T. 25 N., RS. 11 AND 12 E.

By Oliver B. Hopkins.

INTRODUCTION.

The area included within T. 25 N., Rs. 11 and 12 E., lies in the eastern part of the Osage Reservation, southwest of Bartlesville and northeast of Bigheart. (See fig. 1.) There are no towns within the area; the only settlements consist of oil camps and a few small ranches. Bartlesville is the largest town near these townships and the town from which they are most accessible.

Field work on these townships was done between the first of April and the middle of June, 1918, by W. A. English, K. C. Heald, and the writer, assisted by W. G. Gulley, R. L. Triplett, and H. J. Weeth, respectively, as instrument men. The relative areas covered by the three parties are shown on the diagram inserted on Plate XI. The mapping was done entirely by plane table, in part by stadia traverses and in part by triangulation.

STRATIGRAPHY.

EXPOSED ROCKS.

GENERAL CHARACTER.

The exposed rocks in the area are of middle Pennsylvanian age and comprise about 430 feet of alternating beds of shales and sandstones with thin beds of limestones. The general character and thickness of the beds are shown in figure 18. A complete description of the stratigraphy will not be given here; only the most prominent beds or key rocks which were used in mapping the structure will be described.

The lower 180 feet of beds exposed in these townships consists dominantly of shale but contains two prominent sandstones and three thin limestones. All three limestones are found at places along the east side of T. 25 N., R. 12 E., and the upper two are found in the valley of Candy Creek in the southwestern part of the same township. The two lower limestones are well exposed in the road leading up the escarpment near the middle of the east line of sec. 21, T. 25 N., R. 12 E. The lowest limestone in the section is the same as that

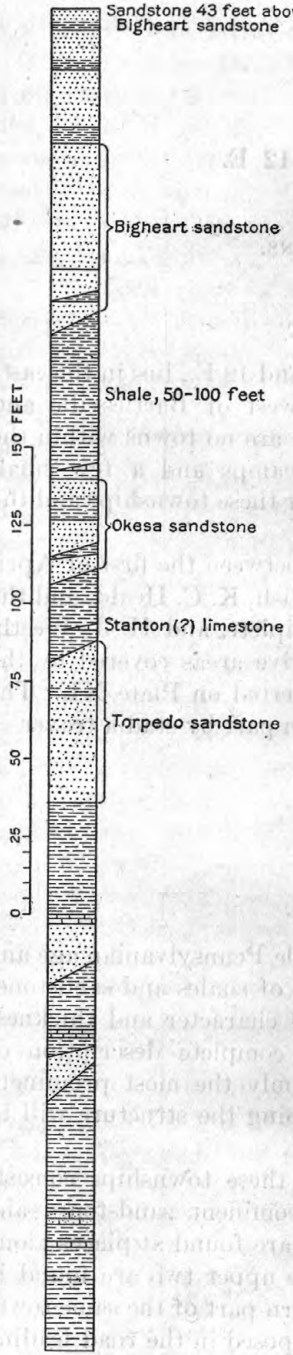


FIGURE 18.—Section showing succession of beds exposed in T. 25 N., Rs. 11 and 12 E.

found in the northern part of T. 23 N., Rs. 11 and 12 E., and described as "*Fusulina*-bearing gray limestone." The most conspicuous beds in the upper 250 feet of exposed rocks are described below. The position of these beds in the section of exposed rocks is shown in figure 18, and their position in relation to the productive formations on Plate XII.

KEY BEDS.

Torpedo sandstone.—The lowest bench of massive cliff-making sandstone about 75 feet above the valley floor at Torpedo is here named the Torpedo sandstone. This sandstone forms the top member of the division described by Shannon and Trout[1] as the Wilson formation. It rims the valley of Sand Creek and is typically exposed 1 mile northwest of Torpedo, on the north side of the creek. Here it consists of about 30 feet of massive medium-grained sandstone which breaks into large ripple-marked blocks. It is immediately underlain by shale and overlain by a bed of hard gray limestone 2 to 3 feet thick, which is loaded with crinoid stems and weathers cinnamon-brown.

This sandstone ranges from 30 to 60 feet in thickness in T. 25 N., R. 12 E., where it is exposed in the valleys along the north township line. It forms the resistant bed near the top of the prominent escarpment along the east side of the township and rims the valley of Candy Creek and its tributaries in the southern part. This sandstone crops out, as shown on Plate XI, in two prominent benches in the northern part of T. 25 N., R. 12 E., but in the southern part the upper bench either merges into the lower or gives place to shale, as only the lower bench is conspicuous there. The lower bench generally forms a nearly vertical cliff,

[1] Shannon, C. W., and Trout, L. E., Petroleum and natural gas in Oklahoma: Oklahoma Geol. Survey Bull. 19, p. 89, 1915.

whereas the upper bench, though somewhat softer and weathering more readily, usually shows a fairly well defined contact with the overlying shale. The thin limestone that overlies this sandstone near Torpedo is present in the northern part of T. 25 N., R. 12 E., but disappears farther north. The writer believes that this limestone may be the Stanton limestone of Kansas and that it is 15 to 20 feet above the horizon of the Birch Creek limestone in T. 24 N., Rs. 10 and 11 E. The Torpedo sandstone, with the overlying limestone, is well exposed in the SW. ¼ SE. ¼ sec. 4, T. 25 N., R. 12 E.

