T. 27 N., R. 11 E.

By Heath M. Robinson and R. V. A. Mills.

INTRODUCTION.

T. 27 N., R. 11 E., is in the northeastern part of the Osage Reservation, as shown in figure 1. The southeast corner of the township is about 5 miles by road from the town of Bartlesville, which is on both the Atchison, Topeka & Santa Fe Railway and the Missouri, Kansas & Texas Railway. Owing to the hauling of heavy loads from Bartlesville to the oil fields in this vicinity the roads are rough, but they are constantly being used by automobiles, motor trucks, and other vehicles. Water for use in drilling is supplied by Buck Creek, Butler Creek, and a number of ponds in which surface water is collected. Except for the country near Buck and Butler creeks the township for the most part is unwooded, which makes it possible to do rapid and efficient plane-table work.

The field work on which this report is based was done by Heath M. Robinson, R. V. A. Mills, Frank Reeves, and Frank R. Clark, geologists, assisted by Lewis Mosburg, instrument man. The area mapped by each geologist is shown by the diagram inserted on Plate XLI. The plane table and telescopic alidade were used in mapping the structure, and the elevations were controlled by a system of triangulation which was checked within itself and with the Government bench marks in this township. All the office work on this report was done by Heath M. Robinson, who is responsible for the statements and conclusions herein presented.

STRATIGRAPHY.

EXPOSED ROCKS.

GENERAL CHARACTER.

The rocks exposed in T. 27 N., R. 11 E., are of middle Pennsylvanian age and comprise about 425 feet of shale, sandstone, and limestone. Shale constitutes the greater part of the section, sandstone a large part, and limestone a very minor part. The limestones, however, are very excellent key beds and consequently were found to be of value in determining the structure of the township.

The character and succession of the exposed rocks are shown graphically in figure 41, which shows also their relation to the

stratigraphic section exposed in the northern part of the Osage Reservation. The data for the section exposed in the northern part of the Osage Reservation were compiled from United States Geological Survey Bulletins 641–B, 691–C, 686–F, and from the field notes on T. 27 N., R. 11 E. The relation between the exposed and the subsurface beds in T. 27 N., R. 11 E., is graphically shown on Plate XLII.

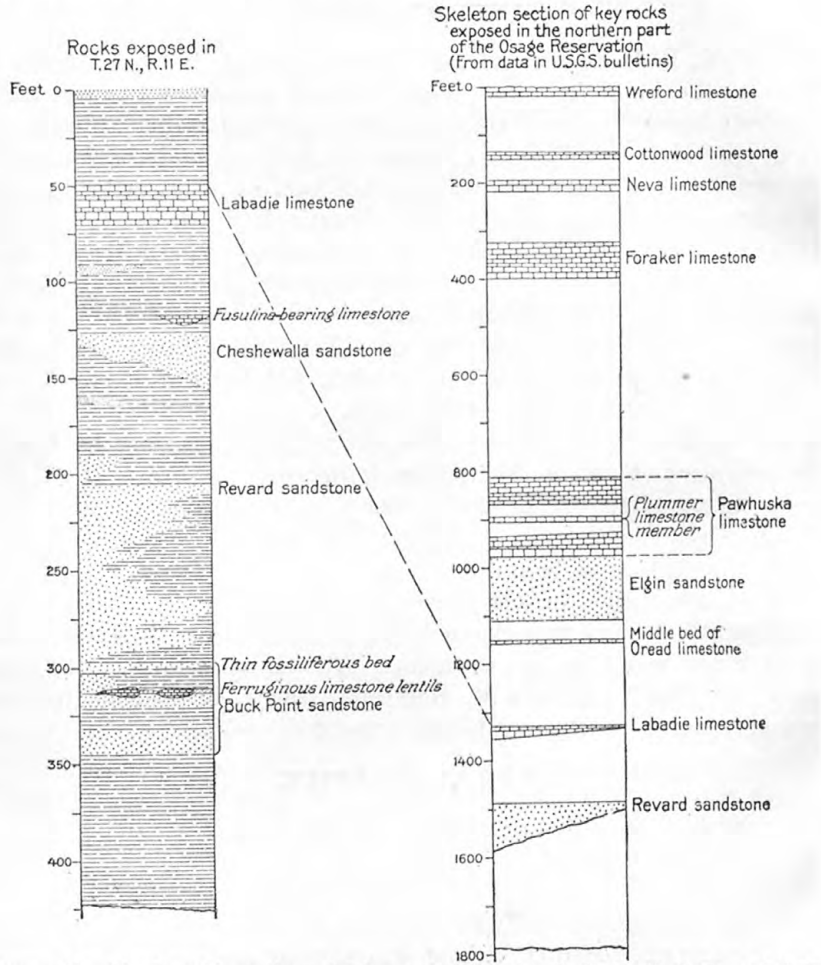


FIGURE 41.—Stratigraphic sections showing rocks exposed in T. 27 N., R. 11 E., and their relation to the section exposed in the northern part of the Osage Reservation.

As this report is strictly economic no attempt is made to give a detailed description of the stratigraphy of the region. However, it is believed that a description of those beds which were found to be useful in mapping the structure will be serviceable to other geologists who may do geologic work in this township after the publication of this report, and hence these key beds are here briefly described.

KEY BEDS.

Labadie limestone.—The outcrop of the Labadie limestone is shown on Plate XLI, and its position with respect to other beds in the township is shown in figure 41. The average thickness of this limestone is about 20 feet, and in this township it does not vary more than 2 or 3 feet from this average. However, a mile or so north of the northern boundary of the township the limestone is much thinner, ranging from less than a foot to 3 or 4 feet in thickness. The main body of the limestone is gray, but in some outcrops the upper part is colored a rich cinnamon-brown. The limestone is not densely fossiliferous, but in most of the outcrops a few scattered fossils may be found. It is more resistant to weathering than the associated shales; consequently it forms the cap rock of many of the small hills in the northwestern part of the township. It commonly weathers into roughly rectangular slablike masses an inch or so thick and 2 or 3 feet in their greatest dimension. In this township its outcrop is free from trees, and because it is in general prominently exposed it makes a very satisfactory bed to use for mapping the structure.

Fusulina-bearing limestone.—The outcrop of the *Fusulina*-bearing limestone is not shown on Plate XLI, but its position in the stratigraphic section is shown in figure 41. As indicated there, it is lenticular, and apparently its outcrop is confined to a few scattered localities in the northern part of the township. It ranges from a few inches to 3 or 4 feet in thickness, is gray on freshly fractured surfaces, and is practically made up of long, slender *Fusulina*. Its outcrop is usually inconspicuous, but because of its marked characteristics and its definite position in the section it was found to be a useful key bed in mapping the structure in this township.

Cheshewalla sandstone.—As shown in figure 41, the Cheshewalla sandstone lies almost directly beneath the *Fusulina*-bearing limestone, described above. Where this limestone was absent the top of the Cheshewalla sandstone was found to serve as a very good substitute in mapping the structure, for the bed was found to be persistent and the outcrop fairly distinct. The sandstone is dark gray on weathered surfaces and is from 5 to 25 feet thick. It is massive and in character has little to distinguish it from other massive sandstones found in the township.

