T. 28 N., RS. 11 AND 12 E.

By Marcus I. Goldman and Heath M. Robinson.

INTRODUCTION.

The area considered in this report lies in the northeastern part of Osage County, Okla. (see fig. 1), 4 miles south of the Kansas line. It comprises all of T. 28 N., R. 11 E., and a little more than half of T. 28 N., R. 12 E., the remainder of which is in Washington County.

There are no towns within this area. The nearest town outside the area is Copan, in Washington County, about 5 miles to the east. The townships can also be conveniently reached from Caney, Kans., and Bartlesville, Okla. Farms and ranches are in large part confined to the creek valleys, the land elsewhere being used for cattle grazing, for which it is admirably adapted. The Osage County & Santa Fe Railway right of way passes through the area, following the valley of Mission Creek in the western part and the valley of Caney River in the northeastern part. The roads for vehicles are generally poor, owing to lack of attention, although the open character of the country and the absence of broad sandstone-covered areas make them much less rough and difficult to traverse than those in some other parts of the Osage Reservation.

The topography is marked by hills and ridges bordered by wide-bottomed valleys with steep sides. The greatest relief is at Sundown Hill, which overlooks the valley of Caney River. On the slopes of this hill is exposed the entire stratigraphic section represented in figure 50 below the top of the Iatan limestone. The strong relief, in conjunction with the wide view over the river valleys, permitted the establishment of a very full net of triangulation for horizontal and vertical control over the area. This control was facilitated by the fact that most of the country is open pasture, although there are two wooded ridges, one running southeastward from the summit of Sundown Hill and the other in sec. 33, T. 28 N., R. 12 E., and there is also some timber in the southwestern part of the area south of Mission Creek. The woods on the uplands are largely confined to land covered with sandy soil or areas where the outcropping rocks are for the most part sandstone.

Two large streams, Caney River and Mission Creek, flow through the townships, and from these streams and their larger branches water for drilling can be obtained throughout the year; but in the high areas between the streams water is scant.

The field work on the area covered by this report was done in the spring of 1918 by Marcus I. Goldman and Heath M. Robinson, assisted by the instrument work of Mary Ware Goldman and Louis Mosburg, respectively. The areas covered by the different men are shown on the key map on Plate LIV (p. 394). All elevations and locations were determined by plane table with telescopic alidade. All important elevations have a 2-foot limit of error, and the allowable limit of error on horizontal location is about 150 feet, but this limit was rarely approached. The senior author is responsible for the report but has incorporated suggestions from the junior author and facts for the area mapped by him.

The authors wish especially to acknowledge their obligation to Miss M. G. Wilmarth, secretary of the committee on geologic names of the United States Geological Survey, for her valuable aid in checking, correcting, and in various ways improving the stratigraphic tables and diagrams included in this report.

STRATIGRAPHY.

GENERAL SECTION.

The larger subdivisions into which the rocks of this region have been grouped and the names given to these subdivisions in adjacent parts of Oklahoma and Kansas are shown in the accompanying table. On Plate LI (p. 378), in columns 9, 10, and 11, the principal beds in these sections are shown graphically for comparison. As the area under consideration lies near the Kansas line, and as the Kansas section was the first to be studied and named and is therefore the standard for this part of the Mid-Continent field, it is considered worth while to reproduce the general section for Kansas as well as for Oklahoma. It will be found more difficult, however, to correlate sections in this area with the type section of Kansas than with those of northeastern Oklahoma. This is due to the fact that the Kansas section has been mostly studied in the central eastern part of the State, where the limestones are best developed. It is generally recognized that with few exceptions the limestones in the Kansas section thin or disappear toward the southern boundary of the State, while the shales between them thicken and become more sandy in that direction. As the shales and sandstones thicken more than the limestones thin, the total section in Oklahoma is thicker than in Kansas, as may be readily seen by comparison of column 11, Plate LI, with columns 7, 8, 9, and 10 on the same plate. The only two shales that are reported to thin toward the south are the Bandera shale[1] and the Vilas shale.[2]

[1] Ohern, D. W., Oklahoma Univ. Research Bull. 4, p. 20, 1910. Moore, R. C., and Haynes, W. P., Kansas Geol. Survey Bull. 3, p. 93, 1917.

[2] Moore, R. C., and Haynes, W. P., op. cit., p. 100.

Sections of Pennsylvanian formations below the top of the Oread limestone, in Kansas and northeastern Oklahoma, with approximate correlations.

1			2		3				4		5		
Classification of U. S. Geological Survey for eastern Kansas.			Moore, R. C., and Haynes, W. P., Oil and gas resources of Kansas: Kansas Geol. Survey Bull. 3, pp. 88-102, table facing p. 24, 1917.		Ohern, D. W., Stratigraphy of the older Pennsylvanian rocks of northeastern Oklahoma: Oklahoma Univ. Research Bull. 4, pp. 10-34, table facing p. 40, 1910.				Shannon, C. W., and Trout, L. E., Petroleum and natural gas in Oklahoma: Oklahoma Geol. Survey Bull. 19, pt. 1, pp. 82-90, 1915.		Classification of U. S. Geological Survey for northeastern Oklahoma.[a]		
Douglas group.	Oread limestone.		Douglas formation.	Oread limestone member.					Oread limestone.			Oread limestone member.	
	Lawrence shale. Sandy facies called "Chautauqua sandstone" by Adams.			Lawrence shale member.					Buxton formation.		Douglas formation.		
	Iatan limestone.			Iatan limestone member.								Iatan limestone member.	
	Weston shale.			Weston shale member.									
Lansing group.	Stanton limestone.		Lansing formation.	Stanton limestone member.	Sapulpa group.	Wann formation.	Stanton limestone member.		Wilson formation.	Avant limestone member.	Wilson formation.	Stanton limestone member.	
	Vilas shale.			Vilas shale member.			Copan member.	Approximate horizon of Avant limestone lentil.				Avant limestone member. Relations to Plattsburg limestone of Kansas not determined.	
	Plattsburg limestone.			Plattsburg limestone member.									
	Lane shale.			Lane shale member.									
?			?										
Kansas City group.	Iola limestone.		Kansas City formation.	Iola limestone member.									
	Chanute shale.			Chanute shale member.				Dewey limestone lentil.	Dewey limestone.		Drum limestone.	Dewey limestone member.	
	Drum limestone.			Drum limestone member.					"Copan member" of Ohern [sic]	Includes Layton sand of the Cushing field.			
							Hogshooter limestone member.		Hogshooter limestone.			Hogshooter limestone member.	
	Cherryvale shale.			Cherryvale shale member.		Curl formation.			Coffeyville formation.	Approximate horizon of "225-foot sand" of Bartlesville region.	Coffeyville formation.		
	Winterset limestone.			Winterset limestone member.									
	Galesburg shale.			Galesburg shale member.									
	Bethany Falls limestone.			Bethany Falls limestone member.						Approximate horizon of "400-foot sand" of Bartlesville region.			
	Ladore shale.			Ladore shale member.									
	Hertha limestone.			Hertha limestone member.									
?													
Pleasanton group.	Dudley shale.		Marmaton formation.	Pleasanton shale member.									
	Parsons formation.	Lenapah limestone member.		Coffeyville limestone member.	Tulsa group.	Lenapah limestone.			Lenapah limestone.		Parsons formation.	Lenapah limestone member.	
				Walnut shale member.		Nowata shale.			Nowata shales. Probably include Wayside sand of Bartlesville region.				
		Altamont limestone member.		Altamont limestone member.		Oologah formation.	Limestone=Altamont limestone.		Altamont limestone.			Altamont limestone member.	Oologah limestone where Bandera shale is absent.
	Bandera shale.			Bandera shale member.			Shale=Bandera shale.		Bandera shales. Probably include Peru sand of Dewey-Bartlesville field.		Bandera shale.		
Henrietta group.	Pawnee limestone.			Pawnee limestone member.			Limestone=Pawnee limestone.		Pawnee limestone.		Pawnee limestone.		
	Labette shale.			Labette shale member.		Labette shale.			Labette shales.		Labette shale.		
	Fort Scott limestone.			Fort Scott limestone member.		Claremore formation.			Fort Scott formation. Probably includes Oswego sand of Bartlesville pool.		Fort Scott limestone.		
	Cherokee shale.		Cherokee shale.		Muskogee group.	Vinita formation.			Cherokee formation.		Cherokee shale.		

[a] How far south and west this classification is applicable has not yet been determined.

In general, it appears that the limestones in the lower part of the section are more persistent than those in the upper part, so that there is better opportunity of correlating the beds encountered in the lower part of a well and therefore of knowing where to look for oil-producing beds. The correlation table and graphic diagrams included in this report are offered to help in carrying these correlations further. This work can be done to some extent by carefully recording the materials penetrated in wells and comparing the logs thus obtained. But to make correlations certain, fossils are generally necessary. Wherever larger fragments are obtained from a well, as in shooting it, they should be collected, carefully labeled as to locality and depth at which they were obtained, and if possible sent in to the Director of the United States Geological Survey, Washington, D. C., for study. By methods now being developed in this Survey it may be possible to make such studies and identifications even from the ordinary fine material obtained in drilling.

The correlation of individual beds is discussed somewhat more in detail in the following paragraphs:

EXPOSED ROCKS.

The rocks exposed in this area are shown in diagrammatic section in figure 50, and on a smaller scale but in their relation to overlying and underlying parts of the section in column 7, Plate LI (p. 378). The section lying above the Bowhan sandstone, as shown in column 7, is copied from the report in this series on T. 28 N., Rs. 9 and 10 E.; T. 29 N., R. 10 E.[3] In the following pages only the rocks exposed within the area of T. 28 N., Rs. 11 and 12 E., are discussed.

Top sandstone.—The massive sandstone shown at the top of the section is probably equivalent to the lower part or to the basal part of the " Chautauqua sandstone " of Adams.[4] (See table facing p. 360, column 1.) If it is the basal part of the " Chautauqua sandstone," it includes the Jonesburg sandstone, which occurs to the north, in T. 29 N., R. 11 E.[5]

Bowhan sandstone.—The Bowhan sandstone is named from Bowhan Point, in sec. 16, T. 28 N., R. 11 E. (see Pl. LIV), which is capped by this sandstone. This is the highest bed used in working out the structure of the area. It is thin and slabby and weathers to a cinnamon color. It forms the top of many ridges in the southwestern part of the area and can generally be recognized by its position at the top of a thick series of shales. It is one of the lower sandstones in the Lawrence shale of the Kansas section (see column 1 of table facing

[3] U. S. Geol. Survey Bull. 686–F, p. 44, 1918.

[4] Kansas Univ. Geol. Survey, vol. 3, pp. 58, 59, 1898; vol. 9, p. 107, 1908 (cf. U. S. Geol. Survey Bull. 686–W, p. 330, 1920).

[5] U. S. Geol. Survey Bull. 686–W, pp. 329–330, 1920.

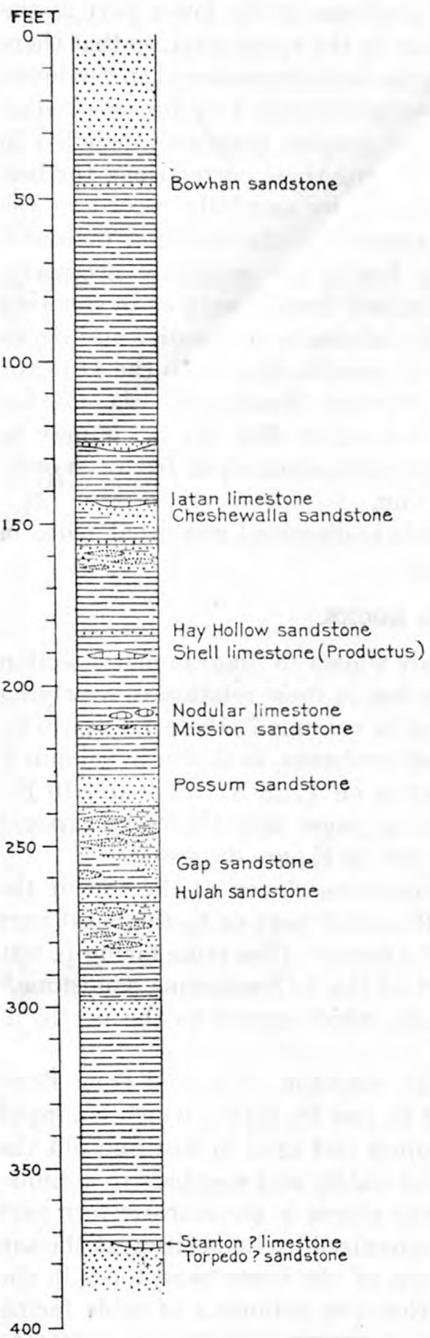


FIGURE 50.—Generalized graphic section of rocks exposed in T. 28 N., Rs. 11 and 12 E.

p. 360), probably the equivalent of the Jonesburg sandstone to the north, in T. 29 N., R. 11 E.,[6] unless the Jonesburg sandstone is the basal part of the massive sandstone at the top of the succession of beds in this township.