Okesa sandstone.—The Okesa sandstone was named by Clark from its exposure near Okesa.[1] It was traced in a conspicuous outcrop halfway across the east side of T. 25 N., R. 11 E., and around the floors of the two principal stream valleys in that township. (See Pl. XI.) In the northern part of T. 25 N., Rs. 11 and 12 E., the Okesa sandstone comprises three prominent sandstone beds separated by thin beds of shale and has an aggregate thickness of about 30 feet. Here it is overlain by red clay shale and in places a thin limestone occurs 7 feet above it. The middle bed was traced in the northern part of these townships. (See Pl. XI.) The Okesa sandstone increases in thickness toward the south, so that on the line between Tps. 25 and 24 N., R. 11 E., it replaces most of the underlying shale and locally rests on the Torpedo sandstone. In the southern part of the townships here described the top of the Okesa sandstone appears as a pronounced bench (see Pl. XI), above which is a 50 to 75 foot bed of shale, forming an open belt of country. The top bed of the Okesa sandstone in this area is a massive to thin, even-bedded sandstone whose upper surface is covered with impressions of fossil pelecypod shells. A thin limestone occurs in places 5 feet above this sandstone, as exposed near the center of sec. 35, T. 25 N., R. 11 E., and in the same area a massive bench of sandstone with a rough, lumpy top surface fringed by trees is exposed 20 feet below it.

Bigheart sandstone.—The name Bigheart sandstone was given by Snider[2] to a series of sandstones [and shales] 175 feet thick exposed in the hills west of the town of Bigheart. In the present report the name is restricted to beds of sandstone 57 to 70 feet thick resting on the same shale as at Bigheart. Thus applied, the Bigheart includes a series of rough massive lenticular sandstones which generally form two prominent benches. It is underlain by 50 to 100 feet of gray shale, which is locally red in its upper 6 feet, and overlain by a thin bed of shale which separates it from the thinner, more slabby sandstones

[1] Clark, F. R., report on T. 26 N., R. 11 E.: U. S. Geol. Survey Bull. 686–I, 1918.

[2] Snider, L. C., Preliminary report on the clays and clay industry of Oklahoma: Oklahoma Geol. Survey Bull. 7, p. 221, 1911.

above. In the eastern part of T. 25 N., R. 11 E., the base of the sandstone was traced (see Pl. XI); in the southwestern part the top of the first bench, from 10 to 26 feet above the base, was traced; and in the northwest corner of the township the top of the sandstone, which is marked by a rough, knotty surface, was traced. The top of this sandstone is well exposed along the road south of the middle of the north line of sec. 21, T. 25 N., R. 11 E.

Sandstone 43 feet above Bigheart sandstone.—The sandstone outcrop in the northwest corner of T. 25 N., R. 11 E. (see Pl. XI), is a rough, blocky bed 43 feet above the top of the Bigheart sandstone. This sandstone is in places a prominent ledge, which is not traceable far beyond the limits of that township.

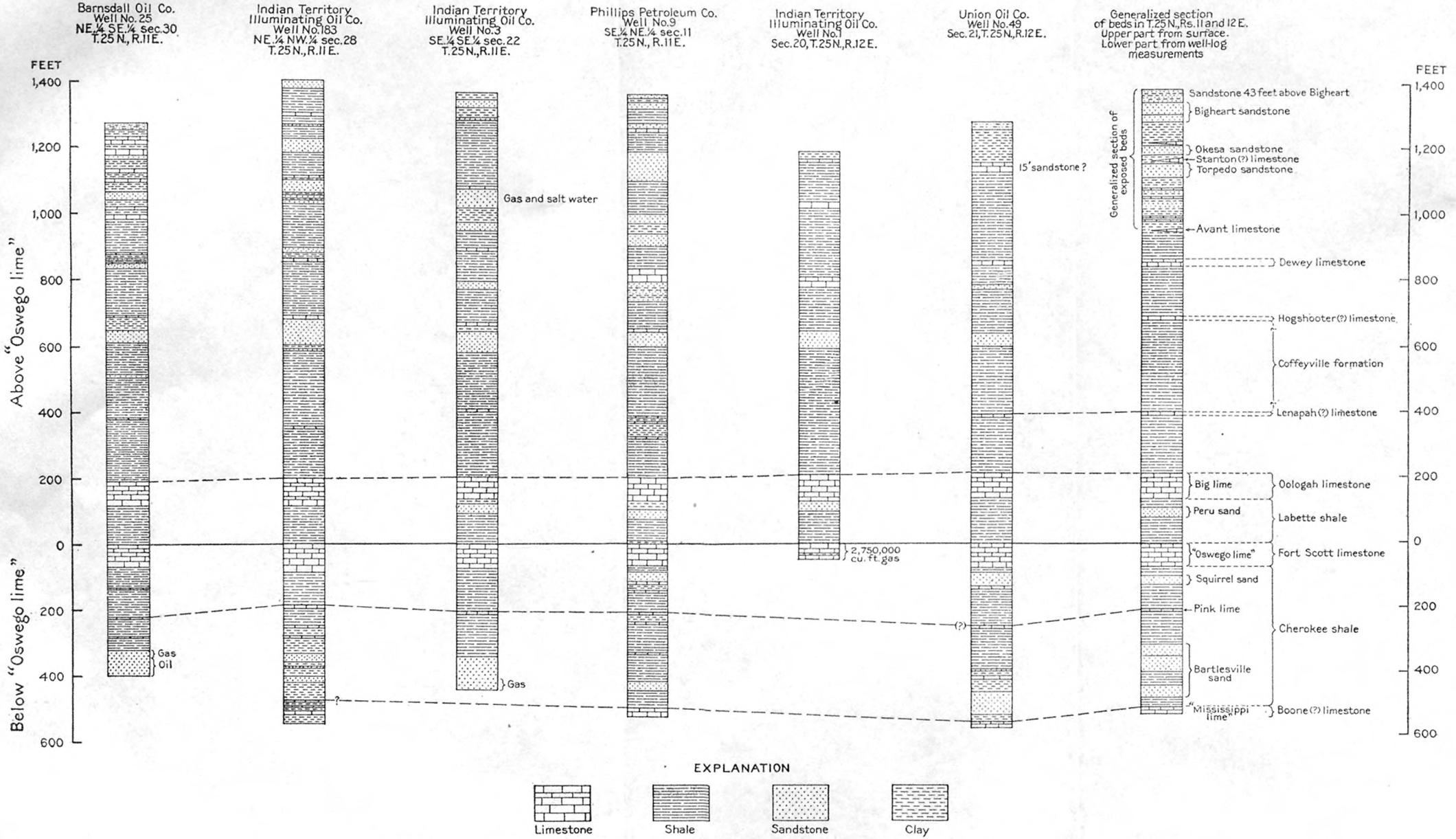
ROCKS NOT EXPOSED.