Revard sandstone.—The outcrop of the top of the Revard sandstone is shown on Plate XLI, and its stratigraphic position is shown in figure 41. This sandstone is as thick as 100 feet in the southwest corner of this township, but in many other localities in the township it measures between 5 and 40 feet. The top of the sandstone was found to be fairly persistent, and the contact between the

overlying predominantly shale series, which generally was unwooded, with this predominantly sandstone series, generally wooded, furnished the most usable datum available for mapping the structure over a good part of the township. The sandstone is massive and cross-bedded and, like the Cheshewalla, has few characteristics to distinguish it from other similar massive sandstones that outcrop in the township.

Thin fossiliferous bed in the Buck Point sandstone.—About 93 feet below the top of the Revard sandstone in the southeastern part of T. 27 N., R. 11 E., is a bed of sandstone which is 1 or 2 feet thick, dark gray on weathered surfaces, and richly fossiliferous. The fossils belong to the genus *Productus* and are large and round. The sandstone weathers into blocks several feet across, and the weathered surface is usually found to have a liberal sprinkling of these fossils, which appear as rounded bumps raised about half an inch above the surface of the sandstone. As the bed is thin, consequently marking a very definite horizon, and as it is easily recognizable in the field, it was found to be very useful in mapping the structure of part of this township.

The outcrop of this bed is shown on Plate XLI and its relation to the other beds found in this township is graphically shown in figure 41. The development of the Buck Point sandstone in T. 26 N., R. 11 E., the township just south of this one, has been described by Frank R. Clark.[1]

Between 8 and 15 feet below the fossiliferous bed described above there crops out in a few scattered localities in this township a dark-brown ferruginous limestone from a thin edge to 8 feet thick. This bed is too lenticular to serve as a key bed, but it was found to be useful in positively identifying the thin fossiliferous bed in the Buck Point sandstone.

ROCKS NOT EXPOSED.

The rocks in T. 27 N., R. 11 E., below the surface beds and above the top of the bed called by the drillers the "Mississippi lime," are known from a study of about 45 records of wells that have been drilled for the most part in the western half of the township. The accompanying table, which has been completed from these records, shows the depth from the surface of the ground to the top of several prominent beds and the thickness of these beds. The location of the wells described in the table is shown in figure 43.

[1] U. S. Geol. Survey Bull. 686–I, 1918.

Well data in T. 27 N., R. 11 E., Oklahoma.

No. in figure 43.	Location. Section.	Location. Quarter.	Depth to top of Big lime.	Depth to top of "Oswego lime."	Depth to top of Bartlesville sand.	Thickness of "Mississippi lime."	Depth to top of "Mississippi lime."	Total depth.	Name or position of pay sand.	Thickness of pay sand.	Type of well.	Initial daily production.
			Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*		*Feet.*		
1	2	SE.	.....	.....	.....	.....	.....	688	.....	.....	Dry	
2	2	SE.	.....	1,418	1,736	28	.....	2,013	Bartlesville sand	28	Abandoned gas well	
3	2	NE.	.....	.....	.....	.....	.....	641	.....	.....	Dry	
4	5	SE.	.....	1,370	1,686	20	1,850	1,886	.....	.....	do	
5	6	SE.	.....	1,446	1,760	25	.....	1,938	.....	.....	do	
6	7	SW.	1,380	1,535	.....	.....	1,964	1,991	"Mississippi lime"	.....	Abandoned oil well	
7	8	SE.	.....	.....	.....	.....	.....	742	Stray sand (730–742 feet)	12	Gas well	3,061,800 cubic feet.
8	9	NE.	.....	.....	1,773	18	.....	1,994	.....	.....	Dry	
9	13	SW.	.....	.....	.....	.....	.....	1,607	.....	.....	do	
11	17	SE.	.....	1,439	.....	.....	1,908	1,932	.....	.....	do	
12	17	SE.	.....	1,435	.....	.....	1,898	1,927	"Mississippi lime"	29	Oil well	20 barrels.
15	18	NW.	1,378	1,538	.....	.....	1,980	2,022	.....do	42	.....do	70 barrels.
17	18	NW.	1,345	1,505	.....	.....	1,949	1,995	.....do	5	.....do	25 barrels.
18	18	NW.	1,358	1,512	.....	.....	1,952	2,012	.....do	50	.....do	70 barrels.
19	18	SW.	1,301	1,453	1,720	5	1,894	1,904	.....do	10	Gas well	4,000,000 cubic feet.
20	18	SW.	1,285	1,440	.....	.....	1,868	1,886	.....do	5	.....do	3,500,000 cubic feet.
21	18	SW.	1,286	1,439	.....	.....	1,874	1,895	.....do	21	.....do	2,750,000 cubic feet.
22	18	SW.	1,285	1,435	.....	.....	1,869	1,881	.....do	12	.....do	4,000,000 cubic feet.
24	19	SW.	.....	.....	.....	.....	1,802	1,831	.....do	29	Oil well	20 barrels.
25	19	SE.	1,304	1,464	.....	.....	1,911	1,952	.....do	7	Gas well	1,600,000 cubic feet.
26	20	SW.	1,245	1,450	1,752	22	1,920	1,995	.....	.....	Dry	
30	20	NE.	1,280	1,435	.....	.....	1,898	1,921	"Mississippi lime"	29	Oil well	
46	27	SW.	.....	1,450	.....	.....	.....	1,941	.....	.....	.....	
48	28	SW.	1,208	1,366	1,671	10	1,832	1,860	"Mississippi lime"	28	Gas well	5,000,000 cubic feet.
50	28	NW.	1,260	1,426	1,740	17	1,901	1,912	.....do	11	.....do	3,000,000 cubic feet.
57	29	NW.	1,266	1,423	1,745	15	1,898	1,914	.....do	16	.....do	2,500,000 cubic feet.
58	29	NW.	1,173	1,305	1,650	2	1,792	1,808	.....do	16	.....do	1,500,000 cubic feet.
59	29	NW.	1,179	1,338	1,668	12	1,818	1,890	.....	.....	Dry	
63	30	NE.	1,315	1,452	1,780	20	1,922	1,957	"Mississippi lime"	21	Oil well	25 barrels.
65	30	NW.	1,250	1,410	.....	.....	1,789	1,888	.....do	.....	.....do	10 barrels.
67	30	NW.	.....	.....	.....	.....	1,723	1,865	.....do	26	.....do	20 barrels.
72	30	NW.	.....	1,372	.....	.....	1,823	1,833	.....do	10	.....do	10 barrels.
73	31	SW.	1,237	1,388	1,740	20	1,885	1,900	Bartlesville sand	20	Abandoned oil well	
74	31	SW.	1,204	1,360	1,717	13	.....	1,747	.....do	13	Oil well	100 barrels.
75	33	NW.	1,257	1,418	1,732	15	1,892	1,910	.....do	15	.....do	60 barrels.
76	33	NE.	.....	.....	1,662	12	.....	1,839	.....do	12	Abandoned gas well	
77	33	NE.	.....	1,320	1,627	18	.....	1,645	.....do	18	Oil well	
78	33	NE.	.....	1,300	1,606	10	.....	1,616	.....do	10	.....do	
79	33	NE.	.....	1,278	1,624	15	.....	1,667	.....do	15	.....do	
80	33	NE.	.....	1,250	1,579	11	.....	1,608	.....do	11	.....do	

Well data in T. 27 N., R. 11 E., Oklahoma—Continued.

