AN ANTICLINAL FOLD NEAR BILLINGS, NOBLE COUNTY, OKLAHOMA.

By A. E. Fath.

INTRODUCTION.

INCENTIVE FOR INVESTIGATION.

During February, 1916, gas was struck in small quantities at shallow depths in a well being drilled by the Mid-Co Petroleum Co. a few miles southeast of Billings, Noble County, Okla. As this discovery was made at a place more than 20 miles distant from any other known oil and gas development it has attracted considerable attention, which is justified by the presence of a large anticlinal fold, a type of structure that should be favorable for the accumulation of oil and gas. A description of the anticlinal fold and a discussion of the possibilities of developing an oil and gas field here are given in this brief report, which is based on a rapid examination of the region made late in February and early in March, 1916.

LOCATION, ACCESSIBILITY, AND CULTURE.

The anticlinal fold to be described lies in the northwestern part of Noble County, Okla. (See fig. 1, p. iv.) It may extend northward into Kay County, but the scarcity of rock outcrops made it impossible to verify this supposition in advance of sufficient drilling to determine the underground structure.

The town of Billings, which is at the terminus of a branch line of the Chicago, Rock Island & Pacific Railway running from Enid, is the nearest shipping point. Bliss and Red Rock are near-by towns on the Atchison, Topeka & Santa Fe Railway, which runs a short distance east of the area shown on the accompanying map (Pl. IX). Perry, the county seat of Noble County, is 9 miles to the south, at the intersection of the Atchison, Topeka & Santa Fe and the St. Louis & San Francisco railroads. The region of the anticline can be reached from any of these towns.

The surface of the area is in general a gently rolling prairie but is modified here and there by low escarpments where the more resistant beds have withstood erosion better than the adjacent softer beds. The region is almost devoid of timber except along the stream valleys. Most of it is under cultivation and it contains many good farms. The roads follow the section lines and most of them are sufficiently good for automobile travel.

METHODS OF FIELD WORK.

For lack of time a detailed map of the entire region was not made, but it is believed that the more important anticlinal features were determined with considerable accuracy. The structure contours on the map (Pl. IX) are based on elevations and locations determined by means of plane table, telescopic alidade, and stadia rod. Such structure contours show how the rock beds lie. They usually refer to some particular bed and represent the elevations or altitude above some datum plane at which this bed may be found. Where the bed has been worn away they represent the elevations at which it lay before it was removed. The elevations shown on Plate IX are based on a bench mark established by B. F. Lewis, surveyor of Garfield County, at the southwest corner of sec. 19, T. 24 N., R. 2 W., and described as a spike in a telephone pole at the northeast corner of the road intersection, elevation 1,036.31 feet. This bench mark is based on the elevation of a United States Geological Survey bench mark at Enid, Okla. At several places where lack of time did not permit accurate plane-table determinations of strike and dip the approximate strike and dip as observed by the writer are shown on the map (Pl. IX) by the ordinary strike and dip symbol.

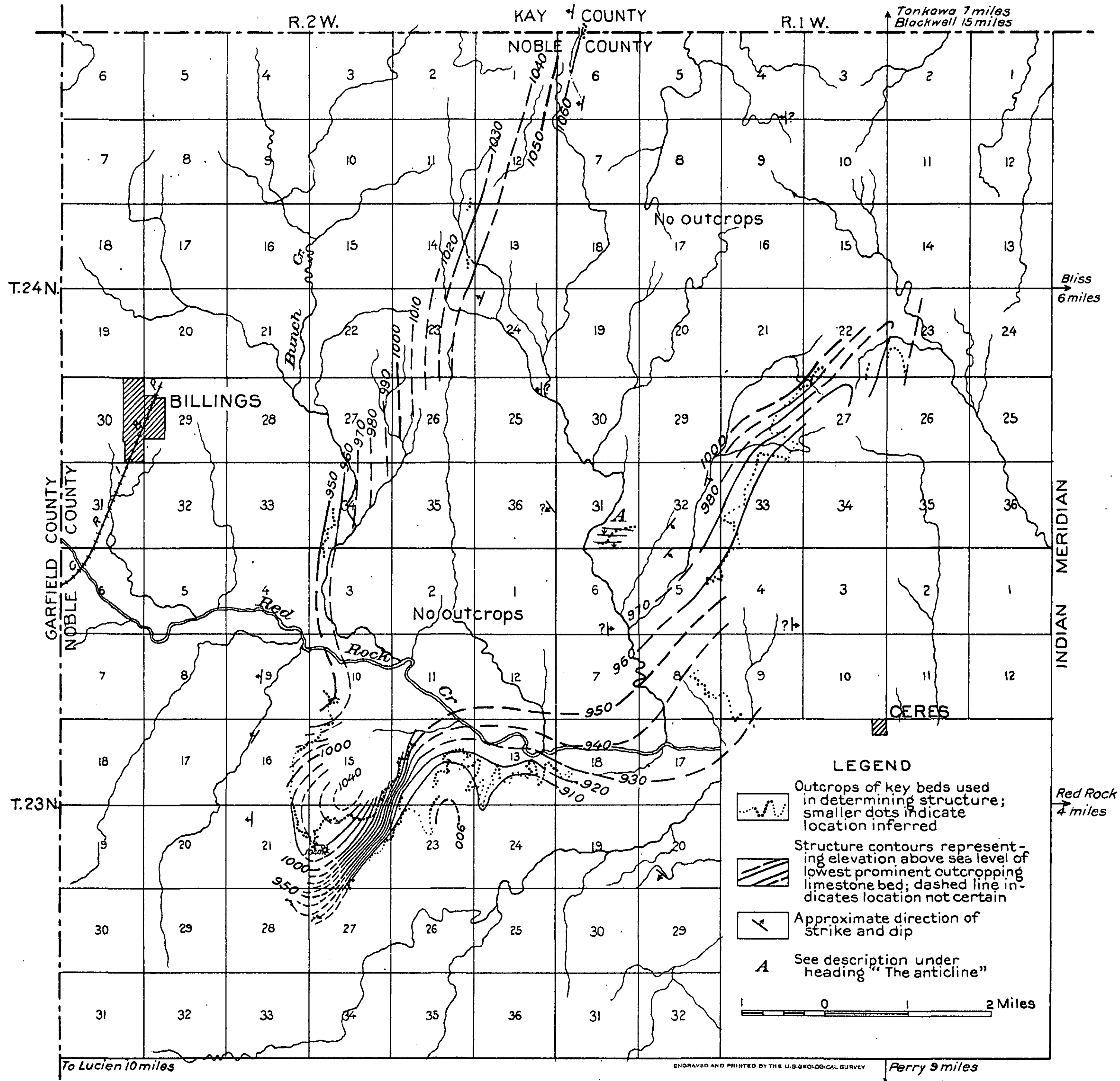
ACKNOWLEDGMENTS.