Iatan limestone.—What is believed to be the same as the Iatan limestone of Kansas has been traced into this area from T. 29 N., R. 11 E., and some of the reasons for believing it to be the Iatan limestone are given in the report on that township.[7] This conclusion is further confirmed by comparison of columns 7 and 11 in Plate LI. In both these sections the distance from the top of the Oread limestone to the top of the bed called the Iatan limestone is the same, 275 feet. The Iatan limestone is lenticular and reaches a maximum thickness of 8 feet. In most of this area it is made up chiefly of the shells of *Fusulina*, resembling grains of wheat. It is fairly constant in the northwestern part of the area on both sides of Caney River, where it averages about 2 feet in thickness, but is absent at many places to the east, south, and southwest at the horizon at which it should occur, tending to disappear altogether on the south side of Mission Creek. Where present to the east it is commonly brecciated, containing fragments of red and yellow limestone 1 inch to 2 inches or more in diameter. Where absent it is in places represented by impressions of fossils on the

[6] U. S. Geol. Survey Bull. 686–W, pp. 329–330, 1920.
[7] Idem, p. 331.

top of the underlying Cheshewalla sandstone. The most easterly exposure found was 5 feet below the summit of Sundown Hill, in the SE. ¼ sec. 18, T. 28 N., R. 12 E., where there are big slabs about 8 inches thick of impure brecciated yellow limestone. It is in many places overlain by 5 feet or so of sandstone and generally underlain by the Cheshewalla sandstone. It occurs about 100 feet below the Bowhan sandstone.

Cheshewalla sandstone.—The Cheshewalla sandstone is a massive sandstone usually 10 feet or more thick in the eastern part of this area but thinning to 3 feet toward the southwest edge. It lies immediately under the Iatan limestone. The top surface generally carries impressions of fossils, especially of *Fusulina*, by which it can be identified in the absence of the overlying limestone, as for instance in the southern part of the area of its outcrop.

Hay Hollow sandstone.—The Hay Hollow sandstone is named from its occurrence along the upper part of Hay Hollow in secs. 25 and 36, T. 28 N., R. 11 E. It is a slabby sandstone, generally about a foot or less in thickness, fine grained, compact, hard, and of a rather warm yellow color. At many places it contains peculiar winding, cylindrical sandstone casts half an inch in diameter, closely interwoven, which cover the surfaces of slabs. As it occurs about 40 feet below the top of the Cheshewalla sandstone, isolated in the midst of a thick series of shale, and weathering out in a well-defined line of large broken slabs, it is easily recognized. Care must be taken, however, not to confuse it with a somewhat similar hard, slabby bed which lies approximately 10 or 15 feet below the top of the Cheshewalla sandstone and likewise forms a conspicuous outcrop in the midst of shale around Sundown Hill and around the point west of the mouth of Hay Hollow. This higher bed is orange-colored rather than yellow and is generally rich in impressions of fossils, especially of bivalves, instead of the wormlike markings that are so common on the surface of the Hay Hollow sandstone.

Beds between Cheshewalla and Hay Hollow sandstones.—In the upper part of the succession of beds between the Hay Hollow and Cheshewalla sandstones, in the 15 feet or so below the Cheshewalla, there are a number of thin lenticular sandstones which in places merge with one another and with the Cheshewalla. The sandstone exposed around Sundown Hill, 10 to 15 feet below the top of the Cheshewalla, is the most persistent of these lenticular beds. Others are well defined for short distances and have been used locally in working out the structure, especially in the eastern part of T. 28 N., R. 11 E., south of Caney River. Below these lenticular sandstones, as far as the Hay Hollow sandstone, the section consists mostly of shale.

Mission sandstone.—The Mission sandstone is named from its prominent occurrence along Mission Creek, especially in secs. 13, 14, 23, 24, and 25, T. 28 N., R. 11 E. Just northwest of the center of sec. 23, T. 28 N., R. 11 E., it is conspicuous as the bed forming the surface of the prairie a few feet above the creek bottom north of the Gordon ranch. In T. 29 N., Rs. 11 and 12 E., it is part of a series of lenticular sandstones overlying the Possum sandstone.[9] In T. 28 N., Rs. 11 and 12 E., it is a very constant, conspicuous bed of hard sandstone, 2 to 4 feet thick, weathering in slabby blocks, prevailingly of a pinkish color, in places carrying fossil shells in the top part and forming the surface bed over a great part of the open country between Caney River and Mission Creek. This last-mentioned fact indicates that it is generally overlain by shale, hence the ease with which it is traced. In the southeastern part of the area, however, it becomes more or less lost in a series of soft, massive lenticular sandstones and appears in sec. 31, T. 28 N., R. 12 E., as part of a continuous massive bed 20 feet or more thick. The distance from the top of the Cheshewalla sandstone to the top of the Mission sandstone is generally about 70 feet, but perhaps decreases to 60 feet near the center of sec. 10, T. 28 N., R. 11 E.

Beds between Hay Hollow and Mission sandstones.—The section between the Hay Hollow and Mission sandstones consists almost entirely of shale. About 20 feet above the Mission sandstone is found locally a very lenticular slightly greenish limestone a few inches thick, consisting almost entirely of the thin, somewhat pearly looking shells of *Productus*, lightly bound together by a matrix of sandy clay. It could nowhere be traced any distance. One of the best exposures of it is on the south slope of a small point near the center of the north edge of the SW. ¼ SE. ¼ sec. 14, T. 28 N., R. 11 E.

The fossiliferous nodular limestone shown in figure 50 (p. 362) in the shale some 2 to 4 feet above the Mission sandstone was found only in the steep south bank of Caney River directly adjacent to the southwest corner of sec. 7, T. 28 N., R. 12 E., where the Mission sandstone locally develops into a more massive bed some 8 feet or more thick.

Not uncommonly there appear at the very top of the Mission sandstone, merging more or less with the sandstone, lenses from a fraction of an inch to a few inches thick of unfossiliferous limy substance, which weathers to a dark, blackish brown, and is therefore probably more or less sideritic and manganese bearing. This material is particularly conspicuous along the south side of Mission Creek in and adjacent to sec. 30, T. 28 N., R. 12 E.

Possum sandstone.—The Possum sandstone is of entirely the same character here as in T. 29 N., Rs. 11 and 12 E.[9] It is a prominent,

[9] U. S. Geol. Survey Bull. 686–W, p. 332, 1920.

persistent, thick, relatively soft massive sandstone, of the same general type as the Cheshewalla sandstone, though usually not so thick. It lies about 15 feet below the top of the Mission sandstone.

Hulah sandstone.—The Hulah sandstone is named from its good development at the top of the small ridge at the east edge of the town site of Hulah, on the unfinished Osage County & Santa Fe Railway, near the center of the SE. ¼ sec. 5, T. 28 N., R. 12 E. It is a hard bed that averages about 4 feet in thickness and usually weathers yellow or orange colored. The interval separating it from the top of the Mission sandstone ranges from 40 to 55 feet and averages about 50 feet. The position of this sandstone in the midst of shales in the eastern and northeastern parts of the area generally causes it to have a well-defined outcrop at or near the tops of ridges there. In the southeastern part of the area numerous lenticular sandstones above and below it make it more difficult to trace. In places it is rather fossiliferous—nowhere more so than at its type locality, just east of the town site of Hulah, where *Productus* is particularly abundant.

Beds between Possum and Hulah sandstones.—In the northeastern part of T. 28 N., R. 12 E., the section between the Possum and Hulah sandstones consists mainly of shale, with only a few lenticular sandstones, such as the Gap sandstone, which pinches out half a mile south of the northeast corner of the township. South and west of Caney River, however, this part of the section consists almost entirely of closely interbedded more or less lenticular sandstones and shales. As a consequence, south of Mission Creek, where this part of the section is mainly exposed, beds can be followed only locally in mapping the structure.

Torpedo (?) sandstone.—The sandstone to which the name Torpedo is here tentatively applied is believed to be the probable equivalent of the Torpedo sandstone described in another chapter of this bulletin.[10] It lies near the bottom of the section exposed in the townships, about 160 feet below the top of the Mission sandstone, and is the lowest bed used in mapping. On account of its prevalent position in the valley floor it is rarely well exposed. A good exposure, however, at the edge of Coon Creek in the SE. ¼ SW. ¼ sec. 9, T. 28 N., R. 12 E., shows 15 to 20 feet of rather soft massive sandstone of the general type of the massive Cheshewalla and Possum sandstones. It is believed that the heavy sandstone that forms the plateau on which stands the schoolhouse in the northwest corner of sec. 28, T. 28 N., R. 12 E., on the point between the valleys of Caney River and Mission Creek, is the same sandstone, and the correlation across Caney River has been based largely on that belief. Along the edge of the plateau there is an excellent cliff-like exposure showing

[10] U. S. Geol. Survey Bull. 686–H, p. 76, 1918.

about 15 to 20 feet of massive sandstone. The record of the well in the SW. ¼ sec. 9, T. 28 N., R. 12 E., which starts just above this (Torpedo?) sandstone, begins with a bed of sandstone 65 feet thick. In the northeast corner of the NW. ¼ NW. ¼ SE. ¼ sec. 9, T. 28 N., R. 12 E., along the edge of the valley of Coon Creek, the upper 5 feet or so of the sandstone was found to pass into a barren limestone and calcareous sandstone overlain by about 5 feet of sandstone, part of which is full of impressions of shells, among which *Pecten* and *Productus* were especially noted. A better-defined occurrence of limestone was found in the bed of Coon Creek adjacent to a road crossing near the west edge of the NW. ¼ SW. ¼ NW. ¼ sec. 16, T. 28 N., R. 12 E. Here there is exposed about 4 feet of very sandy limestone to very calcareous sandstone, ripple marked, full of crinoid stems, with *Productus* and other fossil shells. The relation to the Torpedo (?) sandstone could not be determined here, but the dip and general relations make it practically certain that this limestone is equivalent to the bed occurring in sec. 9 just described and lies at the top of the Torpedo (?) sandstone. As will be explained below, this is very probably the Stanton limestone.

Beds between the Hulah and Torpedo (?) sandstones.—The beds between the Hulah sandstone and the Torpedo (?) sandstone show the same variations as those between the Possum and the Hulah; that is, to the east and northeast they are mostly shale with only thin sandstone, while to the south and west of Caney River they are closely interbedded lenticular sandstones and shales, which can be followed only locally.

Possible correlations of the section between the Iatan limestone and the base of the Torpedo (?) sandstone.—As most of the limestones in this part of the Pennsylvanian series in Oklahoma grow thin or disappear toward the south and west, and the sandstones are very lenticular and not limited to definite horizons, any correlation, except as determined by actually tracing beds, is necessarily inconclusive. To a certain extent beds were traced continuously in preparing this series of geologic reports on the Osage Reservation. However, as the names in use in these reports and in others on northeastern Oklahoma were generally applied to thick series of beds, while the mapping of structure was based on single benches, and different geologists working in adjacent townships did not always use the same benches, the tracing is not entirely continuous. Some further evidence on correlation may be obtained by comparing the generalized section for T. 28 N., Rs. 11 and 12 E. (column 7, Pl. LI, p. 378) with the generalized sections for northeastern Oklahoma (columns 8 and 9, Pl. LI), as there is pretty close agreement in the total interval between the Oread limestone or probable equivalent of the Oread limestone and the top of the Fort Scott limestone or "Oswego lime" in these three sections.

The thick sandstone series exposed in the bluffs west of Bigheart [11] was named the Bigheart sandstone by Snider.[12] The name has, however, been restricted by the geologists of the United States Geological Survey to the basal massive sandstone of this series.[13] As thus defined it is mapped in secs. 1 and 2, T. 24 N., R. 10 E.[14] The top of the Revard sandstone as mapped in sec. 35, T. 25 N., R. 10 E.,[15] is apparently continuous with the top of the Bigheart sandstone as originally described by Snider. The series of sandstones called the Revard sandstone has been traced with sufficient continuity to T. 28 N., Rs. 11 and 12 E., to permit its approximate identification there. Apparently it tends to break up in this northeasterly direction into a number of thinner sandstones with considerable intervening shale, but its relations to the Iatan limestone and the Cheshewalla sandstone underlying the Iatan limestone indicate that the top of the Possum sandstone coincides approximately with the top of the Revard sandstone.

The correlation of the Torpedo(?) sandstone in this area is based on the following facts:

1. It lies in about the same position in the section shown in column 7, Plate LI (p. 378), as the top of the Wilson formation of Shannon and Trout (column 9). The Torpedo sandstone as defined in chapter H [16] of this bulletin lies at the top of the Wilson formation of Shannon and Trout.

2. In chapter H of this bulletin [16] 3 to 4 feet of crinoidal limestone, tentatively correlated with the Stanton limestone, is described as overlying the Torpedo sandstone. From 3 to 4 feet of crinoidal limestone was found at the top of the Torpedo(?) sandstone in T. 28 N., R. 12 E.

3. Ohern [17] states that the Stanton limestone passes into the Pawhuska quadrangle in the middle of T. 28 N. It was near that locality that the limestone overlying the Torpedo(?) sandstone was found. Besides, as the Torpedo(?) sandstone appears to be so nearly the lowest bed exposed in that vicinity, the Stanton limestone of Ohern is not likely to be any lower in the section.

4. Ohern [18] describes the Stanton limestone as very arenaceous near the Kansas-Oklahoma line. The limestone in the bed of Coon Creek in the NW. ¼ sec. 16, T. 28 N., R. 12 E., is very arenaceous.

[11] See column 9, Pl. LI; also Oklahoma Geol. Survey Bull. 19, pt. 1, p. 89, 1915.
[12] Snider, L. C., Oklahoma Geol. Survey Bull. 7, p. 221, 1911.
[13] U. S. Geol. Survey Bull. 686–B, p. 3, 1918.
[14] U. S. Geol. Survey Bull. 686–D, pl. 5, p. 18, 1918.
[15] U. S. Geol. Survey Bull. 686–G, pl. 10, p. 60, 1918.
[16] U. S. Geol. Survey Bull. 686–H, p. 76, fig. 18, 1918.
[17] Oklahoma Univ. Research Bull. 4, p. 33, 1910.
[18] Idem, p. 34.