The Pennsylvanian rocks not exposed in this area are known from their outcrops to the east and from well logs. Plate XII shows in graphic form six typical well logs arranged in general along an east-west line across T. 25 N., Rs. 11 and 12 E., and a generalized section showing the exposed rocks and the most noteworthy unexposed rocks.

Big lime.—The first generally recognized bed encountered in the wells is the Big lime, which is found at depths ranging from 900 feet below the surface on the east side of this area to 1,200 feet on the west side. This is the shallowest productive formation within the area; it yields gas in small quantities—1,000,000 to 2,000,000 cubic feet a day in a number of widely separated wells—but so far as known does not yield oil in this area. It has an average thickness of about 77 feet.

Peru sand.—The Peru sand is generally separated from the Big lime by 20 to 25 feet of shale and is encountered in the wells at depths of 1,000 to 1,300 feet. In these townships this sand is productive of oil in only two wells, so far as known, both in the NE. ¼ sec. 4, T. 25 N., R. 12 E., in which the initial daily production was 1 to 2 barrels. This sand appears to have a maximum thickness of 50 feet and to extend over a considerable area. Under favorable structural and sand conditions it would be expected to yield small quantities of oil.

"*Oswego lime.*"—The "Oswego lime" is about 200 feet below the top of the Big lime, or from 1,100 to 1,400 feet below the surface in this area. It has an average thickness of about 73 feet and is one of the important subsurface key beds in the region. It yields 2,500,000 to 5,000,000 cubic feet of gas a day in wells in the western part of T. 25 N., R. 12 E., and the eastern part of T. 25 N., R. 11 E. The gas is believed to come from the porous dolomitized limestone.



SECTIONS SHOWING TYPICAL WELL LOGS IN T. 25 N., Rs. 11 AND 12 E., AND A GENERALIZED SECTION OF EXPOSED AND UNEXPOSED ROCKS.

Squirrel sand.—The Squirrel sand is the next productive formation below the "Oswego lime" and is usually separated from it by 10 feet or more of shale. This sand is recognized in many of the wells over the entire area and has a thickness of 10 to 40 feet. So far as known, oil is not obtained from the sand in this area, but at least three wells in secs. 4 and 20, T. 25 N., R. 12 E., obtain gas from it. It has yielded a show of oil and much salt water in many wells.

Pink lime.—Below the "Oswego lime" the next bed, which is easily recognizable over a large area, is a hard limestone, from 5 to 8 feet thick, called by drillers "pink lime." It is found approximately 200 feet below the top of the "Oswego lime," or from 1,300 to 1,600 feet below the surface in T. 25 N., Rs. 11 and 12 E. It is a valuable key bed, as it occurs from 100 to 125 feet above the Bartlesville sand.

Bartlesville sand.—Under the name Bartlesville sand are included a group of productive sands lying between the pink lime and the "Mississippi lime." At different places the Bartlesville has been divided into several locally named sands, but these subdivisions are not applicable over a large area, as the sands are essentially lenticular, and although found over a wide area at about the same horizon they represent discontinuous sand bodies. They probably represent that part of the section that is of Pottsville age.

In this area the top of the Bartlesville is reached at a depth of 1,400 to 1,800 feet. It is penetrated in relatively few wells, and consequently its thickness is imperfectly known; it is found, however, to vary irregularly in thickness from 30 feet to a maximum of about 120 feet. Locally it yields large flows, presumably because of its thickness, coarseness, and high porosity, but "offset" wells within 500 or 600 feet of the flowing wells may prove to be only small pumpers, owing probably in part to decrease in the thickness of the sand but mainly to decrease in porosity. Such local variations are marked in secs. 11 and 14, T. 25 N., R. 11 E.

The Bartlesville is the principal productive sand in this area. It yields relatively small quantities of oil, but the wells are generally long lived. The initial daily production of 133 wells in T. 25 N., R. 11 E., was 14,638 barrels, or an average of 110 barrels. Most of the wells producing from the Bartlesville range in initial production from 50 to 150 barrels.

"*Mississippi lime.*"—The Bartlesville sand is usually separated by 25 to 50 feet of shale from the underlying limestone, commonly called the "Mississippi lime." The age of this limestone is not definitely determined, but it is believed to be the equivalent of the Boone limestone of northeastern Oklahoma, as shown in Plate XII.

It has yielded gas in a number of scattered wells in the area but, so far as known, only showings of oil. However, no well should be abandoned as dry until it has tested for oil and gas the upper 300 feet of this limestone, the top of which is reached at depths of 1,500 to 1,900 feet in this area.