The writer is indebted to many individuals and companies for information and suggestions, and desires to express especial obligations to Valerius, McNutt & Hughes, Julius Fohs, Frank B. Van Horn, L. E. Trout, and the drillers of the Mid-Co Petroleum Co.'s well.

GEOLOGY.

STRATIGRAPHY.

The surface rocks of the region have an aggregate thickness of more than 150 feet and are predominantly shale, but include also sandstone and argillaceous limestone, all of Permian age. The position of these rocks in the Permian series is roughly estimated at 500 to 900 feet above the horizon of the Neva limestone, which is generally placed near the top of the underlying Pennsylvanian series. No single outcrop shows the complete succession of rocks exposed in the region, and hence to obtain the following stratigraphic section it was necessary to combine parts of the section measured at three localities.



MAP OF ANTICLINAL FOLD NEAR BILLINGS, OKLAHOMA

Composite section of exposed rocks measured in the Billings region.

Section exposed in the NW. ¼ sec. 23, T. 23 N., R. 2 W.

	Ft.	in.
1. Sandstone, reddish brown, cross-bedded, ripple marked; thickness variable	3±	
2. Shale and thin sandstones, poorly exposed, probably reddish to chocolate-brown in color	19	0
3. Sandstone, reddish brown, thin bedded, poorly exposed	1±	
4. Shale, reddish chocolate-colored	5±	
5. Limestone, composed of angular limestone particles		3
6. Shale, gray; contains four thin limy layers in upper 2 feet	5	3
7. Limestone, argillaceous, light gray		1
8. *a.* Shale, gray to reddish chocolate-colored, about	6±	
b. Shale, gray; near middle contains a 4-inch layer of concretions as much as 2 inches in diameter	3	9
9. Limestone, argillaceous, light gray		2
10. *a.* Shale, gray		1
b. Shale, mottled greenish gray and red, limy near top	5	0
11. Limestone, argillaceous, light gray; thickness variable		6–10
12. *a.* Shale, gray		4
b. Shale, chocolate-colored	2	0
13. Limestone, argillaceous, light gray		2±
14. *a.* Shale, reddish gray		11
b. Shale, reddish chocolate-colored; base not exposed	3+	
c. Poorly exposed; probably all shale	9±	

Section exposed in the NW. ¼ sec. 14, T. 23 N., R. 2 W.

	Ft.	in.
15. Sandstone, dark red, cross-bedded; contains plant remains; thickness variable	1–5	0
16. *a.* Shale, gray	5±	
b. Shale, maroon	1	0
c. Shale, gray	5	0
17. Limestone, argillaceous, light gray, thin bedded; weathers out in small angular fragments		8
18. Shale, gray, limy near top		9
19. Limestone, argillaceous, light gray		3
20. Shale, gray		3
21. Limestone, argillaceous, light gray		3
22. Shale, gray		6
23. Limestone, argillaceous, light gray, rather massive; contains mud cracks		8
24. *a.* Shale, limy, and argillaceous limestone; in beds ½ inch to 3 inches thick; limestone light gray and shale dark gray	2	0
b. Shale, not well exposed but probably gray	6	8

	Ft.	in.
25. Limestone, argillaceous, light gray; contains thin lenses of gray shale; lowest bed 2½ inches thick and contains many shells of the bivalved crustacean (Estherea cf. *E. minuta*). At some localities this bed is sandy		6
26. *a.* Shale, gray to greenish gray	1	9
b. Shale, dark gray, almost black		9
c. Shale, gray to yellowish gray	7	0
27. Limestone, argillaceous, thin bedded; weathers out in small fragments; contains thin lenses of gray shale	1	2
28. *a.* Shale, dark gray	1	1
b. Shale, gray, more resistant near bottom and top than in middle	2	6
c. Shale, gray to greenish gray	5	3
29. Limestone, light gray, thin bedded, weathers out as small slabs or plates; shows some cross and wavy bedding; contains thin lenses of gray shale	1	6
Section exposed in the NW. ¼ sec. 22, T. 23 N., R. 2 W.		
30. *a.* Shale, yellowish gray	5	0
b. Shale, mottled gray and reddish gray	2	0
c. Shale, bluish gray	3	0
d. Shale, very limy		1
e. Shale, gray	5	6
f. Shale, mottled greenish gray and reddish brown	2	6
g. Shale, gray, contains three thin limy layers, one 7 inches, another 13 inches, and the other 18 inches below the top	6	0
h. Shale, reddish chocolate-colored	1	10
i. Shale, gray	3	2
j. Shale, very limy, light gray		2
k. Shale, gray, contains one thin limy layer 3 inches above bottom	2	9
l. Shale, reddish brown	5	6
m. Shale, gray, base not shown	3+	
	154	6+

The three most conspicuous of these strata were used as key beds in determining the details of the structure. These key beds are No. 29 of the section, which is the lowest limestone bed; No. 15, which is the sandstone bed near the middle of the section; and Nos. 1, 2, and 3, the group of sandstones at the top. The structure contours on the map show the position and elevation of bed No. 29, the lowermost limestone, which is generally very thin bedded and weathers out as thin plates or slabs. Where these characteristics are not pronounced or the outcrop is poor the bed can usually be identified by the presence of the less prominent but fossiliferous limestone bed (No. 25) about 20 feet above it. The sandstone beds of the section usually form prominent ledges and can generally be distinguished from one another. The lowermost bed of sandstone (No. 15) ranges in thickness from a few inches to 5 feet and can be distinguished from the upper bed by its association with the thin limestones beneath rather than by any inherent characteristics of its own. The upper sandstones can be identified by the presence immediately beneath them of a considerable thickness of associated chocolate-colored shale. These associations are not uniformly persistent, but by a study of the section in the field the beds can usually be discriminated.

STRUCTURE.

GENERAL FEATURES.

The rock beds of northeastern and north-central Oklahoma generally dip to the west or the northwest, and in north-central Oklahoma the average dip at different places ranges from 25 to 50 feet to the mile. Wherever the dip to the west is typically developed the place is unfavorable for finding oil and gas. Oil and gas are more likely to be found at places where the rocks have been warped or folded and the beds either lie flat or dip to the east. The size and value of the more productive oil fields of Oklahoma depend almost directly on the areal extent of the folds and the amount of their dip to the east, and if these are here the controlling features, the anticlinal fold herein described, which resembles that of the developed oil fields in Oklahoma, should be favorable to the accumulation of oil and gas in this region.