5. Green[19] describes a series of thick sandstones, associated with limestone probably equivalent to the Stanton limestone, in about the same position (cf. column 8, Pl. LI) as the Torpedo(?) sandstone in the section shown in column 7, Plate LI.

6. Like the sandstones in approximately the same position in the sections shown in columns 8 and 9, Plate LI, the Torpedo(?) sandstone in the section shown in column 7 is separated by an apparently persistent shaly series from rather massive sandy series above and below it.

If the Torpedo sandstone and the top of the Revard sandstone are correctly identified, then the Bigheart sandstone as defined by the geologists of the United States Geological Survey[20] must be represented by some of the sandstone in the lower part of the sandstone series above the Torpedo(?) sandstone and below the top of the Revard sandstone. But no one bed in this lenticular series appears preeminent enough in thickness or persistence to permit correlation with the Bigheart sandstone as above defined.

ROCKS NOT EXPOSED.

GENERAL RELATIONS.

The six well logs, two of them incomplete, that are shown on Plate LI (p. 378) are the only record of subsurface conditions available for this area. In figure 51 the locations of these wells are shown, with some of the most significant facts brought out by the logs. With the data obtained from these wells are shown curves representing the interval between the top of the "Oswego lime" and the top of the "Mississippi lime" as given by Berger.[21] As Berger's map is on a much smaller scale than this one, his curves could be transferred only approximately. In general, there is good agreement between his curves and the figures here given, the only pronounced disagreement being in reference to the well in the SW. ¼ sec. 9, T. 28 N., R. 12 E. In the log of this well the distance from the horizon of the Iatan limestone to the "Oswego lime" appears too small and that from the "Oswego lime" to the "Mississippi lime" appears too large, so that there was probably some mistake in reporting the depth of the "Oswego lime." In order to obtain the figures used here some reinterpretation of the logs was necessary, the name "Oswego lime" and other names apparently having been applied by the driller to the wrong bed, or no name having been given by the driller. A further interesting relationship brought out by the diagram (fig. 51) is a parallelism between the

[19] Am. Assoc. Petr. Geologists Bull., vol. 2, p. 121, 1918.

[20] U. S. Geol. Survey Bull. 686–B, p. 3, 1918; Bull. 686–S, p. 240, 1919.

[21] Berger, W. R., The relation of the Fort Scott formation to the Boone chert in southeastern Kansas and northeastern Oklahoma: Jour. Geology, vol. 26, pp. 618–621, 1918.

interval from the Iatan limestone (a surface bed) to the "Mississippi lime" and the interval from the "Oswego lime" to the "Mississippi lime." In the northwestern part of the area the two intervals seem to vary by about the same amounts and in the same direction, which shows that the Iatan limestone and the "Oswego lime" are approximately parallel there. But southeast of Berger's 450-foot curve the interval between the Iatan limestone and the "Mississippi lime" increases abruptly but, so far as can be judged from the meager data available, in a direction parallel to that along

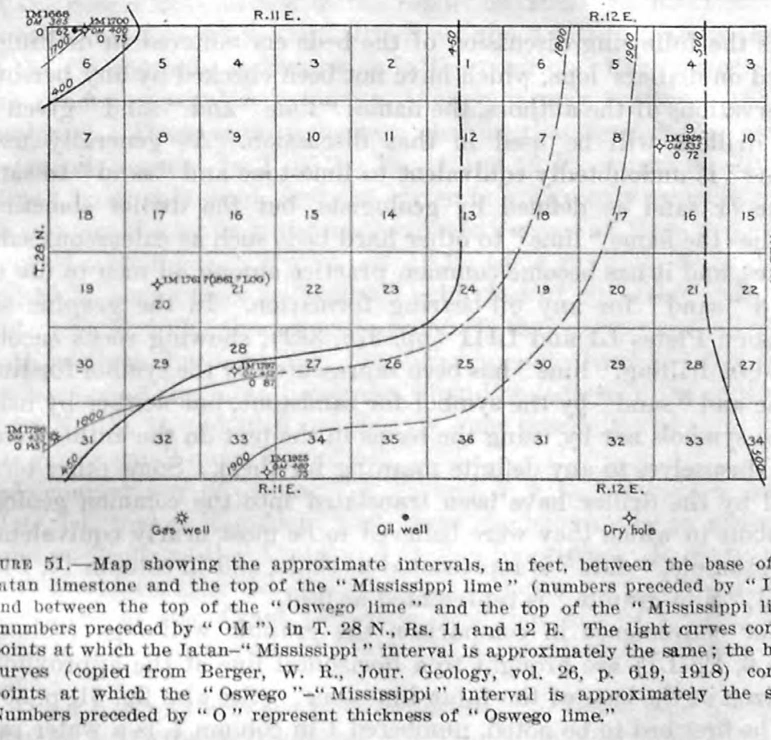


FIGURE 51.—Map showing the approximate intervals, in feet, between the base of the Iatan limestone and the top of the "Mississippi lime" (numbers preceded by "IM") and between the top of the "Oswego lime" and the top of the "Mississippi lime" (numbers preceded by "OM") in T. 28 N., Rs. 11 and 12 E. The light curves connect points at which the Iatan-"Mississippi" interval is approximately the same; the heavy curves (copied from Berger, W. R., Jour. Geology, vol. 26, p. 619, 1918) connect points at which the "Oswego"-"Mississippi" interval is approximately the same. Numbers preceded by "O" represent thickness of "Oswego lime."

which the interval between the "Oswego lime" and the "Mississippi lime" increases.[22] This appears to indicate that the same subsiding basin as that in which the beds between the "Oswego lime" (Fort Scott limestone) and the "Mississippi lime" (Boone limestone) were deposited existed and continued to subside southeast of the position of Berger's 450-foot curve during at least part of the time between the deposition of the "Oswego lime" and the deposition of the Iatan limestone. This is of practical importance, as it gives a rough means of determining, so far as the scanty data permit, the probable depth

[22] The northward extension of the 1,800-foot curve for the interval between the Iatan limestone and the top of the "Mississippi lime" is based on the logs of two wells in sec. 30, T. 29 N., R. 12 E.

to which any well in the area will have to be drilled to reach the "Mississippi lime." The outcrop and structure map (Pl. LIV, p. 394) shows the nearest surface bed, and the generalized section of exposed rocks (fig. 50, p. 362) shows the distance from that bed to the Iatan limestone. By combining these quantities with the intervals between the Iatan limestone and the "Mississippi lime" given on figure 51 the distance from the surface to the "Mississippi lime" can be calculated within about 50 feet or less.

PRINCIPAL BEDS ABOVE THE "MISSISSIPPI LIME" NOTED IN DRILLING.

As the following discussion of the beds encountered in drilling is based on drillers' logs, which have not been checked by any personal observations of the authors, the names "lime" and "sand" given by the drillers will be used in that discussion. As generally used, "lime" is undoubtedly equivalent to limestone and "sand" to sandstone or sand as defined by geologists, but the driller sometimes applies the name "lime" to other hard beds such as calcareous sandstones, and it has become common practice among oil men to use the word "sand" for any oil-bearing formation. In the graphic sections on Plates LI and LIII (pp. 378, 382), showing rocks encountered in drilling, "lime" has been represented by the symbol for limestone and "sand" by the symbol for sandstone, but neither by using these symbols nor by using the terms in the text do the authors commit themselves to any definite meaning for them. Some other terms used by the driller have been translated into the common geologic symbols to which they were believed to be most nearly equivalent—for example, "slate" is represented as shale, and in column 10, Plate LIII, "flint granite" is represented as flint.

For convenience in comparison the graphic well logs (columns 1 to 6, Pl. LI) are brought to a horizontal line at the approximate horizon of the base of the Iatan limestone. (See also fig. 51, p. 369.)

The first bed to be noted, numbered 1 in column 7, is a water sand which in the southwestern part of the area lies about 535 feet below the Iatan limestone. In the well in sec. 9, T. 28 N., R. 12 E. (column 6, Pl. LI), probably the same bed is recorded at about 519 feet below the Iatan limestone. The thickness recorded in different logs is variable. In the wells represented in columns 4 and 5 it probably includes a bed of limestone.

Another water sand (No. 2) lies a short distance lower in the section, at 640 to 670 feet below the Iatan limestone. The thickness of this sand is also highly variable. At the southwest edge of the township, in the NW. ¼ sec. 31, beds 1 and 2 apparently converge and reach their greatest combined thickness of 180 feet, with only 15 feet of blue shale separating them. There they are probably the same as the 60 feet or so of water sand with a show of oil and gas encountered at a depth of about 620 feet in a well in the SE. ¼ sec. 24, T. 27 N., R. 10 E., of which the diagrammatic log is shown in the report on that township.[23] A sand probably equivalent to the upper of these two and yielding gas and water was also encountered in T. 29 N., Rs. 11 and 12 E., about 550 feet below the Iatan limestone.[24] In Tps. 28 and 29 N., R. 10 E., the gas sand numbered 4 in the compiled section 6, Plate IX of Bulletin 686–F, is probably equivalent to the lower of these two sands or to the two converged into one. In the generalized section in the report on T. 27 N., R. 11 E.,[25] the second sandstone above the Little lime, about 670 feet below the top of the Cheshewalla sandstone, is in the position of the lower of the two sandstones under discussion, though it may represent the two combined. There is no indication that in that township it carried water, oil, or gas. In T. 28 N., Rs. 11 and 12 E., no gas or oil is reported from this sand, and the water is apparently generally salt. To sum up, the sands at the approximate horizon of these two gave a show of oil and gas in T. 27 N., R. 10 E., some gas in T. 29 N., Rs. 11 and 12 E., and a trace to 3,000,000 cubic feet of gas a day in Tps. 28 and 29 N., R. 10 E., though more generally they carry only salt water. Both of them, but especially the lower one, at about 650 feet below the horizon of the Iatan limestone, should be looked for in drilling in T. 28 N., Rs. 11 and 12 E., as there is some possibility of their yielding gas or small quantities of oil.

A comparison of columns 4, 5, and 7 with columns 8 and 9, Plate LI, makes it evident that these sandstones are in about the same positions as the Avant and Dewey limestones. It seems probable, therefore, that the limestone in the lower part of bed 1 is the equivalent of the Avant limestone, and that one or both of those directly above and directly below bed 2 represent the Dewey limestone.

About halfway between these sands and the Little lime, about 800 feet below the Iatan limestone, is a sand numbered 3, in column 7, Plate LI (p. 378), which in the log of the well near the west quarter corner of sec. 31, T. 28 N., R. 11 E., is reported to be 18 feet thick and to have yielded a show of oil. According to that log it lies nearly 250 feet above the top of the Little lime, a position which makes it about equivalent to a thin sand with a show of oil recorded 280 feet above the Little lime in the SE. ¼ sec. 24, T. 27 N., R. 10 E.[26] In T. 27 N., R. 11 E., a sand with salt water and a show of oil,[27]

[23] U. S. Geol. Survey Bull. 686–V, pl. 47, p. 306, 1919.
[24] U. S. Geol. Survey Bull. 686–W, fig. 47, p. 334, 1920.
[25] U. S. Geol. Survey Bull. 686–T, pl. 42, p. 262, 1919.
[26] U. S. Geol. Survey Bull. 686–V, pl. 47, p. 306, 1919.
[27] U. S. Geol. Survey Bull. 686–T, pl. 42, p. 262, 1919.

which lies about 250 feet above the Little lime, may be taken as the equivalent of bed 3 in T. 28 N., Rs. 11 and 12 E.

A sand which has been tentatively correlated with this on Plate LI is recorded in the logs of three other wells in T. 28 N., Rs. 11 and 12 E., but is not reported to have yielded indications of oil or gas in any of them. The distance of the bed above the Little lime seems to decrease toward the northeast. At 40 feet above this sand in the well in the NW. ¼ sec. 31, T. 28 N., R. 11 E., occurs a bed of limestone 20 feet thick which on Plate LI has been correlated with limestones in similar positions in other wells in the area. The position and persistence of this limestone favor the belief that it is the equivalent of the Hogshooter limestone shown in columns 8, 9, and 10, Plate LI. If that is so, the sand below it (No. 3, column 7, Pl. LI) appears to be approximately equivalent to the lower of the sands called the Layton sand in column 8, and said to be the equivalent of the 700-foot sand of the Bartlesville region, or to the 225-foot sand of the Bartlesville region shown in column 9. Sand No. 2, column 7, above this limestone, is then about equivalent to the upper of the two sands called the Layton sand in column 8, or to the Layton sand of the Cushing field, column 9. Definite correlation on the basis of sections so generalized is out of the question, but even this rough correlation brings out the fact that there are in this part of the stratigraphic section, between 530 and 825 feet below the Iatan limestone, a number of sands productive in this general region which should therefore be carefully watched for in drilling. In the immediate neighborhood of these townships the lowest of these sands appears the most likely to produce oil.