No. in figure 43.	Location.		Depth to top of Big lime.	Depth to top of "Oswego lime."	Depth to top of Bartlesville sand.	Thickness of "Mississippi lime."	Depth to top of "Mississippi lime."	Total depth.	Name or position of pay sand.	Thickness of pay sand.	Type of well.	Initial daily production.
	Section.	Quarter.										
			Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*		*Feet.*		
81	33	NE.	.....	1,305	1,651	17	.....	1,693	Bartlesville sand	17	Oil well	
82	33	SE.	.....	.....	1,666	.....	.....	1,727	.. ..do.....	(?)	.....do.....	75 barrels.
83	33	SE.	.....	.....	1,645	16	.....	1,661	.....do.....	16	Abandoned oil well.....	50 barrels.
84	34	SW.	.....	1,300	1,634	6	.....	1,655	.....do.....	6	Oil well.....	
85	34	SW.	.....	1,325	1,662	16	.....	1,701	.....do.....	16	.....do.....	
86	34	SW.	.....	1,360	1,680	13	.....	1,693	.....do.....	13	.....do.....	
87	34	SW.	.....	.....	1,687	8	.....	1,705	.....do.....	8	Abandoned oil well.....	
95	36	NW.	.....	.....	.....	.....	.....	1,057	Stray sand (975–1,042 feet).....	67	Oil well.....	10 barrels.

Plate XLII shows graphically four fairly representative well logs and a generalized section indicating the relation between the exposed and unexposed rocks. The subsurface rocks represented in the generalized section consist of about 75 per cent shale, 14 per cent sandstone, and 11 per cent limestone. On the whole these rocks do not "cave" badly when drilled, so that it is a universal practice in the township to use cable tools rather than a rotary for drilling.

The first prominent "lime" usually recorded by the drillers, called by them the Little lime, is about 1,150 feet below the top of the Labadie limestone, which is exposed in the northwestern part of the township. The Little lime has an average thickness of about 28 feet and is separated from the exposed rocks by alternate beds of shale and sandstone interbedded with few thin beds of limestone.

After going through the Little lime the drill usually encounters about 120 feet of shale before reaching the next prominent limestone, commonly called by the drillers the Big lime. The Big lime has an average thickness of about 75 feet and in most of the well records it was reported to be made up entirely of limestone, although in a few a relatively thin parting of black shale was recorded. In other parts of the Osage Reservation oil and gas are produced from this bed, but no production of importance has been recorded from this township. This limestone is probably of the same age as the Oologah limestone, which crops out about 30 miles east of T. 27 N., R. 11 E.

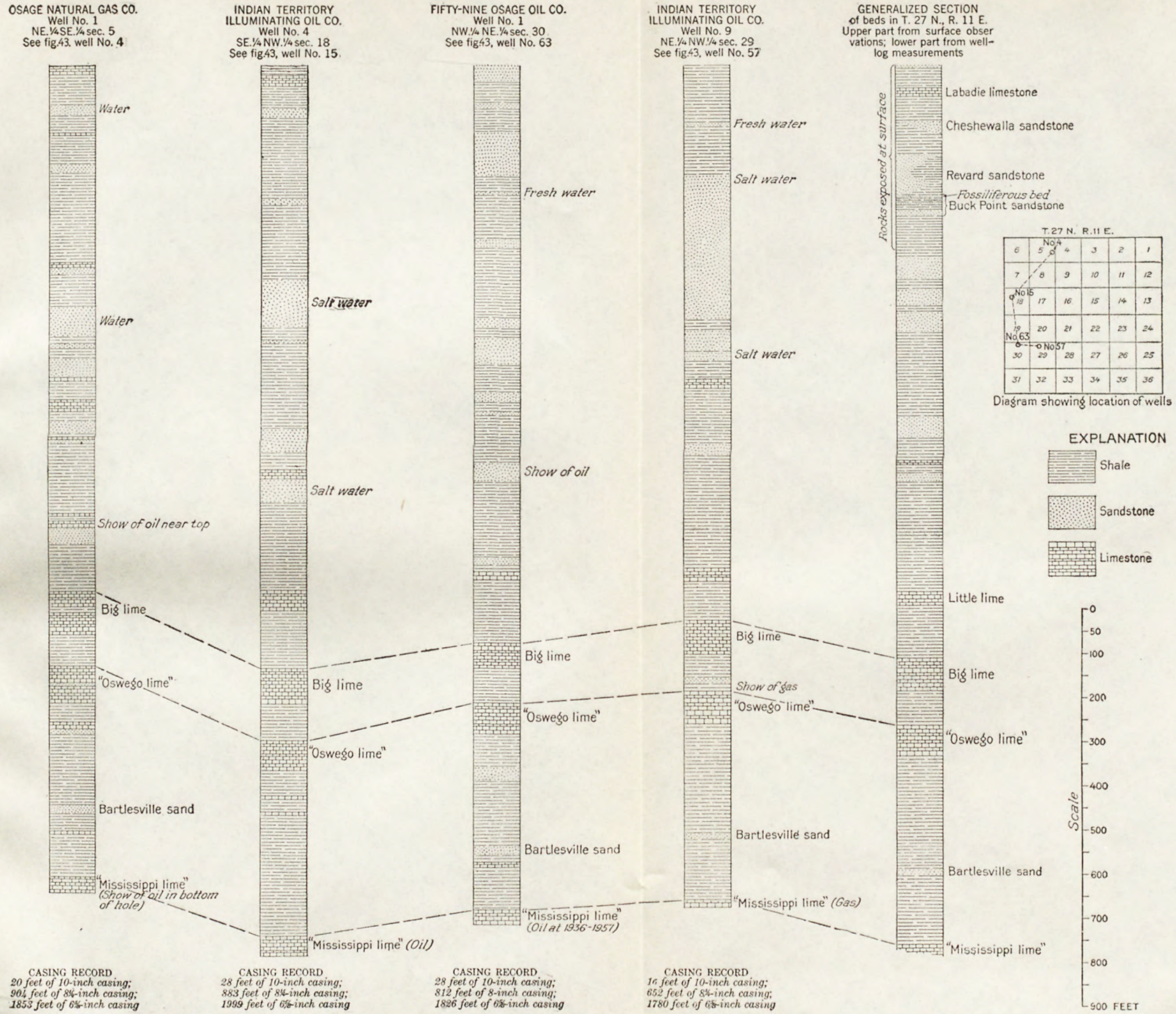
The Big lime overlies the "Oswego lime" and is separated from it by about 80 feet of shale. The "Oswego lime" has an average thickness of approximately 70 feet, and its depth below the surface as well as its thickness is usually noted in records kept by the drillers. It is perhaps the most universally recognized subsurface bed in the township and is probably to be correlated with the Fort Scott limestone, which crops out about 50 miles east of this township. Although oil and gas are found in the "Oswego lime" in other parts of the Osage Reservation no production has been recorded from this bed in T. 27 N., R. 11 E.

The interval between the "Oswego lime" and the underlying sandstone, called the Bartlesville sand, averages about 260 feet and is largely filled with shale, interbedded near the top with relatively thin beds of sandstone and limestone. The Bartlesville sand, as shown in the table of well data with this report, or a sand in a similar stratigraphic position, is found over the greater part of this township that has been drilled. As shown in the table of well data, the maximum thickness of this sandstone is 27 feet in well 2 (fig. 43), in the SE. ¼ sec. 2; an average thickness is about 15 feet; and a number of the well logs, particularly those in secs. 17 and 18, did not record any sandstone at this stratigraphic horizon. It is pointed out in another part of this report that there is little relation between

the oil and gas productivity and the thickness of the Bartlesville sand in this township, but that the oil production from this sand is partly controlled by its porosity. A study of the well records available indicates that in the area marked by shading in figure 43 the Bartlesville sand is more porous than elsewhere in the township.

