# THE STRUCTURE OF THE MADILL-DENISON AREA, OKLAHOMA AND TEXAS, WITH NOTES ON OIL AND GAS DEVELOPMENT.

By O. B. HOPKINS, SIDNEY POWERS, and H. M. ROBINSON.

## INTRODUCTION.

The area treated in detail in this report includes the southern part of Marshall County, Okla., and the northern part of Grayson County, Tex., and extends from the vicinity of Madill on the north to Denison on the south, as shown on Plate IV (in pocket). The report also includes some notes on the geology and developments in the region in Texas lying southeast of Denison, as outlined on Plate I. The area described lies south of the Arbuckle Mountains and is traversed from west to east by Red River. Included in this area are the Madill oil pool, 1 mile east of Madill, and the Enos gas pool, 12 miles south of Madill.

### ACKNOWLEDGMENTS.

The structure mapping in T. 7 S., R. 5 E., and parts of the adjacent townships on the north, west, and south, as shown on the inset on Plate IV, was done with plane table by H. M. Robinson. The rest of the area was mapped by Sidney Powers and O. B. Hopkins by spotting locations on maps and determining elevations with barometers. Mr. Robinson did his part of the mapping independently and prior to that of Mr. Powers and Mr. Hopkins, who did their part of the work during December, 1917, and January, 1918. L. W. Stephenson, who was engaged in a study of the general geology of the area and some of the broader problems of correlation involved in it, worked with Messrs. Powers and Hopkins during the first two weeks of December, 1917, and gave them much helpful information regarding the succession, thickness, and diagnostic characters of the beds. This introduction to the stratigraphy of the area, on which a report[1] has been published, made the detailed mapping of the

[1] Stephenson, L. W., A contribution to the geology of northeastern Texas and southern Oklahoma: U. S. Geol. Survey Prof. Paper 120, pp. 129–163, 1918.

structure a relatively simple problem, especially as Mr. Stephenson had already outlined the broad structural features of the southern part of the area. Much of the information regarding the Upper Cretaceous beds here presented is taken from his report.

The text of this report was written largely by Mr. Hopkins, who has discussed freely the problems involved with the coauthors and has incorporated their ideas with his own. Mr. Stephenson read the report and made many helpful suggestions regarding it.

## TOPOGRAPHY.

The surface features of the area, as shown in some detail on the Denison and Tishomingo topographic maps, published by the United States Geological Survey, have resulted from the erosion of a broad peneplain lying 750 to 850 feet above sea level. Below this general level the streams have cut channels of varying widths and depths. Red River, which is the largest stream in the region, flows here at an elevation of 500 to 550 feet above sea level, giving a maximum relief of 250 to 300 feet. Except for certain broad, flat terraces along Red River, the country is rolling to hilly, and exposures of the underlying strata are numerous.

## STRATIGRAPHY.

### GENERAL FEATURES.

The exposed rocks in the area are of Cretaceous age and overlie rocks of Paleozoic age at depths ranging from 400 feet near Madill to about 1,000 feet near Denison and 2,000 to 2,500 feet near Leonard, Fannin County, Tex. The distribution of the Cretaceous rocks in northeastern Texas and southern Oklahoma is shown on Plate I. The formations found in this area will not be discussed in detail, because they have been well described by Stephenson[2] and Taff.[3] Only the beds that were used as key rocks will be described.

The rocks exposed in the Madill-Denison area, as represented in Plate II, belong to the Comanche series (Lower Cretaceous) and consist in the aggregate of about 400 feet of beds, two-thirds of which is shale and one-third limestone. South and east of Denison the Gulf series (Upper Cretaceous) is exposed to and beyond the limits of the area here considered, as shown on Plate I.

A generalized section of the Paleozoic rocks underlying the Comanche series, as given by Taff, is shown in Plate II. Because of the marked structural unconformity between the rocks of Comanche and Paleozoic age, it can not be forecast in advance of drilling

[2] Op. cit.

[3] Taff, J. A., U. S. Geol. Survey Geol. Atlas, Tishomingo folio (No. 98), 1903.

# GEOLOGIC MAP OF PARTS OF NORTHEASTERN TEXAS AND SOUTHERN OKLAHOMA

(From report by L. W. Stephenson, U. S. Geological Survey Professional Paper 120, 1918)

Scale 1/500,000

5 0 5 10 15 20 25 Miles

1922

Areal geology by L. W. Stephenson, supplemented by data published by R. T. Hill, J. A. Taff, and C. H. Gordon and by data furnished by O. B. Hopkins, Sidney Powers, and H. M. Robinson

Structure contours showing the altitude above sea level of the top of the Goodland limestone by O. B. Hopkins, Sidney Powers, and H. M. Robinson

Structure contours showing the altitude of the base of the Ector tongue of the Austin chalk and the base and top of the Annona tongue of the Austin chalk by O. B. Hopkins and Sidney Powers

ENGRAVED AND PRINTED BY THE U. S. GEOLOGICAL SURVEY

## EXPLANATION

TERTIARY

Eocene series

Te — Midway formation and part of the Wilcox formation (*Sand and clay*)

UNCONFORMITY

CRETACEOUS

Gulf series

Kn — Navarro formation (*Calcareous clay and sand*)

Ktp, Ktw, Kt — Taylor marl (*Shaly calcareous clay*)
Pecan Gap chalk member, Ktp
Wolfe City sand member, Ktw

Ka, Kae, Kaa — Austin chalk (*Ector tongue* (Kae) *and Annona tongue* (Kaa). *Includes for convenience of mapping 10 to 35 feet of unnamed nonchalky clay and sand, down to and including the "fish-bed conglomerate"*)

Kc — Clay equivalent to part of Austin chalk on the west and in part to the Blossom sand and Brownstown marl on the east

Kb — Brownstown marl (*Calcareous clay*)

Kbl — Blossom sand (*Calcareous glauconitic sand*)

Ke — Eagle Ford clay (*Dark shaly clay*)

Kwb — Woodbine sand (*Fine to coarse sand and clay*)

UNCONFORMITY?

Comanche series

Kw, fw — Washita group (*Includes in ascending order Kiamichi clay, Duck Creek formation, Fort Worth limestone, and Denison formation.* fw, *approximate outcrop of top of Fort Worth limestone*)

Kfr — Fredericksburg group, represented in this area by the Goodland limestone

Kts — Trinity sand (*Fine sand and clay*)

600 500 400 — Contours showing altitude of key rocks above sea level. Interval 50 feet

*The altitude of the top of the Goodland limestone in the Preston anticline is represented by the contours in northern Grayson County, Tex., and southern Marshall and Bryan counties, Okla.*
*The altitude of the base of the Ector tongue of the Austin chalk is represented by the contours in the vicinity of Ector and Ravenna, Fannin County, Tex.*
*The altitude of the base of the Annona tongue of the Austin chalk is represented by the contours within a few miles south, east, and northeast of Bonham, Fannin County, Tex.*
*The altitude of the top of the Annona tongue of the Austin chalk is represented by the contours in the vicinity of Leonard, Bailey, Gober, and Honey Grove, Fannin County, Tex.*

X 9707 — Locality at which fossils have been obtained from the Blossom sand. The figures indicate U. S. G. S. collection number