The bed named the Little lime in the graphic logs of wells in these townships on Plate LI was not so named by the drillers in any of these logs, but from its thickness (20 to 52 feet) and its distance above the top of the Big lime (120 to 174 feet) it is evidently the equivalent of the Little lime, as shown in the other graphic sections on Plate LI and in the logs of wells in T. 27 N., Rs. 10 and 11 E.[28] In T. 27 N., R. 10 E., the distance above the top of the Big lime ranges from 85 feet in the extreme southern part of the township to probably 185 feet in the northern part, though the Little lime is generally not identified in the logs in the northern part of that township. In T. 27 N., R. 11 E., the distance above the Big lime is about 120 to 180 feet, in general also increasing toward the north. To the north and west, in T. 28 N., R. 10 E., and T. 29 N., Rs. 10, 11, and 12 E., this bed has not been recognized. It gave a show of oil or gas in a few wells in T. 27 N., Rs. 10 and 11 E., but none in T. 28 N., Rs. 11 and 12 E. It should, however, be watched for in drilling in

[28] U. S. Geol. Survey Bull. 686–T, pl. 42, p. 262, 1919; Bull. 686–V, pl. 47, p. 306, 1919.

T. 28 N., Rs. 11 and 12 E., where it is the first prominent lime encountered and lies about 1,000 to 1,075 feet below the horizon of the Iatan limestone.

As mentioned above (p. 361), the limestones in the lower part of the stratigraphic section in northeastern Oklahoma appear to be continuous over a larger part of the area than those in the upper part of the section. The Little lime is the highest of the beds encountered in drilling in these townships that can be somewhat accurately correlated with the beds exposed at the surface. A comparison of the diagrammatic sections, columns 7, 8, and 9, Plate LI (p. 378), shows that the top of the Lenapah limestone lies exactly the same distance above the base of the "Oswego lime" (440 feet) in columns 7 and 9, and 430 feet above it in column 8. Ohern [29] has recently expressed the opinion that the Checkerboard lime, generally considered the same as the Little lime, corresponds not to the Lenapah limestone but to one that lies 70 feet above the outcrop of the Lenapah limestone at Nowata. However, his correlation seems to apply more to the southeastern part of Osage County, as he bases his conclusion on the fact that the Lenapah limestone does not extend southward beyond Nowata. As T. 28 N., Rs. 11 and 12 E., lie northeast of Nowata, this consideration would not bear on correlation in this direction. In the absence of detailed studies the correlation can be only approximate at best, especially as some of the logs of wells in T. 28 N., Rs. 11 and 12 E., show more than one bed of limestone included in or adjacent to the one tentatively called the Little lime in the diagrammatic sections on Plate LI. In any case, beds of lime approximately corresponding to the Lenapah limestone are to be looked for through an interval of 30 to 75 feet at about 1,000 to 1,075 feet below the horizon of the Iatan limestone.

The interval between the Little lime and the next bed generally recorded below it, the Big lime, is usually occupied by shales, locally with a thin lime or sand. If the Little lime is approximately equivalent to the Lenapah limestone, the position of these beds below that limestone makes them approximately equivalent to the Nowata shales of Ohern and other Oklahoma geologists. (See table facing p. 360, and Pl. LI, columns 9, 10, and 11.) In the log of the well in the southeast corner of sec. 33, however, the Little lime is reported to be underlain by 75 feet of nearly continuous sandstone. In certain areas the sandstone recorded in this (No. 5) interval is an important reservoir for oil, but it is lenticular and irregular in its distribution and character. The drillers in these townships and in adjacent parts of Oklahoma and Kansas have often called this the Peru sand. As in the case of many oil sands, especially if they are

[29] Ohern, D. W., Am. Assoc. Petr. Geologists Bull., vol. 2, p. 122, 1918.

lenticular, considerable confusion exists as to the position of the sand to which the name Peru properly applies. The best means of determining the correct application of such a term would be to determine to which bed it was generally applied in the field in which it originated. The term Peru sand presumably originated in the near-by field around Peru in Chautauqua County, Kans. Unfortunately only one log from this field is available in the files of the United States Geological Survey. This log is plotted in column 12, Plate LI. In addition to this the best evidence available is in a recent report of the Geological Survey of Kansas,[30] in which the Peru sand is said to be about 300 feet above the Bartlesville sand, and the Bartlesville is said to be about 200 feet above the Mississippian limestone. Another sand found to be productive at many places in Chautauqua County and there called the Red or Stray sand is said to lie 125 to 200 feet above the Peru sand. As these definitions are founded on knowledge of the application of the names over a wide area by many people, and as they conform with other evidence to be presented later in discussing what is believed to be the true Peru sand, they seem more reliable than the evidence of a single log from the Peru field and will therefore be accepted. Then the sand called the Peru in the log plotted in column 12, Plate LI (p. 378), is probably the Red or Stray sand. The lime overlying this sand is from its position apparently the Little lime. The sand reported as underlying the bed called the Little lime in the well in the southeast corner of sec. 33, T. 28 N., R. 11 E., corresponds in position approximately with this Red or Stray sand and may therefore be assumed to be its equivalent. At the time the report on T. 29 N., Rs. 11 and 12 E., was prepared records of wells penetrating beds at the horizon of this sand in the southern part of those townships indicated that the sand pinched out in that direction.[31] Since the preparation of that chapter, however, there has been a large production of oil, reported as great as 400 barrels a day, undoubtedly from beds at this horizon in secs. 26, 35, and 36, T. 29 N., R. 11 E. The authors have not seen the logs of these wells, but the reported depth of the producing sand, 905 to 915 feet, leaves little doubt that it is this Red or Stray sand. To the west also, in the West Mission Creek dome in T. 28 N., R. 10 E.,[32] this same sand has apparently yielded shows of oil. Operators in T. 28 N., Rs. 11 and 12 E., should therefore keep a careful watch for this sand. As the Little lime is generally recorded, if not named, by the driller, there should be no difficulty in identifying the Red or Stray sand, which, where present, occurs directly below it.

---

[30] Kansas Geol. Survey Bull. 3, pp. 245–246, 1917.
[31] U. S. Geol. Survey Bull. 686–W, p. 335, 1920.
[32] U. S. Geol. Survey Bull. 686–F, p. 52, 1918.

The identification of the Big lime in the logs of wells in this area has been made entirely from its position, as the drillers either did not report it or applied the name to some other bed. In these townships the top of the bed so named in this report lies from 1,150 to 1,250 feet below the horizon of the Iatan limestone. It is commonly divided into two beds, the upper about 35 feet thick and the lower averaging slightly thicker, separated by a parting consisting mostly of shale and averaging 30 feet thick, giving a total average thickness of about 100 feet. Some drillers call the upper bed the Big lime and the lower bed the Lower Big lime. All or a part of the shale parting is in places black shale. In T. 27 N., Rs. 10 and 11 E., no production of importance is reported from the Big lime. In T. 28 N., R. 10 E., and T. 29 N., Rs. 10, 11, and 12 E.,[33] oil and gas are reported from the upper bed, probably from a sand directly underlying it. In the logs of wells in T. 28 N., Rs. 11 and 12 E., the only production reported from the Big lime is a show of gas from the top of the lower member in the well near the west quarter corner of sec. 31, T. 28 N., R. 11 E.

Directly associated with the Big lime is the true Peru sand (see above, p. 374), but it is difficult to say from the records available what is its correct position. Shannon and Trout[34] state that the Peru sand of the Dewey-Bartlesville field probably comes within the shale member that separates the upper and lower limestone members. In the logs of wells in the northeastern part of Osage County, however, the name seems to be generally applied to a sandstone found in many places directly underlying the lower limestone member, or separated from it by 5 or 10 feet of shale. The name is used for a sand in this position in the logs of the two wells in the NE. ¼ NE. ¼ NW. ¼ sec. 6, T. 28 N., R. 11 E. (See columns 1 and 2, Pl. LI, p. 378.) In the log of the well in the SW. ¼ sec. 9, T. 28 N., R. 12 E., a sand is recorded in this position between the depths of 1,043 and 1,073 feet, though it is not called Peru. (See column 6, Pl. LI.) Finally, in the log of the well in the southeast corner of sec. 33 (column 5, Pl. LI) a water-bearing lime recorded in this stratigraphic position between 1,267 and 1,293 feet may be the equivalent of this bed, as limestones and hard sandstones are not always readily differentiated by the driller. The section described by F. C. Green[35] (column 8, Pl. LI) agrees with the interpretation given above, as he also places the true Peru sand in the Labette shale, which lies between the Big lime and the next generally recognized limestone below it, the "Oswego lime." In the interval between the two lime-

---

[33] U. S. Geol. Survey Bull. 686–F, 1918; 686–W, 1920.

[34] Shannon, C. W., and Trout, L. E., Oklahoma Geol. Survey Bull. 19, pt. 1, p. 87, 1915.

[35] Green, F. C., A contribution to the geology of eastern Osage County: Am. Assoc. Petr. Geol. Bull., vol. 2, p. 119, 1918.

stone members of the Big lime in this area only very thin sandstones are recorded in a few of the logs. The upper member of the Big lime is undoubtedly the approximate equivalent of the Altamont limestone, the lower member the approximate equivalent of the Pawnee limestone, and the shale and sandstone interval separating them the equivalent of the Bandera shale, all three of which crop out together along the west side of Big Creek in the northwest corner of Craig County, about 40 miles to the east. Thence they continue southwest and south along Verdigris River past Nowata to Oologah, in Rogers County. The name Oologah formation is sometimes applied to the Altamont, Bandera, and Pawnee collectively, but the United States Geological Survey restricts the name Oologah to that more southerly part of their outcrop in which the intervening shale member has disappeared and the two limestones are united into one. (See table facing p. 360, columns 3 and 5.) The 100 feet or so of shale and sandstone lying between the lower member of the Big lime and the top of the "Oswego lime" below it is undoubtedly the approximate equivalent of the Labette shale. It is noteworthy that in the upper part of this shale, in the position of what is believed to be the true Peru sand, along its outcrop to the east, Ohern[36] has found a fairly constant sandstone. It thus appears that throughout northern Oklahoma this sandstone, which in this report is called the Peru sand, is considerably more continuous than those between the upper and lower members of the Big lime.

Generally in northeastern Osage County and vicinity the Peru sand below the lower member of the Big lime is a continuous bed of sand 30 to 40 feet thick and one of the important producing sands. In the well near the west quarter corner of sec. 31, T. 28 N., R. 11 E. (see Pl. LI, p. 378, column 3), the portion above a recorded parting of "lime shell" is reported to have yielded water and the portion below a show of oil, but the sand is nowhere productive in the townships under discussion.

At the base of the Labette shale lies probably the most constant limestone of the lower part of the Pennsylvanian series, called the "Oswego lime" by the drillers. It is undoubtedly the approximate equivalent of the Fort Scott limestone, which crops out about 50 miles to the east in the northeastern part of Craig County. According to Ohern[37] the lower part of the "Oswego lime" of Oklahoma was being deposited while the uppermost part of the Cherokee shale was being deposited in Kansas. The thickness of the "Oswego lime" as recorded in logs of wells in T. 28 N., Rs. 11 and 12 E., ranges from 62 to probably 145 feet but averages around 80 to 100 feet. Typically

[36] Ohern, D. W., Oklahoma Univ. Research Bull. 4, p. 17, 1910.

[37] Idem, p. 17.

the formation is divided into three limestones by shaly partings, locally black shale, and at its outcrop coal seams are in many places included in the shale partings. Sometimes more or less than two shale partings are reported, and some well logs record continuous limestone. (See columns 1, 2, and 6, Pl. LI, p. 378.) As brought out above (see text, p. 369, and fig. 51, p. 369), the interval between the horizon of the Iatan limestone and the top of the "Oswego lime" increases toward the southeast. The minimum recorded is 1,283 feet, in the northwest corner of T. 28 N., R. 11 E.; the maximum is 1,445 feet, in the southeast corner of sec. 33, T. 28 N., R. 11 E. In other parts of Osage County oil and gas are reported from the "Oswego lime," but in this northeastern part the only production mentioned is small quantities of gas, referred to in the report on T. 28 N., Rs. 9 and 10 E., and T. 29 N., R. 10 E.[38] In the log of the well in the southeast corner of sec. 33, T. 28 N., R. 11 E. (see Pl. LI, column 5), a small quantity of water is reported from a 3-foot parting of hard shale in this lime.

The reported interval between the base of the "Oswego lime" and the top of the "Mississippi lime" ranges from 323 feet in the northwest corner of the area to 463 feet as recorded in the log of the well in the SW. ¼ sec. 9, T. 28 N., R. 12 E., but there may be some error in this part of that log. Except in this well the greatest interval recorded is 405 feet in the log of the well in the southeast corner of sec. 33, T. 28 N., R. 11 E. The interval may be expected to increase toward the eastern part of the area, according to figure 51 (p. 369), though not as rapidly as the interval between the top of the "Oswego lime" and the top of the "Mississippi lime," because, as shown by the numbers preceded by an O in that figure, the thickness of the "Oswego lime" usually increases somewhat in the same direction as the interval separating it from the "Mississippi lime." This interval consists mainly of shales, including some thin beds of black shale, thin limes, and sands. It is the equivalent of the Cherokee shale, which crops out about 50 miles to the east in eastern Craig County north of Vinita. (See table facing p. 360 and Pl. LI, columns 7 to 11.) In parts of Osage County and adjacent areas some of the most productive beds occupy this interval. Shannon and Trout [39] list as occurring in this interval the Bixler, Markham, Barnett, Bartlesville, and Burgess sands, with which they correlate the Squirrel, Glenn, Tucker, Squaw, Tanaha, and Meadows sands. The Dutcher and Rhodes sands may also belong in this part of the stratigraphic section. It is very doubtful whether any one of these names is always applied to the same bed. More probably there are at about the same horizon in

[38] U. S. Geol. Survey Bull. 686–F, text, p. 48, pl. 9, 1918.

