GEOLOGIC STRUCTURE AND OIL AND GAS PROSPECTS OF A PART OF JEFFERSON COUNTY, OKLAHOMA.

By Heath M. Robinson.

INTRODUCTION.

Area and location.—The area described in this report embraces about 175 square miles in the southern part of Jefferson County, Okla. Its precise location in the State is shown on Plate LI. As shown on Plate LII the mapped area is bounded on the north by the northern boundary of T. 6 S., on the east by the eastern boundary of R. 5 W., on the west by the western boundary of R. 7 W., and on the south by Red River.

Accessibility.—The Chicago, Rock Island & Pacific Railway crosses the western part of the area. The towns of Ryan and Terral are on this railroad and are distributing points for all parts of the area. All the roads shown on Plate LII have been traveled with an automobile, and as the country is characterized for the most part by gentle slopes, the roads have very few steep grades and heavy loads may be transported to practically any locality without great difficulty. Most of the country is open prairie in which it is possible to do rapid and efficient geologic mapping with the plane table and telescopic alidade.

Water available for drilling.—The principal streams that contain water throughout the year within and adjacent to this area are Red River, Beaver Creek, Fleetwood Creek, Red Creek, and Bird Baker Creek. Water for drilling may also be obtained from ponds, "tanks" (artificial reservoirs in which surface water is collected), or shallow water wells.

Previous geologic work in this and adjacent areas.—The area treated in this report is just southeast of a part of the area in Jefferson County mapped and described by C. H. Wegemann.[1] A bulletin of the Oklahoma Geological Survey gives a description of Jefferson County, with particular reference to its oil and gas prospects, and states the conclusion [2] that "Taking everything into consideration, Jefferson County is in favorable territory, and it is probable that in future drilling new fields may be discovered."

[1] Anticlinal structure in parts of Cotton and Jefferson counties, Okla.: U. S. Geol. Survey Bull. 602, 1915.
[2] Shannon, C. W., and others, Petroleum and natural gas in Oklahoma, Part II: Oklahoma Geol. Survey Bull. 19, pt. 2, p. 241, 1917.

Fritz Aurin[3] discusses the general structure of the area covered by the "Red Beds." J. A. Udden and D. McN. Phillips[4] treat in a general way of the country in Texas southwest of Jefferson County, Okla. C. H. Gordon,[5] in a report on the geology and underground waters of the Wichita region of north-central Texas, includes a geologic map that covers the area just south of Jefferson County, Okla., and a very good bibliography on the geology of north-central Texas. Hager[6] cites a number of tests for oil and gas near Red River, which have penetrated Ordovician limestone and in some places granite. According to the map with his paper this uplift of the older rocks includes southern Jefferson County, Okla.

Field work.—The field work on which this report is based was done by the writer, who was assisted during a part of December, 1917, by H. R. Mann, and in June and July, 1918, by Lewis Mosburg.

A 15 by 15 inch plane table and telescopic alidade were used in mapping the structure over that part of the area in which traceable beds of sandstone and conglomerate were found. The land lines form the basis for the areal control of the map (Pl. LII), and the elevations on the rock outcrops were obtained either by direct level readings or by the use of vertical angles. The elevations were checked among themselves by means of a system of triangulation and also with the Government bench marks that have been established in the area, which are shown on the Montague and Addington topographic maps published by the United States Geological Survey.

Acknowledgments.—Thanks are due and are extended to the field assistants for their willingness and efficiency in their work and to the oil companies and individuals who generously supplied copies of the logs of tests and other information. The writer is also indebted to his colleagues of the United States Geological Survey for helpful suggestions and criticisms.

STRATIGRAPHY.

EXPOSED ROCKS.

AGE.

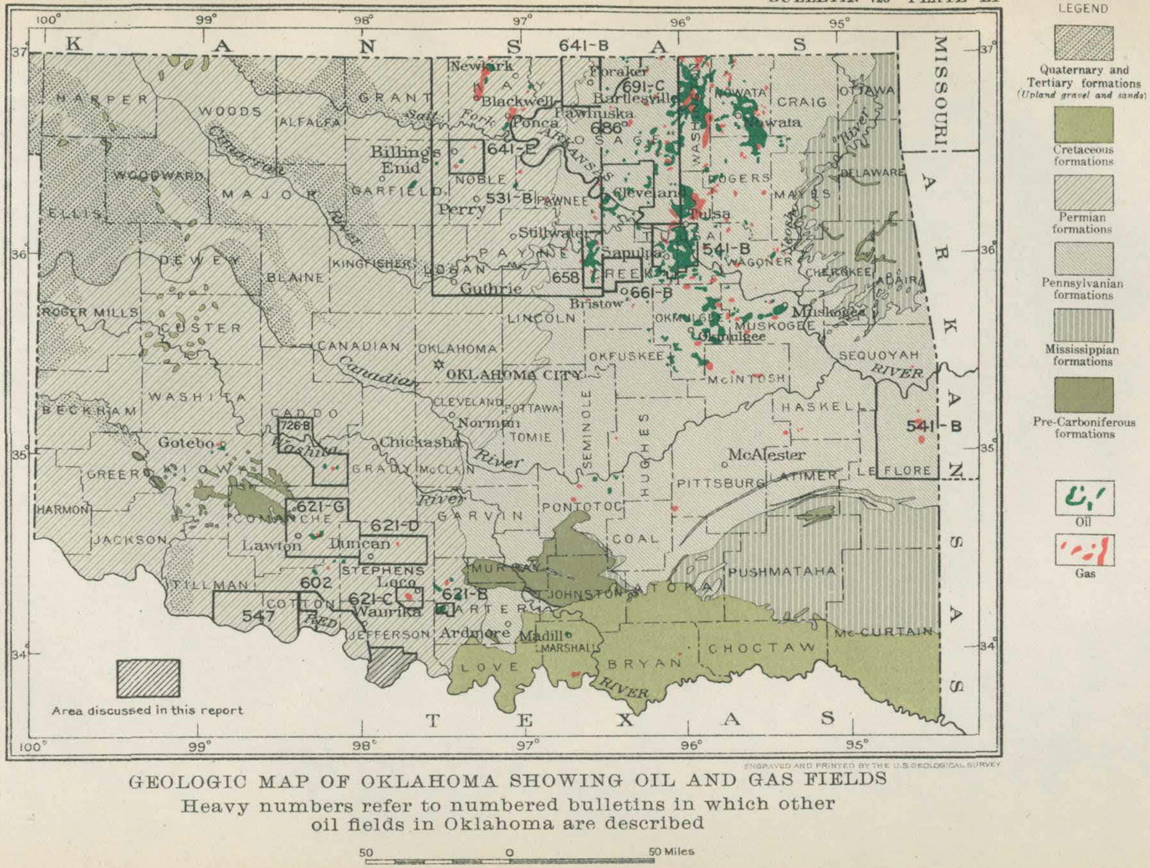
The oldest rocks exposed in the area are probably of Permian age, though possibly the top of the Pennsylvanian is present. The great bulk of the exposed rocks are Permian, a part of the area is covered by unconsolidated sediments which are tentatively classed as Lower Cretaceous, and the youngest rocks are deposits of alluvium and sand dunes of Quaternary age. The hard rocks of the section may be

[3] Geology of the Red Beds of Oklahoma: Oklahoma Geol. Survey Bull. 30, 1917.

[4] A reconnaissance report on the geology of the oil and gas fields of Wichita and Clay counties, Tex.: Texas Univ. Bull. 246, 1912.

[5] U. S. Geol. Survey Water-Supply Paper 317, 1913.

[6] Red River uplift has another angle: Oil and Gas Jour., Oct. 17, 1919.



GEOLOGIC MAP OF OKLAHOMA SHOWING OIL AND GAS FIELDS

Heavy numbers refer to numbered bulletins in which other oil fields in Oklahoma are described

1921

conveniently described under the heading "Red Beds," for their predominant color is red and it is a term that is in very common use.

"RED BEDS."

The "Red Beds" of north-central Texas were originally divided by the Texas Geological Survey into three formations, in descending order the Double Mountain, Clear Fork, and Wichita. Of these only the Wichita formation is present in the area described in this report.

WICHITA FORMATION.

DEFINITION.

The Wichita formation was named from its typical exposures in Wichita County and along Wichita River, Tex. As originally defined[7] it overlies the coal measures (Cisco formation), underlies the Clear Fork formation, and consists of fossiliferous sandstones, sandy shales, clays, and a peculiar conglomerate.

The sandstones and sandy shales are red, gray, and variegated, often containing large oval concretions, ranging in size from one-quarter of an inch to several feet in diameter. The sandstones are often shaly in structure but in places are massive. They are frequently ripple marked and in places have a cross-bedded structure. The concretions are very hard and retain the peculiar structure of the sandstone in which they occur. The clays are red and bluish. In the red clays are nodular masses of clay, iron, and lime, which often take the form of geodes, filled with tabular lime-spar in the center. The bluish clay is copper bearing in many places. The conglomerate is composed of rounded pieces of clay or clay ironstone cemented together by iron.

CORRELATION.