The anticlinal fold in this area trends in general northeastward and occupies parts of at least Tps. 23 and 24 N., Rs. 1 and 2 W. As there are few outcrops its exact magnitude and extent can not be fully determined, but sufficient data are at hand to indicate its general shape and size. The scattered rock outcrops show that the anticlinal fold has at least two parts, an elongated dome to the southwest and a broad anticline to the northeast.

THE DOME.

Near the center of T. 23 N., R. 2 W., the anticlinal fold is narrower and its sides are steeper than elsewhere, as is shown by the rock beds, which are excellently exposed here. This local feature is oval and may be called a short anticline or, preferably, an elongated dome.

Unlike many other anticlines and domes in Oklahoma, whose forms can be determined only by painstaking work or by doubtful correlation of beds, this dome is so well exposed that it can be readily seen even by the layman. The structure can be observed to the best advantage by looking south and west from the northeastern part of sec. 15, T. 23 N., R. 2 W.; and by looking west, north, and east from the top of the escarpment near the center of the northern part of sec. 22 of the same township. From the first point of observation the crest of the fold may be seen near the north quarter corner of sec. 22, where the beds in the escarpment are practically flat. The dip to the east may be seen in the escarpment east of this crest and can be followed into the west side of sec. 14. From the second point of observation the thin limestone beds can readily be seen descending both to the east and the west from the crest of the dome.

The highest part of the dome is in the south-central part of sec. 15. As before mentioned, the dome is oval and appears to extend southwestward into the SE. ¼ sec. 21 and northeastward into the SE. ¼ sec. 10. The southeast dip on the dome persists for at least a mile, and in this distance the beds descend in elevation more than 130 feet. Exactly how far this dip to the southeast persists is not known, for the rock outcrops are insufficient to permit its determination farther.

On the northwest side of the dome the beds dip away steeply for a mile or more before they resume the normally gentle westward dip of the region.

The southwestern termination of the dome appears to be in the NE. ¼ sec. 28, although this assumption could not be definitely proved. It seems probable that the sandstone which crops out in the road about a quarter of a mile east of the southwest corner of sec. 22 is the lowest sandstone bed (No. 15 of the section on pp. 123–124). The sandstone exposed a few hundred feet north of the south quarter corner of sec. 22 is almost certainly the highest sandstone bed (No. 1) of the section. Less certainly, but probably, the sandstone exposed in the center of the SW. ¼ NW. ¼ sec. 27 and the residual sandstone near the center of the NE. ¼ sec. 28 are from this same bed. Whether or not the slope of the surface in the SW. ¼ sec. 22 and the SE. ¼ sec. 21 represents roughly the position in which the underground rock beds lie (dip slopes) can not be certainly determined, but the position of the few scattered outcrops just mentioned seems to lend some basis for this assumption.

The dip of the beds in the NW. ¼ sec. 15 is almost north and indicates that the dome is lower in the northern part of this section than farther south. The structure here could not be exactly determined for lack of outcrops, but it is probable that a "low" or "saddle" in the anticlinal axis in this locality marks the northeastern termination of the dome.

THE ANTICLINE.

The northern and apparently the larger part of the Billings anticlinal fold can not be so fully nor so readily distinguished because of insufficient rock outcrops. It is a broad fold at least 5 miles wide and can be traced with certainty northeastward for about 7 miles. It narrows abruptly at its southern extremity, where it is connected with the dome to the southwest by a "low" or "saddle." Its sides are poorly outlined by two belts of scattered outcrops—an eastern belt, in which the beds dip to the southeast and which extends from the SW. ¼ sec. 23, T. 24 N., R. 1 W., to the NW. ¼ sec. 16, T. 23 N., R. 1 W., and a western belt, in which the beds dip to the west and which extends from the SW. ¼ sec. 31, T. 25 N., R. 2 W., to the NW. ¼ sec. 3, T. 23 N., R. 2 W. The eastern limit of the eastward-dipping beds was determined at but one place—in the SE. ¼ sec. 22, T. 24 N., R. 1 W. On the northeast there are no outcrops that indicate the character and location of that end of the anticline. The axis of the fold is indistinctly indicated at one place; it appears to cross secs. 30 and 31, T. 24 N., R. 1 W., in a northeasterly direction.

In the belts of outcrops mentioned above, the beds exposed are the same as those in the dome to the southwest, and they can be recognized with comparative ease. The almost complete absence of rock outcrops in the northern part of T. 24 N., R. 1 W., leaves the attitude of the northeast end of the anticline a matter of conjecture only. Whether the beds north of secs. 22 and 23, T. 24 N., rise rapidly and resume the normal westward dip, thereby terminating the anticline within this township, or whether they continue to strike northeastward and thereby extend the anticline to the township and county to the north can not be determined. The presence of the broad, silt-covered valley of Salt Fork River would appear to preclude any possibility of finding the northeast end of the anticline in the township on the north, as even the upland on the south contains practically no outcrops.

In the area embraced by the two belts of outcrops that outline the southeastern and northwestern flanks of the anticline there are a few scattered outcrops that expose beds of shale and thin beds of sandstone. These were not traced from place to place, and their exact position with reference to the beds of the measured section on pages 123–124 is not known, but they lie below the limestone-bearing series shown in the section. The strike and dip at several of these outcrops are more or less apparent, and the writer's observations are shown on the map (Pl. IX) by strike and dip symbols. An accurate determination of the strike and dip was made instrumentally in the SE. ¼ sec. 31, T. 24 N., R. 1 W., and these are shown on the map by a few short contours. A dip of 18 feet in 500 feet, or at an angle of about 2°, was measured by hand level and pacing in a "wash" in the SW. ¼ sec. 32, T. 24 N., R. 1 W. The direction of this dip was measured on a line trending S. 72° E. The exact strike of the beds was not determined. These observations, together with the attitude of the beds in the southeastern belt of outcrops mentioned above, indicate a dip to the southeast in a zone that averages more than three-quarters of a mile in width. This southeastward dip doubtless extends in both directions, but how far can not be determined. The amount of dip can also not be determined with any certainty. Estimates of the amount of dip to the southeast by different geologists would probably differ considerably. To the writer, 100 feet would be a low estimate; he would rather consider it equal to or even greater than that of the east dip on the dome, which, measured at one place, was about 130 feet.

The strong dip to the southeast observed in the SW. ¼ sec. 32, the dip to the south measured in sec. 31, and the probable dip to the west observed in the east-central part of sec. 36 and the NE. ¼ sec. 25, T. 24 N., R. 2 W., indicate that the crest of the anticline probably crosses secs. 30 and 31.