STRUCTURAL FEATURES.

The general structure of this area conforms to that of the region as a whole and shows the normal west dip, averaging 40 feet to the mile, interrupted here and there by numerous relatively small folds, as shown on Plate XI. The structure contours on this plate are based on a theoretical datum approximately 200 feet above the top of the Torpedo sandstone. Slight convergences between this sandstone and a lower limestone, which make this interval vary somewhat, are taken into account. Between the Torpedo sandstone and the Bigheart sandstone there is a variation in interval amounting to approximately 50 feet, which was also taken into account and which prevents the structure as shown from conforming exactly with that derived from the local contouring on the basis of the upper beds. The position of the contours shown in Plate XI by broken lines is in doubt, owing to insufficiency of rock outcrops.

The contours on the maps in this report match exactly those for the townships to the south and west, where the same beds were used as key rocks. The contours along the north edge of T. 25 N., R. 11 E., do not tie with those for the adjoining township to the north, because in general higher beds were used for contouring in the southern township than in the northern one and the lenticular character of the beds made it impossible to tie the key rocks together so that the convergences could be correctly taken into account. Along the line between Tps. 25 and 26 N., R. 12 E., the contours tie up fairly closely, and when the work in the northern township is completed they may be found to match exactly, because the same general series of beds was used in both townships.

AREAS OF FAVORABLE STRUCTURE.

T. 25 N., R. 12 E.

In T. 25 N., R. 12 E., there are four well-developed anticlines—the Farrell, Perrier, Zola, and Forty-seven—and parts of two others, the west flank of the County Line anticline and the south flank of an unnamed one which extends into sec. 4. (See fig. 19 and Pl. XI.)

County Line anticline.—The County Line anticline, so named from its position along the Washington-Osage county line, in secs. 15, 22, and 27, has not been outlined in its entirety, as the mapping was not

carried beyond the limits of Osage County. This anticline is separated by a low saddle from the Farrell anticline to the west, and has its crest along the county line in secs. 22 and 27. A large pool

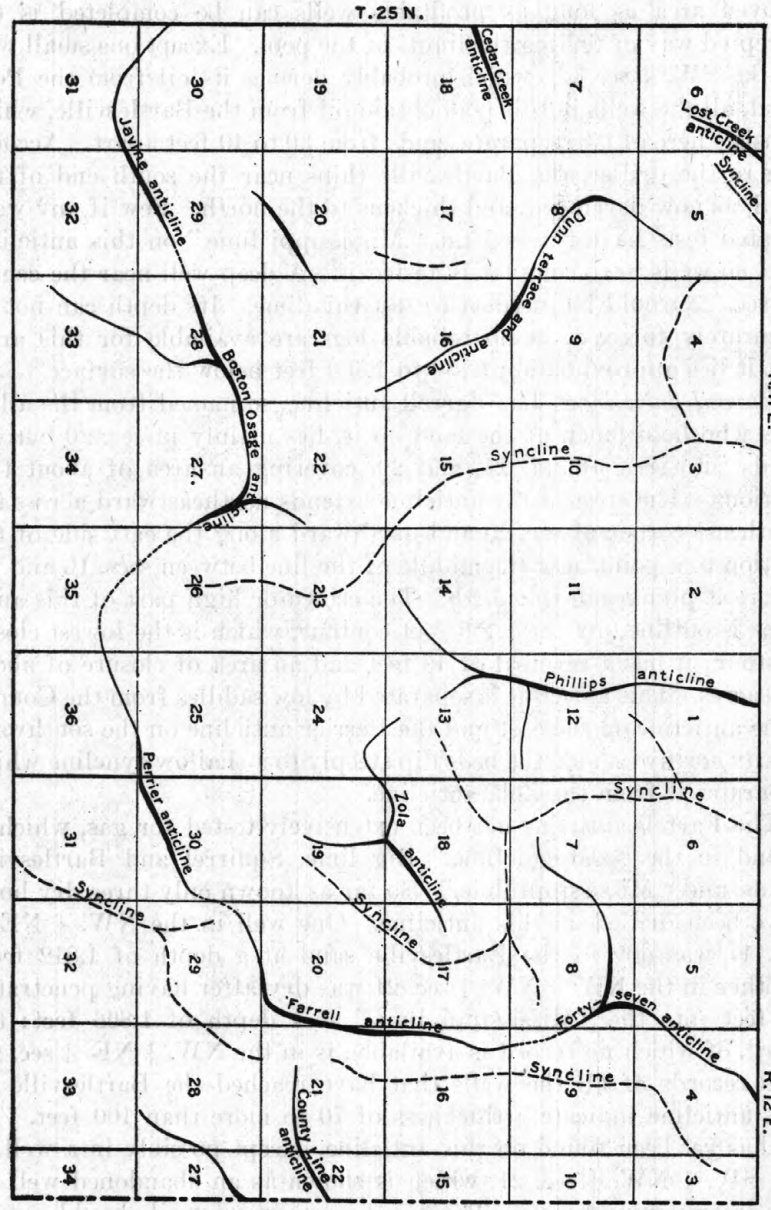


FIGURE 19.—Sketch map showing location of axes of anticlines and synclines in T. 25 N., Rs. 11 and 12 E.

of oil has already been developed on it, as shown on Plate XI, extending down on its western flank almost to the saddle referred to above. The limits of this pool are gradually being extended, espe-

cially to the southwest. To judge by the structure, the pool is more likely to be considerably extended to the south, in secs. 22, 27, and 28, than in any other direction. Continued drilling away from the proved area as long as profitable wells can be completed is the accepted way of finding the limits of the pool. Except one small well in the SW. ¼ sec. 22, which probably derives its oil from the Peru sand, all the wells in this pool obtain oil from the Bartlesville, which consists here of two separate sands from 30 to 40 feet apart. According to the driller, the Bartlesville thins near the south end of the pool, as now developed, and thickens to the north. Few if any well-located tests have reached the "Mississippi lime" on this anticline, and no wells have completely tested it. A deep well near the center of sec. 22 would be justified to test this lime. Its depth can not be accurately forecast, as no reliable logs are available for this area, but it lies approximately 1,450 to 1,500 feet below the surface.