In the area described in the present report the "Red Beds" above and including bed A, described beyond (see fig. 49), are referred without question to the Wichita formation. The beds below bed A may possibly be, at least in part, of Pennsylvanian age and referable to the Cisco formation. The predominant color of the upper part of the Cisco formation in this region is red, and it is difficult to separate the Cisco and Wichita formations on the basis of lithology alone. The boundary between these two formations is indicated on the map by Gordon[8] as intersecting Red River a mile or so west of the Chicago, Rock Island & Pacific Railway bridge about a mile south of Terral, Okla. The boundary line is drawn with dotted lines, indicating that there is doubt about its exact location. The country on the Oklahoma side of Red River near the railway bridge is covered by alluvium, sand dunes, and other unconsolidated sediments, and therefore it is impossible to determine the exact location of the boundary between the Wichita and Cisco formations in the area discussed in this

[7] Dumble, E. T., and Cummins, W. F., Texas Geol. Survey First Ann. Rept., pp. lxvii-lxix, 185-189, 1890.

[8] Gordon, C. H., op. cit., pl. 1.

report. Inasmuch as the Permian is unconformable with the underlying Pennsylvanian rocks in the vicinity of the Arbuckle Mountains, and the basal beds of the Permian in that region are more or less conglomeratic, it would seem logical to assume, in the absence of other more conclusive evidence, that the conglomeratic beds of the area under discussion should be classed as Permian rather than as Pennsylvanian. Therefore the boundary between the Wichita and the underlying Cisco formation is tentatively assumed to be at some horizon below the conglomerate described as bed A.

LOCAL DETAILS.

The hard ledges of sandstone and conglomerate in the "Red Beds" are the most important beds exposed in this area from the viewpoint of the oil geologist who wishes to map the structure of the region, and for that reason these hard ledges are described somewhat in detail below.

The outcrops of the principal sandstone and conglomerate beds are shown on Plate LII by solid lines where they are continuously exposed and by dashed lines where it is believed the beds would crop out if the surface material covering them were removed. The stratigraphic position of these beds and their areal distribution are shown in figure 49. The principal beds shown in this figure have been labeled by letters, and the corresponding beds are shown on Plate LII, similarly lettered. As pictured in figure 49, the sandstone and conglomerate beds are very lenticular. This characteristic is purposely emphasized in the figure by making the vertical scale greater than the horizontal scale, in order to give a more graphic picture of the beds that must be used to map the detailed structure of the area. On an average these rock lenses are less than 2 miles long, and they attain a maximum thickness of about 50 feet. Their upper surfaces are not even, but the thickness of the individual beds being taken into consideration, it is likely that contours drawn on the tops of these beds will not be in error more than 10 feet. As shown in figure 49 and on Plate LII some of these individual beds may be traced for 2 miles, but it is difficult to correlate with certainty one lens with another where it is impossible to follow their outcrops on the ground. In spite of the difficulties, however, it is possible to show very closely the structure of the surface beds where the sandstone and conglomerate beds are well exposed.

A number of these sandstone lenses were found to contain conglomeratic phases, and the lowest lens, bed A (see fig. 49), is made up almost wholly of conglomerate. The pebbles in bed A are composed for the most part of chert, and they have an average diameter of about three-fourths of an inch, although pebbles as thick as 1½ inches were noted. The pebbles are interbedded with

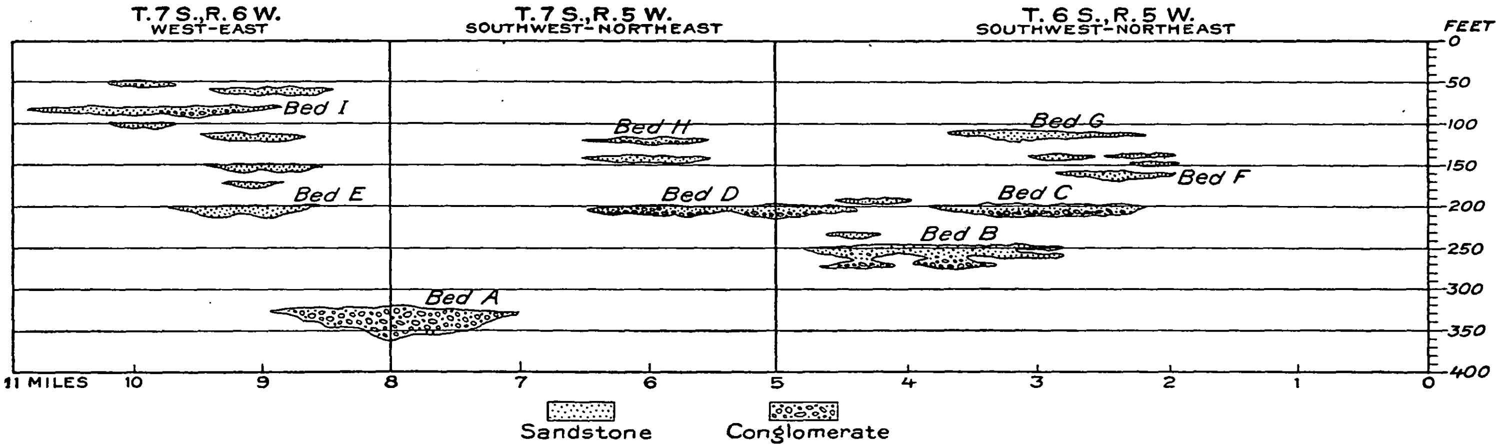


FIGURE 49.—Diagram showing principal sandstone and conglomerate beds that were found serviceable in mapping the structure of a part of Jefferson County, Okla., arranged according to their stratigraphic and areal positions. The material associated with these beds consists mainly of red clay interbedded with variegated clays, shale, and thin friable sandstones. Vertical scale exaggerated. Beds are lettered to agree with text and with Plate LII.

small stringers of sandstone, and the matrix of the conglomerate is made up largely of coarse sand and fine-grained pebbles. The conglomerate is cross-bedded, ripple marks are common on its upper surface, and it attains a maximum thickness of about 50 feet.

Bed B (see fig. 49) is probably stratigraphically higher than bed A, although it was not possible to map the structure between the areas covered by the outcrops of these two beds. This doubtful correlation is also expressed on Plate LII by means of dotted structure contours. Where one bed directly overlies the other the intervals shown in figure 49 are probably very nearly correct, but where one bed does not directly overlie the other the intervals can be considered only approximate. As shown in the figure, the top of bed B is stratigraphically about 70 feet higher than the top of bed A. Bed B is irregular in shape, and its thickness ranges from a few inches to almost 30 feet. The top part of the sandstone in many places weathers into concretionary masses several feet thick, which are dark brown to dark gray on their surfaces that have been exposed to the weather. On fresh surfaces the rock is light gray and contains numerous brown and gray spots. The basal part of the sandstone in some outcrops is conglomeratic.

Bed C and bed D occupy about the same position in the stratigraphic column, and probably they should be correlated. It is not possible, however, to follow the outcrop of bed C where it connects with bed D. The upper part of this sandstone is light gray on both fresh and weathered surfaces. It appears to be made up largely of fairly well rounded quartz grains, and on fresh fractured surfaces it is sprinkled with small black spots, probably due to stains of a manganese mineral. The lower parts of beds C and D are conglomeratic, and the average diameter of the pebbles is about one-fourth of an inch. The pebbles are mostly clear quartz and chert. Both the sandstone and conglomeratic phases are cross-bedded, and the maximum measured thickness of the bed is less than 15 feet.

Bed E is shown in figure 49 to occupy about the same stratigraphic position as beds C, and D, but this correlation is tentative only. Bed E is a nonconglomeratic sandstone which in many places weathers into black concretionary masses and attains a maximum thickness of about 15 feet.

The top of the sandstone called bed F is about 40 feet above the top of bed C and the maximum thickness observed is 10 feet. In some outcrops the sandstone of bed F was found interbedded with small layers of rounded fragments of limestone, but in general the bed is gray on fresh surfaces and differs in no material way from the sandstones described above.

Bed G is stratigraphically about 40 feet above the top of bed F. It is light to dark gray on weathered surfaces, but on fresh surfaces it contains numerous dark specks, which often weather into small concretions or hard masses that are stained by iron or manganese minerals. It is cross-bedded, and the greatest thickness observed was about 12 feet.

Bed H is a sandstone which in some outcrops is conglomeratic. On fresh surfaces it is light gray and resembles many other sandstones found in this area.

Bed I is a sandstone that is about 10 feet thick in most exposures. It contains stringers of conglomerate with pebbles as much as one-fourth of an inch in diameter and in general resembles the sandstones described above. Stratigraphically its top is shown in figure 49 to be about 40 feet above bed H, although this interval must be considered approximate only.

From the above descriptions it will be seen that on the whole there is little to differentiate one sandstone or conglomerate from another, so that the only reliable means of correlation is by tracing out exposures on the ground.