Section from J. A. Taff, U. S. Geol. Survey Geol. Atlas, Tishomingo folio (No. 98), 1903

| SYSTEM | SERIES | FORMATION | THICKNESS IN FEET | CHARACTER OF FORMATION |
|---|---|---|---|---|
| CARBONIFEROUS | Pennsylvanian | Franks conglomerate | 300-500+ | Limestone and chert conglomerates, gritty sandstone, limestone, and shale. Probably represents the upper portion of the Glenn formation and lies unconformably on all the other Paleozoic formations |
| | | UNCONFORMITY | | |
| | | Glenn formation | 1000-3000 | Blue shale, with thin brown sandstone and occasional thin limestone |
| | Mississippian | Caney shale | 1500 | Blue shale, with sandy lentils and small ironstone concretions<br>Black fissile shale, with dark-blue fossiliferous limestone concretions |
| | | Sycamore limestone | 0-160 | Bluish to yellow limestone |
| DEV.? | | Woodford chert [*] | 600 | Thin-bedded chert and fissile black shale; local blue flint lentils at the base |
| SILURIAN | | Hunton limestone [*] | 0-200 | White and yellowish limestone, with flint and chert concretions in upper part |
| | | Sylvan shale | 30-300 | Blue clay shale |
| ORDOVICIAN | | Viola limestone | 750 | White and bluish limestones, with flint concretions in the middle |
| | | Simpson formation | 1600 | Bituminous sandstone, calcareous sandstone, and shale<br>Thin fossiliferous limestone and shale<br>Bituminous sandstone, calcareous sandstone, and shale<br>Fossiliferous limestone and shale<br>Sandstone and shaly beds |
| | | SLIGHT UNCONFORMITY | | |
| | | Arbuckle limestone | 4000-6000 | Massive and thin-bedded white and light-blue limestones with cherty concretions<br>Dull-blue massive and thin-bedded limestones, sandy at the base |
| CAMBRIAN | | Reagan sandstone | 50-150 | Coarse dark-brown sandstone |
| PRE-CAMBRIAN | | Tishomingo granite | | Coarse red granite and monzonite, with diabase, granite porphyry, and aplite dikes |

[*] The Woodford chert is now all classified as Upper Devonian. The name "Hunton limestone" is abandoned, that formation being replaced by two formations of Silurian age (Henryhouse shale and Chimneyhill limestone) and two formations of Devonian age (Bois d'Arc limestone and Haragan shale). The Sylvan shale is now referred to the Ordovician, being of Richmond age

Exposed rocks in Madill-Denison area, Oklahoma and Texas

| SERIES | FORMATION | THICKNESS IN FEET |
|---|---|---|
| GULF (UPPER CRETACEOUS) | Woodbine sand | 15-25 |
| Comanche (Lower Cretaceous) | Denison formation: Grayson marl member | 15-25 |
| | Main Street limestone member | 8-20 |
| | Pawpaw sandy member | 50 |
| | "Quarry" limestone | |
| | Weno clay member | 115 |
| | "Ostrea carinata bed" | |
| | Denton clay member | 45 |
| | Fort Worth limestone | 33 |
| | Duck Creek formation | 67 |
| | "Ammonite bed" | 33 |
| | Kiamichi clay | 40-50 |
| | Goodland limestone | 15-25 |
| | Walnut shaly member | |
| | Trinity sand | 400-700 |

The Cretaceous rests unconformably on Carboniferous rocks

STRATIGRAPHIC SECTIONS SHOWING EXPOSED AND UNEXPOSED ROCKS IN THE MADILL-DENISON AREA, OKLAHOMA AND TEXAS.

which one of the Paleozoic formations will be encountered at different places beneath the Comanche rocks. The bearing of this fact on the possible occurrence of oil in these deeper rocks will be discussed in more detail in subsequent pages.

### KEY ROCKS OF COMANCHE SERIES.

*Goodland limestone.*—The Goodland limestone is the lowest bed in the area that can be easily traced from place to place. It includes (1) the Walnut shaly member at the base, which consists of 3 to 6 feet of very fossiliferous platy limestone interbedded with dark bituminous clay, and (2) 12 to 20 feet of typical hard, massive light-colored limestone. The formation overlies the soft, easily eroded sands of the Trinity and consequently stands up boldly in low cliffs. Both the top of the limestone and the lower shaly member serve as excellent key rocks over a wide area. The Goodland is exposed in the neighborhood of Red River, as shown on Plate I, and over a large area near Madill and Oakland.[4] It was used as the datum for the structure contours of Plate IV (in pocket).

*Kiamichi clay.*—The Kiamichi consists of 40 to 50 feet of dark clay alternating with thin, slabby beds of hard, very fossiliferous limestone. The limestones are particularly prominent and are loaded with *Gryphaea* at the top of the formation, where they are easily traceable. The top of the Kiamichi makes a small but recognizable bench at most places, below which slabs of fossiliferous limestone commonly stand on edge and are often called "edge rocks." Where no conspicuous bench is present the upper limit of these "edge rocks" is easily traced. North of Red River the top of the Kiamichi is 40 to 43 feet above the top of the Goodland.

"*Ammonite bed.*"—About 33 feet above the top of the Kiamichi is a soft white to cream-colored limestone with interbedded shale, from 4 to 6 feet thick, which can be easily recognized because of the abundance of large ammonites, both in the limestone and in the shale. This bed, which forms a part of the Duck Creek formation, is well exposed at Willis Ferry, on Red River. The ammonites readily become detached from the containing rock and are strewn in many places over the slopes below the outcrop of this bed. The abundance of large ammonites in this bed distinguishes it from any other in the region.

*Fort Worth limestone.*—The Fort Worth limestone is well exposed in the east bluff of Red River half a mile south of the mouth of Washita River, where it consists of three divisions.

[4] Taff, J. A., op. cit.

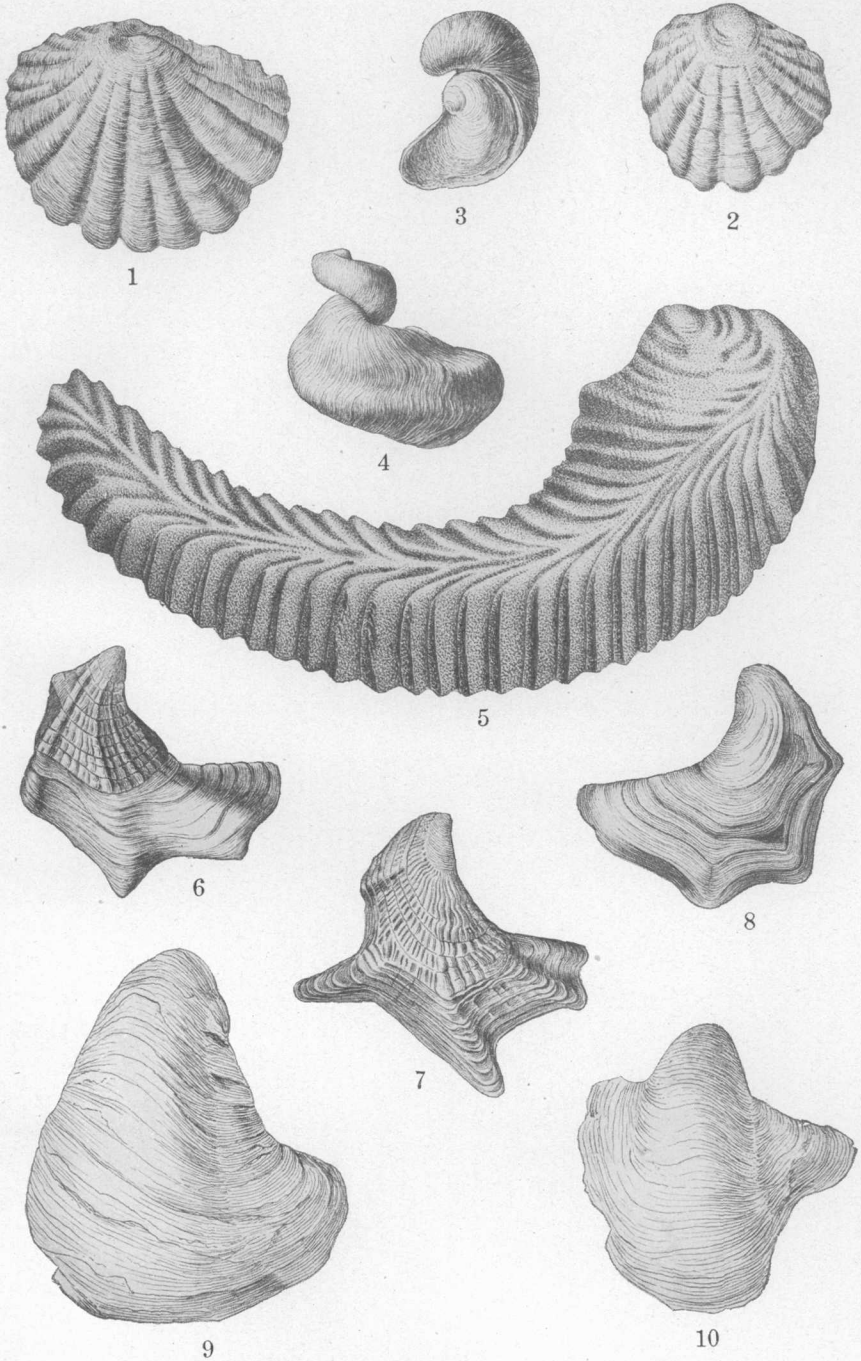
*Section of Forth Worth limestone in east bank of Red River half a mile south of mouth of Washita River, Bryan County, Okla.*

| | Feet. |
|---|---|
| Limestone, hard, thin to massive bedded, nodular | 12 |
| Shale with one or more thin limestone layers | 12 |
| Limestone and shale interbedded, half and half | 10± |