Farrell anticline.—The Farrell anticline, so named from the allottees who hold much of the land on it, lies mainly in sec. 20 but extends into secs. 16, 17, 21, and 29, covering an area of about two sections. The crest of the anticline extends northeastward across the southeast corner of sec. 20 and northward along the east side of the section to a point near the middle of the line between secs. 16 and 17, where it plunges to the north. The crown or high part of this anticline is outlined by the 1,150-foot contour, which is the lowest closed contour; it has a reversal of 40 feet and an area of closure of about 300 acres. This anticline is separated by low saddles from the County Line anticline on the east and the Perrier anticline on the southwest. On its northwest side the beds dip steeply to a shallow syncline which separates it from the Zola anticline.

The Farrell anticline has been extensively tested for gas, which is found in the "Oswego lime," Big lime, Squirrel and Bartlesville sands, and "Mississippi lime." So far as known only three dry holes have been drilled on this anticline. One well in the NW. ¼ NE. ¼ sec. 17 was dry in the Bartlesville sand at a depth of 1,812 feet; another in the NW. ¼ NW. ¼ sec. 21 was dry after having penetrated 21 feet into the "Mississippi lime" at a depth of 1,866 feet; the third, of which no record is available, is in the NW. ¼ NE. ¼ sec. 29. The records of all the wells that have reached the Bartlesville on this anticline indicate a thickness of 70 to more than 100 feet. No oil has yet been found on this anticline, except possibly in a well in the SW. ¼ NW. ¼ sec. 21, which is shown as an abandoned well on the accompanying map. There is no reason why oil should not be found, as the structure and sand conditions are favorable. A favorable place for a test is near the center of the SE. ¼ SW. ¼ sec. 20. The depth to which a well will have to penetrate to reach the dif-

ferent formations, allowance being made for differences in elevation and dip and in the rocks that will be encountered, is shown by the log of the Union Oil Co.'s well No. 49 on Plate XII.

Perrier anticline.—The Perrier anticline lies in secs. 30 and 31, T. 25 N., R. 12 E., and secs. 25 and 36, T. 25 N., R. 11 E. The anticline is bordered on the east by a broad, shallow syncline, whose axis follows the line between secs. 31 and 32 and has a blunt ending in sec. 29, T. 25 N., R. 12 E.; on the north it is separated by an equally broad, shallow syncline from the Zola anticline. To the northeast the Perrier anticline is connected by a low saddle with the Farrell anticline, and to the west a nose of the Perrier anticline may be considered to connect it with the Boston-Osage anticline. The crown or high part of this anticline is in secs. 30 and 31, T. 25 N., R. 12 E., and is outlined by four closed contours, the 1,120 to 1,150 foot contours, forming an inclosed area of approximately 400 acres. From this crown a nose leads off to the west and a smaller and less conspicuous one to the southwest.

Six wells have been drilled on this anticline—one gas well and two oil wells, all now abandoned, and three dry holes. The abandoned gas well in the SW. ¼ NW. ¼ sec. 31, T. 25 N., R. 12 E., found gas in the Bartlesville at 1,649 to 1,696 feet and water at 1,696 to 1,810 feet, the bottom of the well. The logs of the three other wells in this section are not available. The abandoned well in the NW. ¼ NE. ¼ sec. 36, T. 25 N., R. 11 E., had an initial daily production, before being shot, of 5 barrels of oil and 1,000,000 cubic feet of gas from the Bartlesville sand. The Bartlesville was reached at 1,638 feet and extended down to 1,780 feet. The log records gas and water in the "Oswego lime" and gas, a show of oil, and water in the Peru sand, which is 50 feet thick and was encountered at 1,170 to 1,220 feet. The well in the NE. ¼ NE. ¼ of the same section was reported as dry, although its log showed sand from 1,657 to 1,780 and from 1,784 to 1,799 feet, with gas and oil in the upper part. It seems likely that this well might have been successful had it not been drilled so deep into the sand, to a level where it was saturated with water.

Favorable structure, a thick sand, and a good gathering ground indicate that this anticline should be productive. Two wells have been drilled in the NW. ¼ NW. ¼ sec. 31, T. 25 N., R. 12 E., but the records of these wells are not available, and it is not known how deep they were drilled. So far no test has been made of the highest part of the fold, which is in the SW. ¼ sec. 30. It is almost certain that gas can be developed in paying quantities in that quarter section, and it is highly probable that oil can be obtained on the flanks of this anticline in paying quantities over a considerable area. Besides the Bartlesville, the Peru sand, the "Oswego lime," and the upper 300 feet of the "Mississippi lime" should be fully tested. A

favorable locality for a deep test would be on the crest of the fold near the center of the SW. ¼ sec. 30. The depth to the different formations varies considerably with the locality, but the approximate depths will be as follows: "Oswego," 1,325 feet; Bartlesville, 1,650 feet; "Mississippi lime," 1,850 feet.