A limestone, known as the "Mississippi lime," is found about 145 feet below the base of the Bartlesville sand. The interval of 145 feet is made up largely of shale, which is interbedded with a few thin limestones, and in one or two well logs a thin sandstone was also recorded in this interval. In a number of the records a part of the shale between the Bartlesville sand and the "Mississippi lime" is reported as black shale. Most of the oil that has been produced in this township is found in either the Bartlesville sand or the "Mississippi lime," and as the black shale is between these beds there is a possibility that it may have been the source of the oil. Black shale is also reported in a few well logs in the interval between the base of the "Oswego lime" and the Bartlesville sand. The total interval between the base of the "Oswego lime" and the top of the "Mississippi lime" may be the stratigraphic equivalent of the Cherokee shale, but the possibility that the black shale, which in some well logs is shown to lie immediately above the "Mississippi lime" and beneath the Bartlesville sand, may also be of Mississippian age, should at least be considered.

As shown in the table of well data the "Mississippi lime" has been penetrated by the drill to a maximum depth of about 75 feet in well 26, in sec. 20. (See fig. 43.) The bottom of the hole was still in the lime at this locality, consequently the thickness of the lime is greater than 75 feet. The "Mississippi lime" is tentatively classed as the stratigraphic equivalent of the Boone limestone, which is of Mississippian age, and if this correlation is correct it may be expected that the "Mississippi lime" will be several hundred feet thick. Before this correlation is conclusively made, however, the possibility of correlating the "Mississippi lime" with other Mississippian limestones younger than the Boone limestone should be considered. In parts of Oklahoma the Morrow group and Pitkin limestone, the latter of Mississippian age, are known to occupy a position below the Cherokee shale and above the Boone limestone, and they are separated from the Boone by shales and sandstone representing the Fayetteville formation and Batesville sandstone. The possibility of obtaining oil or gas from these sandstones between the Boone and the overlying limestones stamps this problem as one of direct economic importance, and consequently it is appropriate here to consider means of determining the correct correlation of the "Mississippi lime." It is generally agreed that the Boone is very siliceous, much more so than



SECTIONS SHOWING TYPICAL WELL LOGS IN T. 27 N., R. 11 E., AND A GENERALIZED SECTION OF EXPOSED AND UNEXPOSED ROCKS.

the limestones of the Morrow and Pitkin. This means that the Boone should be harder to drill than the Morrow or Pitkin, the silica in the lime making it difficult to keep the bit sharp and in general preventing rapid drilling. The "Mississippi lime" produces both oil and gas in this township, and in some wells it is "shot" to increase its yield. It should be possible to collect, under favorable circumstances, chunks of the "Mississippi lime" from these wells that are shot and to examine them for fossils and their content of silica.

STRUCTURE.

CONVERGENCE OF STRATA.

Whether the producing oil and gas sands are parallel to the beds at the surface of the ground is a very important economic question, because it affects the depth of hole necessary to test the productive sands. By using the information embraced in the table of well data, and by comparing the relative elevations of subsurface beds with the surface structure, taking average rather than extreme results, the conclusions presented below have been developed.

In general the interval between a surface bed and an oil or gas sand is greater in the southwestern part of the township than it is in the northwestern part. The interval between any particular surface bed and the top of the "Oswego lime" is approximately the same in the southwest corner of sec. 31 as it is in the southwest corner of sec. 28, but in the northwest corner of sec. 18 the interval between the same surface bed and the "Oswego lime" is about 30 feet less. In other words, there is a convergence of about 30 feet toward the northwest between the beds at the surface and the "Oswego lime" at the localities mentioned above. From evidence obtained in T. 27 N., R. 10 E., the adjoining township on the west, it is likely that the total convergence toward the north between the surface beds and the "Oswego lime" from the southwest corner of T. 27 N., R. 11 E., to the northwest corner of this township amounts to about 100 feet.

A number of well logs showing the thicknesses of strata between the "Oswego lime" and the "Mississippi lime" were assembled, and the results averaged and distributed according to sections in the township. This showed that there is a convergence toward the north and west between the "Oswego lime" and the "Mississippi lime," which amounts to about 40 feet between sec. 31 and sec. 18, and about 60 feet between sec. 31 and sec. 7. Although the "Mississippi lime" is not parallel to the "Oswego lime" it does not seem that the discordance is due to an unconformity. More probably, inasmuch as the convergence of the beds above the "Oswego lime" is similar in amount

and direction to that of the beds below it, the discordance of dip is logically explained by the fact that the whole section is thinner in the northern part of the township than it is in the southern part. This convergence of the strata means that a well drilled in the southwest corner of the township and starting on the Cheshewalla sandstone should reach the "Mississippi lime" at a depth of about 1,950 feet, whereas a well drilled in sec. 18 and starting on the Cheshewalla sandstone should reach the "Mississippi lime" at a depth of about 1,880 feet, and a well in sec. 6 which started on the same sandstone should reach the lime at a depth of about 1,800 feet.

GENERAL STRUCTURAL FEATURES.

The geologic structure of T. 27 N., R. 11 E., is shown on Plate XLI by means of structure contours that have an interval of 10 feet and are based entirely on surface data. The datum on which the contours are drawn is a theoretical bed 560 feet below the top of the Plummer limestone member of the Pawhuska limestone. A hasty glance at the structure contours leaves the impression that there is no normal dip in the township; rather the structure appears to be made up of irregular dips that form anticlines, domes, terraces, and synclines. However, a closer scrutiny of the map shows that the highest structure contour in the township is in sec. 36, at the southeast corner, and is the 1,070-foot contour, and that the lowest contour (labeled 740 feet) is in sec. 6 at the extreme northwest corner of the township. The general direction of dip, then, is toward the northwest and amounts to about 40 feet in a mile. Both the direction and amount are those generally accepted as representing the normal dip in this part of Oklahoma.

In figure 42 the axes of the principal domes and anticlines are outlined, and for convenience in description and reference these structural features are named. Most of the names are those of the allottees who have title to the land covered by the anticlines and domes. Inasmuch as domes, anticlines, and terraces are generally conceded to be more favorable for the accumulation of oil and gas than rock folds of other types, the areas covered by these structural features are briefly described below.

The Backius anticline plunges steeply toward the southwest and is characterized by relatively steep dips. The axis, as shown in figure 42, intersects the east line of sec. 36 near its northeast corner and the west line of the same section near its southwest corner.

The axis of the Doe Creek dome has a northwesterly trend and cuts across the southwest corner of sec. 34. (See fig. 3.) If the structure contours of this township are matched with those of the town-

ship immediately to the south (T. 26 N., R. 11 E.), it will be noted that the Doe creek dome has a closure between 50 and 60 feet.

The Sand Creek anticline might be described as an elongated dome whose axis has a northeasterly trend. It occupies the greater part of sec. 31 and extends into sec. 6 of T. 26 N., R. 11 E. By matching the contours shown on Plate XLI with those of T. 26 N., R. 11 E., it will be seen that the Sand Creek anticline has a closure of 20 to 30 feet.

