is

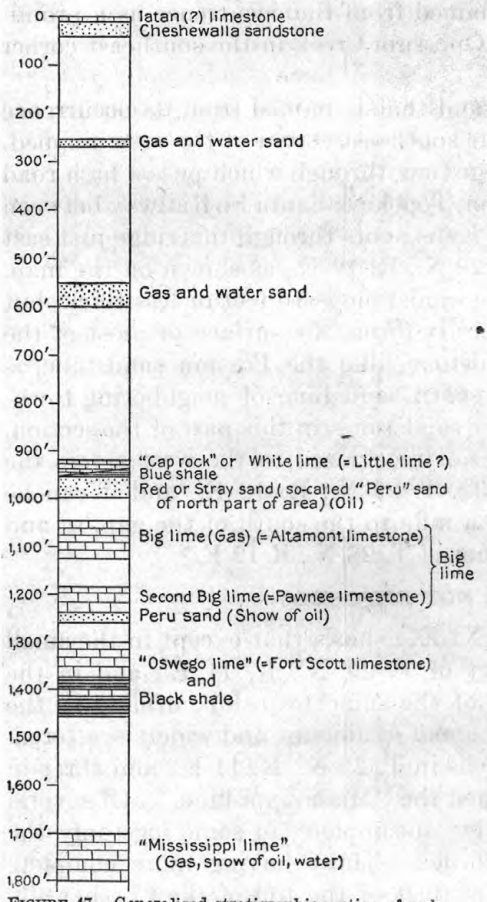

FIGURE 47.—Generalized stratigraphic section of rocks encountered in wells in T. 29 N., Rs. 11 and 12 E.

[1] See U. S. Geol. Survey Bull. 686–F, pl. 9, column 6, 1918.
[2] See Kansas Geol. Survey Bull. 3, pp. 245–246, 1917.

undoubtedly the lower member of the Big lime, sometimes called the Second Big lime in logs of wells in this vicinity. The heavy limestone shown directly above it in the diagrammatic section (fig. 47) is undoubtedly the upper member of the Big lime, generally called merely the Big lime. In one of the three deep wells in T. 29 N., Rs. 11 and 12 E., the true Peru sand gave a show of oil and in another a little gas. The fact that all these deep wells are in the southern part of the area and that none of them record any trace of what might be the higher Red or Stray sand may indicate that that sand disappears to the south. The bed of lime shown just above the Red or Stray sand in figure 47, where recorded at all, generally appears merely as "lime" or "cap rock" in the logs of wells in T. 29 N., Rs. 11 and 12 E., but it is believed to be the equivalent of the bed called the Little lime farther south.[1]

Operators in these townships are strongly urged in all areas where the shallower sands are found to be productive to extend operations to the "Mississippi lime" at a depth of about 1,700 feet and to penetrate it for at least 200 feet.

STRUCTURE.

GENERAL ATTITUDE OF THE BEDS.

The general north to northwest dip that characterizes this region is most evident and uniform along the eastern tier of sections of T. 29 N., R. 12 E., and the eastern 1 to 1½ miles of T. 29 N., R. 11 E. Over most of the remaining area in these townships it is modified by many minor

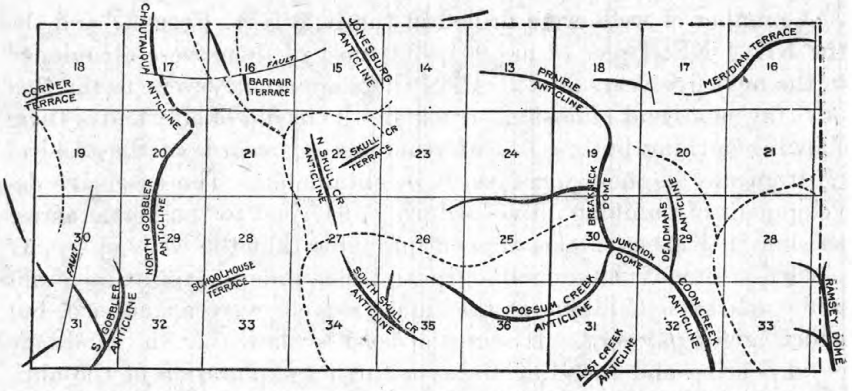

FIGURE 48.—Diagram showing approximate position of axes of folds in T. 29 N., Rs. 11 and 12 E. Dotted lines indicate synclines.

folds and several faults. To a certain extent these minor structural features may be grouped along certain lines. (See fig. 48.) These lines are in two sets, one of which runs approximately north to north-northwest, the other approximately east. Of the northerly lines three or four groups can be recognized. The westernmost runs south

[1] See, for instance, U. S. Geol. Survey Bull. 686–T, pl. 42, facing p. 262; Bull. 686–V, pl. 47, facing p. 306.

from the Chautauqua anticline at the State line in the center of sec. 17 T. 29 N., R. 11 E., to the southern part of sec. 29, and farther south where it is offset toward the west in the South Gobbler axis. Another structural line lies along the east side of the valley of Hickory Creek east of the center of T. 29 N., R. 11 E., starting from the Jonesburg anticline, in the northern part of sec. 15, and running through the North Skull Creek anticline into the south Skull Creek anticline, where it bends toward the east. The most nearly continuous axis is that running from the summit of the Prairie anticline at the center of the south edge of sec. 18, T. 29 N., R. 12 E., south to the Junction dome, in sec. 30, where one of the axes of the east-west set connects it with the north-south axis connecting the Coon Creek and Deadman's anticlines, in secs. 32 and 29, respectively.