The upper part of the formation usually contains more massive beds of limestone than the lower part and forms a bench with the overlying shale. The Fort Worth is characterized by the abundance of large fucoid-like markings, by the presence of smaller ammonites than those in the "Ammonite bed" (especially *Schloenbachia leonensis*), and by Nautili, pectens, and echinoids, which are relatively less common or absent in the contiguous formations. In many of its small, inconspicuous exposures the Fort Worth can not be easily differentiated from the underlying Duck Creek formation, which is very similar to it lithologically. The similarity is greatest in the area north of Red River, where Taff included the two formations under the name Caddo limestone. The top of the Fort Worth is 185 feet above the top of the Goodland limestone near Denison and 179 feet above in the area north of Red River.

"*Ostrea carinata bed.*"—From 45 to 52 feet above the top of the Fort Worth is a bed from 3 to 4 feet thick, which contains the striking fossil *Ostrea carinata* Lamarck and is called the "*Ostrea carinata* bed." (See Pl. III.) South of Red River this bed usually appears as a shell bed composed largely of *Gryphaea washitaensis* Hill, with *Ostrea carinata* present in lesser numbers, as exposed, for example, on the Pottsboro road 5 miles west of Denison, capping the top of a hill in a road cut. North of Red River a hard, dense limestone that occurs at about this horizon, 52 to 55 feet above the top of the Fort Worth limestone, may or may not represent this same bed. It is well exposed in the road leading west near the southwest corner of sec. 14, T. 7 S., R. 6 E., 1½ miles northwest of Woodville. In that region this limestone forms a conspicuous ledge and was used as a key rock. Its most conspicuous fossils are pectens.

"*Quarry*" *limestone.*—The "quarry" limestone is a valuable key bed south of Red River, but north of the river there are several limestones which resemble it so closely that it is difficult to recognize. South of Red River it consists of about 2 feet of hard, dense sandy limestone with large numbers of *Ostrea quadriplicata* Shumard. (See Pl. III.) It is well exposed three-quarters of a mile north of the station at Denison, on the St. Louis-San Francisco Railway. The "quarry" limestone is 347 feet above the top of the Goodland near Denison, 317 feet above west of Pottsboro, and 311 feet above where it was recognized north of Red River.




SOME CHARACTERISTIC FOSSILS OF THE WASHITA GROUP AND EAGLE FORD CLAY.

1, 2, Ostrea lugubris Conrad; 3, 4, Exogyra arietina Roemer; 5, Ostrea carinata Lamarck; 6–8, Ostrea quadruplicata Shumard; 9, 10, Gryphaea washitaensis Hill.

*Main Street limestone member.*—The Main Street limestone member of the Denison formation consists of 8 to 12 feet of hard gray to yellow massive limestone containing an abundance of *Exogyra arietina* Roemer, a small fossil resembling a ram's horn in shape. (See Pl. III.) This limestone is overlain by 15 to 25 feet of marl, known as the Grayson marl member of the Denison, which is the highest member of the Comanche series in this area. The limestone is well exposed in a cut on the Missouri, Kansas & Texas Railway 3 miles west of the station at Denison. The Main Street limestone and the Grayson marl are correlated with the Bennington limestone of Taff of the area near Madill.[5] The base of the Main Street is 392 feet above the top of the Goodland limestone near Denison, 367 feet above west of Pottsboro, and 359 feet above in the area north of Red River.

## KEY ROCKS OF GULF SERIES.

In the area southeast of Denison the Gulf series consists of the following divisions, in descending order:

Navarro formation.
Taylor marl:
  Pecan Gap chalk member.
  Wolfe City sand member.
  Clay and marl.
Austin chalk:
  Annona tongue.
  Unnamed clay.
  Ector tongue.
Unnamed sand and clay.
"Fish-bed conglomerate."
Eagle Ford clay.
Woodbine sand.

The geographic distribution of these formations in the area south and east of Denison is shown on Plate I, with the exception of the "fish-bed conglomerate" and the overlying sand and clay, which are included in the Ector tongue. In this area only the "fish-bed conglomerate," Ector tongue, Annona tongue, Wolfe City sand, and Pecan Gap chalk form outcrops conspicuous enough to be easily traced, and they are therefore the only beds described.

"*Fish-bed conglomerate.*"—The "fish-bed conglomerate," which is about 35 feet below the base of the Ector tongue and consists of a few feet of conglomeratic sandstone, with abundant shark teeth, is considered by Stephenson to represent the basal bed of the Austin chalk, although other geologists have included it in the Eagle Ford. This bed was traced locally in the region of Ector, and elevations on it were referred to the base of the Ector tongue, on which the contours near that town are based.

[5] For a description of its occurrence and distribution in that area see Taff, J. A., op. cit.

*Ector tongue of Austin chalk.*—A thin tonguelike projection of chalk near the base of the Austin chalk is called the Ector tongue, from its exposure near the town of Ector. Its greatest exposed thickness is about 15 feet, and its total thickness probably does not exceed 50 feet. Its outcrop extends from a point near Ector to Ivanhoe, as shown on Plate I. Its base was used locally as a datum for structure contours.

*Annona tongue of Austin chalk.*—The Annona tongue consists of 400 to 500 feet of almost white to dirty-gray or cream-colored chalk, which weathers to form a black prairie soil. All the Annona except its upper 10 feet, which is tough and massive and is locally sawed into block for building purposes, is brittle and breaks into angular fragments with conchoidal fracture. Its outcrop from Leonard to Honey Grove and farther east is shown on Plate I. Both its base and its top were used locally as a datum for structure contours on that plate.

*Wolfe City sand member.*—The sand that crops out near Wolfe City, Tex., and is well exposed in a cut on the Gulf, Colorado & Santa Fe Railway 1½ miles east-northeast of that town has been named by Stephenson the Wolfe City sand member of the Taylor marl. According to him it consists of 75 to 100 feet of fine calcareous gray sand or sandy marl and concretionary ledges of sandstone. The distribution of this sand is shown on Plate I. The hard ledges contained in it were used locally for obtaining the direction and rate of dip.

*Pecan Gap chalk member.*—The Pecan Gap chalk member of the Taylor marl was named by Stephenson, from its exposure near the town of Pecan Gap, in Delta County, Tex. It is exposed also on the Cox place, 3 miles southeast of Wolfe City. It is estimated to be about 50 feet thick and contains abundant specimens of *Exogyra ponderosa* Roemer. The area in which it is found has so little relief that its exposures are poor, and for that reason an attempt to use its top or base as a datum for structure contours was abandoned.

## STRUCTURE.

### GENERAL FEATURES.

The normal dip of the Cretaceous formations in northeastern Texas and southern Oklahoma is south or southeast, toward the coast, at a rate of 30 to 80 feet or more to the mile, according to Stephenson. This general dip is interrupted in this area by two broad structural features—the Preston anticline and a parallel syncline on the southwest, which may be appropriately called the Sherman syncline. In addition to these major structural features, there are a number of

smaller folds such as the Madill and Oakland anticlines, which are described below.

There is no marked structural unconformity between the different subdivisions of the Cretaceous; for this reason a fold in the surface beds is substantially duplicated in all the underlying Cretaceous formations, though it may or may not be duplicated in the Paleozoic rocks which underlie them. A fold in the Cretaceous rocks was certainly caused by movement in the Paleozoic rocks, but this movement may have been due to folding or to faulting, and it may have followed a new line of folding, although it is much more likely to have been along an old line of folding or faulting in the Paleozoic rocks that was developed prior to the deposition of the Cretaceous. Therefore it is not only impossible to forecast what Paleozoic formations underlie the Cretaceous, but it is also impossible to forecast the structure of those formations. It is safe to assume, however, that the major structural features of the Cretaceous rocks, such as the Preston anticline and Sherman syncline, are reflected in the older rocks. It is also likely that the less conspicuous folds, such as the Oakland and Madill anticlines and the syncline separating these folds from the Preston anticline, occur along old lines of folding in the underlying Paleozoic rocks, as all these folds are parallel to one another and to the lines of folding that can be traced in the old rocks where they are exposed to the north and west.