The eastern limit of the easterly dip was determined at one place, in the southeastern part of sec. 22, T. 24 N., R. 1 W., for in sec. 23 of the same township the dip is to the west. The axis of the syncline thus formed by the convergence of eastward and westward dipping beds can probably be followed southward, but the poor outcrops in this locality would necessarily make the work slow and uncertain.

A study of the structure contours shows that the anticline pitches to the southwest. The rise of the anticline to the northeast may produce either a broadening or a flattening of the structure in this direction. If it flattens, the northern extension of the dip to the east may terminate in T. 24 N., R. 1 W., and the beds may there resume their normal dip to the west. If the anticline does not flatten but continues northeastward, it probably extends northward to T. 25 N., R. 1 W. The drill will no doubt at some time furnish much of the information which is now lacking because of the absence of rock exposures.

DEVELOPMENT.

The well in which the original discovery of gas in the Billings region was made was drilled by the Mid-Co Petroleum Co. It is on the W. Hoover farm, near the center of the north line of the SW. ¼ sec. 22, T. 23 N., R. 2 W., and is high on the dome. The mouth of the well is about at the horizon of bed 24 of the stratigraphic section given on pages 123–124. Up to May 8, 1916, drilling had reached a depth of about 1,570 feet.

After the discovery of gas in the dome, the Humphreys Petroleum Co., according to press reports, started two wells[1] on the anticline. One of these is located on the Fred Murray farm, in sec. 17, T. 24 N., R. 1 W., and the other is in sec. 20, T. 24 N., R. 1 W. A depth of about 500 feet has been reported for the one in sec. 17.

[1] The reported locations of these wells were received too late to be incorporated on Plate IX.

OIL AND GAS SANDS.

The Mid-Co Petroleum Co.'s well, which is on the dome, has encountered seven gas sands (see log on p. 133) at depths of 570–582, 740–755, 830–842, 860–870, 880–905, 1,027–1,047, and 1,476–1,545 feet. Each sand encountered increased the production, and, according to the trade journals, the well is now capable of producing several million cubic feet of gas a day.

The Humphreys Petroleum Co.'s well in sec. 17, T. 24 N., R. 1 W., is reported to have struck a gas sand at a depth of 470 feet. Whether or not this gas sand is the same as the highest sand in the Mid-Co Petroleum Co.'s well is not known.

The finding of gas sands in the Mid-Co well shows that the dome is favorable for the accumulation of gas, even at shallow depths. The quantity of gas found in the Humphreys test on the anticline was not reported. Its presence, however, is encouraging, and would seem to indicate that the anticline also contains paying quantities of gas.

In any further discussion of the possibilities for finding additional oil and gas sands in this or any other region the relation of the area to all the near-by oil and gas producing regions should be considered. Three such regions must be considered in relation to the Billings anticlinal fold. Located with reference to the Mid-Co Petroleum Co.'s well, they are the Blackwell oil and gas field, about 30 miles to the north; the Ponca City oil and gas field, about 21 miles to the northeast; and the area in which the Watchorn & Fortuna Oil Co.'s gas wells were recently drilled, 23 miles to the east.

The Watchorn & Fortuna Oil Co.'s first well, in so far as the well record (see p. 134) shows, encountered no oil and gas sands until it reached a depth of 1,990 feet. Twenty-five feet below this depth—that is, at a depth of 2,015 feet—it encountered its main flow, which yielded an initial production of over 35,000,000 cubic feet of gas a day. If this prolific gas sand extends northwestward it should have been penetrated by all the deep wells in the Ponca City field. As far as the writer is aware no prolific gas sand has been reported at Ponca City at a depth of 2,000 to 2,300 feet, where this sand should be found.

In the Ponca City field, northeast of the Mid-Co Petroleum Co.'s well, there are several shallow gas sands and three deeper oil sands, at depths of about 975, 1,330, and 1,550 feet. The two lower are the only productive oil sands.[1] These oil sands or closely related sands are either barren or absent in the region of the Watchorn & Fortuna Oil Co.'s wells. Records of two Ponca City wells are given on pages 134–136.

[1] Ohern, D. W., and Garrett, R. E., The Ponca City oil and gas field: Oklahoma Geol. Survey Bull. 16, pp. 28–29, 1912.

In 1911 a dry hole was drilled on the 101 Ranch, in sec. 25, T. 25 N., R. 1 E., which is 3 miles nearer to the Mid-Co Petroleum Co.'s well than the Ponca City field. The log of the drilling is given on page 136.

In the Blackwell field, in Kay County, north of the area here discussed, there are many gas sands, both shallow and deep, and one deep producing oil sand, from which some wells have had initial productions of over 1,000 barrels a day. Logs of two wells in this field are given on pages 137–138. The Blackwell field is 13 miles distant from the Ponca City field. The two fields are similar in respect to the presence of numerous shallow gas sands. The oil sands of the Ponca City field are either gas bearing, barren, or absent at Blackwell, where it might be expected that they would be found 100 to 400 feet lower than at Ponca City. Similarly, the deep oil and gas sand at Blackwell is either absent or nonproductive in the wells that penetrate its horizon at Ponca City.

As far as it has been developed, the dome in the Billings region is similar to the Ponca City and Blackwell fields in respect to the presence of numerous shallow gas sands. It appears, however, that the producing sands at Blackwell, at Ponca City, or in the Watchorn & Fortuna Oil Co.'s wells, in sec. 33, T. 23 N., R. 3 E., and sec. 4, T. 22 N., R. 3 E., are not of the persistent type, such as the Bartlesville and other sands found farther east in the State. Because of this apparent nonpersistency, especially of the more prolific oil sands, the probability that these particular sands will be productive in the Billings region seems small. However, the fact that the oil sands are more or less local in extent gives hope that local oil sands will also be found in the Billings region.

If any of the producing sands at Blackwell persist southward into the Billings region and are there capable of producing either oil or gas, it is the writer's opinion, which, however, is not based on field work done between the two areas, that, unless there is a considerable change in the thickness of the beds in the intervening area, the sands should be found at practically the same depth with reference to sea level in the two fields, which appear to be almost in line with the regional strike of the rocks. In like manner the producing sands of the Ponca City field should lie 200 to 500 feet lower in the Billings region than at Ponca City, and the gas sand of the Watchorn & Fortuna Oil Co.'s wells should lie 300 to 600 feet lower.