The sediments between the sandstones and conglomerates consist for the most part of red clay, which is interbedded with variegated clays and shales and thin friable sandstones. An outcrop of carbonaceous shale about 6 inches thick was found in the SW. ¼ sec. 18, T. 7 S., R. 5 W., about 8 feet above bed A. This is mentioned because it is the only carbonaceous bed found exposed in the area. Exposures of red clay and massive sandstone were found in an interval of about 100 feet below the top of bed A in the river bluffs in sec. 19, T. 7 S., R. 5 W. The thickness, color, and other characteristics of the individual clay and shale beds are so diverse that it is believed to be impossible to use these beds for purposes of correlation except in a broad and general way.

TRINITY SAND (?).

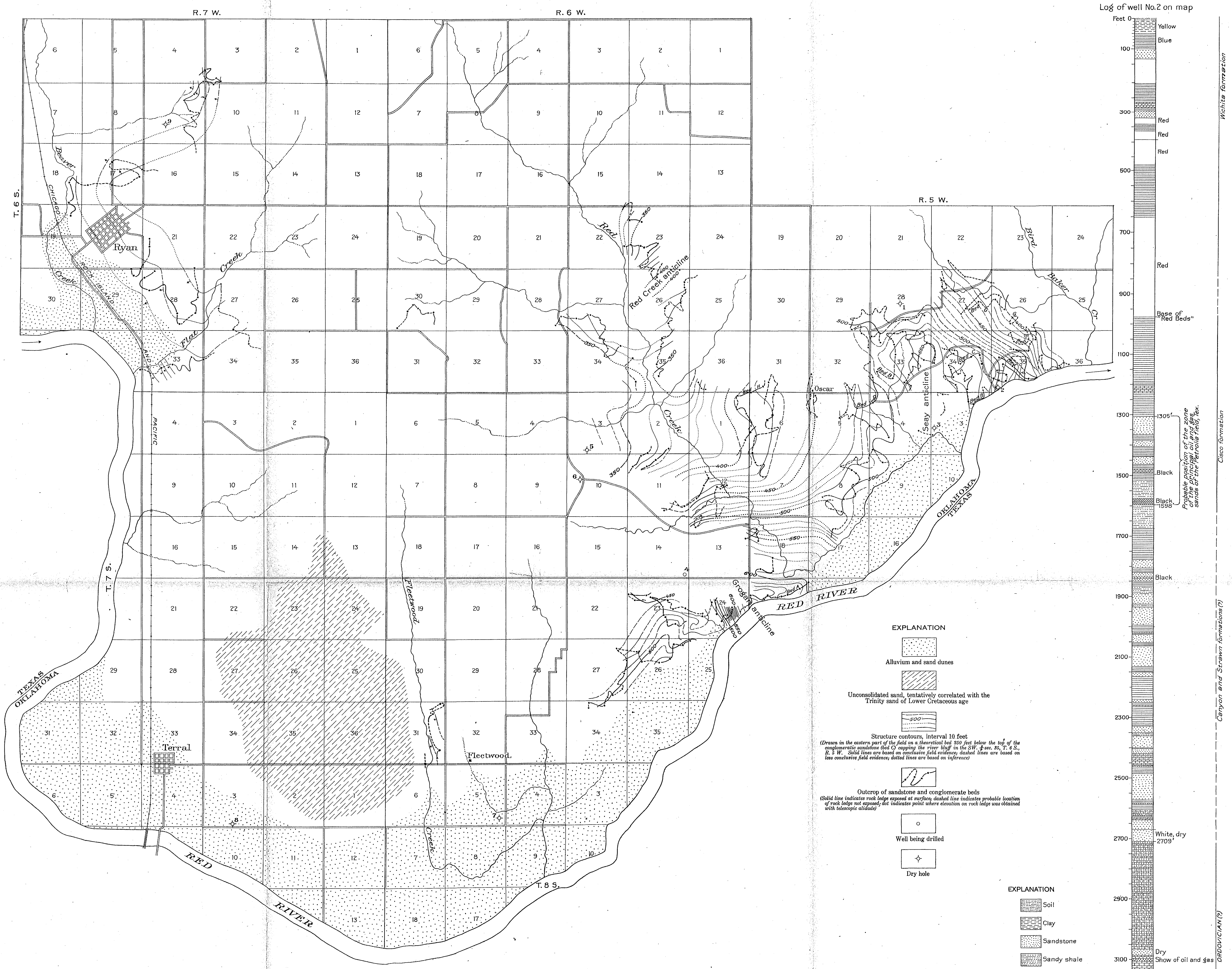
An area embracing about 8 square miles northeast of the town of Terral is covered with loose sand, which is tentatively correlated with the Trinity sand, of Lower Cretaceous age. The area covered by this body of sand is shown on Plate LII. The sand is apparently associated with scattered pebbles, but no well-cemented beds of conglomerate were observed, and it is possible that the pebbles may be of later age than the loose sand. The contact between the sand and the underlying older beds dips toward the southeast, at the rate of about 25 feet to the mile. The contact is over 950 feet above sea level in secs. 22 and 23, T. 7 S., R. 7 W., and a little over 850 feet above sea level in sec. 6, T. 8 S., R. 6 W. Although this sand body is fairly close to the river, it does not seem to be connected with the sand dunes just north of the river in this locality, and the inclined contact would argue against this being a terrace deposit. The topography of the area covered by this sand body is not particularly flat, as would be expected if the deposit were due to the deposition of sand on an old terrace of Red River. In a few localities the wind has scooped out small basins in the sand, which are represented by depression contours on the topographic map of the Montague quadrangle. These basins are similar to the forms found in any very sandy area where the sand is loose enough to be shifted by the wind into dunes.

At present it is impossible to determine the age of this sand body definitely, because no fossils were found in it, and no conclusive lithologic criteria were discovered by which it might be correlated with formations of known geologic age. In lithology, however, it resembles the Trinity sand, which is exposed about 20 miles to the east. The Trinity sand in the southwest corner of Carter County, Okla., consists of a fairly clean quartz sand that makes traveling difficult for an automobile or wagon, a characteristic which is equally well shown by the sand northeast of Terral. The elevation of the base of the Trinity sand in T. 5 S., R. 3 W., about 20 miles northeast of the sand body in the area mapped, is about 900 feet above sea level. The contact between the sand and the underlying beds about 2 miles northeast of the town of Terral (see Pl. LII), southwest of the locality just mentioned, is also about 900 feet above sea level. As the normal strike of the base of the Cretaceous in this general region is southwest, this outlier of sand is in the place where one would expect to find it with a normal dip of the Cretaceous rocks. Furthermore, the rate of dip of the base of the Cretaceous in the vicinity of T. 5 S., R. 3 W., is similar to the rate of dip of the base of the deposit of sand outlined on Plate LII. As both the lithologic and structural evidence point to the correlation of this sand deposit with the lower part of the Trinity sand, of Lower Cretaceous age, it is tentatively assumed that this correlation is correct.

TERTIARY (?) RESIDUAL DEPOSITS.

In many localities in the area treated in this report the surface of the ground is covered with loose pebbles, from 1 to 6 inches in diameter, most of which are made up of vein quartz, quartzite, chert, and fine-grained conglomerate. They were not found consolidated into a conglomerate at any locality and hence must be considered residual deposits, representing either a conglomerate that once covered the surface or old stream gravels that have never been consolidated into a conglomerate. They might easily have been derived from a conglomerate equivalent in age and similar in character to the Grandfield conglomerate, described by Munn.[9] These pebbles

[9] Munn, M. J., Reconnaissance of the Grandfield district, Okla.; U. S. Geol. Survey Bull. 547, pp. 528–530, 1914.



MAP SHOWING GEOLOGIC STRUCTURE IN A PART OF JEFFERSON COUNTY, OKLAHOMA

Scale $\frac{1}{62,500}$

1 0 1 2 3 MILES

1921

Geology by Heath M. Robinson

ENGRAVED AND PRINTED BY THE U.S. GEOLOGICAL SURVEY

are not thick enough to obscure the hard ledges in the "Red Beds," and consequently they are of little importance in determining the oil and gas prospects of this area.

SAND DUNES AND ALLUVIUM OF QUATERNARY AGE.

A belt of country 1 to 2 miles wide that is covered by alluvium and sand dunes borders a large part of the north bank of Red River in this area. The alluvium is made up chiefly of sandy red clay and silt, and the sand dunes are composed of sand that has been carried from the dry part of the bed of the river and deposited on the land near by. The tops of some of these sand dunes are more than 50 feet above the level of the surrounding country. Both the sand dunes and the alluvium serve as a blanket that effectively conceals the underlying "Red Beds," and they are important in pointing out to the oil geologist those areas where it is not possible to find outcrops of the older rocks, which are necessary in order to map the structure accurately. The soil over much of the area that has not been dissected by streams contains more or less of the finer windblown material, which is more pronounced near Red River and less pronounced and finer in texture northward from the river.

UNEXPOSED ROCKS.

Information concerning the rocks beneath the surface of the area under consideration may be obtained in two ways—by a study of these older beds in other localities where they are exposed, and by a study of the well logs in this and near-by areas.

CHARACTER AS SHOWN BY SURFACE STUDIES.