A brief discussion of the individual structural features follows.

CHAUTAUQUA ANTICLINE.

The Chautauqua anticline lies in the northern part of sec. 17, T. 29 N., R. 11 E., but the portion within this township is probably merely the south end of a fold lying to the north, across the line in Kansas. That part of it which is more than about three-eighths of a mile south of the State line is broken by transverse faults and synclinal folds which may tend to cause local "dry" areas. The steepness of the flanks of this anticline, combined with a good closure, is favorable for the trapping of any oil that might work its way up the flanks, but they cover so small an area that the amount of oil is likely to be small.

A number of wells were drilled in the N. ½ NW. ¼ sec. 17 and the the NE. ¼ NE. ¼ sec. 18 in 1904, but most of them were abandoned in the next five years or so. All of them apparently went to the Red or Stray sand, and almost all struck oil, the record of only one of them showing nothing but gas. Unfortunately no records of the yield of oil from any of these wells has been obtainable. The extensive development of pumping oil wells during 1917 just to the north, across the line in Kansas, makes it seem probable that the wells in sec. 17 yielded a steady but small output which did not return a profit under market conditions at the time the wells were abandoned, but which might pay now. It serves at least to show that the sand here is oil bearing and therefore to favor further exploration of the anticline to the south along this general axis. The present production on this anticline in Kansas serves further to indicate that no great amount of water was let into the sand when the oil wells were abandoned. How nearly the old wells were exhausted at the time they were abandoned can not be determined from the information available, but it does not seem probable that the sand adjacent to them was drained in the five years or so during which they yielded. The

indications, therefore, favor resuming operations on this fold—if not in the same locations then in the untried portions. For this purpose the anticline may be regarded as extending to the south line of sec. 17.

There is some doubt about the structure of what is regarded as the southern extension of this anticline and of the area lying between this and the North Gobbler anticline, because it has been worked out from a combination of the elevations obtained on a narrow ridge of the Jonesburg sandstone and on a ledge of the Cheshewalla sandstone. The two beds are separated from each other by a broad area in which no outcrops could be found, and at the same time the correlation of elevations from one bed to the other is complicated by the fact that there is evidently a very great and abrupt convergence between the two beds, of which the exact amount can, under the circumstances, only be estimated. A well drilled in the area between the outcrops of the two beds, in the NE. ¼ sec. 20, at the base of the east side of the ridge capped by the Jonesburg sandstone, should have encountered the Cheshewalla sandstone; yet there is nothing in the record to indicate it. It is, however, almost impossible that the Cheshewalla sandstone, which is a 15 to 20 foot bed at its outcrop about half a mile to the east, should be completely absent at this well.

The well, which is just north of the small domelike summit of the anticline at the northeast edge of sec. 20, T. 29 N., R. 11 E., obtained large flows of gas at two horizons above the "Mississippi lime"—one about 600 feet below the top of the Cheshewalla sandstone, the other in a limestone only 4 feet thick at about 910 feet below the Cheshewalla sandstone and some 700 feet above what is probably the Big lime. This may be the equivalent of the Red or Stray sand. At 10 feet down in the "Mississippi lime," which was entered at 1,737 feet, there was a show of oil; at 20 feet below the top of the lime gas was obtained. Large flows of gas would be expected from the relation of the hole to the structure, and therefore the representation of the structure on the accompanying map is probably essentially correct.

The good showings obtained from the "Mississippi lime" in this well suggest that in the extension of development on the Chautauqua anticline exploration should not be limited to the shallower beds, such as the Red or Stray sand, but should be continued to penetrate 200 to 300 feet into the "Mississippi lime."

The most favorable location for a first deep test of this kind would probably be near the productive shallow wells drilled about 1904, especially in the NE. ¼ NW. ¼ sec. 17, T. 29 N., R. 11 E. Here the "Mississippi lime" should be entered at a depth of about 1,800 to 1,900 feet. If tests in this vicinity prove successful, it may be found that the deeper structure is more uniform and the folding more

extensive than that at the surface, and development might be extended over a greater area than is indicated by the surface structure contours.

Since field work in this township was completed two wells have been drilled on the east edge of the NE. ¼ NW. ¼ sec. 18, of which one gave a showing of oil and the other was dry. As these wells are practically in the syncline bounding the Chautauqua anticline on the west, the unfavorable result accords with the structure.

NORTH GOBBLER ANTICLINE.

The North Gobbler anticline is essentially a southward extension of the Chautauqua anticline, but it is pinched off by two synclinal reentrants in the NE. ¼ sec. 20, T. 29 N., R. 11 E., and may be regarded as extending from the NW. ¼ SE. ¼ sec. 20 through the center of sec. 29 to the south boundary of that section. It is a well-defined, regular, broad fold, with a gathering ground on the west flank about three-fourths of a mile wide. It appears to pitch slightly toward the south.

The only well that has been drilled on this anticline is in the SW. ¼ NW. ¼ sec. 29, too far down the west flank toward the small syncline which bounds it. This well struck gas in the top of the "Mississippi lime" and oil some 40 feet deeper; but the initial production was small, and the well, when seen early in 1918, was connected to yield gas only. Neither this well nor any of those adjacent to it in sec. 31 report any oil or gas from the Red or Stray sand. Nevertheless, it seems probable that the yield from that sand in the NW. ¼ sec. 17 might be duplicated in the two sections to the south, and a more favorable location on the anticline might encounter larger quantities of oil in the "Mississippi lime." Locations in the NE. ¼ and SE. ¼ NW. ¼ sec. 29 are suggested as the most favorable for tests. The "Mississippi lime" should be reached at depths of 1,700 to 1,750 feet.