The value of a commercial oil or gas pool depends directly on the areal extent and richness of the pay sands and inversely on the depth at which the oil or gas is found. The deeper the sands the richer must the production be to put the wells on a commercial basis. The deepest known producing sands in north-central Oklahoma are in the Blackwell field, at a depth of about 3,300 feet. There is no apparent reason why oil or gas bearing sands may not exist in the Billings region at the same or even greater depths than at Blackwell, and for this reason a favorably located deep test well should be drilled there at some future time. If highly productive sands are found at shallow depths such a deep test will naturally be deferred until it seems advisable to look for additional producing sands.

RELATIVE VALUES OF THE PROSPECTIVE OIL AND GAS LANDS.

The region discussed in this report is probably all under lease by oil and gas companies, and it is therefore believed that the dome and anticline will be thoroughly tested. The insertion here of any statement as to the value of different parts of the region for drilling will probably not seriously influence any plans for development, but inasmuch as this report is for the benefit, not only of geologists and oil and gas producers, but also of the general public and those unfamiliar with the interpretation of geologic structure with reference to oil and gas, a few notes are given. It is a generally accepted fact that only the drill can determine the exact oil and gas value of any piece of land. For this reason the following discussion of land values must be tentative and suggestive only. It is based entirely on geologic structure and the fact that the rocks underlying the region are yielding commercial quantities of oil and gas in localities near by, these being the only factors governing the occurrence of oil and gas that can be determined by a study of the surface of the region. It must also be understood that other geologists may arrive at different conclusions from those here presented, and inasmuch as any such conclusions are more or less theoretical, all of them may carry equal weight.

Until drilling has definitely demonstrated the relative value for oil and gas of the different land units in the field, the crests of the dome and the anticline must be assumed to be the most valuable. The land lying immediately adjacent to the crests ranks next to them in value. Farther from the crests, however, the value decreases rapidly, being governed by the rate of dip and the distance from the crests. The greater the dip the greater is the corresponding decrease in value with increasing distance, and in the troughs of the neighboring synclines the lands theoretically have no oil and gas value.

On applying the principles above given to the dome, it would appear that the most valuable land on this structure is included in the NW. $\frac{1}{4}$ sec. 22, the E. $\frac{1}{2}$ NE. $\frac{1}{4}$ sec. 21, the southeastern part of the SE. $\frac{1}{4}$ sec. 16, and the SW. $\frac{1}{4}$ and W. $\frac{1}{2}$ SE. $\frac{1}{4}$ sec. 15. The rest of sec. 15, the northwest half of sec. 22, the northeast half of sec. 21, the southeast half of sec. 16, the SE. ¼ sec. 10, the southwestern part of sec. 11, and a small area in the western and northwestern parts of sec. 14 are to be considered as next in value. Outside of these areas the probable value of the land decreases rapidly as its distance from the central area increases. As the dip is greater on the southeast side of the dome, the value of the land in this direction decreases more rapidly than it does on the west and northwest flanks.

The valuation of the land on the anticline is much more difficult than of that on the dome, because the rock outcrops on which the determination of structure depends are much fewer in number. If the dip of the rocks on the anticline corresponds to the dip of the rocks on the dome, the steeper dips should be found on the southeast side, a relation which places the crest nearer the eastern than the western margin of the anticline. The crest appears to be twice as far from the belt of rocks outlining the western margin of the fold (see p. 127) as from the similar belt on the east and probably crosses secs. 30 and 31, T. 24 N., R. 1 W., as indicated by dips in a few rock outcrops in that vicinity. The highest land values would probably be included in a strip about a mile wide extending from sec. 1, T. 23 N., R. 2 W., northeastward to sec. 16, T. 24 N., R. 1 W. This strip would include parts or all of sec. 1, T. 23 N., R. 2 W.; sec. 6, T. 23 N., R. 1 W.; sec. 36, T. 24 N., R. 2 W., and secs. 31, 32, 30, 29, 19, 20, 21, 17, and 16, T. 24 N., R. 1 W. Land adjacent to this strip is promising territory, although not of equal value with the strip. Because of the greater dip on the southeast side of the anticline, land values decrease more rapidly in that direction than on the northwest side. To the northeast, where practically nothing can be determined as to the structure of the rocks, the values may also decrease.

CONCLUSIONS REGARDING THE POSSIBILITIES OF THE FIRST THREE TEST WELLS.

In view of the fact that the original test well in this region is being drilled on the dome, interest naturally centers on this local structure. Though the well is not on the highest point of the dome, which is in the south-central part of sec. 15, yet it is believed that if it is drilled deep enough it will make a fair test of the dome.

The anticline, because of its larger areal extent and possible greater dip to the east, may be more promising than the dome. The two wells being drilled by the Humphreys Petroleum Co. appear to be located on a favorable part of the anticline. Whether they are on the highest part of the anticline can not be determined because of the doubt as to the location and configuration of the anticlinal crest. At the time this report was written these wells were not deep enough to base any definite conclusions on their findings.

WELL RECORDS.

The following detailed records of wells were obtained in the course of the investigation:

Log of Mid-Co. Petroleum Co.'s No. 1 well in the N. ½ SW. ¼ sec. 22, T. 23 N., R. 2 W., near Billings, Okla.

	Thickness.	Depth.		Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Earth	6	6	Hard sand	15	640
Lime	24	30	Red rock	56	696
Sand	4	34	Hard slate	19	715
Slate	16	50	Red rock	25	740
Red rock	10	60	Gas sand	15	755
Blue slate	37	97	Slate	10	765
White shale	13	110	Soft gray lime	42	807
Red rock	5	115	Red rock	23	830
Slate	20	135	Gas sand	12	842
Red rock	105	240	Red rock	18	860
White slate	10	250	Hard sand and gas	10	870
Red rock	15	265	Red rock	14	884
Lime	4	269	Hard, gritty lime, gas	21	905
Red rock	46	315	Hard slate	10	915
Slate	10	325	Red rock	112	1,027
Red rock	5	330	Gas sand	20	1,047
White slate	8	338	Blue slate	2	1,049
Red rock	17	355	Sand and lime	17	1,066
Soft slate	10	365	Red rock	64	1,130
Soft red rock	15	380	Lime	6	1,136
Lime	8	388	Red rock	14	1,150
Sand rock	7	395	First water sand; water salty	20	1,170
White slate	25	420	Slate	25	1,195
Hard lime	15	435	Lime	23	1,218
Soft lime	15	450	Red rock	52	1,270
White slate	42	492	Lime	30	1,300
Red rock	28	520	Brown slate	15	1,315
Gray lime	15	535	Lime	75	1,390
Red rock	25	560	Blue slate	5	1,395
Hard slate	10	570	Lime	5	1,400
Gas sand	12	582	Lime and slate	76	1,476
Red rock	38	620	Gas sand	69	1,545
Blue lime	5	625	Slate	25	1,570

Log of the Watchorn & Fortuna Oil Co.'s 101 Ranch well No. 1, in the SW. ¼ sec. 33, T. 23 N., R. 3 E.