Zola anticline.—The Zola anticline, so named from the Zola Oil Co., which holds leases on most of it, lies 2 miles north of the Perrier anticline, mainly in secs. 17, 18, and 19, T. 25 N., R. 12 E., but extends into the SE. ¼ sec. 13 and the NE. ¼ sec. 24, T. 25 N., R. 11 E. This anticline has unusually steep dips on its north and northwest flank and gentle dips on its east, south, and southwest flank. It is bounded on the northwest and southeast by synclines which separate it from the Phillips and Farrell anticlines. The lowest closed contour is the 1,090-foot and the highest is the 1,120-foot, giving a closure of 30 to 40 feet and an area of closure of approximately one section, or 640 acres. This area of closure is in the southeastern part of sec. 18, the southwestern part of sec. 17, and the northern part of sec. 19.

This anticline is entirely untested; the nearest wells are two dry holes in the syncline three-quarters of a mile southeast of the crest of this fold. Structurally this anticline is favorable for oil and gas accumulation, and though nothing is known of the local conditions of the sands, it may be inferred from the conditions on the Farrell anticline, a mile to a mile and a half to the east, that they would be favorable here. It would be reasonable to look for gas in the Big lime, "Oswego lime," Bartlesville sand, and "Mississippi lime" and for oil in the Bartlesville. A favorable place to test this anticline for gas would be near the center of the SE. ¼ sec. 18, and for oil in the SW. ¼ SW. ¼ of the same section, T. 25 N., R. 12 E., or in the NW. ¼ NE. ¼ sec. 24, T. 25 N., R. 11 E. Near the crest of this fold and in the bed of Candy Creek the top of the Big lime may be expected at about 925 feet and the other formations at depths below corresponding to the intervals shown on Plate XII.

Forty-seven anticline.—The Forty-seven anticline, so named from its position near the center of lot 47, is mainly in secs. 5 and 8 but extends into adjacent sections. It is bounded on the east by a closed synclinal depression; it is connected on the south by a saddle with the Farrell anticline, on the west-southwest by a long, projecting nose and saddle with the Phillips anticline, and on the northeast by another saddle with the unnamed anticline which extends into sec. 4. The lowest closed contour is the 1,090-foot and the highest one is the 1,120 foot, giving a closure of 30 to 40 feet and an area of closure of about one-third of a section, or 200 acres. The highest part of the anticline is largely in the NE. ¼ sec. 8 but extends into the edge of the adjoining sections on the north and east. The anticline is

roughly triangular in outline, the three points of the triangle being represented by the three noses which are connected by low saddles with the three anticlines mentioned above. The nose extending to the southwest is broad and flat, possessing a form resembling somewhat a terrace, as shown in the W. ½ sec. 8 and the E. ½ sec. 7.

Oil has been obtained in large quantities on the north and northwest sides of this fold, and the productive area is almost continuous across the saddle which connects it with the anticline to the northeast. The oil comes exclusively from the Bartlesville sand, and the initial daily yield of the wells is usually from 20 to 30 barrels. The Peru sand is reported to be about 40 feet thick here, but so far has been found to be unproductive. From a consideration of the structure the most likely region where an extension of the pool will be found is in the NE. ¼ and the E. ½ NW. ¼ sec. 5 and in the N. ½ sec. 8. So far as known, the wells on this anticline have not reached the "Mississippi lime," which will probably be productive of gas. A good location for a test well in the "Mississippi lime" would be in the NW. ¼ NE. ¼ NE. ¼ sec. 8. At this locality the depth to the "Mississippi lime" is approximately 1,850 feet.

T. 25 N., R. 11 E.

General features.—The dominant structural features of T. 25 N., R. 11 E., consist of a belt from 1 to 2 miles wide, crossing the township diagonally from sec. 2 to sec. 30, in which the dip is strong to the northwest, and areas of more gentle dips with gentle folds on both sides of this belt. (See Pl. XI and fig. 19.) The eastern margin of this belt of strong northwest dips is believed to afford exceptionally favorable structural conditions for the accumulation of oil and gas, especially where anticlines occur.

In this township the Bartlesville sand varies widely in thickness and porosity, causing the initial production of wells to vary markedly from place to place. In the northeastern part of the township, on what is subsequently described as the Phillips anticline, the sand varies irregularly in porosity, and consequently the wells have a wide range in initial production. In the southwestern part of the township the sand conditions are particularly favorable in a belt stretching from a point near the southwest corner of sec. 30 to the southeast corner of sec. 16, in which the initial production of the wells ranges from 100 to 1,000 barrels a day. The particularly favorable character of the sand in this belt probably accounts for the occurrence of oil in the synclinal depression in the SE. ¼ sec. 17, which would be expected from structural considerations to be barren of oil. It is not certain, however, that this minor syncline in the surface rocks is repeated in the Bartlesville sand.

Only one fault of considerable extent, which may affect the deeply buried rocks, has been found, but there are a number of small faults which are believed to affect only the surface rocks. A conspicuous small local fault, which is not traceable more than a quarter of a mile, occurs in the SW. ¼ SW. ¼ sec. 14. It strikes almost due east and has a downthrow of about 35 feet on the south side. The largest fault found in this township is in sec. 34, and although it is difficult to trace, it is believed to be about a mile long. It trends N. 20° W. and has a downthrow on the northeast side, amounting to about 60 feet near its middle.