SOUTH GOBBLER ANTICLINE.

The axis of the broadly dome-shaped South Gobbler anticline runs from about the quarter corner between secs. 29 and 30, T. 29 N., R. 11 E., to the quarter corner between secs. 31 and 32, whence it swings off to the southwest, crossing the south township line about a quarter of a mile west of the southeast corner of sec. 31. The principal part of the anticline lies in the SE. ¼ sec. 31; the west flank of the tonguelike northern part is narrower, more irregular, and therefore less favorable for the accumulation of oil. A north-northeasterly fault that bounds the entire west flank of the anticline may have limited the gathering ground for oil. At the time the area was mapped only two test holes had been drilled on this structure. The evidence that they afford is uncertain. One was in the NE. ¼ SE. ¼

sec. 31, slightly east of the axis, which, though somewhat less favorable than a location on the west side of the axis, is still a good position. Near the top of the "Mississippi lime" oil was encountered, which at a slightly greater depth was followed by water, and when seen early in 1918 the well was blowing off gas and salt water. Furthermore, gas was encountered in sands 555 feet and 630 feet and in the Big lime 1,030 feet below the top of the Cheshewalla sandstone, and oil and water were found in a sand about 680 feet below the top of the Cheshewalla. The occurrence of gas at several horizons is to be expected from the position of the well near the top of the fold. The other test hole completed at the time the area was being studied is in the SW. ¼ NE. ¼ SE. ¼ sec. 30. This is well down the west flank of the plunging north end of the anticline. It obtained only a showing of oil, which is all that would be expected from its position with relation to the structure.

Since the field work in this township was completed two other wells have been reported. They are near the east edge of the SE. ¼ NE. ¼ sec. 31. The more southerly of the two, lying nearer the summit of the anticline, is said to yield 25 barrels of oil a day, and the other 10 barrels, from a bed at about 1,700 feet, presumably the "Mississippi lime." The locations are good, though somewhat too near the synclinal reentrant in the NE. ¼ sec. 31. The indications they give for further developments are favorable and agree with what would be expected from the structure as represented. Other favorable locations for further tests would be in the NW. ¼ and SW. ¼ SE. ¼ sec. 31, on the west flank of the main structure.

EXTENSION OF WEST TURKEY CREEK ANTICLINE.

In the SW. ¼ sec. 30 and the NW. ¼ sec. 31, T. 29 N., R. 11 E., there may be a small dome. It is shown on the map in broken lines, on account of the poor surface exposures here, which make the structure uncertain. If correctly mapped it is essentially merely a southeastern extension of the West Turkey Creek anticline, in T. 29 N., R. 10 E.,[1] from which it is separated by a small synclinal pinch. Considered in connection with the adjacent fold in T. 29 N., R. 10 E., it is evidently very insignificant, but if the productive area on the West Turkey Creek anticline is carried in this direction it might be extended to include this small dome. As the surface of this dome lies about 120 feet below the surface of the West Turkey Creek anticline, the Red or Stray sand should be encountered at a depth of about 950 feet and the "Mississippi lime" at about 1,650 feet.

[1] U. S. Geol. Survey Bull. 686-F, pp. 50-51, 1918.

ANTICLINE IN SW. ¼ SEC. 31, T. 29 N., R. 11 E.

Some development work has been done on the southeast flank and summit of the small, sharp, elongated northeasterly anticline in the SW. ¼ sec. 31, T. 29 N., R. 11 E., with very irregular results. A hole near the crest of the fold had an initial yield of 1,500,000 cubic feet of gas a day from the "Mississippi lime"; of two farther down the southeast flank, one was reported to have an initial daily production of 225 barrels of oil from the "Mississippi lime," but the other, 600 feet west of it, yielded only 8 barrels from the same lime and was abandoned. A number of others were dry or yielded only moderate amounts of gas. These results may indicate local variations in the porosity of the "Mississippi lime" or the presence in this sharp little fold of small faults, which perhaps can not be detected at the surface but which nevertheless cut off the flow of oil into parts of the anticline. The shallower sands apparently do not yield oil or gas here. In spite of the great depth to the "Mississippi lime," the fact that a 225-barrel well was obtained on the southeast flank makes it worth while to do further drilling on the more favorable northwest flank of this fold, also on the northeast end in the W. ½ NE. ¼ SW. ¼ and the E. ½ NW. ¼ SW. ¼ sec. 31. Beyond this township the axis of the anticline bends more to the south and extends only about half a mile into the northwest corner of T. 28 N., R. 11 E.

CORNER TERRACE.

A well-defined terrace in the SW. ¼ sec. 18, T. 29 N., R. 11 E., is here called the Corner terrace. The axis runs about due east and pitches west. It has a pronounced summit at its east end, represented by a single closed contour, which gives it a domelike character at that end. From this summit it expands toward the west and southwest. Its position between the Chautauqua anticline on the east and the Turkey Creek anticline on the west, in T. 29 N., R. 10 E., is favorable, offering the possibility of production from at least three beds—the Red or Stray sand, which is to be looked for at about 1,100 feet; the Peru sand, at about 1,200 feet; and the "Mississippi lime," at about 1,750 to 1,800 feet.

TERRACES WEST OF HICKORY CREEK.