The Pennsylvanian rocks of north-central Texas are briefly described by C. H. Gordon [10] as follows, in descending order:

Section of Pennsylvanian formations in Wichita region, Tex.

	Feet.
Cisco formation (clay, shale, conglomerate, and sandstone, with some limestone and coal)	800
Canyon formation (alternating beds of limestone and clay, with some sandstone and conglomerate)	800
Strawn formation (alternating beds of sandstone and clay, with some conglomerate and shale; the lower 1,000 feet consists of blue and black clay locally containing beds of limestone, sandstone, or sandy shale and a coal seam at the top)	1,900
	3,500

The Wichita formation, classed as Permian, overlies the Cisco formation (Pennsylvanian) and is exposed over the greater part if not the whole of the area treated in this report. It constitutes at least

[10] Gordon, C. H., op. cit., p. 14.

the upper and probably the major part of the "Red Beds" penetrated in the test holes which have been drilled in this area. According to Gordon [11] the upper part of the Cisco formation is red in the vicinity of Red River, and the boundary between the Cisco and the Wichita formations can be located only approximately where these formations crop out farther south, in Archer and Montague counties, Tex.

From surface studies only it could be forecast that a test well in southern Jefferson County would probably pass through several hundred feet of "Red Beds" belonging to the Wichita formation and possibly at the base to the Cisco formation, then into several hundred feet of blue and gray shales and sandstones belonging to the Cisco formation, and then into the underlying Canyon and Strawn formations.

CHARACTER AS SHOWN BY A STUDY OF WELL LOGS.

Although it is possible to get many useful data concerning the subsurface formations by a study of these formations at their outcrop, more detailed information can be obtained by a study of the logs of test holes that have been drilled in or near the area under study, if enough holes have been drilled and if good records have been kept. In the area treated in this report nine test holes have been drilled for oil and gas. They are indicated on Plate LII and for convenience in description are numbered.

The available information concerning these holes is given below. The well records are given just as they were reported by the drillers, and it is probable that careful examination of the drill cuttings would give somewhat different logs. However, the records as given can be used for general purposes of correlation.

Test hole No. 1, near the center of sec. 28, T. 6 S., R. 5 W., is reported to have been drilled with cable tools to a depth of 2,091 feet. It was a dry hole at this depth. The following is a copy of the driller's log of this test:

1. *Driller's log of B. B. Jones well, on Oscar Seay farm.*

	Feet.		Feet.
Surface	0–20	Red rock	273–300
Sandrock	20–25	Blue shale	300–315
Red rock	25–45	Sand; water	315–330
Sand; water	45–65	Red rock	330–345
Light shale	65–90	Blue shale	345–350
Red rock	90–205	White slate	350–365
Sand; water	205–237	Blue shale	365–380
Red rock	237–260	Black slate	380–390
Blue shale	260–273	Sand; water	390–400

[11] Gordon, C. H., op. cit., p. 19.

1. *Driller's log of B. B. Jones well, on Oscar Seay farm*—Continued.

	Feet.		Feet.
Red rock	400–425	Red rock	1,130–1,140
Sand; water	425–455	Blue shale	1,140–1,150
White shale	455–466	Lime shell	1,150–1,155
Red rock	466–475	Blue shale	1,155–1,195
White clay	475–485	Red rock	1,195–1,220
Sand, brown; water	485–515	Pink shale	1,220–1,240
Red rock	515–565	Sandy lime	1,240–1,243
Light slate	565–575	Blue shale	1,243–1,245
Red rock	575–680	Sand; water	1,245–1,270
Blue shale	680–700	Blue shale	1,270–1,420
Sand	700–710	Sand, water	1,420–1,435
Hard rock	710–713	Blue shale	1,435–1,500
Sand	713–725	White mud	1,500–1,540
Blue slate	725–745	Shell	1,540–1,542
Sand; water	745–765	Brown shale	1,542–1,570
Lime	765–770	Sand; water	1,570–1,580
Blue slate	770–775	White shale	1,580–1,610
Sand	775–795	Sand; water	1,610–1,635
Blue slate	795–818	Blue shale	1,635–1,795
Sand; water	818–835	Shell	1,795–1,797
Flint	835–890	Sandy shale	1,797–1,845
Light shale	890–893	Blue shale	1,845–1,850
Sand, hard	893–899	Blue shale	1,850–1,900
Brown shale	899–901	Brown shale	1,900–1,930
Lime and sand	901–914	Blue shale	1,930–1,950
Blue shale	914–1,014	White shale	1,950–1,973
Lime shell	1,014–1,019	Hard lime	1,973–2,010
Blue shale	1,019–1,095	Blue shale	2,010–2,020
Red rock	1,095–1,105	Hard lime	2.020–2,091
Light slate	1,105–1,130		

Test hole No. 2, in the SW. ¼ SW. ¼ sec. 35, T. 6 S., R. 5 W., is reported to have been drilled with cable tools to a depth of 3,358 feet and abandoned. The following is a copy of the log of this test:

2. *Drillers' log of Oscar Seay well No. 1.*

	Thickness.	Depth.		Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Soil	10	10	Sand	60	1,365
Clay, yellow	40	50	Shale	20	1,385
Shale, blue	50	100	Sand	18	1,403
Sand	32	132	Shale	35	1,438
Rock, red; fresh water	70	202	Sand	25	1,463
Shale	63	265	Shale	15	1,478
Lime	20	285	Lime	12	1,490
Shale	10	295	Shale, black	5	1,495
Sand	25	320	Shale, blue	20	1,515
Rock, red	20	340	Sandy shale	60	1,575
Shale	23	363	Slate, black	23	1,598
Rock, red	30	393	Sandy shale	77	1,675
Rock, red	87	480	Sand	5	1,680
Shale	172	652	Shale	100	1,780
Rock, red	325	977	Sand	25	1,805
Shale	227	1,204	Shale	15	1,820
Lime	24	1,228	Sand	15	1,835
Shale	77	1,305	Lime, black	5	1,840

2. *Driller's log of Oscar Seay well No. 1*—Continued.

	Thickness.	Depth.		Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Sand	10	1,850	Shale	2	2,402
Shale	10	1,860	Sand	18	2,420
Sand	5	1,865	Sandy lime	20	2,440
Sandy lime	25	1,890	Lime	18	2,458
Sand	35	1,925	Sand	5	2,463
Sandy shale	10	1,935	Lime	22	2,485
Sand	60	1,995	Sand	87	2,572
Shale	5	2,000	Shale	10	2,582
Shale	17	2,017	Sand	5	2,587
Sand	5	2,022	Sandy shale	18	2,605
Shale	4	2,026	Sandy lime	22	2,627
Sand	25	2,051	Shale	3	2,630
Shale	11	2,062	Broken lime	7	2,637
Sand	70	2,132	Sand	33	2,670
Lime	18	2,150	Sand, white; dry	39	2,709
Sand	15	2,165	Sandy lime	356	3,065
Lime	75	2,240	Sand; dry	20	3,085
Hard sand	10	2,250	Lime	12	3,097
Shale	9	2,259	Sand; showing of gas	8	3,105
Lime	2	2,261	Lime	137	3,242
Shale [a]	67	2,328	Sand; water	5	3,247
Sand	22	2,350	Lime, blue	53	3,300
Sandy shale	10	2,360	Broken lime and shale	58	3,358
Sand	40	2,400			

[a] Last shale horizon. From this point down the drill cuttings show continuously a sand formation; most of the cuttings run 80 per cent sand and 18 to 20 per cent lime; sand grains are very small, cemented by $CaCO_3$.

Test hole No. 3, in the SW. ¼ sec. 3, T. 7 S., R. 5 W., was drilled to a reported depth of about 2,350 feet and abandoned. A copy of the log of this hole to a depth of 2,207 feet follows:

3. *Driller's log of Seay well No. 2, Empire Gas & Fuel Co.*

	Feet.		Feet.
Soil	0–6	Blue shale	443–466
Sand	6–38	Red rock	466–474
Blue shale	38–70	Blue shale	474–510
Water sand	70–99	Water sand	510–515
Red rock	99–105	Red rock	515–520
Blue shale	105–150	Blue shale	520–540
Gritty shale	150–155	Gray shale	540–564
Sand	155–175	Blue shale	564–590
Shale	175–178	Sand	590–620
Sand	178–200	Lime	620–630
Shale	200–230	Water sand	630–668
Sand	230–250	Blue shale	668–710
No record	295–300	Hard sandy lime	710–716
Blue shale	250–262	Blue shale	716–806
Sand	262–295	Shell	806–807
No record	295–300	Blue shale	807–828
Red rock	300–323	Shell	828–830
Blue shale	323–326	Blue shale	830–975
Shale	326–330	Water sand	975–1,004
Red rock	330–392	Lime	1,004–1,032
Blue shale	392–396	Blue shale	1,032–1,099
Red mud	396–422	Sand	1,099–1,121
Blue shale	422–430	Shale	1,121–1,126
Red mud	430–443	Blue shale	1,126–1,180

3. *Driller's log of Seay well No. 2, Empire Gas & Fuel Co.*—Continued.