[39] Oklahoma Geol. Survey Bull. 19, pt. 1, p. 84, 1915; pt. 2, table facing p. 526, 1917.

different wells unconnected lenticular sands to which the same name is applied.[40] Of the sands in the Cherokee shale enumerated above the Bartlesville sand or a sand called the Bartlesville is found over the widest area and is the most generally productive, and in this region a sand by that name is the only one reported to be productive. It is reported in logs of wells covering most of T. 27 N., Rs. 10 and 11 E., but is productive only in the center of the eastern part of T. 27 N., R. 10 E.,[40a] and along the south edge of T. 27 N., R. 11 E.[40b] In T. 27 N., R. 10 E., its top lies about 110 feet above the "Mississippi lime"[40c]; in T. 27 N., R. 11 E., about 160 feet.[40d]

Toward the north it appears to thin and lose its porosity, so that in T. 28 N., Rs. 11 and 12 E., it is not reported at all. It seems possible that a thin sand and a thin lime reported 151 and 160 feet, respectively, above the "Mississippi lime" in the wells in secs. 28 and 33, T. 28 N., R. 11 E. (columns 4 and 5, Pl. LI), may be the equivalent of the Bartlesville sand, but on account of the number and lenticularity of the sands in this part of the section the identification is doubtful. To the north in T. 29 N., Rs. 11 and 12 E., neither the Bartlesville sand nor any beds with showings of oil or gas are reported in this interval, while to the east and northeast in T. 28 N., Rs. 9 and 10 E., and T. 29 N., R. 10 E.,[40e] only traces of oil are recorded from sands in this part of the section. In the Peru field, about 10 miles to the north, in Kansas, a sand called the "Bartlesville"[41] lies about 200 feet above the "Mississippi lime." (See column 12, Pl. LI.) In drilling in T. 28 N., Rs. 11 and 12 E., the possibility of finding a productive sand about 1,650 to 1,750 feet below the horizon of the Iatan limestone should be considered.

THE "MISSISSIPPI LIME" AND POSSIBLE UNDERLYING BEDS.

"Mississippi lime" is the name in general use for the series of limestones shown in the diagrammatic sections in Plate LIII. It is the deepest bed usually reached in drilling. There is some doubt whether the top of this limestone as encountered in wells is of Mississippian or basal Pennsylvanian age.[42] In fact, it is probably of different ages at different places, owing to the fact that the beds of Mississippian age were exposed to wearing away at the surface of

---

[40] As regards the Bartlesville sand cf. U. S. Geol. Survey Bull. 686–V, p. 307, 1919, and Berger, W. F., Am. Assoc. Petr. Geologists Bull., vol. 2, p. 123, 1918.

[40a] U. S. Geol. Survey Bull. 686–V, p. 307, pl. 48, p. 314, 1919.

[40b] U. S. Geol. Survey Bull. 686–T, p. 268, fig. 43, p. 267, 1919.

[40c] Idem, pl. 42, p. 262.

[40d] U. S. Geol. Survey Bull. 686–V, pl. 47, p. 306, 1919.

[40e] U. S. Geol. Survey Bull. 686–F, pl. 9, p. 48, 1918.

[41] Kansas Geol. Survey Bull. 3, p. 246, 1917.

[42] See U. S. Geol. Survey Bull. 686–A, p. xi, 1918; Bull. 686–T, pp. 262, 263, 1919; Bull. 686–V, pp. 308, 309, 1919; and Oklahoma Geol. Survey Bull. 24, pp. 21–51, 1915.

GRAPHIC SECTIONS OF BEDS EXPOSED AND BEDS ENCOUNTERED IN DRILLING IN T. 28 N., RS. 11 AND 12 E., AND ADJACENT PARTS OF OKLAHOMA AND KANSAS

ENGRAVED AND PRINTED BY THE U.S. GEOLOGICAL SURVEY

the earth for a long time before the beds of Pennsylvanian age were deposited on top of them, and the amount and duration of this erosion differed in different areas. Berger's map and discussion of the interval between the top of the "Mississippi lime" and the "Oswego lime"[43] gave much evidence as to the conditions that existed. Thus he has shown that in several places there are indications of the existence of old stream channels in the "Mississippi lime." Where these existed deeper members of the series are to be expected. In general also one would expect to find that the nearer any particular locality lies to the edge of the old Pennsylvanian basin the older, other things being equal, would be the bed forming the top of the Mississippian there and the fewer the basal Pennsylvanian beds that would be encountered, for submergence by the Pennsylvanian sea spread outward from the center of the basin, and while the deeper central parts of the basin were already under water the upper beds of the Mississippian were being worn away along the outer parts of the basin. In Plate LIII some of the principal logs of wells drilled into the "Mississippi lime," especially those that were carried farthest below its top, are represented, arranged in order from the shallowest to the deepest part of this probable old basin, as shown on Plate LII. With these diagrammatic logs is shown also a section of the Mississippian in northeastern Oklahoma generalized from the bulletin by Snider.[44] It has generally been assumed that the "Mississippi lime" of the drillers is the equivalent of the Boone limestone. If this is so, then the formations which lie between the Cherokee shale and the Boone limestone to the east are entirely lacking here, unless shales and limestones recorded above the "Mississippi lime" in the logs of some of the wells belong to these formations instead of to the Cherokee shale. The absence of thick limestones between the "Oswego lime" and the "Mississippi lime" in the logs of wells, even in the deepest part of the post-Mississippian basin,[45] is opposed to this last assumption. The Boone limestone is generally assumed to be a cherty limestone, yet only one of the logs (No. 10) represented on Plate LIII records chert or flint. A consideration of these logs with relation to the old post-Mississippian basin throws little light on the problem of the age in different wells of the beds called "Mississippi lime." The continuous thickness of limestone penetrated in the well at the extreme western edge of the basin (No. 1, Pl. LIII) and in the deeper eastern parts of the basin (Nos. 11 to 18, Pl. LIII) is about the same. The only noticeable difference is the occurrence apparently of more limestone and shale under the massive limestone to the west and of more

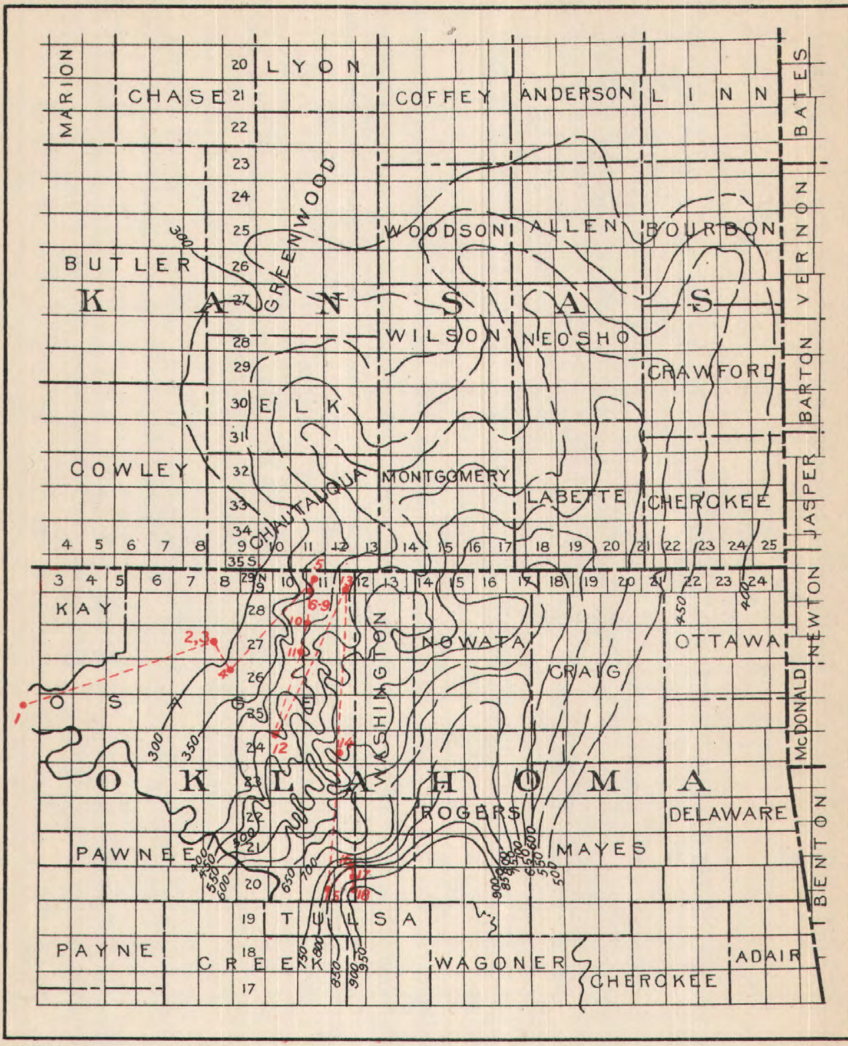
[43] Jour. Geology, vol. 26, pp. 618–621, 1918.
[44] Snider, L. C., Oklahoma Geol. Survey Bull. 24, pt. 1, plate facing p. 22, 1915.
[45] U. S. Geol. Survey Bull. 686–N, pl. 28, p. 174, 1919.

sandstones to the east; but this distinction is, for various reasons, of little use in determining the relative age. The one conspicuous fact calling for explanation brought out by these diagrammatic logs is that if the "Mississippi lime" is the equivalent of the Boone limestone, it is here underlain by a great deal of sandstone and light-colored shale instead of by the black Chattanooga shale. These sandstones may either occupy part of the interval represented to the east by black shale, or they may be sandstones in the Mississippian occupying part of the interval represented to the east by limestones. The former alternative seems the more probable and has therefore been made the basis of correlation on Plate LIII. The top of the first shale underlying the "Mississippi lime" has been taken as the top of the Chattanooga shale. If this assumption is correct, it implies a westward shallowing of the sea in which the Chattanooga shale was deposited, with increase of sand and lighter colored shale.[46]

If there is to be more deep drilling below the top of the "Mississippi lime" in the Osage region (and there should be), it becomes a very practical question, especially on account of the unconformity at the top of the "Mississippi lime," to know in what part of these formations a test hole is at any particular stage. This will be possible only if careful observations are made of the materials encountered in drilling. The recognition of chert where it is present will be helpful in identifying the Boone limestone, although the presence of chert will by no means positively identify the bed as the Boone. Fossils are particularly needed, and all larger fragments obtained from shots in the "Mississippi lime" should therefore be kept and examined for fossils. As far as time permits, the Geological Survey will be glad to help in the examination of these materials.

From the logs shown on Plate LIII and from the previous bulletins of this series, it appears that oil or gas may be obtained from beds at various horizons below the top of the "Mississippi lime." Of wells producing from the "Mississippi lime" in and adjacent to T. 28 N., Rs. 11 and 12 E., the most notable is the one in the southwest corner of sec. 31, T. 29 N., R. 11 E. (No. 7, Pl. LIII), which reported 225 barrels of oil, apparently from a sand 47 feet below the top of the "lime." Another directly adjacent (No. 8, Pl. LIII) obtained 1,500,000 cubic feet of gas, presumably from the upper 60 feet of the "Mississippi lime," though the log also records "little gas at 1,069 feet," which is about 600 feet above the top of the "Mississippi lime." In the southwest corner of the NW. ¼ sec. 31, T. 28 N., R. 11 E. (No. 10, Pl. LIII), gas was obtained from the

[46] For a summary discussion of the beds below the Pennsylvanian in this region, see Heald, K. C., Geologic structure of the northwestern part of the Pawhuska quadrangle, Okla.: U. S. Geol. Survey Bull. 691, pp. 74–77, pl. 15, 1918.



PRINTED BY THE U.S. GEOLOGICAL SURVEY

10 0 10 20 30 40 50 60 MILES

SKETCH MAP SHOWING LOCATION OF WELLS DRILLED INTO "MISSISSIPPI LIME" IN OSAGE COUNTY, OKLA.

In relation to the probable basin in Mississippian rocks in which the lower Pennsylvanian sediments were deposited (to accompany Pl. LIII)

Curves represent interval between the top of the "Mississippi lime" and the top of the Fort Scott limestone ("Oswego lime")

Copied from Berger's map in Journal of Geology, vol. 26, page 619, 1918

"Mississippi lime," apparently from the upper 25 feet. Some of the biggest oil wells in Osage County have produced from the upper 50 feet of the beds underlying the main bed of "lime," 300 feet or more below its top, and it is quite possible that there are other producing sands not far below these. As stated in previous bulletins of this series, a test can therefore not be considered adequate until it has penetrated from 300 to 400 feet below the top of the "Mississippi lime," and wells now producing from higher levels should, if possible, before being abandoned, be deepened into the "Mississippi lime."

STRUCTURE.[47]

GENERAL CHARACTER.

The predominant attitude of the Carboniferous beds in the general region of Osage County and adjacent territory is a monoclinal dip to the west or northwest. In the townships under consideration the northward component is small, the dip being nearly west. Throughout this region the monoclinal dip is interrupted by eastward to southeastward reversals that produce folds with a general trend parallel to the northeasterly monoclinal strike, and by terrace-like or tonguelike structural features with a general trend either across or parallel to the strike. In T. 28 N., Rs. 11 and 12 E., the interruptions to the monoclinal dip are so numerous and irregular that they largely conceal it, but it appears most clearly along the east border of the area and along the westernmost tier of sections of T. 28 N., R. 12 E. The map (Pl. LIV, p. 394) shows the very irregular relations of the axes of folding to each other and the fact that in these townships the east-west trend predominates over the north-south.

RELATION OF TOPOGRAPHY TO STRUCTURE.