Along the west side of Hickory Creek in the tier of sections from 16 to 33 there is a prevailing easterly dip toward Hickory Creek, interrupted by minor folding along axes more or less transverse to this. The east slopes are everywhere relatively short, so that the amount of rock from which oil might accumulate in the upper parts of the slopes is small, and any large production is therefore not to be expected. The writer believes that the steepness of these folds on their slopes toward Hickory Creek may be exaggerated somewhat by slumping,

not in blocks but as a whole bed, of the heavy Cheshewalla sandstone, as a result of the cutting away and slow sliding toward Hickory Creek of the underlying shales, which are in places at least 70 feet thick.

In the valley of Hickory Creek, which runs approximately due north throughout the center of T. 29 N., R. 11 E., alluvium conceals the structure, but it is evident that the valley is underlain by strong synclines with possibly one or more approximately north-south faults.

A brief discussion of the principal individual folds on the general east dip along the west side of Hickory Creek follows.

BARNAIRE TERRACE.

The Barnaire terrace is a very low, flat-topped terrace whose axis runs about due north through the center of the S. ½ sec. 16, T. 29 N., R. 11 E. Although it is not a pronounced structural feature, it is very significant because of the extensive development that has taken place on and around it. The structure in this area is rather difficult to determine on account of the prairie which covers a large part of the area and on account of the valley of Hickory Creek just east of the terrace. There is a practically continuous group of producing wells in the SE. ¼ sec. 16, the SW. ¼ sec. 15, and the NE. ¼ sec. 21. The Barnaire terrace itself has a very slight reversal of dip on its east flank, beyond which the flattening of the beds appears to continue eastward to form practically a westward nose of the small Jonesburg anticline in sec. 15. This structure accounts satisfactorily for the production in secs. 15 and 16. The producing wells in the NE. ¼ sec. 21, however, fall in an area represented as having synclinal structure. Although the mapping of this area is uncertain, the structure being therefore represented by broken contours, the discrepancy between the output that has been obtained and the absence of oil that would be expected is nevertheless noteworthy. The oil is obtained entirely from the so-called "Peru" sand (probably the Red or Stray sand, as explained on p. 334), which is encountered at a depth of about 950 feet, the surface being mostly formed by the top of the Cheshewalla sandstone. The initial production is nowhere large, approximating in most of the wells 20 barrels a day, but on account of the great number of successful wells within a small area and the small cost of the wells it probably yields a considerable profit. Many of the wells have been pumped for about eight years. This is significant for the entire adjacent region as indicating that structural features that appear weak at the surface may offer favorable sites for drilling. The good production obtained in the shallow

sand here makes it desirable that test holes be drilled through to the "Mississippi lime," which should be entered at a depth of about 1,700 feet.

On the north the Barnaire terrace is bounded by a roughly east-west fault against which the downthrust beds on the north side are strongly folded, apparently on a northward continuation of the axis of the terrace. There is in this region some evidence of a general tendency for structural features to be steepened in this way where they are crossed by faults. Something of the same kind appears, both in the next syncline and in the next anticline to the west, along what is probably the same fault. In all these places the steepening is on the downthrown side of the fault, as if the beds had been crowded as a result of a shortening of the arc occupied by them. The anticline mentioned forms a pronounced hill at the surface, but it may be too small to yield a commercial production. Apparently the same axis continues northward to the center of the north edge of the section and doubtless beyond the State line into Kansas. It is quite possible that the productive area on the Barnaire terrace may be found to continue along the northward extension of its axis. In that direction, however, the surface of the central part of the terrace is formed by the Jonesburg sandstone, which lies about 160 feet above the Cheshewalla sandstone, so that there would be that additional distance to go in drilling to the same beds as underlie the Barnaire terrace.

SCHOOL HOUSE TERRACE.

A terrace with east-west axis and easterly pitch on the west edge of Hickory Creek, in the northern part of sec. 33 and southern part of sec. 28, T. 29 N., R. 11 E., is here called the School House terrace. It may have a small closure on its east end, but the exact form of its top is uncertain, on account of the prairie which covers most of it. It has not been tested for oil but appears to be favorable. The Red or Stray sand may not extend as far south as this, but if it is absent production might still be expected from the Peru or some other sand below the Big lime or from the "Mississippi lime." As the Cheshewalla sandstone caps most of the terrace the base of the Big lime should lie at about 1,035 feet below the surface and the top of the "Mississippi lime" at about 1,700 feet. The most favorable position for a test would be about in the SE. ¼ SE. ¼ SW. ¼ sec. 28. To a certain extent this terrace is an easterly extension of the nose running eastward from the South Gobbler anticline at the east edge of the NE. ¼ SE. ¼ sec. 31, and if oil is obtained near the location suggested for a test it might be found to continue westward to the summit of the South Gobbler anticline.

ANTICLINE IN SEC. 33, T. 29 N., R. 11 E.

The tonguelike northeasterly anticlinal ridge in the southeast corner of sec. 33 is essentially a northward extension of a strong upfold just to the south, in sec. 4, T. 28 N., R. 11 E. Its steep east flank seems to offer favorable conditions for the accumulation of oil, though the northwest slope is rather flat and short. In any case testing of it should await developments on the more favorable southward extension in T. 28 N., R. 11 E.

ANTICLINES EAST OF HICKORY CREEK.

Interpretation of the structure directly east of the valley of Hickory Creek is made difficult by the lack of knowledge of what underlies the valley alluvium. As stated above, however, the beds are pretty certainly either synclinal or faulted. In either case the gathering ground, from which oil might have been accumulated, in the upper parts of the small synclines and domes along the west side of the creek is limited, so that large yields are not to be expected, but steady yields of small quantities, like those found in sec. 16, T. 29 N., R. 11 E., may be obtained. The principal individual folds are discussed below.