Over a large part of sec. 30 and a part of the S. ½ sec. 19 the structure contours show that the rocks are practically flat-lying, and this structural feature is named the Levelette terrace.

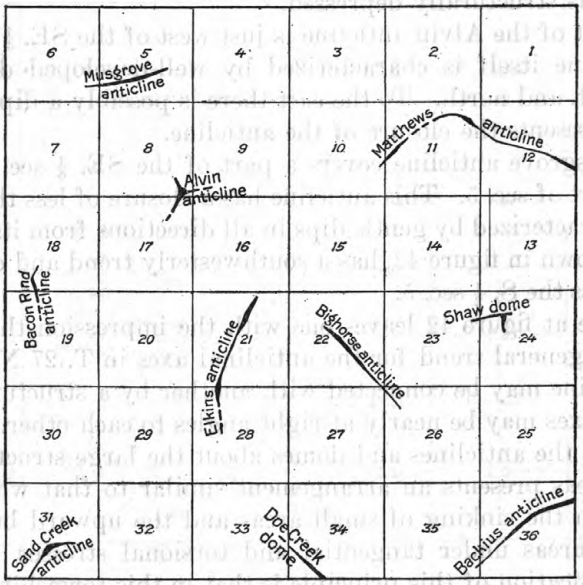


FIGURE 42.—Diagram showing approximate position of anticlinal axes in T. 27 N., R. 11 E.

The northern edge of the Levelette terrace merges into the Bacon Rind anticline, which covers a part of the N. ½ sec. 19 and a part of the S. ½ sec. 18. The axis has a southerly trend which toward the south is inclined to be slightly southeast.

The axis of the Elkins anticline cuts across sec. 21 with a northeasterly trend, and the anticline itself has relatively steep dips on its northwest, southeast, and southwest flanks. Its crest is structurally between 10 and 20 feet higher than the saddle on its northeast end, or in other words the anticline has a closure of 10 to 20 feet.

The Bighorse anticline is just east of the Elkins anticline and is connected with it by the structural saddle in the NE. ¼ sec. 21. The axis of the Bighorse anticline, which has a southeasterly trend, intersects the southeast corner of sec. 22 and extends into sec. 26. The

anticline might be described as an elongated dome with a closure between 30 and 40 feet.

The Shaw dome is a relatively small structural feature which occupies the greater part of the W. ½ sec. 24 and a small part of the E. ½ sec. 23. It has a closure between 10 and 20 feet and is connected with the Bighorse anticline by a small structural saddle in sec. 24.

A part of the NE. ¼ sec. 13 and a smaller part of the SE. ¼ sec. 12 are covered by a small structural feature called the Rutter terrace. The structure contours show a flattening of the strata at this locality.

The Matthews anticline is shown on the contour map as a curved anticline with gentle dips which tends to encircle an area to the south of it that is structurally depressed.

The crest of the Alvin anticline is just west of the SE. ¼ sec. 8, and the anticline itself is characterized by well-developed dips to the south, west, and north. To the east there is possibly a dip of 10 feet which represents the closure of the anticline.

The Musgrove anticline covers a part of the SE. ¼ sec. 6 and the central part of sec. 5. This anticline has a closure of less than 10 feet and is characterized by gentle dips in all directions from its axis. Its axis, as shown in figure 42, has a southwesterly trend and cuts diagonally across the S. ½ sec. 5.

A glance at figure 42 leaves one with the impression that there is very little general trend for the anticlinal axes in T. 27 N., R. 11 E. One anticline may be connected with another by a structural saddle, but their axes may be nearly at right angles to each other. The disposition of the anticlines and domes about the large structurally depressed areas presents an arrangement similar to that which might result from the sinking of small areas and the upward buckling of bounding areas under tangential and torsional stresses. The economic application of this principle is that in this township it is very difficult to determine even approximately the position of an unmapped anticline by extending the trend of the axis of one that has been mapped.

There seems to be a broad relationship between the structure and the topography of this township. The principal divides are for the most part areas of upfolds, and many of the stream valleys coincide with structurally depressed areas. However, this generalization must be used with extreme care in forecasting the structure of an area in this township, because in detail there are so many exceptions to the rule that it is difficult to apply it except as a generalization.

SAND CONDITIONS.

General features.—The condition of the productive sand is one of the very important factors that control the production of oil or gas

from any area. If the sand is too tight to serve as a reservoir it will not carry oil or gas in commercial quantities, and this condition or the absence of the sand may be more important than the structure of an area in determining its production.

In T. 27 N., R. 11 E., there are two main oil and gas producing beds, the "Mississippi lime" and the Bartlesville sand, and in addi-

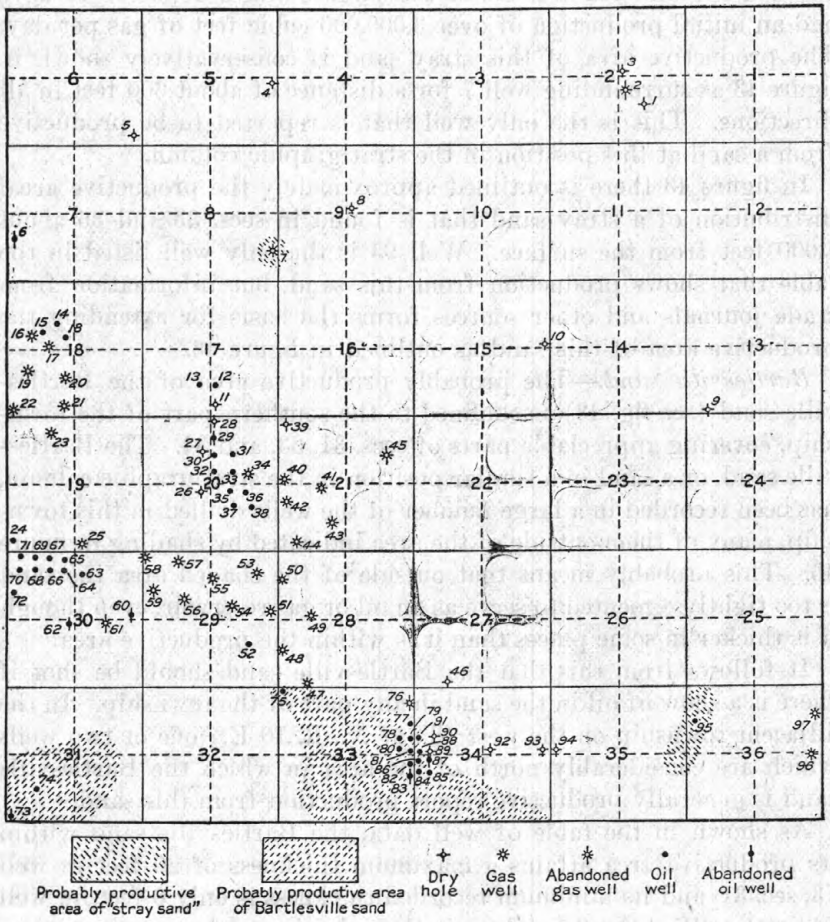


FIGURE 43.—Sketch map showing development work and productive territory of stray sands and Bartlesville sand in T. 27 N., R. 11 E.

tion several shallow oil-bearing sands that are called "stray sands" because they are local in their distribution and can not be correlated with any bed that is productive over a wide area. Figure 43 is designed to show the wells, dry holes, and abandoned wells, which are numbered to agree with the table of well data, on pages 259–260, the probable productive area of the stray sands, and the probable productive area of the Bartlesville sand. The shaded areas are purposely not

definitely outlined but are left with irregular edges, for at best they represent estimates which can only approximate the actual productive area as proved by the drill. Both the shaded and the unshaded portions of the map represent territory that may be productive of oil or gas from the "Mississippi lime" provided the structure is favorable.