Phillips anticline.—The Phillips anticline, so named from the Phillips Petroleum Co., which has a large camp on it, is an elongated fold extending from sec. 13 almost due north through secs. 12 and 1 into sec. 36 of the adjoining township. The 1,050-foot contour is the lowest closed contour, and the area of closure is about one and a half sections. There are two crowns or domes on this anticline, one at the north end, in the N. ½ sec. 1, which may be appropriately called the North Phillips dome; and another near its south end, in the SW. ¼ sec. 12 and the NW. ¼ sec. 13, which may be called the South Phillips dome. The North Phillips dome, which is outlined by the 1,060 and 1,070 foot closed contours, shows steep dips to the west, north (in the adjoining township), and east; to the south it is connected by a low, narrow, closely folded saddle with the South Phillips dome. The South Phillips dome is also outlined by the 1,060 and 1,070 foot closed contours and shows a strong dip to the west and gentle dips to the north, east, and south.

The known limits of the oil and gas pool on this anticline are now being rapidly extended. Gas has been found on the crowns at the two ends of the anticline, and oil on its west flank. Gas will probably be obtained in large amounts in a large part of the area surrounded by the 1,050-foot contour, especially in the S. ½ sec. 12, the NW. ¼ sec. 13, and the E. ½ NW. ¼ and the W. ½ NE. ¼ sec. 1. The oil pool will probably be found to extend to the north over the W. ½ W. ½ sec. 1, the E. ½ E. ½ sec. 2, the E. ½ sec. 11, the greater part of sec. 12 except the NE. ¼, the E. ½ sec. 14, and the NW. ¼ sec. 13.

Oil in this pool is produced exclusively from the Bartlesville sand. The wells here range in initial production from a fraction of a barrel to 1,000 barrels a day, but most of them produce from 10 to 100 barrels. There is a wide variation in the production of wells only 500 to 600 feet apart. This variation, which is believed to be due to local sand conditions, is marked in the NE. ¼ sec. 14, where there are a 1,000-barrel well and a 10-barrel well 500 feet apart. In an area where the sand shows so wide a variation in thickness or porosity, or both, a dry hole should not be considered to condemn even a quarter section, provided it is in an area of favorable structure.

Although it is likely that a number of small wells and dry holes will be drilled in the area outlined above as probably productive, it is believed that oil will eventually be obtained in much of the area. As the long west dip favors drainage to this fold the entire area of favorable structure should be carefully tested. It seems probable that a small quantity of oil may be found in the Peru sand, which is reported to have a thickness of 30 feet or more. Gas has been found here in the "Oswego lime," Bartlesville sand, and "Mississippi lime." So far as known, only one well in this area has penetrated more than 10 or 20 feet into the "Mississippi lime," which is worthy of a deep test. Favorable localities for deep tests are in the SW. ¼ SW. ¼ sec. 12 and near the center of the NW. ¼ sec. 1. The depth to the top of the "Mississippi line" in the first locality is approximately 1,860 feet, and in the other about 75 feet less.

Boston Osage anticline.—The Boston Osage anticline, so named from the oil company that holds leases to a considerable part of it, is in the south-central part of the township, largely in secs. 21, 22, 23, 26, 27, and 28. It is a broad, irregular-shaped anticline with two crowns. It has fairly strong dips on its southwest, west, and northwest flanks and gentle dips on the east into a broad, shallow syncline. On the southeast it is connected by a saddle with a long anticlinal nose which projects from the Perrier anticline. The dips on its south flank are locally increased by a fault which trends N. 20° W. and has a downthrow of about 60 feet on its east side. The eastern crown of this anticline, which lies largely in the NE. ¼ sec. 27, is outlined by the 1,040-foot contour, which incloses approximately 250 acres. The western crown is largely in the NE. ¼ sec. 28 and is outlined by the 1,030-foot contour; it has a reversal of about 20 feet and an area of closure of approximately 140 acres.

The Boston Osage anticline has a number of scattered oil and gas wells on its northern and northwestern flanks. Gas is derived from both the Bartlesville sand and the "Mississippi lime"; oil is derived from the Bartlesville only. The oil wells so far drilled have been small producers, yielding from 10 to 20 barrels daily. The gas in wells on the flanks of the anticline is derived from the "Mississippi lime." The fold is large and well placed with reference to the belt of steep dips. To judge from the area of favorable structure and the scattered oil and gas wells on it the productive area can be considerably extended by further drilling. The chances for extension are particularly good in secs. 21, 22, 27, and 28 and the western part of sec. 23, and possibly in the northern part of sec. 33. It is likely that the Bartlesville sand will yield largely gas on the crowns and oil on the north and northwest flanks of the anticline. Drilling should be continued away from the already productive wells in an effort to ascertain if the pool extends over the area of favorable structure as

outlined above. Structurally this area is comparable to that of the Phillips anticline, and if the sand conditions are favorable a pool approaching the one on that anticline may be discovered here.

Javine anticline.—The Javine anticline, so named from the allottees who own much of the land on it, lies in secs. 29, 30, 31, and 32. This anticline has strong dips to the northwest, west, and south; on the east it is separated from the Boston Osage anticline by a shallow, broad saddle. It has a closure on the east of not more than 10 or 20 feet. It is not certain whether the 970-foot contour is closed as indicated on Plate XI; if it is, the area of closure amounts to about 400 acres and lies in the SW. ¼ sec. 29, the SE. ¼ sec. 30, the NE. ¼ sec. 31, and the NW. ¼ sec. 32. From the main part of this anticline a nose leads off toward the northwest into sec. 25 of the adjoining township. The 930-foot contour shows a small area of closure on this nose along the township line.