JONESBURG ANTICLINE.

The Jonesburg fold differs from the others along the east side of Hickory Creek in that the synclinal depression along that creek flattens and practically disappears at this north end, so that, as explained above, structurally the Jonesburg anticline is essentially continuous with the Barnaire terrace on the west side of the creek. This continuity is also indicated by the distribution of the wells. It is a low, flat, broad terrace-like anticline whose axis trends about north-northwest and runs through the NE. ¼ and the N. ½ SE. ¼ sec. 15, T. 29 N., R. 11 E. The highest part is in the SW. ¼ NE. ¼ sec. 15, whence a nose extends slightly south of west toward the west edge of the section. The productive area in the SW. ¼ sec. 15, referred to above in connection with the Barnaire terrace, is on the flank of this anticline, and there is no apparent reason why it should not be found to extend over the entire northern three-quarters of the section. Three wells were drilled in 1903 along the western part of the north line of the section. All these wells produced gas (amount not recorded) from a sand that was encountered at about 950 feet and therefore is apparently the same as that from which oil is obtained to the south and southwest. The interpretation of the occurrence of gas instead of oil here depends somewhat on knowledge of the structure to the north and northwest. If there is an extensive slope in that direction oil may occur farther down on it, while gas has accumulated in this upper part. The other possibility is that here, as

in some other areas, the sand is gas bearing without reference to any structural condition. Most of the wells in the SW. ¼ sec. 15 were completed in 1904 and 1905 and are at present pumping about half a barrel a day each. Records of their initial production are not available. Most of the productive area lies south of the small east-west fault, the holes directly north of it being dry or very small producers. This condition may be due to the interception of oil from lower parts of the slope on the south by the fault. All these wells appear to be obtaining their oil from the Red or Stray sand. The fact that a dry hole was put down just north of the fault suggests the possibility that the southern part of the anticline just north of the fault in the eastern part of the section may also be unfavorable, but it does not seem probable that this would affect the northern part of the anticline in the northwestern part of the section, as oil in this part would gather from the west flank.

NORTH SKULL CREEK ANTICLINE AND TERRACE.

The structure of the North Skull Creek anticline is somewhat indeterminate, the rocks being largely concealed by grazing land with little topographic relief. It is believed, however, that here, as in many other places, there is a general agreement between topography and structure and that the flat prairie corresponds in a general way to the terrace-like structural features shown on the map.

The anticline is long and narrow, and its axis trends about north-northwestward from the center of the N. ½ sec. 27 to the SE. ¼ NW. ¼ sec. 22, T. 29 N., R. 11 E. It forms the western limit of the east-northeastward-trending North Skull Creek terrace. It has a pronounced summit at its south end and a broader, flatter one at its north end. The short west flank of the anticline limits the gathering ground for oil, so that a large production is not to be expected, but pumping wells yielding 5 to 20 barrels a day, like those in adjacent parts of secs. 15, 16, and 21, may be obtained. This result is all the more likely, as the presence of several such wells in the northwest corner of sec. 22 shows the tendency already noted in this area (see p. 341) for even structural features that are not represented as anticlinal to yield oil. It is believed, however, that the best yield should be obtained from the sharp little dome on the south end of the anticline, in the SE. ¼ NE. ¼ NW. ¼ and the NE. ¼ SE. ¼ NW. ¼ sec. 27.

A conductor slowly overflowing oil in about the SW. ¼ NE. ¼ NE. ¼ sec. 27 (no record of this well could be obtained), on the edge of the syncline, just east of this little dome, is a favorable indication. On these folds, as elsewhere, there is also a good possibility for production from the "Mississippi lime," which should be reached at about 1,750 feet. The best positions for deep tests would probably be those just indicated, on the dome at the south end of the anticline.

There is a record of a dry hole drilled to the "Mississippi lime" at 1,700 feet in the NW. ¼ sec. 27. This is probably the one shown on the location map of the Bureau of Mines as in the southwest corner of the SW. ¼ NW. ¼ NW. ¼ sec. 27, a position which would place it in the syncline shown on the accompanying structure map (Pl. XLIX). In that position the failure is what would be expected from the structure.

SOUTH SKULL CREEK ANTICLINE.

The South Skull Creek anticline is essentially a southward extension of the North Skull Creek anticline from which it is separated by a rather deep synclinal lobe. The axis runs northwestward about the center of the S. ½ sec. 35, crosses the west edge of that section about an eighth of a mile north of the west quarter corner, and thence bends north-northwestward toward the North Skull Creek anticline. Along this axis two summits may be distinguished—an elongated one along most of the axis in sec. 35 and a terrace-like expansion in the SE. ¼ sec. 27. In the W. ½ NW. ¼ sec. 35 a branch bends off to the north to a small sharp dome in the NW. ¼ NW. ¼ sec. 35. If the interpretation of the covered portion along the east side of Hickory Creek in the central part of sec. 34, represented on the map by broken lines, is correct, this is one of the most promising folds in T. 29 N., R. 11 E. The broad west flank, extending half to three-quarters of a mile from the axis, with a difference of elevation of 60 feet in 3,000 feet, affords a large gathering ground for oil, and the summits are well defined. No faults of any importance appear to break the continuity of the anticline. No drilling is known to have been done on this anticline. The Cheshewalla sandstone is the highest bed over most of this area, except in the southern and eastern parts of the W. ½ sec. 35, where the valley bottom is about 60 to 75 feet below the top of that sandstone. The Red or Stray sand probably does not extend this far south. If it does, however, it should be looked for at a depth of about 950 to 1,000 feet. In any case oil might be expected from the Peru sand at about 1,200 to 1,250 feet and from the "Mississippi lime" at about 1,700 to 1,750 feet. There are many good locations for a test, but perhaps the best would be between the main axis and the small branch north dome in the NW. ¼ SW. ¼ NW. ¼ sec. 35.