The structure of the surface formations in the area is outlined on Plate I by structure contours, or lines connecting points of equal elevation on a particular bed. In the Madill-Preston area the contours represent the top of the Goodland limestone and show its elevation above sea level (Pls. I and IV). The elevations were determined with aneroid barometers, and the readings, taken in duplicate, were carefully adjusted by comparison with a barograph. Most of the elevations are believed to be correct within 10 feet. In the vicinity of Ector and Bells, in Fannin County, Tex. (see Pl. I), the contours are referred to the base of the Ector tongue of the Austin chalk. The contours in the area near Randolph and Dodd City, in the same county, are referred to the base of the Annona tongue of the Austin chalk, and those near Leonard and Gober are referred to the top of the Annona tongue.

## PRESTON ANTICLINE.

The Preston anticline, as outlined by the contours on Plates I and IV, is a large plunging arch that extends southeastward from a point near the northwest corner of T. 7 S., R. 5 E., passing south of Bonham through Ector and dying out in the vicinity of Gober. It represents a maximum upthrust of 700 to 800 feet. It is

bordered on the north by a broad, shallow syncline, which extends from the vicinity of Platter northwestward just north of Kingston to a point 3 miles west-southwest of Oakland. On the south it is bordered by the even broader and shallower Sherman syncline. The highest part of the axis of the Preston anticline, shown in Plate IV, extends from the southeast corner of sec. 8, T. 7 S., R. 5 E., past the southeast corner of that township, to a point 5 miles north-northeast of Pottsboro. From this point it plunges to the southeast. The crest of the anticline is represented by the closed 800-foot contour near Shay and Enos, where a number of gas wells have been drilled. It is probable that the fold is higher than is indicated by the 800-foot contour, but as the Goodland limestone is absent within the area inclosed by that contour, it is not possible to determine the highest point of the fold. As outlined, however, this anticline has a reversal of dip to the northwest amounting to at least 60 feet. The mapping of the crest of the anticline in the vicinity of Red River may be only approximately correct, because of the absence of significant exposures there.

The dips range in general from 60 to 140 feet to the mile on the flanks of the fold and are somewhat steeper on the southwest than on the northeast flank. In a narrow belt 2 miles northeast of Pottsboro, however, the dip amounts to 400 feet or more to the mile. These steep dips are on the south and west sides of a nose that leads off to the south from the main anticlinal axis.

Near Ector the plunging axis of the anticline is represented by a strong swing of the contours around that town. Near Gober, however, the effect of the plunge is almost negligible.

### LEONARD-CELESTE MONOCLINAL NOSE.

The contours based on the top of the Annona tongue make a distinct swing around the town of Leonard in the southern part of Fannin County, Tex. (see Pl. I); and farther south, near Kingston, Hunt County, the Wolfe City sand and the Pecan Gap chalk also make a pronounced reentrant to the southeast, thus indicating the presence of a slightly plunging anticline or monoclinal nose in that area. The axis of this nose, which is doubtless a branch of the axis of the Preston anticline, is shown on Plate I. According to a cross section drawn by Stephenson[6] on the basis of surface data and well records, this uplift near Celeste amounts to over 200 feet. He estimates that on the axis of this nose near Celeste the top of the Woodbine may be reached at a depth of 1,500 feet and the top of the Goodland at 2,600 to 2,700 feet.

[6] Op. cit., pl. 30.

### OAKLAND ANTICLINE.

The Oakland anticline, a long plunging anticline or anticlinal nose in Marshall County, Okla., extends from the southeast corner of sec. 13, T. 5 S., R. 4 E., southeastward through Oakland and the southwestern part of Madill to the northeast corner of sec. 3, T. 6 S., R. 5 E., where it plunges to the southeast and disappears. The trend of this anticline is parallel to that of the Preston and Madill anticlines and also to that of the folds in the underlying Paleozoic rocks. The crest of the Oakland anticline is in Glasses Creek valley. This valley is rimmed on both sides by the Goodland limestone, which forms the sides of the eroded arch.

There are no significant exposures along the crest of the anticline, so that the mapping of the crest may be only approximately correct. As shown, it passes from a point near the center of the NE. ¼ sec. 3, T. 6 S., R. 5 E., past the northwest corners of secs. 34 and 28, T. 5 S., R. 5 E., to the northwest corner of sec. 19 of the same township. Over this distance the axis dips only gently to the southeast. Northwest of sec. 19 the anticline is not mapped because of the absence of key beds. There is probably no reversal of dip, however, in that direction. The dip on the southwest side of the anticline is fairly steep, ranging from 110 to 130 feet to the mile; on the northeast side it ranges from 25 to 80 feet to the mile.

### MADILL ANTICLINE.

The Madill anticline, so named from the small oil pool on its northwest end, extends in a southeasterly direction from sec. 36, T. 5 S., R. 5 E., passing 1 mile northeast of Cliff and 1½ miles south of Aylesworth. Its extreme southeast end is not outlined on Plate IV, but the part shown is 12 miles long. The axis of this fold dips gently to the southeast through its entire length at a rate of 20 to 40 feet to the mile. The dip on the flanks of the anticline amounts to as much as 90 feet to the mile. The trend of the Madill anticline is parallel to that of the Preston anticline, from which it is separated by a broad, shallow syncline.

The Madill anticline may be a direct continuation of the Oakland anticline which has been offset by a cross fault in the underlying rocks. This hypothesis would account for the abrupt southeast termination of the Oakland anticline and also for the presence of the very small Madill oil pool, as the cross fault would form an avenue of escape for oil from the petroliferous Paleozoic rocks into the Trinity sand, where it is found.

## DEVELOPMENT.

### MADILL OIL POOL.[7]

The presence of oil seeps in the region near Madill led to prospecting with the drill and finally in March, 1909, to the discovery of a small pool of oil 1½ miles east of the town. Oil was discovered by the Mal-Millan Oil Co. on the Arbuckle farm, in the SW. ¼ sec. 25, T. 5 S., R. 5 E., and this pool is sometimes called the Arbuckle pool. Active drilling was begun immediately after the discovery, but the pool has not been extended beyond the limits of the quarter section (see Pl. IV, in pocket), although showings of oil were found in widely scattered parts of the surrounding area. By April 20, 1909, eight wells had been drilled in this pool, four of which were productive. The largest well in the pool was completed March 22, 1909, and had an estimated initial daily production of 400 barrels. During January, 1918, only one well was producing, at the rate of about 8 barrels a day. One well was drilled through 18 inches of sand at 420 feet and abandoned dry at 460 feet during that month. The Kanoky Oil Co. is reported to have completed a 5-barrel well at 430 feet in the northwest corner of the SW. ¼ SW. ¼ sec. 25, T. 5 S., R. 5 E., in July, 1918.

The wells here start near the top of the Goodland limestone and find the oil sand at a depth of 420 to 460 feet, presumably near the base of the Trinity sand. The oil-bearing sand is lenticular and ranges in thickness from 1½ to 20 feet. It is considered of Trinity age because the rocks above it are soft, and no fragments of shale or sandstone that might be of Paleozoic age could be found in the cuttings. In a report of the Oklahoma Geological Survey, however, it is suggested that the oil-bearing sand (which the Oklahoma geologists call the "Arbuckle sand") may be of Pennsylvanian age.[8] Structurally the oil is found here near the northwest end of the Madill anticline. (See Pl. IV.) The oil pool is on what, if viewed locally, may be considered a terrace.

The oil from the Madill pool is of high grade. It has a specific gravity of 0.7887 (47.5° Baumé) at 60° F. and yields 60 per cent of gasoline and kerosene, about 7 per cent of paraffin, and little or no asphalt. It is 13° Baumé lighter than the average Mid-Continent crude oil.