	Feet.		Feet.
Sand	1,180–1,183	Sandy lime, hard	1,744–1,750
Sand	1,183–1,208	Lime	1,750–1,810
Blue shale	1,208–1,234	Break, shale	1,810–1,812
Hard shell	1,234–1,247	Lime, dark	1,812–1,823
Blue shale	1,247–1,280	Blue shale	1,823–1,852
Dark shale	1,280–1,335	Lime, pink	1,852–1,895
Shale	1,335–1,345	Blue shale	1,895–1,900
Sand	1,345–1,370	Sandy shale	1,900–1,920
Dark shale	1,370–1,450	Shale, blue	1,920–1,930
Lime shell	1,450–1,455	Shale, sandy	1,930–1,955
Shale	1,455–1,482	Shale, blue	1,955–1,965
Sand; little water	1,482–1,487	Shale, sandy	1,965–1,985
Shale	1,487–1,490	Sand, water	1,985–2,005
Blue shale	1,490–1,535	Shale	2,005–2,010
Sandy shale	1,535–1,545	Lime shell	2,010–2,012
Shale, light	1,545–1,581	Sandy shale	2,012–2,017
Lime shell	1,581–1,582	Blue shale	2,017–2,030
Shale	1,582–1,602	Water sand, white	2,030–2,040
Sandy shale	1,602–1,614	Sandy shale	2,040–2,060
Water sand	1,614–1,642	Water sand	2,060–2,075
Shale	1,642–1,662	Water sand	2,075–2,100
Sand, hard	1,662–1,680	Blue shale	2,100–2,105
Shale	1,680–1,690	Sandy shale	2,105–2,120
Sand, hard	1,690–1,697	Sandy shale	2,120–2,125
Sandy shale	1,697–1,714	Blue shale	2,125–2,130
Shale	1,714–1,718	Lime, white, hard; stopped in this limestone at about 2,350 feet	2,140–2,350±
Water sand, soft	1,718–1,723		
Sand	1,723–1,740		
Shale	1,740–1,744		

Test hole No. 4, in the SE. ¼ sec. 14, T. 7 S., R. 6 W., was reported as being drilled in October, 1920.

Test hole No. 5, in the SW. ¼ sec. 3, T. 7 S., R. 6 W., is reported to have been drilled with a rotary to a depth of 1,592 feet and abandoned. Shows of oil and gas were reported at 665 and 1,568 feet. A copy of the log of this hole follows:

5. *Driller's log of test hole in the SW. ¼ sec. 3, T. 7 S., R. 6 W.*

	Feet.		Feet.
Sand, hard	0–81	Shale	203–314
Sand, hard	81–91	Sand, hard	314–322
Shale, red, sandy	91–126	Shale	322–337
Sand and shale	126–133	Sand	337–366
Sand	133–157	Sand, hard	366–391
Shale	157–163	Gumbo	391–407
Sand	163–165	Sand, hard	407–438
Red gumbo	165–171	Sand, hard	438–490
Shale, mixed	171–189	Blue shale	490–518
Sand	189–192	Gumbo	518–536
Shale, mixed	192–198	Sand	536–540
Shale	198–203	Gumbo	540–566

5. *Driller's log of test hole in the SW. ¼ sec. 3, T. 7 S., R. 6 W.*—Continued.

	Feet.		Feet.
Shale	566–590	Sand, hard	1,178–1,184
Sand, hard	590–604	Blue gumbo	1,184–1,222
Sand, hard	604–616	Sand, hard	1,222–1,224
Blue gumbo	616–664	Blue gumbo	1,224–1,248
Oil sand (light showing)	664–680	Shale	1,248–1,252
Shale	680–710	Blue gumbo	1,252–1,272
Sand, hard	710–724	Blue shale	1,272–1,287
Blue gumbo	724–810	Sand, hard	1,287–1,293
Shale	810–866	Blue shale	1,293–1,313
Sand, hard	866–884	Sandy shale	1,313–1,324
Sandy shale	884–900	Sand, hard	1,324–1,326
Blue gumbo	900–937	Shale	1,326–1,358
Gumbo	937–941	Sand, hard	1,358–1,376
Shale	941–951	Black shale	1,376–1,388
Sand, hard	951–963	Blue shale	1,388–1,449
Blue gumbo	963–975	Sand, hard	1,449–1,471
Shale	975–986	Limerock	1,471–1,499
Sand, hard	986–1,017	Blue gumbo	1,499–1,517
Blue gumbo	1,017–1,038	Sand, hard	1,517–1,541
Oil sand	1,038–1,046	Blue gumbo	1,541–1,551
Gumbo, blue	1,046–1,052	Black shale	1,551–1,561
Sand, hard	1,052–1,163	Limerock	1,561–1,567
Blue gumbo	1,163–1,178	Gas and oil sand	1,567–1,592

Test hole No. 6, in the SW. ¼ NW. ¼ sec. 10, T. 7 S., R. 6 W., is reported to have been drilled with cable tools to a depth of 2,000 feet and abandoned. A show of gas was reported at 1,525 feet. A copy of the log follows:

6. *Driller's log of Marion Oil & Gas Co.'s well No. 1, on Samuel Wray farm.*

	Feet.		Feet.
Cellar	0–18	Sand; water	740–760
Sandrock	18–21	Red rock	760–820
Red rock	21–130	Sand; water	820–840
Sand; water	130–140	Red rock	840–900
Red rock	140–170	Blue shale	900–1,000
Sand; water	170–180	Sand, dry	1,000–1,010
Red rock	180–210	Blue shale	1,010–1,030
Sand; water	210–225	Sand; water	1,030–1,050
Red rock	225–300	Brown shale	1,050–1,065
Sand; water	300–340	Sand, dry	1,065–1,075
Red rock	340–380	Blue shale	1,075–1,100
Blue shale	380–410	Sand, dry	1,100–1,110
Red rock	410–430	Blue shale	1,110–1,120
Sand, dry	430–445	Sand; water	1,120–1,140
Blue shale	445–505	Sandy lime	1,140–1,160
Sand; water	505–525	Blue shale	1,160–1,165
Red rock	525–600	Sand, hard; gas; water	1,165–1,250
Blue shale	600–640	Blue shale	1,250–1,375
Sand; water	640–680	Sand; water	1,375–1,395
Red rock	680–740	Blue shale	1,395–1,495

6. *Driller's log of Marion Oil & Gas Co.'s well No. 1, on Samuel Wray farm*—Contd.

	Feet.		Feet.
Sand, dry	1,495–1,505	Sand; water	1,850–1,925
Blue shale	1,505–1,535	Blue shale	1,925–1,930
Sand; gas (8 to 10 million cubic feet).	1,535–1,560	No record	1,930–1,950
Blue shale	1,560–1,615	Blue shale	1,950–1,965
Sand; water	1,615–1,640	Sand; water	1,965–1,990
Blue shale	1,640–1,850	Blue shale	1,990–2,000

Gas sand found from 1,535 to 1,560 feet carried water in the bottom, which was drilled into and was unable to get water shut off and could not be saved for gas well.

Test hole No. 7, in the SE. ¼ sec. 5, T. 8 S., R. 6 W., is reported to have been drilled to a depth of 1,450 feet.

Test hole No. 8, in the southeast corner of the SW. ¼ sec. 3, T. 8 S., R. 7 W., is reported to have been drilled to a depth of 1,040 feet and abandoned.

Test hole No. 9, in the NE. ¼ SW. ¼ sec. 9, T. 6 S., R. 7 W., is reported to have been drilled to a depth of 1,735 feet and abandoned. A copy of the log of this test follows:

9. *Driller's log of Ryan City Oil Co.'s well.*

	Thickness.	Depth.		Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Gumbo, red	40	40	Sand, brown	18	910
Rock, red	15	55	Gumbo, blue	73	983
Gumbo, red	32	87	Rock, brown	47	1,030
Gumbo, blue	43	130	Gumbo, blue, brown	81	1,111
Rock, red, sandy	6	136	Rock, lime mixture	6	1,117
Gumbo, red	53	189	Gumbo, blue	62	1,179
Sand, white, dry	7	196	Rock, blue and red	20	1,199
Gumbo, blue	62	258	Sand, white; water	8	1,207
Rock, red, sandy	73	331	Gumbo, blue	48	1,255
Gumbo, blue	84	415	Gumbo, reddish	73	1,328
Pack sand, reddish	37	452	Rock sand, red	27	1,355
Rock, brown sand	48	500	Gumbo, brown	35	1,390
Rock, sandy, red	17	517	Gumbo, blue	83	1,473
Gumbo, reddish	68	585	Rock, limish	7	1,480
Rock, brown	23	608	Sand, white; gas showing	13	1,493
Shale, blue	90	698	Gumbo, blue	96	1,589
Sand, white; gas showing	9	707	Sandrock, reddish	34	1,623
Gumbo, blue	57	764	Gumbo, blue	93	1,716
Pack sand, reddish	43	807	Rock, brown, lime; casing set	4	1,720
Gumbo, red	72	879	Sand, brown-white; gas showing	15	1,735
Rock, sandy, red	13	892			

A number of deep test holes that have been drilled in the territory surrounding the area mapped give valuable information concerning the structure and the character of the rocks below the surface.