REMAINDER OF T. 29 N., R. 11 E.

The remainder of T. 29 N., R. 11 E., to the east shows few structural features of importance. Such as there are consist mainly of terrace-like westward extensions from anticlines in T. 29 N., R. 12 E., and may best be considered in connection with those anticlines. (See below.) Separate mention, however, may be made of a small east-west anticline whose summit lies in Kansas, just north of the

north corner of secs. 13 and 14, T. 29 N., R. 11 E. The south flank of this fold within this township consists of a broad, gentle slope, which might afford some favorable locations at the north edge of the sections, but the production would probably be small, like that of the area on and adjacent to the Barnaire terrace, in sec. 16.

ANTICLINES AND DOMES IN T. 29 N., R. 12 E.

In T. 29 N., R. 12 E., may be recognized an unusually well defined anticlinal axis which extends northward from the summit of the anticline in T. 28 N., R. 12 E., crosses the south line of sec. 32 about an eighth of a mile west of the southeast corner of that section, and bends westward to the Junction dome, in the center of the east half of sec. 30, with a branch that continues its northern direction extending into the Deadman's anticline in the center of the N. ½ sec. 29 and the S. ½ sec. 20. From the Junction dome the main axis again turns due north, continues through the Breakneck dome to the Prairie anticline, in the northern part of sec. 19, turns westward, and continues practically due west into the terrace-like extension of the Prairie anticline in the northeastern part of T. 29 N., R. 11 E. Similar to the westward extension of the main axis beyond the Prairie anticline are axes running westward into T. 29 N., R. 11 E., into terrace-like extensions of the Breakneck and Junction domes, and a fourth such westward-trending axis may be recognized as an extension of an axis running southwestward from the Junction dome into the terrace-like Opossum Creek anticline, in the northwestern part of sec. 31, T. 29 N., R. 12 E., and the northeastern part of sec. 36, T. 29 N., R. 11 E. A brief discussion of the individual folds along these axes follows.

COON CREEK ANTICLINE.

The Coon Creek anticline lies mostly in sec. 32. On the map almost the entire east flank of this fold is represented by broken lines, which carry the structure across the valley of Coon Creek, where there are practically no rock exposures. There is in that area the double possibility of error in determining how the beds on the two sides of the creek are related to each other and of making wrong assumptions as to the connection of the structure on the two sides. It is only at the north end of the anticline that a small eastward reversal of dip could actually be observed. It is possible, therefore, that the contours continue straight across Coon Creek instead of forming the strong synclinal reentrant shown, or that a fault runs along the west edge of Coon Creek here and that the reversal of dip observed is the dragging down of the beds along such a fault. Finally, the possibility that the apparent reversal of dip is really slumping of the heavy sandstones on the thick masses of shale which underlie

them in this steep west bank of Coon Creek must be considered. If the structure is correctly represented this anticline has several very favorable features. Its west flank is steep and about 1 mile broad, and the summit is pronounced. However, as the summit lies in T. 28 N., R. 12 E., it is considered in the discussion of that township. The part in T. 29 N., R. 12 E., is less favorable on account of the northward pitch here and the syncline in the northeastern part of sec. 31, which cuts into the west flank and greatly reduces the gathering ground for oil. Perhaps the most favorable part of this end of the anticline is the terrace-like expansion at the north end, in the southwestern part of sec. 29. A good location for a test hole on this part of the fold would be about the center of the SW. ¼ SW. ¼ sec. 29. No development work is known to have been done on this anticline, but from the records of wells in sec. 30, T. 29 N., R. 12 E., the Red or Stray sand, possibly containing oil, should be struck at a depth of about 1,050 feet, the Peru sand at about 1,150 to 1,200 feet, and the "Mississippi lime" at about 1,700 to 1,750 feet.

DEADMAN'S ANTICLINE.

The Deadman's anticline lies near the center of the N. ½ sec. 29 and the S. ½ sec. 20. As pointed out above, it is essentially a northward extension of the Coon Creek anticline. It does not promise to be important as a source of oil, being rather terrace-like in form, broad and flat, with only one (doubtful) closing contour and only one contour separating it from synclines on three sides. It is appropriate, moreover, to draw special attention here to the possibility, previously referred to, of the surface exaggeration of structure by slumping, not in blocks but as a whole bed, of a heavy sandstone like the Cheshewalla on the 60 feet or so of shale underlying it. The valleys of Coon Creek and its tributaries adjoin the three sides of the anticline corresponding to the synclines and expose the shale in steep faces. These steep shale slopes afford conditions unusually favorable for slumping and have produced all around this valley effects that may be very misleading as to the structure of the deeper-lying beds. The most conspicuous of these effects is the tilting of large masses of sandstone along the edges of the ridges in some places to or even beyond a vertical position, with a strike approximately at right angles to the elongation of the ridges. When followed along their strikes up the ridge these masses of sandstone are found to flatten rapidly till they merge into the unbroken flat bed at the top of the ridge. The condition is undoubtedly one of surface slumping, though it may be related to minor deeper lines of faulting or to lines of stress resulting from the larger folding of the beds. The same observation has been made and the same conclusion reached by other members of the Geological Survey working in