In view of the generally marked agreement between structure and topography in this region it is interesting to note to what degree the larger streams, like Caney River and Mission Creek, follow synclines in their courses. The structure here is not such as to afford a continuous syncline or series of contiguous synclines for a stream to follow, yet it is evident that Caney River has been drawn into the larger synclinal depressions, perhaps cutting its way between them

[47] As the townships covered by this report are bounded on three sides by townships whose structure has been described and mapped in earlier chapters of this bulletin, all the slight errors in measuring distances between beds and in mapping structure in these townships have been thrown into these two townships alone, with the result that there are two more contours in the surrounding townships than in these two. The excess contours in the surrounding townships have therefore been dropped where it seemed that they would least affect the form of the structure, namely, at the north edge of sec. 1, T. 28 N., R. 11 E., on both sides of the south corner common to secs. 35 and 36, T. 29 N., R. 11 E. (See Pl. LIV, p. 394; also U. S. Geol. Survey Bull. 686–W, Pl. XLIX, p. 330, 1920.) This is just north of the locality where the contours are drawn across the broad alluvium-filled valley of Caney River.

without much regard to structure. It is, moreover, quite possible that in some places where no synclines are shown in the projection of the structure across Caney River valley, especially in connection with the peculiar long anticlinal ridges in sec. 7, T. 28 N., R. 12 E., and sec. 12, T. 28 N., R. 11 E., minor structural depressions really exist.

The portion of Mission Creek in this area shows much less regard for the structure. In sec. 32, T. 28 N., R. 11 E., it lies in a syncline; in secs. 26 and 27 it follows the strike of the beds; and just beyond, in secs. 23 and 24, it lies at the edge of a synclinal depression; but over the rest of its course it seems to cut directly across monoclines or anticlines.

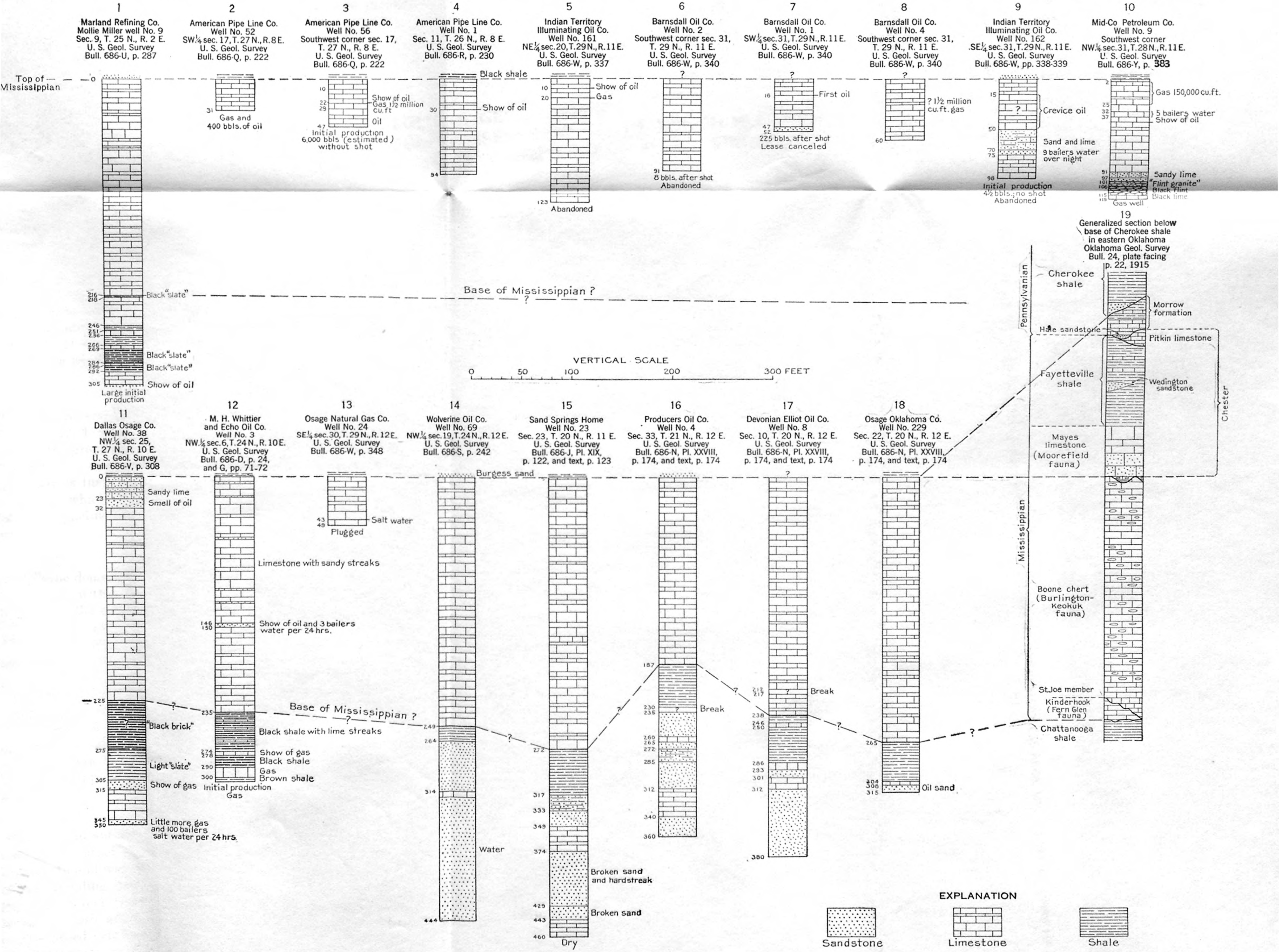
At best these broad, alluvium-filled valleys are a serious obstacle to the mapping of the structure. The areas covered by alluvium are therefore delimited on the structure map (Pl. LIV), and the structure of the beds underlying them is generally shown by broken lines. From what has been said above, and on account of the greater width of Caney River valley, it is evident that the projection of the structure across Caney River valley is much less certain than that across the valley of Mission Creek.

INDIVIDUAL FOLDS.

EAST MISSION CREEK DOME.

As the summit of the East Mission Creek dome lies in sec. 36, T. 28 N., R. 10 E., the dome has already been discussed in the chapter of this bulletin dealing with that township.[48] That description is therefore repeated here with slight modifications. The East Mission Creek dome occupies the SE. ¼ sec. 25 and most of sec. 36, T. 28 N., R. 10 E., and extends eastward into secs. 30 and 31, T. 28 N., R. 11 E. The crest of the dome lies about 1,000 feet west-northwest of the east quarter corner of sec. 36; the closure on the east amounts to about 40 feet. The dome has a fairly good gathering ground to the north but very little to the west and south. It has not been developed, but the conditions here are probably somewhat similar to those on the West Mission Creek dome, where there are several gas wells, each yielding from the "Mississippi lime" 750,000 to 4,500,000 cubic feet of gas as initial daily production, but no oil wells. The lower slopes of that dome do not seem to be productive, and some holes in an apparently favorable relation to the structure have been dry. The logs of some of the wells reported traces of oil from sands 35, 450, and 650 feet above the top of the "Mississippi lime." The depth to the "Mississippi lime" at the crest of the East Mission Creek dome is probably about 1,800 to 1,850 feet. Since field work in this area

[48] U. S. Geol. Survey Bull. 686–F, p. 53, pl. 8, p. 44, 1918.



GRAPHIC SECTIONS OF THE "MISSISSIPPI LIME" AND ASSOCIATED BEDS BELOW THE BASE OF THE CHEROKEE SHALE IN NORTHEASTERN OKLAHOMA.

was completed gas has been obtained from the east flank of this dome by a well in the southwest corner of the NW. ¼ sec. 31, T. 28 N., R. 11 E. The diagrammatic log of this well is shown in column 3, Plate LI (p. 378). Although experience has shown that the best production from anticlinal folds in this region is generally on the westerly flanks, the large gathering ground to the north of this dome may be favorable to the accumulation of oil on its east flank in sec. 31, T. 28 N., R. 11 E., and the producing area might also be extended to the northeast flank in the SW. ¼ sec. 30, T. 28 N., R. 11 E.

MUSGROVE TERRACE.

The Musgrove terrace lies in the E. ½ SE. ¼ sec. 31, and the W. ½ SW. ¼ sec. 32, T. 28 N., R. 11 E. It is a small tonguelike extension from the Musgrove anticline, in sec. 5, T. 27 N., R. 11 E.[49] The Musgrove anticline does not appear to be very favorable structurally, hence there is little reason for anticipating much production from this terrace, which is low and narrow and is cut off directly to the west by a syncline that separates it from the East Mission Creek dome.

CRANE DOME.

The Crane dome lies mainly in the southern part of sec. 29, T. 28 N., R. 11 E., with a slight extension into the NW. ¼ sec. 32. The summit is in the center of the E. ½ SW. ¼ sec. 29. Its axis strikes about northeast and may be regarded as the extension of the northeasterly branch axis of the East Mission Creek dome. The dome is weak, having a closure of only about 20 feet, broad, gently sloping flanks, and a low, flat western flank between the syncline separating it from the East Mission Creek dome and the summit. Toward the north-northwest it has a very extensive slope, but this slope is also the west flank of the Bowhan anticline described below. As oil in this country usually rises toward the southeast, the relations of the Crane dome are moderately favorable to the accumulation of oil. The "Mississippi lime" should be entered about 1,850 feet below the surface.

BOWHAN ANTICLINE.

The Bowhan anticline lies almost entirely in sec. 21, T. 28 N., R. 11 E. It is rather irregular in trend and shape. The main axis trends north and may be regarded as a north extension of the northeastward-trending axis of the Crane dome. From the south end, however, a branch runs off due east into a small domelike extension. The north, south, and northeast flanks are very short, being bounded by pronounced synclines that give the anticline an almost tongue-

[49] U. S. Geol. Survey Bull. 686–T, pl. 41, p. 258, 1919.

like character; but the west flank is very extensive, about 1½ miles wide and 110 feet high from the bottom of the syncline in the SE. ¼ sec. 18 to the top of the anticline. This west flank curves to the west and forms the north flank of the Crane dome. There is therefore some question which of the two folds would receive most of the oil that might rise up this flank. The best localities for tests would be near the center of the NW. ¼ or in the NW. ¼ NE. ¼ SW. ¼ sec. 21, T. 28 N., R. 11 E. Tests in about this location, if started below the ridge capped by the Bowhan sandstone, should encounter the "Mississippi lime" at a depth of about 1,800 feet. Unless some production is obtained from wells along the main anticline the small dome on the southeast end is to be regarded as unpromising.

TRUMBLEY ANTICLINE.

The Trumbley anticline lies in the W. ½ sec. 15, T. 28 N., R. 11 E. Its main axis trends north, but a westward extension of the south end forms a sort of connection with the Bowhan anticline. The east half of the anticline is cut off by a fault trending slightly west of north, with the east side thrown down and a sharp little syncline taking the place of the anticline on that side. If the Bowhan anticline proves unproductive, little is to be expected from the Trumbley anticline. It has the same broad west flank as the Bowhan anticline, but the upper part of this west flank is very flat, rather terrace-like in form, with a slope of not more than 40 feet in 1½ miles. The presence of a fault so near the summit is also a slightly unfavorable feature, as it might afford an opening for the escape of any oil or gas that may have risen toward the top of the anticline, or it may have facilitated the circulation of solutions that filled the pores of sands underlying the anticline. Should any oil or gas be obtained on the Bowhan anticline, however, the Trumbley anticline will be tested. One location for such a test would be along the west edge of sec. 15, especially adjacent to the west quarter corner. The outcrop of the Iatan limestone, as shown on the map (Pl. LIV, p. 394), runs near this corner along the edge of the valley of Caney River. A test might, therefore, start either on the limestone or in the valley bottom below it. The "Mississippi lime" should be encountered about 1,750 feet below the Iatan limestone. Another location would be in the west ¼-mile strip of sec. 16, as many of these terrace-like features in Osage County are found to be productive where the change from steep to flat dip takes place. A test in that strip would start either just above the Bowhan sandstone or just above the Iatan limestone. The top of the "Mississippi lime" may be expected at about 1,740 feet below the Iatan limestone, and the bed should be penetrated for at least 400 feet.

WOODRING ANTICLINE.

The Woodring anticline is a long, narrow plunging anticline whose axis extends approximately north along the west edge of sec. 34, T. 28 N., R. 11 E., and from the northwest corner extends northwest to about the center of sec. 28. Along its south half the west flank curves into the east-west strike which prevails to the south of it.[49a] The north half, however, is bounded on the west by a sharp syncline that gives a difference of elevation of 60 feet in a mile between the top and bottom of the west flank. The east flank is rather steep along its entire length but does not show a reversal dip of more than about 20 feet. Two tests holes have been drilled on this anticline—one in the northeast corner of the SW. ¼ sec. 28 (column 4, Pl. LI, p. 378), the other in the southeast corner of sec. 33 (column 5, Pl. LI). Both were drilled into the "Mississippi lime" and are reported dry. The log of the one in sec. 28 records the top of the "Mississippi lime" at a depth of 1,797 feet. It obtained a show of oil and gas in the upper 25 feet of the "Mississippi lime" but encountered water 75 feet below the top of the lime. The well in sec. 33 recorded the top of the "Mississippi lime" at 1,860 feet and was drilled 30 feet into it, which is not deep enough to test it adequately. The best locality for a further test would probably be in the northeast corner of sec. 33, at the break between the terrace-like top in the NW. ¼ sec. 34 and the steep west slope. A well in this location would be in the bottom of the valley of Mission Creek and should encounter the "Mississippi lime" at a depth of about 1,825 feet.