A test hole 5 miles north of Myra, Cooke County, Tex., and about 35 miles southeast of the Oscar Seay test hole in sec. 35, T. 6 S., R. 5 E., Okla., is reported[12] to have found black shale from 1,590 to 1,640 feet and lime from 1,640 to 2,675 feet. Hager states that the hole was drilled to a depth of about 3,000 feet and that lime was

[12] Hager, Lee, Oil and Gas Jour., Oct. 17, 1919, p. 64.

found between 2,675 and 3,000 feet. He also says that "Dr. Udden has identified samples from this well as of Ordovician age."

In the same paper is given a condensed log of the test hole known as the Producers Oil Co.'s Byers No. 36, which is in the Petrolia oil and gas field, in northern Clay County, Tex. This field is about 18 miles west of the western boundary of the area shown on Plate LII. Hager reports that Ordovician fossils were found in samples from the drill cuttings of this test hole.

Byers No. 41, drilled by the same company near Petrolia, Tex., is a very deep hole. Although it is outside of the area described in this report, it is important in the matter of correlating subsurface beds between the Petrolia field and the beds found in the test holes drilled in southern Jefferson County, and consequently the detailed log is published and discussed below.

Driller's log of Texas Co.'s Byers No. 41 well, in the southeast corner of block 19, Byers subdivision, W. R. Gaston survey A-191, near Petrolia, Clay County, Tex.

	Feet.		Feet.
Clay	0–68	Gray wet sand	1,385–1,390
Wet sand	68–78	Hard white lime, dry	1,390–1,393
Clay, red	78–175	Hard blue shale, dry	1,393–1,710
Dry sand, gray	175–190	Soft red shale	1,710–1,735
Red shale	190–280	Blue shale, dry, soft	1,735–1,753
Brown shale	280–300	Hard dry gas sand	1,753–1,758
Red shale	300–565	Blue shale	1,758–1,780
Brown shale	565–635	Hard blue shale and slate	1,780–1,820
Gray wet sand	635–660	Blue slate	1,820–1,845
Blue hard shale	660–690	Sand, wet; hole full	1,845–1,975
Hard gray wet sand	690–703	Blue hard sandy shale	1,975–1,990
Soft blue shale	703–715	Wet sand; hole full	1,990–2,010
Red and blue shale	715–723	Hard blue lime and sand	2,010–2,040
Soft red shale	723–795	Hard sand; big water sand	2,040–2,080
Brown shale	795–820	Gray sandy lime, wet	2,080–2,090
Soft red shale	820–900	Hard wet sand	2,090–2,105
Hard brown shale	900–945	Gray sandy lime	2,105–2,125
Hard brown sandy shale	945–965	Wet sand	2,125–2,170
Red shale	965–970	Hard dry sand	2,170–2,175
Hard gray wet sand	970–980	Hard white dry lime	2,175–2,195
Soft blue shale	980–1,016	Wet sand	2,195–2,205
Hard blue sandy shale	1,016–1,036	Gray lime	2,205–2,250
Soft blue shale	1,036–1,110	Wet sand	2,250–2,275
Hard gray wet sand	1,110–1,128	Blue shale	2,275–2,281
Soft blue shale	1,128–1,140	Wet sand, hard	2,281–2,300
Hard blue shale	1,140–1,160	Dry gray lime	2,300–2,330
Soft blue shale	1,160–1,195	Wet sand	2,330–2,340
Hard gray sand	1,195–1,215	Hard blue shale	2,340–2,344
Hard blue shale	1,215–1,230	Wet sand, hard	2,344–2,355
Soft red dry shale	1,230–1,255	Hard gray lime	2,355–2,370
Soft blue dry shale	1,255–1,350	Hard blue shale	2,370–2,390
Hard gray dry sand	1,350–1,360	Hard sandy lime, dry	2,390–2,420
Blue shale	1,360–1,385	Hard blue shale	2,420–2,423

Driller's log of Texas Co.'s Byers No. 41 well, in the southeast corner of block 19, Byers subdivision, W. R. Gaton survey A-191, near Petrolia, Clay County, Tex.—Contd.

	Feet.		Feet.
Hard sandy lime, dry	2,423–2,460	Hard blue lime	3,395–3,400
Hard sandy lime	2,460–2,480	Blue shale	3,400–3,420
Gray lime	2,480–2,495	Gray lime	3,420–3,435
Blue lime	2,495–2,510	Blue slate	3,435–3,480
Gray lime	2,510–2,535	Gray lime	3,480–3,510
Blue shale	2,535–2,538	Blue shale	3,510–3,555
Gray lime	2,538–2,600	Gray lime	3,555–3,560
Yellow lime	2,600–2,625	Blue shale	3,560–3,585
Gray lime, hard, sandy	2,625–2,670	Blue lime	3,585–3,630
Gray lime	2,670–2,685	Blue shale	3,630–3,710
Gray sandy lime	2,685–2,745	Blue shale and lime shells	3,710–3,748
White sandy lime	2,745–2,780	Gray lime	3,748–3,775
Gray lime	2,780–2,935	Blue shale	3,775–3,780
Blue shale	2,935–2,940	Blue lime	3,780–3,860
Gray lime	2,940–3,000	Gray lime	3,860–3,870
Gray flint lime	3,000–3,010	Gray sandy lime	3,870–3,910
Gray lime	3,010–3,050	White lime	3,910–3,921
Hard gray sandy lime	3,050–3,070	Gray lime	3,921–4,015
Gray lime	3,070–3,180	Gray sandy lime	4,015–4,020
Blue shale, soft	3,180–3,182	Gray lime	4,020–4,105
Gray lime	3,182–3,205	Blue shale and lime	4,105–4,135
Blue shale	3,205–3,270	Gray lime	4,135–4,150
Blue lime	3,270–3,360	Blue shale and lime shell	4,150–4,210
Blue shale	3,360–3,365	Water sand, hard	4,210–4,240
Blue lime	3,365–3,383	Red lime (granite)	4,240–4,289
Blue shale	3,383–3,395		

The following is a copy of a letter from Mr. P. V. Roundy, of the United States Geological Survey, to the writer, describing samples from this test:

In regard to the Byers No. 41, Clay County, Tex., I wish to state that I have examined under a binocular microscope the well cuttings from 2,700 to 2,905 feet and am unable to find any fossils. Unfortunately the horizons above 2,700 feet are represented in our collections by only one sample, so I am unable to contribute any information concerning that part of the well.

Lithologically the sixteen samples from 2,700 to 2,820 feet consist of white limestone, white chert, fragments of clear quartz crystals, and pyrite. Except for a slight variation in the relative amounts of these constituents, the samples are practically alike. All samples show considerable iron stain.

2,820 to 2,830 feet is not represented in our collections.

The thirteen samples from 2,830 to 2,905 feet consist essentially of the same materials as in the samples above, but there is a greater variation in the relative amounts. On the whole there is much less superficial iron stain. The limestone also varies in color, some pieces having a faint gray to brownish-gray cast.

I consider that the samples from 2,700 to 2,905 are probably from one formation; certainly those from 2,700 to 2,820 are from a single lithologic unit. Without the aid of fossil evidence definite age determinations are of course impossible. I am inclined, on purely lithologic grounds, to consider that these samples all come from rocks of pre-Carboniferous age. If they were from the north-central Texas region, I would consider them as coming from the Ellenburger limestone.

In a letter to the Director of the United States Geological Survey, Mr. Lee Hager states that samples from the Byers No. 41 show the rocks from the bottom of the test hole to be red granite; that at 2,800 feet Ordovician rock was encountered; and that samples obtained above 2,800 feet indicate rocks of Carboniferous age.

It will be noted that Mr. Roundy found that the samples from a depth of 2,700 feet resembled Ordovician rocks, but that Mr. Hager classified the rocks to a depth of 2,800 feet as Carboniferous. It is probable that the contact between the Carboniferous and the Ordovician rocks is an uneven one and does not parallel the lower Carboniferous beds. For this reason a test hole drilled in southern Jefferson County might encounter the top of the Ordovician at a different depth relative to the overlying beds than one drilled in the Petrolia field. It may be concluded that the contact between the Carboniferous and Ordovician rocks in Byers No. 41 is between the depths of 1,919 and 2,800 feet and probably above 2,700 feet.

A test hole drilled on the Halsell lease, 6 miles southeast of Henrietta and about 18 miles southwest of Petrolia, Tex., reached a depth of 3,985 feet without encountering Ordovician rocks.

The log of the test hole drilled on the Oscar Seay farm (No. 2, Pl. LII), in sec. 35, T. 6 S., R. 5 W., shows a great predominance of limestone in the basal 650 feet and a predominance of sandstone and limestone in the 1,000 feet directly overlying the 650 feet of limestone. The section below 1,780 feet is thus made up largely of limestone and sandstone with only a small amount of shale.