### ENOS GAS FIELD.

The Enos gas field is 7 miles south of Kingston, Okla., near a store called Enos. Twelve or more wells have been drilled here, and most

[7] Taff, J. A., and Reed, W. J., The Madill oil pool, Okla.: U. S. Geol. Survey Bull. 381, pp. 504–513, 1910. Petroleum and natural gas in Oklahoma: Oklahoma Geol. Survey Bull. 19, pt. 2, pp. 316–321, 1917.

[8] Petroleum and natural gas in Oklahoma: Oklahoma Geol. Survey Bull. 19, pt. 2, p. 318, 1917.

of them made at least showings of oil and gas. The gas is found more abundantly than the oil. Few of the wells were drilled to a depth of more than 800 feet. In the SW. ¼ NW. ¼ sec. 36, T. 7 S., R. 5 E., a well, known as the J. C. Everett well No. 1 of the Wascomb Thorne Oil & Gas Co., was drilled to a reported depth of 600 feet. It encountered gas at a depth of 500 feet and had an estimated volume of 2,000,000 cubic feet of gas a day, but salt water drowned the gas out. The Signal Mountain Petroleum Co.'s Thomas well No. 1, in the SW. ¼ SW. ¼ sec. 36 of the same township, is said to have had a flow of 2,000,000 cubic feet of gas a day, with a show of oil at a depth of 475 feet. The Smith-Coleman well No. 1, in the southwest corner of the NW. ¼ SE. ¼ sec. 35, is reported to have had an original capacity of 5,000,000 cubic feet of gas a day, from a depth of 493 feet. It is now the only producing well in the field. A salt-water sand is found directly below the oil sand, and all the wells, with the exception of this one, were drilled too deep into it. Smith-Coleman well No. 2, sometimes called the Greer well, was drilled in the SW. ¼ NE. ¼ SW. ¼ sec. 35, T. 7 S., R. 5 E., to a depth of 1,625 feet. It is reported to have encountered gas at 520 feet and showings of oil at 800, 1,000, and 1,480 feet. The log is given below.

*Driller's log of Smith-Coleman well No. 2, Kingston, Okla., in the SW. ¼ sec. 35, T. 7 S., R. 5 E.*

| | Thickness. | Depth. | | Thickness. | Depth. |
|---|---|---|---|---|---|
| | *Feet.* | *Feet.* | | *Feet.* | *Feet.* |
| Clay, red and blue | 10 | 10 | Rock, hard | 14 | 437 |
| Lime | 4 | 14 | Gumbo, white | 6 | 443 |
| Sand, gray | 5 | 19 | Sand, hard | 5 | 448 |
| Lime and boulders | 11 | 30 | Lime, hard | 2 | 450 |
| Sand, yellow | 10 | 40 | Gas sand | 15 | 4 5 |
| Quicksand and gravel | 8 | 48 | Gumbo, blue | 32 | 4 7 |
| Sand, red | 12 | 60 | Oil sand | 4 | 501 |
| Sand, yellow | 10 | 70 | Gas sand; biggest oil sand in bottom | 19 | 5?0 |
| Soapstone, blue | 6 | 76 | Gumbo | 10 | 530 |
| Sand and soapstone | 34 | 110 | Gas rock; bailed at 532 feet; got dry gas | 4 | 534 |
| Rock, hard sand | 5 | 115 | Red beds | 7 | 541 |
| Sand, water | 4 | 119 | Oil sand | 26 | 567 |
| Lime boulders | 1 | 120 | Rock, hard | 3 | 570 |
| Gas sand | 18 | 138 | Oil sand; good show | 20 | 590 |
| Gumbo | 16 | 154 | Red beds | 4 | 594 |
| Rock, hard | 2 | 156 | Oil sand | 15 | 609 |
| Shale, blue | 29 | 185 | Red beds | 6 | 615 |
| Lime-shells rock | 4 | 189 | Oil sand | 12 | 627 |
| Shale, blue | 4 | 193 | Oil sand, brown shale | 36 | 663 |
| Gumbo, red | 7 | 200 | Sand, hard, sandrock | 49 | 712 |
| Shale, red | 4 | 204 | Shale, hard, brown | 3 | 715 |
| Gumbo, blue; set 10-inch casing | 5 | 209 | Rock, hard | 2 | 717 |
| Shale, blue | 3 | 212 | Shale, black slate | 3 | 720 |
| Gas sand No. 2 | 12 | 224 | Shale, black | 278 | 998 |
| Oil sand | 2 | 226 | Shale, hard, black | 10 | 1,008 |
| Gas sand | 4 | 230 | Oil sand, dark | 3 | 1,011 |
| Oil sand | 9 | 239 | Rock, hard sand | '19 | 1,030 |
| Oil sand | 3 | 242 | Shale, hard, and sandrock | 506 | 1,536 |
| Shale, blue | 5 | 247 | Rock, hard sand | 3 | 1,539 |
| Rock, hard sand | 7 | 254 | Shale, blue | 36 | 1,575 |
| Oil sand | 10 | 264 | Lime shells | 1 | 1,576 |
| Sand, water | 10 | 274 | Rock, hard | 2 | 1,578 |
| Shale, blue | 73 | 347 | Sand, fine, black; show of gas | 17 | 1,595 |
| Sand, hard | 3 | 350 | Shale, brown | 3 | 1,598 |
| Rock, hard | 1 | 351 | Sand, hard, black | 2 | 1,600 |
| Shale, blue | 29 | 380 | Shale, blue, sandy | 2 | 1,602 |
| Gumbo, blue | 31 | 411 | Sand, black | 23 | 1,625 |
| Rock, shale | 10 | 421 | | | |
| Gumbo | 2 | 423 | | | |

The Tobe Greer well, in the SE. ¼ NW. ¼ SW. ¼ sec. 35 of the same township, was drilled to a depth of 515 feet and is reported to have yielded showings of oil at 220 and 420 feet and a volume of gas estimated at 1,500,000 cubic feet. In the southwest corner of the SE. ¼ SW. ¼ sec. 25 the Roy Milliken well was drilled to a depth of 760 feet and reported a showing of about 1,000,000 cubic feet of gas and a trace of oil. In the northeast corner of the NE. ¼ sec. 2, T. 8 S., R. 5 E., the Deeren well was drilled to a reported depth of 620 feet. Gas was found below 507 feet with an estimated volume of 4,000,000 cubic feet. Another well was drilled by the Wascomb Thorne Oil & Gas Co. on the J. A. L. Wolff farm, in the northwest corner of the SE. ¼ sec. 1, T. 8 S., R. 5 E., to a depth of 550 feet. A volume of gas estimated at 4,000,000 cubic feet was found at 500 feet, but the gas was drowned out by water. In the northwest corner of the SW. ¼ sec. 6, T. 8 S., R. 6 E., two wells were drilled by the Whitewright Oil Co. The western well was drilled to a depth of 620 feet and at 540 feet encountered 18 feet of sand that made a strong showing of high-grade oil. The other well was abandoned at a depth of 350 feet.

A well 350 feet deep drilled in the northeast corner of sec. 27, T. 7 S., R. 5 E., was reported to have yielded only salt water. Favorable showings of oil were found in the Waite well, in the southeast corner of the SW. ¼ sec. 23 in the same township, which had reached a depth of 1,800 feet in January, 1918. (See plotted log on Pl. V, in pocket.) In September, 1918, it was reported that a 100-barrel well had been completed in sec. 23 at a depth of 410 feet. In October of the same year it was reported that the Kingston Dome Oil Co.'s well No. 3, on the Anotubby farm, also in sec. 23, would make 3 barrels of oil a day from a sand at 431 to 432 feet, and later that the hole was lost at 1,800 feet.

The gas and the best showings of oil in this pool are found near the crest of the Preston anticline (see Pl. IV), at its northwest end, which is its highest part. The gas wells obtain their gas from sandy lenses in the lower part of the Trinity sand. The largest gas wells have been drilled in secs. 25, 35, and 36, T. 7 S., R. 5 E. Oil has been found in sand lenses near the base of the Trinity and also in sandy beds in black shale of the Caney (?) formation. The best oil showings have been found in sec. 23, T. 7 S., R. 5 E., in the Trinity sand.