Stray sands.—Well 7, in the SE. ¼ sec. 8, produces gas from a sand between 730 and 742 feet below the surface and is reported to have had an initial production of over 3,000,000 cubic feet of gas per day. The productive area of this stray sand is conservatively shown in figure 43 as surrounding well 7 for a distance of about 600 feet in all directions. This is the only well that is reported to be productive from a sand at this position in the stratigraphic column.

In figure 43 there is outlined approximately the productive areal distribution of a stray sand that is found in secs. 35 and 36 about 1,000 feet from the surface. Well 95 is the only well listed in the table that shows production from this sand, but information from trade journals and other sources forms the basis for extending the productive area of this sand as outlined in figure 43.

Bartlesville sand.—The probably productive area of the Bartlesville sand (see fig. 43) is confined to the southern part of the township, covering appreciable parts of secs. 31, 33, and 34. The Bartlesville sand, or a sand in a similar position in the stratigraphic column, has been recorded in a large number of the wells drilled in this township, many of them outside of the area indicated by shading in figure 43. This probably means that outside of the shaded area the sand is too tightly cemented to serve as an oil or gas reservoir, even though it is thicker in some places than it is within the productive area.

It follows from this that the Bartlesville sand should be shot if there is a show of oil in the sand in any part of the township. In the adjacent township on the west (T. 27 N., R. 10 E.) one or two wells which are considerably north of the area in which the Bartlesville sand is generally productive report production from this sand.

As shown in the table of well data, the Bartlesville sand within its productive area attains a maximum thickness of 20 feet in well 73, sec. 31, and its minimum recorded thickness is only 6 feet, in well 84, in the SW. ¼ sec. 34. The initial production of four wells producing from the Bartlesville sand ranges from 50 to 100 barrels of oil a day.

"*Mississippi lime.*"—The oil and gas that have been produced from the "Mississippi lime" in this township come from the upper 50 feet of this limestone. All the wells shown in figure 43, except those within the shaded areas, produce from the "Mississippi lime." As the wells within the shaded areas tap sands that are shallower than the "Mississippi lime," that bed has not been tested in these

areas. Production from the "Mississippi lime" is more widely distributed than from any other bed, and in fact the statement seems warranted that wherever in T. 27 N., R. 11 E., the geologic structure is favorable there is a very good chance of obtaining either oil or gas from the "Mississippi lime." The average initial production of the wells in this township from the "Mississippi lime" is about 24 barrels of oil a day. An initial production above 30 barrels or below 10 barrels a day is rare.

Possible productive sands below the "Mississippi lime."—In other parts of Oklahoma production of oil has been reported from sands more than 300 feet below the top of the "Mississippi lime." The following is an informal communication from Mr. R. H. Wood, dated January 25, 1919, concerning the possibility of obtaining oil from such lower beds:

> The oil limitations are not reached at the top of the "Mississippi lime" in northeastern Oklahoma, as oil has been found in a number of localities by drilling into or through that formation some 300 feet.
>
> Concrete examples may be found in the Barnsdall Oil Co.'s wells Nos. 374 and 407, in sec. 8, T. 20 N., R. 12 E. In the former well the "Mississippi lime" was reached at 1,850 feet and the top of a sand at 2,125 feet, which continued to 2,178 feet. This is 275 feet below the top of the lime. This deep sand produced initially, according to the superintendent, 1,000,000 feet of gas and 312 barrels of oil a day. Farther west, in sec. 14, T. 22 N., R. 8 E., the Red Bank Oil Co. has within the last two weeks completed a "Mississippi lime" well, but no data are available except those appearing in the trade journals. It is reported that the "Mississippi lime" was found at 2,545 feet and some oil at 2,579 feet. A sand was found at 2,850 feet, and drilling continued to 2,886 feet. The well is now said to be producing 30 barrels daily, presumably from the deep sand.
>
> In T. 20 N., R. 11 E., the Phoenix Refining Co. has drilled a number of wells near Sand Springs some 300 feet below the top of the "Mississippi lime" and obtained oil there. The first of these wells was reported to produce initially 1,500 barrels daily. This oil is of very high grade.
>
> Between Sapulpa and Tulsa, and nearly east of Sapulpa, some wells have been drilled several hundred feet into the "Mississippi lime" and produce high-grade oil.
>
> With meager data in hand it is impossible to determine in every instance whether the "Mississippi lime" is Boone or Morrow and Pitkin.

Other reports concerning the production of oil from sands well below the top of the "Mississippi lime" have appeared in the daily press from time to time. In sec. 25, T. 27 N., R. 10 E., less than a mile from the western edge of T. 27 N., R. 11 E., a well is reported to have obtained 1,500,000 cubic feet of gas a day from a sand more than 300 feet below the top of the "Mississippi lime."

It seems clear that in order to test conclusively any area that is favorably located with reference to structure the test hole should be drilled to a depth of 400 feet below the top of the "Mississippi lime."

AREAS OF FAVORABLE STRUCTURE FOR THE ACCUMULATION OF OIL AND GAS.

GENERALIZATIONS.

In outlining the areas which are believed to represent territory that gives greater promise for the production of oil or gas than areas not so outlined, the writers have used certain generalizations which are based primarily on the relation between structure and production that has been found to prevail over a large part of the Osage Reservation. In general the crests of the anticlines and domes are more likely to be productive of gas than of oil. The western flank of an anticline is more likely to be productive of oil than the eastern flank, and production may be expected farther down, structurally, from the crest of the fold on the western flank than on the eastern flank. The large anticlines and domes with high closure should be rated better than terraces or anticlines with small closure, although broad terraces or anticlines with small reversals and gentle dips that cover several sections are known to produce oil and gas in T. 27 N., R. 11 E., and in other townships in the Osage Reservation. Until more intensive work is done in this region on the relation between surface structure and the production of oil and gas it is difficult to go further than the statements outlined in the generalizations above. Therefore, even if the sands that carry the oil and gas were equally open and porous throughout the township, it would not be possible now, ahead of the drill, to outline definitely the productive areas of the several structural features of the township. As a matter of fact it is known that the sands are not equally open and porous, and so the difficulty of definitely outlining the productive areas is increased. Hence the outlines of the productive areas as set forth below must not be considered mathematically exact, but they represent an attempt on the part of the writers to give the reader their best guess or estimate of the more favorably located areas for prospective oil and gas territory. It is therefore emphasized that the recommendations made below do not in any way guarantee that oil or gas will be found in the favorably located areas, but it is believed that by first testing these favorable areas futile drilling and expense will be saved and in general the township as a whole will be developed more efficiently than by promiscuous drilling.

ANTICLINES, DOMES, AND TERRACES.

BACKIUS ANTICLINE.

Stray sand.—The probable productive area of the sand found in well 95 between 975 and 1,042 feet from the surface is indicated in figure 43. The productive area of this sand may probably be extended to the north, west, and south of the shaded area to conform

with what is regarded as the productive area of the "Mississippi lime." It has been reported through the press that a well was drilled in the SW. ¼ NW. ¼ sec. 36 to the "Mississippi lime" and obtained 2,000,000 cubic feet of gas a day. Presumably there was no production in the stray sand at this locality so the productive eastern limit of this stray sand probably can not be extended much beyond the shaded area.