From the data at hand it is impossible to establish definitely the exact age of the rocks found in the test holes drilled within the area shown on Plate LII, but it is possible to draw certain conclusions that are of interest to the oil or gas operator who contemplates drilling in this area.

In a zone extending from north-central Cooke County, Tex., across northeastern Montague County, Tex., and southern Jefferson County, Okla. (including the area discussed in this report), and through the Petrolia oil and gas field, in northern Clay County, Tex., thick bodies of limestone, sandy limestone, sandstone, and granite have been encountered at relatively shallow depths in the deeper test holes. The data given above show that thick beds of limestone, sandstone, and sandy limestone were encountered in central Cooke County at 1,640 feet and in Byers No. 41 at Petrolia at 2,010 feet. In southern Jefferson County in the test hole drilled in sec. 35, T. 6 S., R. 5 W. (No. 2, Pl. LII), the rocks below 1,865 feet are made up largely of limestone and sandstone, with shale practically absent from the section below 2,630 feet. Granite has been reported from a few test holes drilled within this zone below the thick bodies of limestone.

In the test hole in sec. 35, T. 6 S., R. 5 W. (No. 2, Pl. LII) a little less than 900 feet of rocks were found between the base of the "Red Beds," at 977 feet below the surface, and the top of the predominant limestone-sandstone series, at 1,865 feet. Over three-fourths of this interval is composed of shale; it contains a number of sands that are between 5 and 60 feet thick, a few thin limestones, and several black shales and limestones. This association of thick sands with a predominance of shale and with a few beds of black shale or black limestone is about the combination that the oil geologist ordinarily looks for in a prospective oil and gas field. The beds between 977 and 1,865 feet in the test hole in sec. 35, T. 6 S., R. 5 W., therefore constitute the critical part of the section, which should be carefully tested in drilling for oil or gas within the area outlined by Plate LII. The log of this same test hole shows some shale between 1,865 and 2,709 feet, and test holes drilled in Montague County, Tex., to the south, show black shale closely associated with sandstone as deep as 2,500 feet. Therefore, this part of the section also should be tested, but the sands are not as promising as they are in the overlying beds described above. Below a horizon corresponding to the top of the thick limestone found at 2,709 feet in the test hole in sec. 35, T. 6 S., R. 5 W., the chances are believed to be too poor to warrant drilling these beds, and it is recommended that future test holes in this area be drilled to a depth corresponding to this horizon but not below it. The beds below 2,709 feet in the test hole in sec. 35, T. 6 S., R. 5 W., are probably of Ordovician age; they contain no shale but are made up largely of siliceous limestone.

Although it is particularly difficult to make long-distance correlations in this area because of the unusual subsurface conditions and the likelihood that the formations below the surface here are different in thickness and character from their surface exposures, it is still possible to make certain tentative correlations that may be used until detailed examination of the fossils which may be found in the drill cuttings or other evidence makes these or other conclusions more certain. The Petrolia oil and gas field, in northern Clay County, Tex., is the nearest producing field to the area outlined on Plate LII, and this field has been studied and described by both the United States Geological Survey and the Texas Geological Survey. Generalizing the logs at Petrolia and in southern Jefferson County causes certain characteristics to stand out that are common to both localities. At Petrolia the base of the "Red Beds" is found in many logs at about 1,200 feet below the surface, the principal oil and gas sands are usually found between 1,500 and 1,750 feet, and the top of the thick limestone series is about 275 feet lower. In southern Jefferson County the test holes drilled near Red River show the base of the "Red Beds" to be close to 1,000 feet below the surface; between

1,300 feet and 1,600 feet there are a number of thick sands which are associated with black shales and which have produced shows of gas in a number of test holes, shown on Plate LII, and the top of a thick sandstone-limestone series in the test hole in sec. 35, T. 6 S., R. 5 W., is taken to be at 1,865 feet below the surface.

The interval between the base of the "Red Beds" and the top of the series producing oil sands at Petrolia is in round numbers 300 feet, and this same figure may be used for the interval between the base of the "Red Beds" and the series of sands associated with black shales encountered in the test holes drilled in southern Jefferson County. The interval between the base of the series of producing sands at Petrolia and the top of the thick limestone-sandstone series is about 250 feet, and the interval between the base of the sandstone series associated with black shales and the top of the thick limestone-sandstone series found in the test hole in sec. 35, T. 6 S., R. 5 W., is 267 feet. It should be recognized that the base of the "Red Beds" is not a clean-cut horizon, but it can be used for correlation by grouping together a number of well logs in a locality and determining a general depth at which this horizon is reached. It should also be recognized that even though these intervals agree fairly well, it should be possible to make more conclusive correlations through the study of fossils that may be found in the samples of the drill cuttings.

From the data at hand the most plausible correlation between the logs in the Petrolia field and the test hole in sec. 35, T. 6 S., R. 5 W., is as follows:

Depth, in feet, of certain horizons at Petrolia, Tex., and in Jefferson County, Okla.

	Petrolia, Tex. (generalized section).	Test hole in sec. 35, T. 6 S., R. 5 W., Okla.
Base of "Red Beds"	1,200±	1,000±
Top of series of most promising sands	1,500	1,300
Base of series of most promising sands	1,750	1,600
Top of limestone-sandstone series	2,010	1,865
Top of Ordovician	Between 2,600 and 2,800?	2,700±?

As no determinations of fossils or studies of samples from the test hole in sec. 35, T. 6 S., R. 5 W., have been made, the correlation of the thick limestone found at 2,709 feet with the Ordovician rocks reported in the Petrolia field must be considered at present questionable.

According to Udden and Phillips [13] the principal oil sands in the Petrolia field (1,500 to 1,750 feet below the surface) are of Cisco age, and therefore if the above correlation is accepted the sands and shales

[13] Udden, J. A., and Phillips, D. McN., Geology of the oil and gas fields of Texas: Texas Univ. Bull. 246, p. 90, 1912.

between 1,300 and 1,600 feet in the test hole in sec. 35, T. 6 S., R. 5 W., are also to be assigned to the Cisco. As the top part of the Cisco is red the line between the Wichita and the Cisco would be at some horizon between the surface and 1,000 feet below the surface. The age of the rocks between 1,865 and 2,709 feet can not be established until more detailed fossil determinations are made, and they are tentatively classified here as probably representing rocks of Canyon and Strawn age. The rocks below 2,709 feet are tentatively assigned to the Ordovician. The log of the test hole drilled in sec. 35, T. 6 S., R. 5 W., is graphically shown on Plate LII for use as a type log in this district.

STRUCTURAL FEATURES.

The structure of a prospective oil and gas region is of great economic importance, because it is generally conceded that certain structural features such as anticlines and domes serve to trap the oil and gas in pools where the sand is uniform and other conditions are favorable. The determination of the structure in a region which is known to be underlain by formations that carry oil in other localities but in which there has been very little drilling is particularly desirable, because in such a region the structure is the dominating factor in the selection of locations of test wells for oil and gas.

REGIONAL STRUCTURE.

It is difficult to say what is the normal or regional dip of the surface rocks in southern Oklahoma south of the Arbuckle and Wichita mountains. A clue to this is given by Aurin,[14] who has shown the depth to the base of the "Red Beds" over central and western Oklahoma. Although it is known that the base of the rocks that are red is not parallel to a stratigraphic horizon, it is probable that this contact between red and nonred rocks follows in a general way the major structural features of central and western Oklahoma. As shown on Plate I in Aurin's paper this contact dips north in the southern part of Jefferson County and southwest in the northern part. It is probable that this is a close approximation of the general structure of the region, for in general the rocks of Pennsylvanian age dip toward the south and southwest from the Arbuckle and Wichita mountains on the southern flanks of these mountains, and in northern Texas the normal dip of the Pennsylvanian rocks is toward the northwest.

Another factor that is of interest in the consideration of the general structure of this region is the reported occurrence of Ordovician rocks and granite in the zone extending across southern Jefferson County, Okla., and into northern Clay and Cooke counties, Tex. From the evi-

[14] Aurin, Fritz, Oklahoma Geol. Survey Bull. 30, 1917.

dence at hand it looks as if there is a buried ridge of older rocks along this zone, for deep test holes drilled to the north and south of it have reported neither Ordovician rocks nor granite. As this is an economic paper and as it is believed that more detailed studies of the fossils in the drill cuttings should be made before sound conclusions can be reached, this feature is discussed here only in so far as it has a bearing on the oil and gas possibilities of the area under consideration. A buried ridge of rocks made up of such rigid materials as limestone and granite, on which younger and less rigid sediments were unconformably deposited, should exert a strong influence on the folding of these younger beds when they were subjected to the stresses that produced folding. It might be logically assumed that local folding would be concentrated along this zone and that the general structure of this zone of local folding in the younger rocks would be that of an uplift. This might be classed as favorable general structure for the accumulation of oil and gas. The Petrolia field appears to be in this zone, and the Burkburnett and Electra fields may possibly be along parallel zones of folding, slightly offset from the zone in which the Petrolia field lies.