this territory, but the disturbance is here so strongly developed as to deserve special mention. One of the most striking examples of it is afforded by Deadman's Rock, a nearly vertical ridge of the Cheshewalla sandstone, near the center of the south edge of sec. 20, north of the M ranch, on the northeast flank of this anticline. The only recorded development work on the Deadman's anticline is a dry hole shown on the location map of the Bureau of Mines as in the southeast corner of the NW. ¼ sec. 29. No further record of this hole is available. Its position is in the bottom of the saddle between the Coon Creek and Deadman's anticlines, and it is therefore not a conclusive test, yet the indications it affords are not favorable. It would be best to postpone further tests here till the more favorable Prairie anticline, to the northwest, has been explored. The best position for a test on the Deadman's anticline would be in the NW. ¼ NE. ¼ NW. ¼ sec. 29.

JUNCTION DOME.

The Junction dome may be regarded as a domelike expansion on the terrace-like northwestern extension of the axis of the Coon Creek anticline. It lies in the center of the W. ½ sec. 30. The dome does not appear very promising, on account of the gentleness of the slope of the west flank, with no pronounced flattening or reversal at the top to catch whatever oil might gather from the lower parts of the slope. It has been tested by a hole drilled almost on the summit of the dome, in about the NW. ¼ NE. ¼ SE. ¼ sec. 30, which penetrated 50 feet into the "Mississippi lime" and filled with salt water. This well can not be regarded as a conclusive test of the dome as a whole. A location on the west side of the crest would be better, and the entire dome can not be condemned until one or more tests are made along the brows of the flanking terraces.

BREAKNECK DOME AND PRAIRIE ANTICLINE.

From the Junction dome northward through the Prairie anticline the entire structure may be considered as a unit. Essentially it represents the eastward ridgelike summit of a slope extending up for 2½ to 3 miles from the eastern part of T. 29 N., R. 11 E. There are terrace-like expansions in this slope, but none of these is sharply enough defined by steep dips at its outer edge to make it appear especially favorable for the accumulation of oil. The Breakneck dome is a small summit represented by a single closed contour on this ridge in the SE. ¼ sec. 19, T. 29 N., R. 12 E. The reversal of dip is very slight here, and the terrace-like westward slope is very gentle and is partly interrupted by a synclinal pocket in the SE. ¼ sec. 24, T. 29 N., R. 11 E., which sends a tongue almost to the top of the anticlinal ridge a quarter of a mile north of the Breakneck dome. All these are

factors that may reduce the chances of obtaining production from the dome. The only drilling known to have been done near this dome is a hole sunk on the top of the anticlinal ridge about halfway between the Junction and Breakneck domes. A show of oil was obtained in a sand, probably the Red or Stray sand, at 1,100 feet, and another in the Peru sand at 1,240 feet. The "Mississippi lime" was penetrated for 8 feet, from 1,780 to 1,788 feet, but no showing was reported. The "Mississippi lime" should have been penetrated for at least 200 feet. The location is less favorable than one to the northwest of the Breakneck dome or possibly than others fixed with special reference to the terrace features. A further test might be made on the Breakneck dome near the west edge of the NE. ¼ SW. ¼ SE. ¼ sec. 19. However, the writer believes that it would be better not to make any additional tests on this dome until the Prairie anticline, which is the most promising looking part of the general structural ridge, has been tried out. If this does not yield oil it is less likely to be found in other parts of the ridge.

The Prairie anticline is a broad, flat-topped fold striking about northwest, in the northeastern part of sec. 19 and the southwestern part of sec. 18, T. 29 N., R. 12 E. Beyond the summit the axis turns due west and pitches in that direction down the long slope which extends for almost 2 miles into T. 29 N., R. 11 E. The fold has a closure of 10 to 20 feet, with a doubtful small closed contour at about the south quarter corner of sec. 18. Although the eastward reversal of dip is slight and there is no sharp change of slope near the top to trap oil rising from the lower parts of the slope, the extensive west flank affords a large gathering ground for oil, part of which at least may be expected to have accumulated near the top of the anticline. No development work is known to have been done on this anticline. A favorable position for a test would be in the SW. ¼ SW. ¼ sec. 18, or possibly somewhat nearer the summit in the SW. ¼ SE. ¼ SW. ¼ of the same section. Immediately adjacent to the south quarter corner of sec. 18 gas would be expected. The Red or Stray sand should be found at a depth of about 1,100 feet, the Peru sand at about 1,250 feet, and the "Mississippi lime" at 1,750 to 1,800 feet.

OPOSSUM CREEK ANTICLINE.

From the Junction dome the main anticlinal axis continues southward with a slight curvature to the west and in the NW. ¼ sec. 31, T. 29 N., R. 12 E., turns west through the tonguelike Opossum Creek anticline, which crosses the township line about a third of a mile south of the northwest corner of sec. 31 and extends for at least half a mile into sec. 36, T. 29 N., R. 11 E. There is very little eastward reversal of dip and but one closed contour on this fold, which therefore has more the character of a terrace than of an anticline. Synclines south

and northwest of it limit the gathering ground for oil, which is restricted to the west and west-northwest slope. The gentleness of this slope and the absence of any pronounced flattening at the top are further unfavorable features. No development work is known to have been done on this fold. A good position for a test would be just west of the summit in the NW. ¼ SE. ¼ NE. ¼ sec. 36, T. 29 N., R. 11 E.

RAMSEY ANTICLINE.