### TEST WELLS NORTH OF RED RIVER.

The location of all the wells that have been drilled in that part of the area that lies north of Red River, so far as is known, is shown on Plate IV. The data regarding most of these wells are fragmentary, and many of them are not entirely trustworthy. No in-

formation is available regarding many of the wells shown on this map.

T. 5 S., R. 4 E.

On the M. S. Swain place, in the SW. ¼ SE. ¼ sec. 25, T. 5 S., R. 4 E., a water well drilled to a depth of 310 feet reached the top of the Goodland limestone at 225 feet, and the top of the Trinity, which yields fresh potable water, at 249 feet.

T. 5 S., R. 5 E.

A water well in sec. 10, T. 5 S., R. 5 E., on the Everett Bucholtz place, yields a strong showing of oil from a depth of 332 feet, or 257 feet below the base of the Goodland limestone. The potable water from this well is pumped into a tank on which a thick scum of oil accumulates.

The Ardmill Oil & Gas Co.'s Sacra well No. 3, in the SW. ¼ sec. 17, was drilled to a depth of 2,004 feet. This well starts near the top of the Goodland limestone and penetrates Trinity sands and shales (see diagrammatic log on Pl. V) to a depth of 402 feet. Black shale, probably a part of the Caney shale, was penetrated at 500 to 1,450 feet, and black shale with thin layers of oil-bearing sands at 1,724 to 2,004 feet. Some barrels of oil having a gravity of 66.2° Baumé were obtained from this well at a depth of 1,700 to 1,942 feet, and some oil of 47.0° Baumé was obtained near 2,000 feet. The high-grade oil found here is comparable to that found in the Ordovician beds in the Healdton field and is probably the highest-grade oil found in Oklahoma.

Well No. 1 on this same farm was drilled in 1906 to a depth of about 1,480 feet, and No. 2 was drilled in 1913 to a depth of 1,700 feet. Both wells were near No. 3, shown on Plate IV, and made showings of oil.

A well, sometimes called the W. E. Ramsey well, in the southwest corner of sec. 18, was drilled by the Kinney Oil & Refining Co. to a depth of about 300 feet. In January, 1918, the well was temporarily abandoned at that depth.

A well was drilled during 1915 (?) on the C. N. Love place, in the center of the SW. ¼ sec. 19, to a depth of 896 feet. Oil sand was reported in this well at 420 feet and dry sand at 800 feet.

*Driller's log of well on C. N. Love farm, in sec. 19, T. 5 S., R. 5 E., Okla.*

| | Thickness. | Depth. | | Thickness. | Depth. |
|---|---|---|---|---|---|
| | *Feet.* | *Feet.* | | *Feet.* | *Feet.* |
| Soil | 6 | 6 | Rock, red | 128 | 378 |
| Sand, packed | 94 | 100 | Shale, blue | 62 | 440 |
| Sand, blue; mud mixed; little water | 40 | 140 | Sand | 20 | 460 |
| White formation | 110 | 250 | Rock shell, red, mixed | 296 | 756 |
| | | | Sand; salt water | 50 | 806 |

In the southeast corner of sec. 22 the Ardmore Oil Co. drilled Lillie Sacra well No. 1 to a depth of 376 feet and obtained a show of oil and gas. The well was abandoned.

*Driller's log of Lillie Sacra well No. 1, Ardmore Oil Co., in sec. 22, T. 5 S., R. 5 E., Okla.*

| | Thickness. | Depth. | | Thickness. | Depth. |
|---|---|---|---|---|---|
| | *Feet.* | *Feet.* | | *Feet.* | *Feet.* |
| Lime | 8 | 8 | Lime | 4 | 264 |
| Shale | 40 | 48 | Shale | 11 | 275 |
| Sand, water bearing | 17 | 65 | Sand, water bearing | 15 | 290 |
| Shale | 41 | 106 | Shale | 30 | 320 |
| Sand, water bearing | 14 | 120 | Sand, water bearing | 15 | 335 |
| Shale | 70 | 190 | Shale | 21 | 356 |
| Sand, water bearing | 15 | 205 | Sand, Arbuckle; both gas and oil | 20 | 376 |
| Shale | 55 | 260 | | | |

In the SE. ¼ NE. ¼ sec. 24, on the John Null farm, a well was drilled to a depth of 430 feet. From 7 to 8 feet of oil-bearing sand in the top of the Trinity was reported at a depth of 420 feet.

In sec. 27, in the town of Madill, a number of shallow water wells and deep test wells have been drilled. Two water wells were drilled near the electric-light plant, in the NW. ¼ SW. ¼ sec. 27 (the only one shown on the map), to depths of 200 and 207 feet. These wells furnished the town water supply in 1918 from a depth of 165 to 207 feet. The water is sulphurous but potable. A well 1½ blocks southwest of the station at Madill, in the NW. ¼ SE. ¼ sec. 27, was drilled to a depth of 150 feet and yielded sulphur water and enough gas to burn with a flame 5 feet long. In a well drilled by Mr. Davidson, of Ardmore, in the yard of the county jail, near the center of the north line of the SW. ¼ sec. 27, to a depth of 1,100 feet, a show of gas was found at a depth of 800 to 1,100 feet. Another well was drilled in the SW. ¼ NE. ¼ sec. 27, across the railroad from the cotton-oil mill, to a reported depth of 1,750 feet. A well near the railroad coal chute, near the center of the NW. ¼ SE. ¼ sec. 27, was drilled to a depth of 325 feet and is said to yield fresh water.

Oscar Hughes, of Oakland, drilled two wells at the waterworks power house, in the SE. ¼ SW. ¼ sec. 28, to depths of 260 and 480 feet. Salt water was found at 430 feet in the deeper well, which started about 40 feet below the top of the Goodland.

On the Ida B. Lynn farm, in the SW. ¼ SE. ¼ sec. 31, a water well drilled to a depth of 440 feet encountered the top of the Goodland limestone at about 200 feet and water-bearing sands at 235, 300, and 425 feet. A few hundred feet east of this water well Dr. Schaffer drilled a test well to a depth of 600 feet and encountered what was reported to be a dry oil sand at 580 to 600 feet.

In the NE. ¼ sec. 34 the Taliaferro well was drilled in 1913 (?) to a depth of approximately 1,000 feet. It is said that this well was located under a stump by the "forked stick" method.

Four or more wells have been drilled in sec. 36, but the record of only one well, which is given below, is available.

*Driller's log of Jim Albertson well, drilled by the Ardmore Oil Co. in the SE. ¼ sec. 36, T. 5 S., R. 5 E., Okla.*

| | Thickness. | Depth. | | Thickness. | Depth. |
|---|---|---|---|---|---|
| | *Feet.* | *Feet.* | | *Feet.* | *Feet.* |
| Lime (Goodland) | 20 | 20 | Sand, water bearing | 40 | 300 |
| Shale | 20 | 40 | Shale | 40 | 340 |
| Sand, water bearing | 12 | 52 | Sand, water bearing | 15 | 355 |
| Shale | 38 | 90 | Shale | 30 | 385 |
| Sand, water bearing | 20 | 110 | Sand, water bearing | 20 | 405 |
| Shale | 60 | 170 | Shale | 34 | 439 |
| Sand, water bearing | 35 | 205 | Sand, Arbuckle; gas, no oil | 23 | 462 |
| Shale | 55 | 260 | | | |

T. 5 S., R. 6 E.

The Crumwell Oil & Gas Co. drilled a well in the SW. ¼ SE. ¼ sec. 16, T. 5 S., R. 6 E., to a depth of 1,500 feet and abandoned it without obtaining a favorable showing of oil or gas. The same company drilled a well in the SE. ¼ NW. ¼ sec. 27 and abandoned it at a depth of 645 feet.

A hole drilled in the NW. ¼ SE. ¼ sec. 28 to a depth of 800 feet and another drilled in the SW. ¼ SW. ¼ sec. 30 to a depth of 500 feet were dry.

T. 6 S., R. 5 E.

The approximate location of a well on the Willis Williams farm, in the NE. ¼ sec. 7, T. 6 S., R. 5 E., is shown on Plate IV. This well is reported to have reached a depth of 500 to 600 feet.

T. 6 S., R. 6 E.

A well was drilled about 1915 on the south side of the railroad at Kinlock, in the SE. ¼ sec. 4, T. 6 S., R. 6 E., to a depth of about 700 feet, without favorable results.