It might be argued that the ridge of older rocks represents an uplifted zone in these older rocks and that movements along old lines of uplift have produced folds in the overlying Pennsylvanian and Permian rocks that parallel the old lines of folding in the Arbuckle Mountains. It would be very reasonable to assume that an uplift of the magnitude of that which produced the Arbuckle Mountains would be paralleled by other uplifts, perhaps of lesser magnitude, and it would not be surprising to find these uplifts arrayed en échelon or in parallel arrangement, slightly offsetting one another. It may be concluded that the area outlined on Plate LII is in a region where it would be reasonable to expect to find anticlines and domes favorable for the accumulation of oil and gas, provided proper subsurface conditions exist.

LOCAL STRUCTURE.

GENERAL CONDITIONS.

It was impossible to map the structure of the "Red Beds" over the entire area treated in this report, because in many places there are no hard ledges exposed that could be traced. The absence of exposures of the hard ledges in the "Red Beds" is due partly to the fact that these beds are in places covered by more recent deposits, such as the deposits of sand northeast of Terral and the dune sand and alluvium bordering Red River, and also to the fact that over much of the area the ground is not dissected enough to produce very good outcrops of these hard ledges. All exposures of hard ledges that could be followed for a reasonable distance were mapped, and the direction and amount of dip of these beds are shown on Plate LII by means of structure contours. These contours have an interval of 10 feet and in the eastern part of the area are so drawn as to show the elevation above sea level of a theoretical bed 350 feet below the top of bed C (fig. 49 and Pl. LII). The contours based on conclusive field evidence are drawn as solid lines; if the evidence is inconclusive the contours are dashed; and the dotted contours are not based on field evidence but are sketched in between areas where the dip is known.

In classifying the localities in an area as to their relative prospective oil and gas value the localities where the rocks have been locally folded into anticlines and domes should receive first consideration if the other factors are equal. Therefore, the anticlines shown by structure contours on Plate LII are briefly described below.

SEAY ANTICLINE.

The Seay anticline is in the south-central part of T. 6 S., R. 5 W., and the north-central part of T. 7 S., R. 5 W. The east dip of this anticline amounts to more than 170 feet within a distance of a little over 2 miles, and fairly well defined dips have been mapped on its northern and western flanks. No dips to the south from the crest of this anticline are shown on Plate LII, and therefore the anticline is not known to be closed.

GROGAN ANTICLINE.

The Grogan anticline covers parts of secs. 18 and 19, T. 7 S., R. 5 W., and parts of secs. 13 and 24, T. 7 S., R. 6 W. The western flank of the anticline has a relatively very steep dip toward the southwest, showing on Plate LII a drop of 160 feet within half a mile. The dips on the eastern and northern flanks of the anticline are relatively gentle, and there is a suggestion of a structural nose on its eastern flank. Toward the northwest, in secs. 13 and 14, the rocks are not well enough exposed to establish structure contours.

RED CREEK ANTICLINE.

The axis of the Red Creek anticline has a northeasterly trend and roughly bisects sec. 26, T. 6 S., R. 6 W. On the whole the dips of this anticline are rather poorly defined, but there is enough field evidence to show a well-defined northwest dip, a poorly defined south or southeast dip, and a fairly well defined southwest dip.

OTHER FOLDS.

East of the town of Ryan the rocks appear to be bowed up into a broad structural arch. On the whole the field evidence is rather poor, and on Plate LII many of the structure contours are dotted and dashed, indicating doubt as to the correct interpretation of the structure over part of the area. Secs. 15, 16, 21, and 22 probably cover the crest or top of this broad anticlinal feature.

Over much of the area here considered it was impossible to map the structure, as is represented by the lack of structure contours in parts of Plate LII. With regard to that part of the area where the structure has been mapped it may be stated that the structure is either favorable or not favorable for the accumulation of oil or gas, but with regard to the area where the structure is unknown the geologist must confess his inability to classify the different localities as to their relative prospective oil and gas value and can only give the general rating of the entire region.

SUGGESTIONS TO PROSPECTORS.

GENERAL RATING OF THE AREA.

Anyone who contemplates investing funds in a prospective oil and gas area wishes to know whether the area as a whole is a "likely oil country," and if it is he wishes to know what part or parts of the area give the greatest promise for oil and gas production.

The most obvious factor in classifying an area is its distance from and geographic relation to productive oil and gas pools. Other conditions being equal, an area that is relatively close to and surrounded by producing oil and gas pools gives greater promise than an area that is not so geographically located or one that is relatively far from producing territory. The area treated in this report is about 18 miles southwest of the Healdton oil field, Okla., 25 miles southeast of the producing oil and gas wells near Walter, Okla., and about 18 miles due east of the Petrolia oil and gas field, Tex. No commercial production of oil or gas has been reported within a reasonable distance south or east of the area.

A factor that is more important than the geographic location is the relation of the rocks below the surface in the area under discussion to the rocks in the near-by oil and gas fields. It is probable that the same beds which carry oil and gas in the Petrolia field, to the west, underlie the surface in southern Jefferson County at depths that can be easily reached by the drill. Although no attempt has been made to correlate the oil sands of the Healdton and Walters fields with the subsurface rocks in southern Jefferson County, the oil sands in these producing fields are probably represented in southern Jefferson County by beds of the same age which are not too deep to be reached by the drill.

To summarize briefly, the area outlined on Plate LII is underlain by beds at relatively shallow depths which carry productive oil and gas sands in other areas near by, and the general structure is favorable, but the area is not very close to any commercially productive oil and gas field. It might properly be classed as a promising prospective oil and gas area in which there are good speculative chances but in which the business risk is relatively high compared to that involved in drilling within a mile or so of producing wells in an area of favorable structure. On the whole, the parts of anticlines recommended below should be classed as good risks, and as there is no good reason to condemn absolutely any part of the area there is a chance that, owing to irregular sand conditions, oil or gas may be obtained from a test hole drilled at any other point within the area. The difference is that tests on the recommended anticlines are good risks, but tests at random are not; consequently the importance of properly locating test wells on these anticlines is obvious.

RECOMMENDATIONS.

Four anticlines are shown on Plate LII and described above—the Grogan anticline, the Seay anticline, the Red Creek anticline, and a poorly defined anticline east of the town of Ryan. The territory covered by these anticlines should be regarded as the most promising prospective oil and gas territory within the area mapped, and of the four the Grogan anticline should receive the highest rating. That part of the Seay anticline shown by structure contours on Plate LII has probably been tested, but it is possible that the top part of this anticline or dome is still farther south and has not been tested. The Red Creek anticline is not so large or so well defined as the Grogan anticline, and consequently it should be given a lower rating. On the meager evidence in hand, the anticline east of the town of Ryan should be regarded as only slightly more promising than the surrounding country and much less promising than the other anticlines described.

The Grogan anticline is well worthy of a test to a depth of 2,800 feet, and the test hole should be drilled a quarter of a mile south and 300 feet east from the northwest corner of sec. 19, T. 7 S., R. 5 W. This anticline is believed to be distinctly promising because (1) it represents the highest area structurally within the boundaries of the area shown on Plate LII according to the available information; (2) there is an unusually large gathering ground around it; (3) the shape of the contours suggests that the structural top of the anticline may be very close to the recommended location. The most promising sands should be encountered between 1,300 and 1,700 feet below the surface, but other sands that may produce oil or gas may be found to a depth of 2,800 feet.

As two dry holes have been drilled on the Seay anticline deep enough to test the most critical sands, additional tests on the anticline as mapped on Plate LII hardly seem warranted. As water was reported in several of the deep sands in the test hole drilled in sec. 3, T. 7 S., R. 5 W., it seems likely that the dips indicated on the map are part of an anticlinal nose that plunges to the north. If they are, the structural nose may open into a structural dome toward the south, or the dip may change into a monoclinal dip. In any event no new tests on this anticline are recommended unless new development changes the general rating of the region or additional information is obtained on the structure to the south.

As the structure of the Red Creek anticline is rather poorly defined it is difficult to determine definitely whether the dips to the northeast close this fold. From the information at hand the highest part structurally of the anticline is about 1,500 feet north of the center of sec. 26, T. 6 S., R. 6 W. and this should be the location of the first test well, if this anticline is drilled. The most promising sands should be expected between 1,500 and 1,800 feet below the surface, but if commercial quantities of oil are not found at a lesser depth the hole should be drilled to a total depth of 2,900 feet. Although the structure is rather poorly defined and the reverse dip is not very large, this reverse dip to the south and southwest is believed to be strong enough to justify a test at the location recommended above, unless future drilling changes the general rating of this region. It should be remembered that this anticline has a lower rating than the Grogan anticline.

The anticline east of Ryan is not recommended for testing, but if this area should be drilled a test should be made near the southeast corner of sec. 16, T. 6 S., R. 7 W. The chance of obtaining commercial quantities of oil or gas here, however, would be only slightly better than in the surrounding country.

CONCLUSIONS.

It should be emphasized that the recommendations in this paper do not guarantee that oil or gas will be found at the localities described. Experience has proved, however, that the chance of failure, particularly in regions far removed from producing wells, is materially reduced if the localities for tests are selected according to recommendations made after careful study of the available geologic information.