The Ramsey anticline is probably the most important structural feature in T. 29 N., R. 12 E. Its axis lies just east of the township line in Washington County, strikes almost due north, and extends with a northward pitch to a point opposite the northeast corner of sec. 28. The west flank extends at its widest part about three-fourths of a mile into T. 29 N., R. 12 E., but narrows toward the nose in the northern part of sec. 28. Oil is obtained all along this fold across the line in Washington County, and there is every reason for assuming that the productive area could be extended into T. 29 N., R. 12 E. The Indian office in Pawhuska has a record that two wells were drilled in the NE. ¼ sec. 33, T. 29 N., R. 12 E., in 1904 and 1905, but no further information about these wells is available. The most favorable location for beginning developments would be along the Osage-Cherokee line in the small sector of sec. 34 included in T. 29 N., R. 12 E., especially in the SW. ¼ NW. ¼ SW. ¼ sec. 34 and westward into sec. 33, T. 29 N., R. 12 E. As oil is obtained also farther down the nose to the north, just across the line in sec. 27 in Washington County, it is likewise to be expected in the small strip of that section in T. 29 N., R. 12 E., and in the eastern part of sec. 28. Most of the oil produced in the adjacent part of Washington County seems to come from a sand lying about 750 to 820 feet below the surface and overlain by 20 to 30 feet of lime "cap rock," in some places with 15 feet or so of shale intervening. In the record of one well drilled to the "Mississippi lime" the following beds are recorded:

	Feet.
Lime showing oil (Peru?)	1,175–1,185
"Oswego lime"	1,300–1,334
"Mississippi lime"	1,650–1,782

The Gap sandstone, which forms the surface of the Ramsey anticline in T. 29 N., R. 12 E., lies about 120 feet below the Cheshewalla sandstone. (See the standard section, fig. 46, p. 330, and Pl. XLIX.) The beds on which the different wells in the adjacent parts of Washington County started are not known. The depths just given to the productive beds in these wells do not show any consistent relation to the standard section, the "Oswego lime" being at the same depth below the surface here as below the Cheshewalla sandstone in the standard section but

the "Mississippi lime" and the Peru sand being shallower. Possibly the sand at 750 to 820 feet is the Red or Stray sand, though it appears to be shallower. The nearest estimate that can be made of the depth to the different beds in the Ramsey anticline in T. 29 N., R. 12 E., is as follows: First productive sand (Red or Stray sand?), around 800 feet; Peru sand, 1,000 to 1,200 feet (?); "Mississippi lime," around 1,600 feet.

MERIDIAN TERRACE.

The Meridian terrace is a tonguelike terrace whose axis starts about one-fifth mile south of the northwest corner of sec. 15, T. 29 N., R. 12 E., runs west about half a mile, and then bends off to the southwest. A north-south anticlinal ridge of which this would be a lateral branch may be just east of the township line. An unofficial record shows a series of oil wells near the township line in the E. ½ NE. ¼ sec. 16, T. 29 N., R. 12 E., but there is no other record of these wells. If they actually exist their location is not really unfavorable with respect to the structure, especially if there is a north-south anticlinal ridge to the east of the township. Production there would encourage further exploration along the terrace to the west and southwest. Perhaps the most favorable location for a test is the point where a steep westerly dip is followed by a pronounced flattening[1] in the SE. ¼ NE. ¼ NW. ¼ sec. 16. A test might also be made at the top of the nose in the SE. ¼ NW. ¼ NE. ¼ sec. 16.

DOME WEST OF MERIDIAN TERRACE.

The small dome faulted on the east side which is shown on the map as occurring in the SE. ¼ sec. 18 and the SW. ¼ sec. 17, T. 29 N., R. 12 E., may be regarded as lying on an extension of the axis of the Meridian terrace. Its position just off the northeast flank of the Prairie anticline, from which it is partly separated by a small fault, is not very favorable. There is an unofficial record of a dry hole on the extreme northeast corner of this dome, just west of the fault in the northwest corner of the SW. ¼ sec. 17, T. 29 N., R. 12 E., but nothing further is known about it. A test might be made, as on the Meridian terrace, at the place where the terrace-like westward nose drops off more steeply, in the NE. ¼ NW. ¼ SE. ¼ sec. 18, but it would be best to await developments on the Prairie anticline, which, if successful, might be extended in this direction. Directly east of the hole in the SW. ¼ sec. 17, just mentioned, the same unofficial record shows two more dry holes, one of which when seen in the field was slowly flowing oil and therefore evidently yielded a showing. The location of these holes is not very favorable, as they appear to be rather too far north

[1] U. S. Geol. Survey Bull. 686-F, p. 58, 1918.

of the extension of the axis of the Meridian terrace, and on that side the gathering ground for oil is very small. The position of three wells, of which records are available, in the SE. ¼ sec. 17, T. 29 N., R. 12 E., is more favorable. The exact form of the extension here of the Meridian terrace is not known, but these wells are evidently all approximately near the top or a slight distance down on the flank of that terrace. Two of these wells record oil; one of them had an initial daily production of 5 barrels, but the yield of the other well was not given. The oil was obtained apparently from the Red or Stray sand, and the result offers some encouragement for further developments along this axis. If oil is found in the shallow sand drilling should be continued to the "Mississippi lime." In wells drilled in the bottom of Coon Creek valley where it crosses this terrace the "Mississippi lime" should lie at a depth of about 1,600 feet, the dry hole in the group of three having entered it at 1,607 feet. Wells on the ridges should enter it at a depth 100 to 150 feet greater.