In the southwest corner of sec. 9 the Dundee Petroleum Co. drilled a well to a depth of 2,270 feet in 1916 and 1917. A strong showing of gas was found at 263 feet, and oil and gas at 610 feet. From 696 to 2,270 feet the well penetrated black and gray shale, probably belonging to the Caney formation. (See plotted log, in Pl. V.)

In the southeast corner of sec. 13, on the John Moore farm, a well was drilled to an unknown depth. A show of gas was reported from a depth of 300 to 400 feet.

The Pro Ratio Oil Co. drilled a well to a depth of 800 feet in the northeast corner of sec. 14, without favorable results. In the SE. ¼ SE. ¼ sec. 22 two wells were drilled to depths of 350 to 700 feet, with a reported showing of gas in one of them.

The Larrick Oil Co. drilled a well in the NE. ¼ NW. ¼ sec. 25, but the result of the test is not known.

A well was drilled in 1909 by the Kingston Oil & Gas Co. on the Fred Mutz farm, in the northeast corner of sec. 31, to a reported depth of 600 feet.

Kingston is supplied by a well in the south edge of the town, in the NW. ¼ sec. 31, which yields soft, fresh water from a depth of 500 feet. An analysis of the water by the International Filter Co., of Chicago, showed about 29 grains per gallon of sodium carbonate and 2 or 3 grains of sodium chloride and sodium sulphate. The character of this water suggests the absence of oil in the Trinity in this locality.

T. 6 S., R. 7 E.

The Blue Bell Oil & Gas Co. drilled a well in the SW. ¼ SE. ¼ sec. 29, T. 6 S., R. 7 E., and encountered the top of the Goodland limestone at 228 feet and a strong show of oil below in the Trinity. Another well was drilled in the SW. ¼ SW. ¼ sec. 29, but no information is available regarding it other than the fact that it was dry.

T. 7 S., R. 4 E.

In the northeast corner of the SW. ¼ NW. ¼ sec. 5, T. 7 S., R. 4 E., near the village of Lebanon, a well was drilled on the Askew farm to a depth of 2,070 feet. Only one showing of oil was reported, at a depth of 503 feet. The well reached the base of the Trinity sand at 285 feet and penetrated the Glenn (?) formation from that depth to 2,070 feet, where it was abandoned.

*Driller's log of Dulsa Askew well No. 1, sec. 5, T. 7 S., R. 4 E., Okla.*

| | Thickness. | Depth. | | Thickness. | Depth. |
|---|---|---|---|---|---|
| | *Feet.* | *Feet.* | | *Feet.* | *Feet.* |
| Surface soil | 40 | 40 | Red rock | 5 | 400 |
| Quicksand and water | 20 | 60 | Sand | 5 | 405 |
| Pack sand with water | 80 | 140 | Red rock | 15 | 420 |
| Quicksand | 10 | 150 | Sand, very hard | 30 | 450 |
| Lime shell | 10 | 160 | Blue shale | 53 | 503 |
| Lime | 10 | 170 | Sand, showing of oil | 5 | 508 |
| Sand with water | 20 | 190 | Blue shale | 12 | 520 |
| Sand with water | 70 | 260 | Sand, 2 bailers water | 30 | 550 |
| Lime shell | 5 | 265 | Blue shale | 57 | 607 |
| Sand with water (base of Trinity sand) | 20 | 285 | Lime | 2 | 609 |
| Blue mud (Glenn formation?) | 15 | 300 | Brown shale | 126 | 735 |
| Lime shell | 25 | 325 | Red rock | 20 | 755 |
| Red rock | 15 | 340 | Yellow shale | 25 | 780 |
| Sand shell | 10 | 350 | Sand with water | 25 | 805 |
| Yellow rock | 20 | 370 | Red rock | 15 | 820 |
| Lime shell | 20 | 390 | Water sand | 40 | 860 |
| Blue mud | 5 | 395 | Blue mud | 30 | 890 |
| | | | Red rock | 16 | 906 |

*Driller's log of Dulsa Askew well No. 1, sec. 5, T. 7 S., R. 4 E., Okla.*—Continued.

| | Thickness. | Depth. | | Thickness. | Depth. |
|---|---|---|---|---|---|
| | *Feet.* | *Feet.* | | *Feet.* | *Feet.* |
| Blue mud | 9 | 915 | Blue shale | 416 | 1,716 |
| Water sand | 25 | 940 | Lime shell | 5 | 1,721 |
| Brown shale | 25 | 965 | Blue shale | 65 | 1,786 |
| Brown and yellow shale | 55 | 1,020 | Lighter shale | 9 | 1,795 |
| Water sand | 40 | 1,060 | Red bed | 40 | 1,835 |
| Red rock | 15 | 1,075 | Sandy shale | 20 | 1,855 |
| Blue shale | 10 | 1,085 | Sand, light | 2 | 1,857 |
| Red, yellow, and blue (shale) | 75 | 1,160 | Red rock, very hard | 3 | 1,860 |
| Red bed | 12 | 1,172 | Sandy shale, light | 10 | 1,870 |
| Blue shale | 18 | 1,190 | Blue shale, very light and thin, shells occasionally | 20 | 1,890 |
| Red rock | 10 | 1,200 | Salt water | 180 | 2,070 |
| Blue shale | 90 | 1,190 | | | |
| Water sand | 10 | 1,300 | | | |

T. 7 S., R. 5 E.

The Indian Chief Oil & Gas Co. drilled a test well on the Willis farm, in the NE. ¼ NE. ¼ SW. ¼ sec. 19, T. 7 S., R. 5 E., to a depth of 2,540 feet. (See plotted log, Pl. V.) This well started 30 feet above the top of the Goodland limestone, reached the base (?) of the Trinity at 616 feet, and penetrated red and brown shale and sandstone to 2,540 feet. The rocks encountered below the Trinity in this well differ radically from those penetrated in the Ardmill Oil & Gas Co.'s Sacra well No. 3, in sec. 17, T. 5 S., R. 5 E.; the well of the Dundee Petroleum Co. in sec. 9, T. 6 S., R. 6 E.; the Waite well, in sec. 23, T. 7 S., R. 5 E.; and the Smith-Coleman Greer well No. 2, in sec. 35, T. 7 S., R. 5 E. In those wells the strata lying below the Trinity are believed to belong to the Caney shale, whereas in the Willis, Dulsa Askew, and Owens wells and in the Westover well at Orlena, Tex., the corresponding strata are believed to belong to the Glenn formation. (Compare the plotted logs of these wells on Pl. V with the generalized section of Paleozoic rocks on Pl. II.) This well was abandoned without favorable showings of oil or gas.

T. 7 S., R. 7 E.

Three wells have been drilled on the Owens farm, in the southern part of sec. 17, T. 7 S., R. 7 E. Well No. 1 reached the top of the Goodland limestone at 410 feet and the base (?) of the Trinity at 1,024 feet, below which it penetrated red, yellow, and black shale, probably belonging to the Glenn formation, to a depth of 1,215 feet, and was then abandoned. Showings of oil and gas were found in this well at about 1,000 feet. No information is available regarding well No. 2. Well No. 3 reached the top of the Goodland at 362 feet and was abandoned at 1,200 feet.

*Driller's log of well No. 1 on the R. A. Owens farm, in sec. 17, T. 7 S., R. 7 E., 3 miles northeast of Woodville, Okla.*

| | Thickness. | Depth. | | Thickness. | Depth. |
|---|---|---|---|---|---|
| | *Feet.* | *Feet.* | | *Feet.* | *Feet.* |
| Slate and shale (13½-inch casing set) | 60 | 60 | Sand | 60 | 900 |
| Slate | 150 | 210 | Slate | 10 | 910 |
| Lime | 10 | 220 | Sand | 30 | 940 |
| Slate and shale | 190 | 410 | Slate | 58 | 998 |
| Lime (Goodland limestone) | 23 | 433 | Top of gas and show of oil | | 998 |
| Top of Trinity sand; 12-inch casing set | 7 | 440 | Bottom of sand (base of Trinity sand) | 26 | 1,024 |
| Sand; 10-inch casing set | 120 | 560 | Red and yellow slate; 8-inch casing set | 86 | 1,110 |
| Sand; 8-inch casing set | 78 | 638 | White slate | 10 | 1,120 |
| Sand and lime | 62 | 700 | Black slate | 30 | 1,150 |
| Sand | 50 | 750 | Red slate | 5 | 1,155 |
| Lime | 20 | 770 | Black slate | 60 | 1,215 |
| Slate | 70 | 840 | | | |

T. 8 S., R. 7 E.

In the southeast corner of sec. 14, T. 8 S., R 7 E., 2 miles west of Colbert, a well was drilled in 1918 by the United Oil & Refining Co. of Denver and Oklahoma City. Nothing is known regarding the findings in this well.