Oil has been obtained in large amounts on the west flank, and particularly on the northwest flank, of this anticline. The oil pool extends to the northeast beyond the limits of this anticline to the Dunn terrace, to be described later. So far the crest of this anticline has not been drilled; when it is drilled it is likely to prove gas bearing, as the wells highest up on its flank yield large amounts of gas with the oil. The belt in which the wells show the greatest yield, ranging in initial daily production generally from 100 to 200 barrels and exceptionally to as much as 1,000 barrels, trends northeastward from a point near the southwest corner of sec. 30 to the southwest corner of sec. 16. This belt has its maximum width of half a mile near the northeast corner of sec. 30. Both northwest and southeast of this belt the wells diminish in production to 10 barrels or less. The greater productivity of the wells along this belt is believed to be due to the greater porosity and thickness of sand along it.

The extensions of the oil pool on this anticline will most probably be found in the N. ½ sec. 31, the NW. ¼ sec. 32, and probably the greater part of sec. 29 except the SE. ¼. Gas will probably be found over much of the area inclosed by the 970-foot contour. Continued drilling away from the productive area will gradually define the limits of the pool in the most economical way.

Dunn terrace.—The Dunn terrace is a broad, poorly defined area of relatively flat beds, covering the greater part of secs. 8 and 9, the W. ½ secs. 10 and 15, and most of secs. 16, 17, 20, and 21. It is bordered on the east and southeast by an area of relatively steep west and northwest dips; on the west and north it is less clearly defined but is considered to be limited by the 930-foot contour. On the surface of this terrace are two small anticlines and one closed synclinal depression. The larger of the anticlines, in the SW. ¼ sec. 9 and the NW. ¼ sec. 16, is dome shaped and is outlined by the 960-foot

contour. It has an area of closure of slightly more than a quarter of a section and a reversal of dip amounting to 20 feet. The other anticline lies largely in the SE. ¼ sec. 20 and has only one closed contour, the 960-foot contour. It has strong dips on its west and northwest sides, but on the east it merges into the terrace and is poorly defined. The synclinal depression is outlined by the 940 and 930 foot closed contours and lies largely in the SE. ¼ sec. 17 but extends over into the sections adjoining on the east and south.

The oil pool on the Javine anticline, described above, extends northeastward to the southern part of the Dunn terrace. Oil has been found in the area of favorable structure and also in the synclinal depression described above. Its presence is probably due to the belt of favorable sand which crosses this area. (See p. 88.) This pool is being actively drilled and extended at this time (August, 1918). Large wells have been drilled in the SW. ¼ and the NE. ¼ sec. 20 and in the SW. ¼ sec. 16; the maximum initial daily production has been 1,000 barrels. To judge from the structure and the present developments, this pool extends over practically the whole of sec. 20 and probably a large part of secs. 21 and 16, the eastern part of sec. 17, and the SW. ¼ sec. 9. This area is along the trend of large producing wells and is believed to offer good prospects for oil production because of favorable sand conditions. Oil may be found on the northwestern edge of the Dunn terrace; a favorable place to test this area would be near the center of the NW. ¼ sec. 8.

Cedar Creek anticline.—Leading to the west from the Dunn terrace is the Cedar Creek anticline, which extends from the N. ½ sec. 18 into the adjoining township, where it is largely developed. In this township this anticline has the form of an anticlinal nose, with its high part trending west through the center of the N. ½ sec. 18. A favorable locality for testing this anticline is in the center of the NW. ¼ NW. ¼ sec. 18. The depths of the different formations there are approximately the same as in the dry hole drilled in the SE. ¼ sec. 7, where the Bartlesville was penetrated at 1,786 to 1,846 feet and the "Mississippi lime" at 1,915 to 2,207 feet. In that hole the Bartlesville was reported to be barren of oil and water.

Lost Creek anticline.—The Lost Creek anticline, which is mainly in T. 26 N., R. 11 E., extends into this township along the line between secs. 5 and 6. There the high part of the anticline is outlined by the 910-foot contour, which is closed in the two townships. This part of the anticline shows moderately strong dips to the west and east, but on the south the beds are relatively flat. A favorable locality to test this anticline would be near the center of the NE. ¼ sec. 6. There the Bartlesville and the "Mississippi lime" may be reached at substantially the same depths as in the well in the SE. ¼ sec. 7, as stated above, allowance being made for the difference in elevation of the mouths of the wells.

AREAS OF UNFAVORABLE STRUCTURE.

T. 25 N., R. 12 E.

Oil is commonly found in the Osage country associated with anticlines, terraces, or structural noses, and most commonly on the west and northwest sides of these features; it is seldom found in major synclines or in areas of featureless normal west dips. Therefore, the areas least likely to be productive of oil are synclines such as that trending southward from sec. 29 along the line between secs. 31 and 32, T. 25 N., R. 12 E., into the adjoining township on the south and that trending south along the creek in sec. 6 to the southern edge of sec. 7, where it forks. Another unfavorable area is in the closed syncline which extends from the center of sec. 4 southward to the southern edge of sec. 9 and in its more constricted extension southward through the center of sec. 16. Oil has been found on the west flank of the Forty-seven anticline, but it probably does not extend down the dip much, if any, below the 1,050-foot contour. The low, flat syncline extending southwestward from the center of sec. 17 to the southwest corner of sec. 19 is also likely to be unproductive of oil.

T. 25 N., R. 11 E.

The southern part of secs. 32 and 33, T. 25 N., R. 11 E., are parts of a broad syncline which extends into the adjacent township to the south and will probably be unproductive of oil. The large closed syncline in secs. 3 and 4 and the lower part of the area of west dip in the western part of secs. 2, 11, and 14 and the eastern part of secs. 10 and 15 are also quite likely to be barren of commercial accumulations of oil. In general this township can best be developed by testing first the favorable folds and by drilling the productive pools until they are completely defined.