Bartlesville sand.—The record of the well mentioned in the paragraph above, which produced 2,000,000 cubic feet of gas a day from the "Mississippi lime," reported the Bartlesville sand to be dry. If the Bartlesville sand is found to be productive at all on the Backius anticline, the productive area will probably cover the southern tier of 40-acre tracts in sec. 36 and possibly a part of the SE. ¼ sec. 35. As the sand is probably tightly cemented it should be shot if the drill uncovers a good showing of oil. At the date of this writing (February, 1919) there is no evidence at hand that oil or gas has been obtained from the Bartlesville sand on the Backius anticline.

"*Mississippi lime.*"—On the assumption that the "Mississippi lime" is likely to be productive of oil or gas where the structure is favorable, it may be expected that this limestone will yield either oil or gas in the greater part of sec. 36, a large part of the S. ½ sec. 25, and the central and southern parts of the E. ½ sec. 35. Probably that part of the area in this township which includes the structure contours above the 1,020-foot contour will be productive, principally of gas from the "Mississippi lime."

DOE CREEK DOME.

Stray sands.—There is no particular reason to believe that oil or gas will be obtained from beds above the Bartlesville sand on the undrilled part of the Doe Creek dome, for the drilling that has been done has not disclosed any such productive beds. Because of the fact, however, that stray sands are irregular in their distribution there is always a chance in a large undrilled area that production may be obtained from such sources.

Bartlesville sand.—The probable productive area of the Bartlesville sand as outlined in figure 43 covers a good portion of the Doe Creek dome. The shaded area was drawn so as to include a large part of the west flank of the dome and a relatively small part of the east flank. Well 82 had an initial daily production of 75 barrels, well 83 an initial production of 50 barrels, and well 75, which probably should be classed with the Elkins anticline, an initial production of 60 barrels. As recorded in the table of well data, the thickest measurement of the Bartlesville sand in the area covered by this dome was 18 feet and the minimum measurement 6 feet.

"*Mississippi lime.*"—The productive area of the "Mississippi lime" on the Doe Creek dome probably coincides fairly well with the productive areas as outlined for the Bartlesville sand. None of the wells on this dome recorded in the table of well data were deep enough to test the "Mississippi lime," and so it can not be stated from actual tests whether or not this limestone is productive in this locality. However, as the "Mississippi lime" has yielded either oil or gas in practically all the wells that have been drilled in this township in areas of favorable structure, it is reasonable to assume that there is a good chance of obtaining such production here by deepening the present wells or by drilling others deep enough to reach the lime.

SAND CREEK ANTICLINE.

Stray sands.—No production of oil or gas from sands above the Bartlesville sand has been recorded in the wells that have been drilled on the Sand Creek anticline, and although there is a possibility of tapping small local lenses or stray sands here it must be classed as a possibility rather than a probability.

Bartlesville sand.—The probable productive area of the Bartlesville sand on the Sand Creek anticline, as shown in figure 43, covers a large part of sec. 31. Wells 73 and 74 are reported to have produced oil from the Bartlesville sand, and well 74 is credited with an initial daily production of about 100 barrels. The sand in these two wells was 20 and 13 feet thick, respectively. The shaded area is controlled by the structure contours of the Sand Creek dome and is so outlined as to cover more of the northwestern flank of the anticline than the southeastern flank.

"*Mississippi lime.*"—Well 73 is reported to have penetrated the "Mississippi lime" to a depth of 15 feet without getting oil or gas. It is believed, however, that this result does not condemn the "Mississippi lime" for the Sand Creek dome, and that the Bartlesville sand wells should eventually be deepened so as to test this horizon thoroughly. The area outlined as probable oil and gas territory for the Bartlesville sand might be put in a similar class with respect to the "Mississippi lime."

LEVELETTE TERRACE.

Stray sands and the Bartlesville sand.—On the Levelette terrace a number of wells have been drilled through the Bartlesville sand, and no oil or gas has been obtained either in this sand or in any sands above it. Inasmuch as this structural terrace has been fairly tested by these wells it is probable that the Bartlesville sand or the sands above it will not supply any large amount of oil or gas here.

"*Mississippi lime.*"—A number of wells which produce both oil and gas from the "Mississippi lime" have been drilled on the Levelette terrace. The initial production of these wells ranges from about 10 barrels to 25 barrels of oil a day. In a general classification the major part of the N. ½ sec. 30 and of the SW. ¼ sec. 19 may be considered oil territory, and the territory along the crest of the anticline which connects the Bacon Rind anticline with the Levelette terrace will probably be productive of gas. This gas territory will probably cover substantial portions of the SE. ¼ and NW. ¼ sec. 19.

BACON RIND ANTICLINE.

Stray sands and the Bartlesville sand.—The Bartlesville sand and the horizons of stray sands above it have been pierced by the drill on the Bacon Rind anticline, but no oil or gas has been obtained from them. It may be concluded that these sands will furnish very little oil or gas in the area covered by this anticline.

"*Mississippi lime.*"—The crest of the Bacon Rind anticline is proved gas territory, and the gas comes from the "Mississippi lime." The initial production of these wells ranges from about 2,500,000 to 4,000,000 cubic feet of gas a day. This gas territory covers practically all of the SW. ¼ sec. 18, and, as stated in the discussion of the Levelette terrace, it will probably be found to extend diagonally across sec. 19. Oil has been found over a part of the northern flank of the Bacon Rind anticline, and the record of wells 15 and 18 (see table, p. 259) show an initial daily production of 70 barrels each from the "Mississippi lime." The prospective oil territory on the north flank of the Bacon Rind anticline can probably be extended at least 1,000 feet north of well 14, and toward the northwest it may be limited by the 790-foot structure contour (Pl. XLI). Although the eastern flanks of the anticlines in the Osage Reservation are commonly not as productive as the western flanks, there are exceptions to this rule, and the W. ½ SE. ¼ sec. 18 may be classed as territory in which there is a chance of obtaining oil from the "Mississippi lime," and this territory may be extended for a short distance into the NE. ¼ sec. 19.

ELKINS ANTICLINE.

Sands above the "Mississippi lime."—The Bartlesville and higher sands have been very well tested by the wells drilled through them on the Elkins anticline, but no production of oil or gas (except that obtained from well 75, which is discussed under the Doe Creek dome) from these sands is recorded in the table of well data. It is not improbable that the Bartlesville sand will be found to be productive in parts of the SW. ¼ sec. 28 and the SE. ¼ sec. 29. If in drilling these

areas a show of oil is found, the sand should be shot, for this territory borders the northern boundary of the productive area of the Bartlesville sand, and the sand is unproductive probably because it is tight or closely cemented.

"*Mississippi lime.*"—The "Mississippi lime" has furnished practically all the oil and gas obtained on the Elkins anticline. Drilling has proved that the greater part of the anticline must be considered gas territory, although some oil has been found well down on its northwestern and southwestern flanks. The maximum initial daily production recorded for a gas well on this anticline is 5,000,000 cubic feet, and the average initial daily production of the oil wells on the northwestern flank of this fold is probably about 25 barrels. The prospective oil territory may reasonably be expected to extend southward from well 37 to the gas territory in the NE. ¼ sec. 29, and northeast of the productive area in the NE. ¼ sec. 20 it may be extended to include the area between wells 39 and 40, a part of the SE. ¼ SW. ¼ sec. 16, and a part of the SW. ¼ SE. ¼ sec. 16. It is not improbable that a narrow strip of productive oil territory will be found to border the southwestern edge of the gas territory in sec. 29.