	Thickness.	Depth.
	Feet.	*Feet.*
Red bed	40	40
Sandstone	5	45
Red bed	5	50
Sandstone	20	70
Red bed	190	260
Lime	2	262
Red bed	28	290
Water sand	5	295
Lime	10	305
Red bed	10	315
Water sand (hole filled with water)	35	350
Lime	18	368
Red mud	5	373
Red bed	62	435
Water sand	10	445
Red bed	10	455
Blue slate	20	475
Red bed	25	500
Lime	6	506
Blue shale	14	520
Lime	10	530
Blue shale	70	600
Red bed	10	610
Water sand	10	620
Blue slate	10	630
Blue shale	195	825
Red bed	15	840
Blue shale	25	865
Lime	5	870
Blue shale	70	940
Water sand	10	950
Red bed	35	985
Blue shale	65	1,040
Water sand	10	1,050
Blue shale	5	1,055
Water sand	20	1,075
Blue shale	30	1,105
Lime	4	1,109
Blue shale	26	1,135
Lime	5	1,140
Blue shale	50	1,190
Lime	5	1,195
Blue shale	90	1,285
Gray sandy shale	30	1,315
Lime	4	1,319
Sand	16	1,335
Blue shale	65	1,400
Sand	25	1,425
Sandy shale	25	1,450
Blue shale (streak water sand 1,555)	120	1,570
Hard sand	5	1,575
Blue shale	105	1,680
Red bed	10	1,690
Water sand	15	1,705
Sand (shelly)	15	1,720
Hard sand	5	1,725
Blue shale	5	1,730
Broken sand	25	1,765
Blue shale	35	1,800
Blue slate	10	1,810
Hard lime	5	1,815
Sandy lime	15	1,830
Broken lime, sandy	30	1,860
Hard lime	5	1,865
Broken lime	10	1,875
Broken lime, shelly	20	1,895
Broken lime	20	1,915
Blue shale	20	1,935
Sand	25	1,960
Blue shale	30	1,990
Sand; gas enough to blow water out of hole	5	1,995
Sand	5	2,000
Broken sand	12	2,012
Shell	3	2,015
Sand shelly, big gas	5	2,020
Sand shelly, gas increasing	20	2,040

Casing record: 15½-inch, 373 feet; 12½-inch, 859 feet; 10-inch, 1,561 feet; 8¼-inch, 2,016 feet; 6⅝-inch, 2,041 feet.

Log of 101 Ranch Oil Co.'s Flossie Running After Arrow well No. 16, in the W. ½ NE. ¼ sec. 17, T. 25 N., R. 2 E.

	Thickness.	Depth
	Feet.	*Feet.*
Unrecorded	34	34
Red rock	56	90
Lime	10	100
Red rock	120	220
Shale, brown	13	233
Lime, sandy	14	247
Red rock	53	300
Lime	10	310
Red rock	26	336
Lime	31	367
Red rock	63	430
Lime	14	444
Red rock	34	478
Lime	4	482
Red rock	63	545
Sand (gas)	30	575
Red rock	25	600
Lime	73	673
Sand (gas)	10	683
Shale, sandy	22	705
Red rock	10	715
Lime	50	765
Slate, blue	15	780
Lime shells	72	852
Lime	10	862
Gray shale	43	905
Lime	7	912
Sandy shale	13	925
Blue slate	45	970
Sand (oil and gas)	24	994
Shale, gray	41	1,035
Lime shells	15	1,050
Shale, gray	50	1,100
Lime shells	50	1,150
Sandy shale	86	1,236
Lime	14	1,250
Blue shale	30	1,280
Lime	7	1,287
Red rock	13	1,300
Blue shale	20	1,320
Lime	20	1,340
Sandy shale	10	1,350
Sand (oil)	13	1,363
Sand (water)	22	1,385
Shale, blue	10	1,395
Lime	14	1,409
Sandy shale	36	1,445
Lime	30	1,475
Brown shale	33	1,508
Lime	22	1,530
Brown shale	17	1,547
Red rock	17	1,554
Sand (gas)	14	1,568

Casing record: 8¼-inch, 1,035 feet; 6⅝-inch, 1,320 feet; 4⅞-inch, 1,445 feet; packer, 1,520 feet.

Log of Margaret Primeaux No. 7 well in sec. 4, T. 25 N., R. 2 E.