TABLE TOP ANTICLINE.

The Table Top anticline lies mainly in the northeastern part of sec. 4, T. 28 N., R. 11 E. It is one of the most promising folds in the area. Its presumptive extension to the south is concealed by the alluvium of the valley of Caney River. As projected from the contours on both sides of the valley, the axis runs nearly due north through about the center of the E. ½ sec. 4 from a point a little south of the south edge. Toward the north edge of the section the axis turns northeastward into a long tongue, mainly in sec. 33, T. 29 N., R. 11 E.[50]

The portion of the anticline in sec. 4, T. 28 N., R. 11 E., has a closure of about 40 feet. It appears to be nearly symmetrical with respect to the axis, and the flanks have a slope of about 60 feet in half a mile. Part of the west flank ends in a small synclinal tongue that is perhaps slightly faulted. The presence of this fault is some-

[49a] U. S. Geol. Survey Bull. 686–T, pl. 41, p. 258, 1919.

[50] See U. S. Geol. Survey Bull. 686–W, top of p. 343, and pl. 49, p. 330, 1920.

what unfavorable, as it may have permitted the escape of oil and gas or the circulation of water solutions which deposited mineral matter in the pores of the sand. The west flank, from which oil might have gathered, is not wide, but the sharpness of the fold assures the retention near the top of whatever oil might be present. The best localities for tests would be just west of the summit in the W. ½ SW. ¼ NE. ¼ sec. 4, T. 28 N., R. 11 E. These tests might start from 20 to 50 feet below the Iatan limestone, which caps the summit of the anticline, and should encounter the "Mississippi lime" at about 1,700 feet.

TONGUE ANTICLINE.

The Tongue anticline is a tonguelike plunging anticline of very irregular shape, with a general north to northeast trend. The axis runs slightly north of east from the south quarter corner of sec. 35, T. 28 N., R. 11 E., turns due northeast in the NE. ¼ sec. 35, and runs about a quarter of a mile into section 25. The flanks of this anticline are so short and the westward reversal of dip is so slight that it can not be considered of any importance as a source of oil or gas. There are records of two tests on this anticline—one a gas well, probably abandoned, in the NW. ¼ NW. ¼ SE. ¼ sec. 35, on the crest of the anticline, the other a dry hole in the southeast corner of the NW. ¼ SE. ¼ sec. 35, on the east flank at the head of the synclinal tongue which runs in from the northeast.

GORDON ANTICLINE.

Most of the Gordon anticline lies in sec. 26, T. 28 N., R. 11 E. It may be regarded as a northward extension of the Tongue anticline, which it offsets slightly to the west. The trend of its axis is about north-northeast from the center of the south edge of the SW. ¼ sec. 26 to and a little beyond the north edge of the NE. ¼ sec. 26. The anticline has a rather broad, steep west flank, three-quarters of a mile wide, with a difference of elevation of about 55 feet, and a broad, irregular east flank, about a mile wide at its widest part, extending in the form of a plunging terrace into the large Hay Hollow syncline in sec. 25. The closure is only about 10 feet. No adequate test of this fold has been made. There is a record of a dry hole or abandoned well with a showing of oil in the SE. ¼ SW. ¼ SW. ¼ sec. 23, which is almost in the bottom of the syncline that bounds the anticline on the northwest, and of another dry hole in the SE. ¼ NE. ¼ NE. ¼ sec. 27, still farther into the syncline. Some of the best locations for a test would probably be in the SE. ¼ NE. ¼ NW. ¼ sec. 26 and in the 10-acre lots directly to the north and south of that. Wells in this position may be expected to enter the "Mississippi lime" at a depth between 1,750 and 1,800 feet.

HAY HOLLOW SYNCLINE.

The Hay Hollow syncline is worth brief mention both on account of its size, which is unusual for this region, and on account of its relation to other synclines. It seems to lie along a fairly well defined line of synclines extending from the large one in secs. 14 and 11, T. 27 N., R. 11 E.,[51] through a smaller one in the northeastern part of sec. 1, T. 27 N., R. 11 E., and on across a north-south constriction at the back of the South Caney River terrace to the syncline in the southwestern part of sec. 6, T. 28 N., R. 12 E.

WHALEBACK ANTICLINE AND SOUTH CANEY RIVER TERRACE.

The Whaleback anticline is a large plunging east-west anticline lying in secs. 11, 12, 13, and 14, T. 28 N., R. 11 E. Its axis extends approximately from the NE. ¼ sec. 13 through the northwest corner of that section and on slightly beyond the west edge of sec. 14 a little south of the northwest corner. From this main anticline several smaller tonguelike plunging anticlines or broad, short terraces extend in northerly and southerly directions. Essentially the axis is the westward extension of the east-west axis of the South Caney River terrace in and adjacent to the NW. ¼ sec. 18, T. 28 N., R. 12 E.

On account of the uniform plunge of the anticline no part of it stands out as specially favorable for the accumulation of oil. Probably the South Caney River terrace, at the upper end, and some of the branch terraces are the most favorable sites. The only position along the main axis of the anticline that looks more favorable than others is near the middle of the north line of sec. 14, T. 28 N., R. 11 E., where there is a slight break in slope between the flat narrow top of the terrace and the steeper western nose. This position might be about 30 to 50 feet below a narrow ridge in sec. 14 capped by the Cheshewalla sandstone. Depths to different possible oil sands may therefore be estimated from figure 50 (p. 362) and figure 51 (p. 369). From these it appears that the "Mississippi lime" should be encountered at a depth of about 1,720 to 1,740 feet. A test might also be made in the northeast corner of sec. 15, at the outer edge of a small terrace-like expansion of the nose of the anticline.

The South Caney River terrace, which lies in the NW. ¼ sec. 18, T. 28 N., R. 12 E., and the E. ½ NE. ¼ sec. 13, T. 28 N., R. 11 E., is a small terrace of almost circular outline, pinched off at its back end by two north-south synclinal reentrants which almost produce a closed contour. The best point to test it would be at its front (outer) edge. An old test hole, shown on Plate LIV (p. 394), was put down

[51] U. S. Geol. Survey Bull. 686–T, pl. 41, p. 258, 1919.

at very nearly the position that would seem most favorable, appearing to be only 400 to 500 feet too far west. This test is known only from the iron leader found in the field projecting from the ground. No record is available, but the indications are that it was a dry hole. If this is true, it may be an unfavorable indication, but it is quite possible that the hole was not drilled deep enough.

GRAY, GORDON, AND SUNDOWN TERRACES.

Three small terraces, all with axes trending about south-southwest, run out from the south flank of the Whaleback-South Caney River fold. None of them is of much promise. Perhaps the least promising one is the most westerly, the Gray terrace, which lies mainly in the NW. ¼ sec. 23, T. 28 N., R. 11 E. Its flat, irregular west slope is terminated at its base by a pronounced north-south fault about three-quarters of a mile west of the axis of the terrace. There is no pronounced change of slope on any part of it—in fact, it is more of a tongue than a terrace.

The Gordon terrace is essentially a northward extension of the Gordon anticline, from which it is separated by a saddle probably not more than 10 feet deep. It lies mostly in the NW. ¼ sec. 24, T. 28 N., R. 11 E. Its exact form is uncertain, but it seems to be broad-topped with a short but steep west flank. So far as can be judged from what is known about its shape, the best place for a test would be at the top of this steep west slope, in about the SE. ¼ NW. ¼ NE. ¼ sec. 23, T. 28 N., R. 11 E. This would be on top of the Mission sandstone just above Mission Creek. A hole 800 feet or so to the south, in the NE. ¼ SW. ¼ NE. ¼ sec. 23, would be in the valley bottom of Mission Creek, perhaps 25 feet below the Mission sandstone, would be cheaper and more convenient to drill, and should be but little less favorable as a test. The "Mississippi lime" here lies probably about 1,700 feet below the Mission sandstone.

The Sundown terrace lies in the NW. ¼ sec. 19, T. 28 N., R. 12 E. Like the Gordon and South Caney River terraces it is pinched off at its back (north) end by two synclinal reentrants, which almost produce a closed contour. The west flank is unusually steep and shows a very abrupt change to the flat top of the terrace. As this west flank is nearly half a mile wide and has a difference of elevation of some 50 feet, the structural conditions appear favorable for the accumulation of oil. The best location for a test would be near the middle of the west edge of the NW. ¼ sec. 19, T. 28 N., R. 12 E. A test hole in this position would start in the alluvium of the valley of Mission Creek, 100 feet or so below the Mission sandstone, at the foot of a steep bank capped by that bed. The "Mississippi lime" should be encountered at a depth of about 1,625 feet.

MINOR FOLDS ON THE NORTH FLANK OF THE WHALEBACK ANTICLINE.

The width of the Caney River valley, which lies just north of the Whaleback anticline, makes it difficult to correlate the structure from one side to the other of the valley. Consequently, there is much doubt about the long tongues shown on Plate LIV (p. 394) as running north from the Whaleback anticline. The westerly tongue running along the boundary between secs. 10 and 11, T. 28 N., R. 11 E., seems well established as far north as the northwest corner of sec. 11, but beyond that nothing is known about it. What is known shows a narrow anticline with a rather gentle west flank at least a mile broad. Of the east flank less is known, but a gentle slope half a mile wide, with a reversal of dip of 30 to 40 feet, is indicated. The structure appears not unfavorable, and the anticline might be tested anywhere in the easternmost tier of 10-acre lots of the NE. ¼ sec. 10, T. 28 N., R. 11 E. A narrow ridge, capped by the Cheshewalla sandstone with the Iatan limestone overlying much of it, runs along this edge of the NE. ¼ sec. 10. For convenience and economy, the test should be made west of this ridge, as far below the Cheshewalla sandstone as possible. The best opportunity to get below the ridge in the east tier of 10-acre lots is in the NE. ¼ SE. ¼ NE. ¼ sec. 10, T. 28 N., R. 11 E. A test hole in this position should enter the "Mississippi lime" at a depth of about 1,750 feet.

The mapping of the long tongue running north through the E. ½ sec. 12 and into the SE. ¼ sec. 1, T. 28 N., R. 11 E., is much more questionable. This tongue is faintly indicated in the 1,130-foot contour, where it is mapped as turning north from the Whaleback anticline, on the south side of Caney River valley, but the continuation across the valley of the contours that form the tongue is, as indicated by the broken lines on the map, entirely hypothetical. The further possibility should here be mentioned that the relation of the contours on the two sides of Caney River valley, which makes it possible to interpret the structure as shown on the map, may be due to a convergence between the beds used for mapping the structure on these two sides, as the south side was mapped mainly on the Mission and Cheshewalla sandstones and the north side mainly on the Possum and Hulah sandstones. In any case, whether there is such a convergence or not, it is quite possible that most of the contours continue east and west across the assumed tongue, leaving a domelike uplift on the north side of Caney River, separated by a more or less pronounced east-west syncline from the practically smooth flank of the Whaleback anticline on the south side. In the lack of known elevations to prove the presence of the intervening syncline, however, it was considered best to assume the simpler structure indicated, though the occurrence of synclines on both sides and the apparent tendency of

Caney River to flow in synclines give much reason for assuming that the syncline is, nevertheless, there. In either case the best location for a test is just off the west edge of the terrace-like north end, near the west edge of the SW. ¼ SE. ¼ sec. 1, T. 28 N., R. 11 E. The north half of this strip is on the Possum sandstone and the south half in the bottom of Caney River valley, about 40 to 50 feet below.

The parallel north-south tongue in the NE. ¼ sec. 7 and SE. ¼ sec. 6, T. 28 N., R. 12 E., is even more uncertain than the one just discussed, all but the north end falling in the alluvium-covered area. It should be tested in the same position—that is, at the west edge of its terrace-like north end, in the NE. ¼ SW. ¼ SE. ¼ sec. 6, T. 28 N., R. 12 E. This falls in the valley bottom of Caney River, about 50 feet below a ledge of Hulah sandstone. The "Mississippi lime" should therefore be encountered here at a depth of about 1,630 feet.

LOST CREEK ANTICLINE.

The Lost Creek anticline is a moderate fold striking about northeast, which lies mostly in the NE. ¼ sec. 6, T. 28 N., R. 12 E., with a slight extension into T. 29 N., R. 12 E.[52] On account of its smallness and numerous irregularities the anticline may be somewhat unfavorable to the occurrence of oil or gas in commercial quantities near the summit. The best location for a test would be either in the NE. ¼ NW. ¼ NE. ¼ or the NW. ¼ NW. ¼ NE. ¼ sec. 6, T. 28 N., R. 12 E., or between the two faults shown in Plate LIV (p. 394) in the NW. ¼ SW. ¼ NE. ¼ sec. 6.

COON CREEK ANTICLINE.

The summit of the Coon Creek anticline lies in the NW. ¼ sec. 4, T. 28 N., R. 12 E. Thence it plunges with a north-northwest trend about a mile into T. 29 N., R. 12 E. It has been discussed at some length in the report on that township,[53] where the fact was brought out that there is some doubt about the existence of the eastward reversal shown on the map, and, as a consequence, about the existence of the entire anticline. This doubt is due to the fact that almost the entire area of the assumed east flank, except a small portion of the north end, lies under the alluvium of the valley of Coon Creek. If the structure is at all as indicated, the anticline is one of the best in the area under consideration. It has a steep west flank about a mile wide and a well-defined domelike summit, with a closure of 30 to 40 feet. It is possible that there is a north-northwesterly fault along the west side of the valley of Coon Creek cutting the anticline just east of the axis. Such a fault might have afforded a channel for the escape of oil and gas accumulated near the top of the anticline.