BIGHORSE ANTICLINE.

The Bighorse anticline has not been tested with the drill for oil or gas, and therefore the sand conditions over this area are unknown. The anticline is probably north of the productive area of the Bartlesville sand in this township, and unless a stray sand is found, which, of course, could not be predicted in advance of the drill, the "Mississippi lime" must be considered the most probable source of production. All the territory surrounded by the 950-foot structure contour (Pl. XLI), which includes a large part of sec. 22, a part of the SW. ¼ sec. 23, the NW. ¼ sec. 26, and a part of the NE. ¼ sec. 27, should be classed as structurally favorable for the accumulation of oil and gas. The central part of this oblong area is more likely to be productive of gas than of oil, and a strip a few hundred feet wide on the southwestern flank of the anticline may be found to produce oil southwest of the line made by the 950-foot structure contour.

SHAW DOME.

As the Shaw dome has not been tested with the drill for oil or gas the same conclusions relative to the sands may be applied to it that were applied to the Bighorse anticline—that is, that the dome is probably north of the productive area of the Bartlesville sand and that the "Mississippi lime" must be considered the most probable source of production here. The territory surrounded by the 950-foot

structure contour may be conservatively classed as an area that is located more favorably with respect to structure for the accumulation of oil or gas than the surrounding territory. This area of favorable structure is believed to be less valuable as prospective oil and gas territory than the area covered by the Bighorse anticline, but more valuable than the area covered by the Rutter terrace, which is described below.

RUTTER TERRACE.

As the Rutter terrace is a relatively small structural feature its value as prospective oil or gas territory should be rated considerably lower than that of the Shaw dome or the other structural features which have been described above. The territory partly surrounded by the 910-foot contour, embracing a part of the S. ½ SE. ¼ sec. 12 and a part of the N. ½ NE. ¼ sec. 13, constitute the area most favorable for the accumulation of oil or gas. The Rutter terrace has not been tested with the drill, but it is probable that the "Mississippi lime" offers the most likely source of oil or gas here.

MATTHEWS ANTICLINE.

The value of the Matthews anticline as prospective oil and gas territory should be rated higher than that of the Rutter terrace and lower than that of the Shaw dome. The most likely area on the Matthews anticline for the accumulation of oil and gas may be roughly outlined as extending 600 feet on both sides of the axis (see fig. 42) of the anticline and embracing a strip with a northwesterly trend about a quarter of a mile wide across sec 12, a large fraction of the NE. ¼ sec. 11, and a strip with a northeasterly trend across the W. ½ sec. 11. The Matthews anticline has not been tested with the drill, but well 2, in the SE. ¼ sec. 2 (see fig. 43), is reported as an abandoned gas well that produced from the Bartlesville sand, which had a thickness of 27 feet. As this well is within half a mile of the Matthews anticline there is a chance that the Bartlesville sand may be open enough to yield oil or gas in the area outlined above. If this area is tested and a good show of oil or gas is found in the Bartlesville sand, the sand should be shot in order to test it thoroughly. The top of the "Mississippi lime" offers a better chance of obtaining oil or gas than the Bartlesville sand and, of course, should be tested if this anticline is drilled.

ALVIN ANTICLINE.

Stray sand.—Well 7 (see fig. 43) is reported to have had an initial production of over 3,000,000 cubic feet of gas a day from a sand 13 feet thick, found at a depth of 730 feet from the surface. The pro-

ductive area of this sand is outlined in figure 43 as extending for 600 feet in all directions from the well, but it is not improbable that future drilling may show it to extend still farther.

Bartlesville sand.—Well 7, mentioned above, was not drilled deep enough to test the Bartlesville sand, but the wells in the southern part of sec. 17 were drilled through this sand without obtaining oil or gas. The probable productive area of the Bartlesville sand is shown in figure 43 to lie to the south of this anticline, so that, all things considered, it does not seem likely that any large quantity of oil will be obtained from the Bartlesville sand in the area covered by the Alvin anticline. However, if a good show of oil or gas is encountered in this sand it should be shot in order to test it thoroughly.

"*Mississippi lime.*"—The only records of oil produced from the "Mississippi lime" on this anticline were those of wells 12 and 13, in the southern part of sec. 17. (See fig. 43.) Well 12 is reported to have had an initial daily production of 20 barrels of oil from the "Mississippi lime." The territory in which gas may be obtained from the "Mississippi lime" on the Alvin anticline is estimated to include the area partly surrounded by the 880-foot structure contour, which embraces the territory surrounding the southeast corner of sec. 8. The western flank and part of the northern flank of the anticline between the 880-foot and 840-foot structure contours may be conservatively classed as having a better chance for oil production than the adjacent territory. This embraces the major part of the SE. ¼ sec. 8 outside of the gas territory, a very large part of the SW. ¼ sec. 8, and a large part of sec. 17. Oil has been produced as far down on the southwestern flank of the anticline as the 840-foot structure contour, and consequently the area between well 12 and the southeastern edge of the probable gas area, outlined above, may be classified as fairly promising oil territory. The territory east of the probable gas territory is not rated in regard to its oil value as high as the areas outlined above, but it is not improbable that oil or gas will be obtained on the terrace-like structural feature just east of the Alvin anticline.

MUSGROVE ANTICLINE.

Wells 4 and 5 (fig. 43), which were not located in the most favorable places structurally on the Musgrove anticline, were drilled through the horizons of the stray sands and the Bartlesville sand without getting oil or gas. It is probable that the "Mississippi lime" is the most promising source of oil or gas in the area covered by this anticline. The area surrounded by the 810-foot structure contour and also the area on the north and northwest flanks of the anticline between the 810 and 800 foot contours are classed as offering a better

chance for oil or gas production than the territory immediately surrounding them. However, these areas should receive a general rating less favorable than that of the Alvin anticline and more favorable than that of the Matthews anticline.

QUALITY OF THE OIL AND GAS.

No attempt is made in this report to discuss analyses of the oil and gas that have been produced in this township. That discussion is reserved for the final report on the Pawhuska quadrangle. For the benefit of the man who is entirely unfamiliar with this field, however, it may be pointed out that the oil is of relatively high grade and is classed in price with the oil from the Cushing and Bartlesville fields.

GENERAL RECOMMENDATIONS.

No part of T. 27 N., R. 11 E., is absolutely condemned for oil or gas, because, even in areas where the structure is unfavorable, there is always a possibility of obtaining these substances from lenticular sands or sands in which the production is controlled by irregular cementation. However, if the areas that are located favorably with respect to the geologic structures are tested first, the risk of failure is very much lowered. The principal effort in geologic work of this type is to reduce that risk as much as possible, with the realization always in view that even on the soundest available evidence it is still impossible to outline productive areas definitely ahead of the drill.

The necessity and importance of testing the sands below the "Mississippi lime" are again emphasized. Such a test should first be made on the top of some well-developed structural feature, such as the Doe Creek dome, and if it is unsuccessful another well-developed anticline should be tested. It is recommended that the tests be carried to a depth of 400 feet below the top of the "Mississippi lime."