	Thickness.	Depth.
	Feet.	*Feet.*
Soil	2	2
Slate	48	50
Sand and gravel	8	58
Lime	6	64
Slate	10	74
Red rock	96	170
Lime	5	175
Slate	10	185
Lime	50	235
Red rock	65	300
Lime	2	302
Shale	4	306
Lime	3	309
Shale	13	322
Lime	11	333
Slate	4	337
Lime	13	350
Red rock	90	440
Sand (13,000,000 feet of gas)	12	452
Slate	138	590
Lime	4	594
Slate	13	607
Lime	11	618
Slate	5	623
Lime	42	665
Slate	25	690
Lime	40	730
Slate	40	770
Lime	5	775
Slate	15	790
Lime	10	800
Slate	40	840
Lime	5	845
Slate	75	920
Lime	10	930
Slate	25	955
Sand	15	970
Slate	70	1,040
Lime	5	1,045
Slate	60	1,105
Lime	3	1,108
Slate	17	1,125
Lime	5	1,130
Slate	35	1,165
Lime	13	1,178
Slate	22	1,200
Sand	20	1,220
Slate	15	1,235
Lime	10	1,245
Slate	25	1,270
Lime	20	1,290
Slate	35	1,325
Lime	10	1,335
Slate	10	1,345
Sand (hole full of water)	30	1,375
Slate	25	1,400
Lime	5	1,405
Slate	13	1,418
Lime	3	1,421
Slate	14	1,435
Lime and sand (water)	13	1,448
Lime	4	1,452
Slate	18	1,460
Lime	6	1,466
Slate	24	1,490
Lime	20	1,510
Slate	10	1,520
Lime	3	1,523
Slate	9	1,532
Lime	4	1,536
Slate	3	1,539
Red rock	2	1,541
Slate	1	1,542
Sand (showing of oil)	10	1,552
Slate	25	1,577
Red rock	3	1,580
Lime	5	1,585
Slate	10	1,595
Lime	15	1,610
Slate	35	1,645
Lime	10	1,655
Sand	10	1,665
Slate	15	1,680
Sand	5	1,685
Slate	15	1,700
Sand (hard; bad cave)	35	1,735
Slate	12	1,748
Lime	10	1,758
Red rock	5	1,763
Lime	70	1,770
Black shale (very cavy)	44	1,814
Lime	13	1,827
Slate	13	1,840
Lime	7	1,847
Slate	43	1,890
Lime	5	1,895
Slate	3	1,898
Lime	4	1,912
Slate	91	2,003
Sand (hole full of water)	32	2,035
Slate	3	2,038
Lime	7	2,045
Slate	15	2,060
Lime	12	2,072
Slate	32	2,104
Lime	10	2,114
Slate	14	2,128
Lime	10	2,138
Slate	11	2,149
Lime (3 feet below water)	1	2,150
Sand (3,000,000 feet of gas at 2,150 feet)	75	2,225
Lime and sand	120	2,355
Sand	10	2,365
Black slate	47	2,412
Sand	3	2,415
Slate	125	2,540
Lime	8	2,548
Brown shale	82	2,630
Lime	4	2,634
Brown shale	31	2,665
Lime	8	2,673
Brown sand	15	2,688
Light sand	12	2,700
Slate	16	2,716
Sand	24	2,740
Coarse sand	15	2,755
Light sand	15	2,770
White sand (3 bailers water)	10	2,780
Blue lime (very hard)	25	2,805
Black slate	90	2,895
Sandy shale	35	2,930
Black slate	65	2,995
Lime	7	3,002
Brown shale	4	3,006
Lime	14	3,020
Blue shale	22	3,042
Bluish sand	23	3,065
Blue slate	20	3,085
Gray sand	13	3,098
Gray slate	27	3,125
Blue shale	43	3,168
Lime	19	3,187
Blue shale	13	3,200
Lime (very hard)	2	3,202
Shale	9	3,211
Lime	16	3,227
Sand and lime	15	3,242
Shale	6	3,248
Lime	62	3,310
Black shale	5	3,315
Lime	10	3,325
Black shale	2	3,327
Lime	13	3,340
Black shale	7	3,347
Lime	7	3,354
Black shale	18	3,372
Lime	8	3,380
Black shale	10	3,390
Lime	7	3,397
Black shale	30	3,427
Lime	3	3,430
Black shale	5	3,435
Sandy lime (water)	10	3,445
Shale	10	3,455
Sandy lime	2	3,457

Log of Margaret Primeaux No. 7 well in sec. 4, T. 25 N., R. 2 E.—Continued.

	Thickness.	Depth.		Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Black shale	11	3,468	Hard lime	5	3,570
Red rock	2	3,470	Sand, hard	5	3,575
Lime	2	3,472	Blue shale	5	3,580
Sand, gray, very hard	10	3,482	Lime shells and shale	11	3,591
Blue shale	14	3,496	Lime	7	3,598
Sand, like oil sand	14	3,510	Blue shale	27	3,625
Blue shale	15	3,525	Sand, little oil	8	3,633
Lime	3	3,528	Hard sand	15	3,648
Shale	7	3,535	Lime	4	3,652
Red rock	5	3,540	Sand, very hard, showing of oil	73	3,725
Blue shale	15	3,555	Lime, very hard	29	3,754
Lime	5	3,560			
Black shale	5	3,565			

Casing record: 12½-inch, 73 feet; 10-inch, 610 feet; 8¼-inch, 1,260 feet; 6⅝-inch, 2,038 feet; 5$\frac{3}{16}$-inch, 2,632 feet.

Log of 101 Ranch Oil Co.'s 101 Ranch well No. 1, in the NE. ¼ sec. 25, T. 25 N., R. 1 E.

	Thickness.	Depth.		Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Sandy soil	19	19	Black slate	10	1,460
Gravel	40	59	Very hard sand	56	1,516
White clay (water)	10	69	Black shale	6	1,522
Red rock	12	81	Fine hard sand	7	1,529
Gritty slate	8	89	Soft shale	20	1,549
Red rock	21	110	White sand (water)	28	1,577
White shale or clay	42	152	Blue shale	3	1,580
Lime shell	9	161	Gritty lime	5	1,585
White shale or clay	44	205	Black slate	53	1,638
Red rock	26	231	Sandy lime	25	1,663
Lime shell	3	234	Soft black shale	22	1,685
Red rock	60	294	Red shale	5	1,690
Brownish lime	4	298	White sand	15	1,705
Hard black slate	28	326	Black slate	3	1,708
Reddish lime	24	350	White sand	28	1,736
Red rock	35	385	Black shale	20	1,756
Gritty slate	20	405	Lime shell	7	1,763
Red rock	22	427	Soft black shale	36	1,799
White shale	8	435	White sand (water)	39	1,838
Brownish lime	8	443	Soft shale	4	1,842
Hard grayish lime	22	465	Gritty gray lime	10	1,852
Red shale	35	500	Black shale	6	1,858
Lime shell	12	512	Slate and shell	22	1,880
Red rock	58	570	Soft black shale	5	1,885
Red sand	23	393	Red shale	7	1,892
Hard white lime	5	598	White lime	30	1,922
Red shale	27	625	Soft black shale	13	1,933
White sand	35	660	Soft red shale	15	1,950
Red shale	42	702	White lime	28	1,978
White sand	34	736	Red rock (cavy)	22	2,000
Black slate	6	742	Hard gray lime	15	2,015
Hard lime	38	780	Lime shell	3	2,018
White slate	50	830	Sandy lime	19	2,037
Grayish lime	24	854	Brown shale	3	2,040
Black slate with shells	18	872	White sand	5	2,045
Black slate with hard shells	24	896	White shale	13	2,058
Black slate	6	902	White sand	30	2,088
Slate and shells	21	923	Black shale	20	2,108
Reddish tinted slate	37	960	Hard lime	6	2,114
Gritty shell in black slate	45	1,005	Black slate	49	2,163
White and black sand	12	1,017	Hard shell	3	2,166
Black slate	45	1,062	Black slate	14	2,180
Slate and shell	4	1,066	Hard white sand	10	2,190
Soft slate	85	1,151	Red brown shale	4	2,194
Lime	4	1,155	White slate	5	2,199
Very soft slate	75	1,230	Very hard white lime (water)	43	2,242
Hard white sand	6	1,236	Black slate	26	2,268
Soft black slate	24	1,260	Dark lime	11	2,279
Dark soft shale	12	1,272	Black shale	3	2,282
Lime cavings	43	1,315	White sand (salt water)	18	2,300
White sand (water)	19	1,334	Dark shale	3	2,303
Slate and shells	33	1,367	Very white sand	59	2,362
Hard lime	18	1,385	Shale, black	43	2,405
Soft dark lime	10	1,395	Dark lime	6	2,411
Soft black shale	23	1,418	Blue shale	54	2,465
Red rock	15	1,433	White shale	20	2,485
White sand	17	1,450	Dark blue shale	35	2,520
			White sand	56	2,576

Log of H. F. Wolf well No. 1, SW. ¼ sec. 6, T. 28 N., R. 1 E.