---

[52] U. S. Geol. Survey Bull. 686–W, pl. 49, p. 330, 1920.
[53] Idem, pp. 346–347.

One of the best locations for a test would be in the SW. ¼ NW. ¼ NW. ¼ or the NW. ¼ SW. ¼ NW. ¼ sec. 4, T. 28 N., R. 12 E. This would bring the mouth of the test hole a little above the Hulah sandstone, and the "Mississippi lime" should therefore be encountered at a depth of about 1,800 feet. Another position for a test would be about the center of the N. ½ sec. 5, T. 28 N., R. 12 E., at the west edge of the terrace-like expansion in the NE. ¼ of that section. A hole in this position would start in the valley bottom of Lost Creek north of the town site of Hulah and about 50 feet below the top of the Hulah sandstone. The "Mississippi lime" should therefore be encountered at a depth of about 1,700 to 1,720 feet. If either of these locations is found to be productive, the producing territory might be expected to extend all or part of the way toward the other.

DIVIDE TERRACE.

The Divide terrace is an east-west terrace that lies southeast of the Coon Creek anticline and extends through the S. ½ secs. 3 and 4 and the SE. ¼ sec. 5 and into the northern parts of secs. 9 and 10, T. 28 N., R. 12 E. The assumed central part of it, across its axis, is concealed by the alluvium of Coon Creek. So far as can be determined, it is unusually broad and flat, but nevertheless it does not look very favorable for the accumulation of oil, because it appears to have no well-defined outer edge where the dip abruptly flattens. Perhaps the nearest approach to such a change in dip is about in the center of the S. ½ sec. 5, T. 28 N., R. 12 E., and a test might be made there. A well in this position would start at about the same horizon as that suggested in the N. ½ sec. 5 on the Coon Creek anticline, and should encounter the "Mississippi lime" at the same or a slightly greater depth—that is, about 1,700 to 1,725 feet.

Another slightly favorable position for a test would be in the NW. ¼ SW. ¼ NW. ¼ sec. 9, T. 28 N., R. 12 E. The presence of a dry hole with salt water near the top of the "Mississippi lime" about half a mile to the south (see column 6, Pl. LI, p. 378) is, however, an unfavorable indication for this test. A well in this position would start about 80 feet below the top of the Hulah sandstone and should encounter the "Mississippi lime" at a depth of about 1,725 feet.

BUTTE DOME.

The Butte dome lies mainly in the SE. ¼ sec 8, T. 28 N., R. 12 E. It is the summit of a tonguelike southwestward-plunging anticline which branches off from the Divide terrace. The south and west extension of this anticline is concealed by the alluvium of the Caney River valley, but it appears probable that in the N. ½ sec. 17, T. 28 N., R. 12 E., the axis turns west and is practically continuous with the axis of the South Caney River terrace and Whaleback anticline, though a syncline in the area covered by alluvium may separate the two axes. This dome is small and not very promising and has already been tested (see Pl. LIV, p. 394) by a dry hole with considerable salt water that went 63 feet into the "Mississippi lime" in the NW. ¼ NW. ¼ SW. ¼ sec. 9, T. 28 N., R. 12 E. (see column 6, Pl. LI), and, as reported, by a gas well abandoned in the northeast corner of the SE. ¼ SE. ¼ sec. 8, T. 28 N., R. 12 E. There is much doubt of the existence of this gas well. The locality given is in a favorable position on the dome, but the occurrence of salt water in the other well so near by appears inconsistent with the presence of gas in this well. It may be more reasonable to assume that the dome is unproductive.

SUNDOWN ANTICLINE.

As represented on the geologic map (Pl. LIV) the axis of the Sundown anticline runs southeast from the NE. ¼ sec. 19 toward the southeast corner of sec. 20, T. 28 N., R. 12 E. The structure is very doubtful, however, because it was mapped from a thick series of lenticular sandstones exposed along a narrow, heavily wooded ridge lying between the alluvium of Caney River on one side and that of Mission Creek on the other. There appear to be two slight domelike summits along this axis, one around the west quarter corner of sec. 20, the other about the center of the S. ½ sec. 20. The former is by far the better, as it has a wide west flank; the latter appears to be situated at the head of a syncline. The former might be tested by a hole in the SW. ¼ SE. ¼ NE. ¼ sec. 19, T. 28 N., R. 12 E. A hole in this position would be near the foot of the ridge in the valley bottom of Mission Creek, about 100 feet below the Mission sandstone, and should encounter the "Mississippi lime" at a depth of about 1,700 feet. If this proves productive, drilling might be continued toward the other small anticlinal summit in the S. ½ sec. 20, T. 28 N., R. 12 E.

TRIPLET DOME.

The Triplet dome is a small uplift in the SW. ¼ sec. 16 and NW. ¼ sec. 21, T. 28 N., R. 12 E. The mapping of it is based mainly on a few elevations taken on a small hill bounded on three sides by alluvium, so that its form, like that of the Sundown anticline, is not well determined. A single contour incloses the elliptical summit, of which the longer axis measures about 1,500 feet. The extent of the west flank is entirely unknown, as this flank is covered by the alluvium of Caney River valley. The best location for a test, and that is not promising, would be on the northwest side of the small hill that lies on the west edge of the summit of the dome, about in the SW. ¼ SE. ¼ SW. ¼ sec. 16, T. 28 N., R. 12 E. A hole in this position would start on the

Hulah sandstone, which caps this hill, and should encounter the "Mississippi lime" probably at a depth of about 1,850 to 1,900 feet, though the distance is hard to estimate accurately in the absence of other wells in the neighborhood.

SCOTT ANTICLINE.

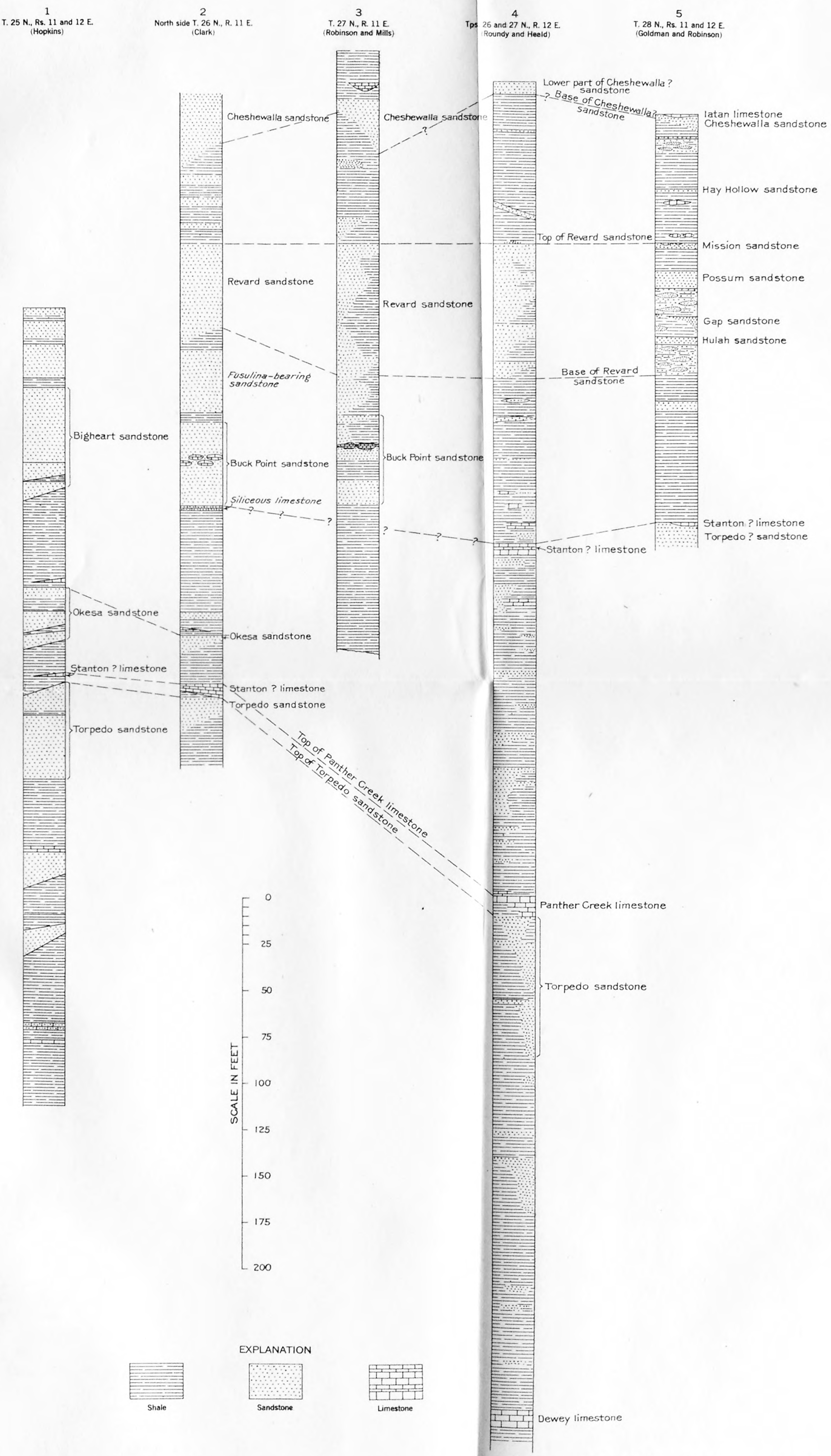
The Scott anticline is a small northeastward-plunging anticline lying mainly in the SE. ¼ sec. 36, T. 28 N., R. 11 E. Like the Tongue anticline, about a mile to the west, it is a plunging fold projecting from a broad northward-dipping slope south of it in the northern part of T. 27 N., R. 11 E.[54] The short, broad northwest slope and the lack of any closure on this anticline make it rather unfavorable for the accumulation of oil. There is no record of any development work on this fold. Probably the best locations for tests would be about the center of the SE. ¼ SW. ¼ and the southeast corner of the NW. ¼ SE. ¼ NE. ¼ sec. 36, T. 28 N., R. 11 E. In each of these locations the hole would start at a horizon between the tops of the Cheshewalla and Hay Hollow sandstones and should encounter the "Mississippi lime" at a depth of about 1,900 feet.

LOOKOUT ANTICLINE.

The Lookout anticline lies in the southeast corner of the area here considered. It is like many of the folds described in the preceding pages in that the details of its form are uncertain. It was defined mainly by elevations taken on the thick series of lenticular sandstones below the horizon of the Hulah sandstone exposed on narrow, heavily wooded ridges in the southern part of T. 28 N., R. 12 E., and correlated with elevations across the alluvium-filled valleys of Mission Creek and Caney River near their junction, a gap in places as great as 2 miles. It appears to be an elongated anticline plunging a little north of west. Near the east end of the narrow wooded ridge in the northern part of sec. 33, T. 28 N., R. 12 E., there is pretty good evidence for a reversal of dip, with a single closed contour marking the summit of the anticline lying mostly in the NE. ¼ of that section. It is reported that a dry hole was sunk just south of the north quarter corner of that section, at the edge of the closed contour shown on the geologic map (Pl. LIV). This would appear to be a favorable location for a test. Unfortunately only the record of the position of this hole, without any further information, is available. Moreover, the advantage that this location seems to possess from its position near the summit of the anticline is largely offset, on the one hand, by the uncertainty as to the actual existence of the wide north-northwest

[54] U. S. Geol. Survey Bull. 686–T, pl. 41, p. 258, 1919.

flank, which would be the principal gathering ground for oil toward the summit, as the area occupied by this assumed flank is almost entirely concealed by the alluvium of Mission Creek and Caney River, and on the other hand by the gentle, terrace-like slope of the plunging top of the anticline to the west. Oil coming from this direction might have been caught at the top of the west nose of the anticline, in the SE. ¼ SW. ¼ sec. 29, T. 28 N., R. 12 E., where the sharp change in dip occurs. A further test should therefore be made in the SW. ¼ SE. ¼ SW. ¼ sec. 29 or the NW. ¼ NE. ¼ NW. ¼ sec. 32, T. 28 N., R. 12 E. Tests in these locations might start on the Hulah sandstone near the top of the ridge or by moving a little farther west down the nose they could be started in the valley bottom, probably 100 feet or slightly more below the Hulah sandstone. The distance to the "Mississippi lime" is hard to estimate here, in the absence of any records of wells near by, but may be taken as about 1,850 feet below the Hulah sandstone. It must be admitted that the indications from the test at the northwest edge of the summit of this anticline, referred to above, are unfavorable, for even if the oil rising on the fold was caught at the west nose gas at least might be expected at the summit. Still, in view of the scant knowledge about this test another hole might be sunk near by, in the northeast corner of the NW. ¼ sec. 33, T. 28 N., R. 12 E. A hole in this position would start in the alluvium along the bank of Mission Creek near its mouth, at the foot of the high wooded ridge mentioned above, probably about 225 feet below the horizon of the Hulah sandstone. A rough estimate would place the "Mississippi lime" at a depth of 1,700 to 1,750 feet in this hole.



GRAPHIC SECTIONS OF THE ROCKS EXPOSED IN TPS. 26 AND 27 N., R. 12 E., OSAGE COUNTY, OKLA., COMPARED WITH THOSE EXPOSED IN THE ADJACENT TOWNSHIPS

ENGRAVED AND PRINTED BY THE U.S. GEOLOGICAL SURVEY