	Thickness.	Depth.		Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Soil	5	5	Shale	25	1,255
Clay	55	60	Lime	70	1,325
Lime	17	77	Shale	15	1,340
Clay	2	79	Lime and shale	70	1,410
Lime	17	96	Lime	45	1,455
Slate	14	110	Sand	30	1,485
Lime	15	125	Shale	40	1,525
Slate	5	130	Lime	175	1,700
Lime	5	135	Red rock	5	1,705
Slate	20	155	Lime	20	1,725
Lime	8	163	Shale	85	1,810
Slate	7	170	Sand (water)	55	1,865
Lime	45	215	Shale	5	1,870
Slate	10	225	Lime	45	1,915
Lime (gas)	20	245	Shale	15	1,930
Red rock	25	270	Sand	15	1,945
Slate	25	295	Red rock	7	1,952
Lime	10	305	Shale	5	1,957
Slate	10	315	Sandy lime	13	1,970
Lime	5	320	Red rock	5	1,975
Slate	25	345	Blue slate	5	1,980
Sand (gas)	40	385	Sand (oil showing)	8	1,988
Lime	10	395	Blue shale	6	1,994
Slate	5	400	Lime	36	2,030
Red rock	20	420	Blue slate (cavy)	50	2,080
Slate	20	440	Shale	125	2,205
Lime	5	445	Sandy lime	15	2,220
Shale	15	460	Shale	35	2,255
Sand (gas)	25	485	Sand (6,000,000 feet of gas)	15	2,270
Lime	10	495	Shale	20	2,290
Slate	10	505	Sand (water)	50	2,340
Red rock	10	515	Slate	265	2,605
Lime	10	525	Sandy slate (hard)	5	2,610
Brown shale	15	540	Sand (gas)	10	2,630
Red rock	5	545	Sand, brown (gas)	20	2,650
Lime (gas at 555 feet)	25	570	Sand (showing oil)	7	2,657
Red rock	15	585	Lime sand (water)	8	2,665
Brown shale	5	590	Sand	65	2,730
Lime	10	600	Shale	30	2,760
Blue shale	30	630	Sand	25	2,785
Red rock	10	640	Shale	135	2,920
Lime sand (gas)	5	645	Lime	10	2,930
Red rock (cavy)	15	660	Green slate	20	2,950
Sand (gas at 670 feet)	20	680	Sand (500,000 feet of gas)	50	3,000
Shale	17	697	Slate	20	3,020
Lime	23	720	Lime	10	3,030
Shale	5	725	Slate	5	3,035
Lime	90	815	Lime	20	3,055
Lime (gas)	45	860	Black slate	5	3,060
Shale	5	865	Lime	35	3,095
Lime	17	882	Black slate	10	3,105
Shale	33	915	Lime	65	3,170
Lime (gas)	50	965	Black slate	5	3,175
Shale	215	1,180	Shale	65	3,240
Lime (gas)	40	1,220	Sandy shale (very hard)	10	3,250
Lime	10	1,230	Sand (30,000,000 feet of gas)	20	3,270

Casing record: 15½-inch, 135 feet; 12½-inch, 680 feet; 10-inch, 1,040 feet; 8¼-inch, 2,080 feet; 6⅝-inch, 2,360 feet; 5$\frac{3}{16}$-inch, 2,734 feet.

Log of Gus Swenson well No. 1, NE. ¼ sec. 32, T. 29 N., R. 1 E.

	Thickness.	Depth.		Thickness.	Depth.
	Feet.	*Feet.*		*Feet.*	*Feet.*
Soil	5	5	Lime	20	1,230
Clay (water)	9	14	Slate	60	1,290
Shale	12	26	Lime	10	1,300
Gypsum	4	30	Slate	120	1,420
Shale	16	46	Lime	24	1,444
Gypsum	8	54	Sand (water, little gas)	36	1,480
Shale	25	79	Lime	20	1,500
Lime	3	82	Shale	110	1,610
Shale	19	101	Lime	20	1,630
Lime	4	105	Shale	10	1,640
Red rock	18	123	Lime	3	1,643
Shale	140	263	Shale	97	1,740
Red rock	34	297	Lime	10	1,750
Shale	30	327	Sand (gas)	25	1,775
Lime	5	332	Red rock	15	1,790
Shale	14	346	Shale	10	1,800
Lime	4	350	Sand (water)	25	1,825
Sand (gas)	20	370	Shale	15	1,840
Shale	65	435	Red rock	60	1,900
Lime, sand (water)	7	442	Lime	40	1,940
Red rock	15	457	Shale	20	1,960
Shale	41	498	Sand (oil, good showing)	25	1,985
Lime	3	501	Sand (water)	2	1,987
Slate	26	527	Slate	13	2,000
Lime	10	537	Lime	7	2,007
Shale	20	557	Slate	83	2,090
Sand (gas, into water)	33	590	Lime	10	2,100
Shale	22	612	Red rock	10	2,110
Lime	7	619	Lime	105	2,215
Slate	21	640	Slate	63	2,278
Red rock (caved badly)	21	661	Sand (oil, good showing)	15	2,293
Shale	6	667	Slate	5	2,298
Slate	2	669	Sand (water)	12	2,310
Lime	5	674	Slate	345	2,655
Shale	41	715	Sand (oil)	32	2,687
Sand	27	742	Sand	73	2,750
Shale	28	770	Slate	5	2,755
Sand (water)	26	796	Lime	10	2,765
Shale	80	876	Sand (water)	15	2,780
Lime	9	885	Lime	220	3,000
Red rock	17	902	Shale	50	3,050
Shale	18	920	Sand (oil, fair showing)	20	3,070
Sand (gas)	22	942	Lime	130	3,200
Lime	3	945	Shale, slate	100	3,300
Sand (water)	55	1,000	Sand (water)	30	3,330
Red rock	30	1,030	Slate	25	3,355
Shale	70	1,100	Sand (gas)	10	3,365
Lime	15	1,115	Oil sand (still in sand)	20	3,385
Shale	95	1,210			

Casing record: 10-inch, 686 feet; 8¼-inch, —— feet; 6⅝-inch, 2,408 feet; $5\frac{3}{16}$-inch, 2,800 feet, and underreamed to 3,337 feet.