## TEST WELLS SOUTH OF RED RIVER.

### GRAYSON COUNTY, TEX.

A well was drilled by C. V. Westover in the northwest corner of Grayson County, Tex., 2½ miles south-southeast of Orlena, on the Thorn & Handy farm. This well started at the horizon of the Goodland limestone, penetrated the Trinity sand, which is interpreted to be 655 feet thick, and drilled through red and blue shale and sand of the Glenn (?) formation from 655 to 2,410 feet. An oil sand is reported at 1,200 feet in this formation.

*Driller's log of C. V. Westover well No. 1, near Orlena, Grayson County, Tex.*

| | Thickness. | Depth. | | Thickness. | Depth. |
|---|---|---|---|---|---|
| | *Feet.* | *Feet.* | | *Feet.* | *Feet.* |
| Limestone, white (Goodland) | 20 | 20 | Slate, white | 10 | 550 |
| Slate, blue (top of Trinity sand) | 30 | 50 | Sand, white | 50 | 600 |
| Sandstone, white | 25 | 75 | Slate, white | 5 | 605 |
| Slate, blue | 15 | 90 | Sand, white | 10 | 615 |
| Sand, white | 60 | 150 | Slate, blue | 5 | 620 |
| Slate, blue | 20 | 170 | Sand, light | 20 | 640 |
| Sandstone, white | 110 | 280 | Slate, blue | 15 | 655 |
| Rock, red | 20 | 300 | Sand, white (base of Trinity sand) | 20 | 675 |
| Slate, white | 25 | 325 | Slate, blue (Glenn formation) | 10 | 685 |
| Rock, red | 15 | 340 | Rock, red | 15 | 700 |
| Sand, white | 40 | 380 | Sand, white | 40 | 740 |
| Slate, white | 6 | 386 | Slate, blue | 20 | 760 |
| Sand, white | 15 | 401 | Sand, gray | 20 | 780 |
| Sandstone, white | 39 | 440 | Slate, blue | 10 | 790 |
| Sand, white | 10 | 450 | Sand, gray | 10 | 800 |
| Slate, white | 35 | 485 | Rock, red | 15 | 815 |
| Sand, white | 15 | 500 | Shale, blue, sandy | 15 | 830 |
| Slate, white | 10 | 510 | Sand, white | 10 | 840 |
| Sand, white | 30 | 540 | Rock, red | 35 | 875 |

*Driller's log of C. V. Westover well No. 1, etc.*—Continued.

| | Thickness. | Depth. | | Thickness. | Depth. |
|---|---|---|---|---|---|
| | *Feet.* | *Feet.* | | *Feet.* | *Feet.* |
| Slate, blue | 25 | 900 | Slate, white | 6 | 1,691 |
| Sand, light | 25 | 925 | Rock, red | 49 | 1,740 |
| Slate, blue | 25 | 950 | Slate, white | 10 | 1,750 |
| Sand, white | 50 | 1,000 | Rock, red | 40 | 1,790 |
| Slate, blue | 80 | 1,080 | Slate, blue | 10 | 1,800 |
| Sand, white | 20 | 1,100 | Rock, red | 25 | 1,825 |
| Limestone, light, sandy | 25 | 1,125 | Sand, water | 2 | 1,827 |
| Sand, light | 25 | 1,150 | Sand, light | 18 | 1,845 |
| Slate | 25 | 1,175 | Slate, blue | 20 | 1,865 |
| Limestone, light, sandy | 10 | 1,185 | Sand, light | 10 | 1,875 |
| Slate, blue | 15 | 1,200 | Slate, blue | 25 | 1,900 |
| Oil sand | 10 | 1,210 | Rock, red | 25 | 1,925 |
| Slate, blue | 20 | 1,230 | Slate, blue | 25 | 1,950 |
| Rock, red | 30 | 1,260 | Sand, light | 65 | 2,015 |
| Lime rock, gray | 6 | 1,266 | Slate, blue | 10 | 2,025 |
| Rock, red | 34 | 1,300 | Coal, black | 2 | 2,027 |
| Sand, white | 30 | 1,330 | Shale, brown | 43 | 2,070 |
| Slate, blue | 55 | 1,385 | Sand, light | 8 | 2,078 |
| Sand, white | 45 | 1,430 | Shale, dark | 47 | 2,125 |
| Slate, blue | 15 | 1,445 | Sand, dark | 18 | 2,143 |
| Sand, white | 20 | 1,465 | Sand, broken | 62 | 2,205 |
| Slate, blue | 15 | 1,480 | Shale, brown | 28 | 2,233 |
| Sand, white | 40 | 1,520 | Slate | 2 | 2,235 |
| Slate, blue | 40 | 1,560 | Sand, light | 75 | 2,310 |
| Sand, white | 55 | 1,615 | Slate, brown | 5 | 2,315 |
| Slate, blue | 10 | 1,625 | Slate, red | 5 | 2,320 |
| Rock, red | 10 | 1,635 | Mud, red | 30 | 2,350 |
| Limestone, white | 15 | 1,650 | Slate, blue | 20 | 2,370 |
| Rock, red | 35 | 1,685 | Sand, light | 40 | 2,410 |

About 2½ miles south of the C. V. Westover well the Snyder Oil & Gas Co. drilled a well on the east slope of Brushy Mound, on the Calvin Barnes farm. The well had reached a depth of 450 feet in December, 1917. Both this well and the C. V. Westover well are in an area of steep southerly dips, southwest of the Preston anticline. (See Pl. IV.) Seven miles southwest of this well, in Cooke County (not shown on the maps accompanying this report), the Fortuna Oil Co. drilled a well on the Thomas Ward farm to a reported depth of 2,360 feet.

The Whitesboro Oil & Gas Co. drilled a well on the Joe Rich farm, 1 mile southeast of Bed Branch, to a depth of about 1,300 feet. The top of the Trinity was reached at about 700 feet, with no significant show of oil or gas. This well is down in the syncline on the southwest side of the Preston anticline, approximately 740 feet below its crest.

Five wells have been drilled near Preston, 9 miles by air line north-northwest of Denison. These wells, drilled by a local company, are on the north slope of the Preston anticline from 160 to 230 feet below its crest. They are said to have made showings of gas, but because of the close association of water with the gas they could not be completed as gas wells. The well three-fourths of a mile west of Preston was drilled in 1904 or 1905 on the Charles Carroll (now James Jackson) farm to a depth of 500 to 600 feet. Wells Nos. 1 and 2 on the Meadows farm, the two nearest the road leading to Thomp-

son Ferry, were drilled to about the same depth. Well No. 1 on the J. W. Kennedy (now Joseph Micodow) farm, half a mile due east of Preston, was the deepest well near Preston and is reported to have reached a depth of 1,300 feet. The fifth well, on the Williams farm, half a mile southeast of Preston, was drilled to a depth of 500 to 600 feet.

Six miles due north of Pottsboro, on Little Mineral Creek, a well that was begun by J. T. Bryant and later taken over by the Lone Star Gas Co. was drilled on the J. L. Campbell farm to a depth of 2,455 feet. This well started in the Trinity sand, 72 feet below the base of the Goodland limestone, and penetrated alternating beds of sand and clay that appear to belong to the Trinity to a depth of 694 feet, and shales with thin beds of limestone and sandstone from 694 to 2,455 feet. (See Pl. V.) However, the rocks were soft and caved to a depth of 545 feet, below which they were harder and stood up, suggesting that the base of the Trinity may have been reached at that depth. At 545 feet a considerable flow of gas, estimated by Mr. Bryant at 1,500,000 feet, was struck, but its volume was not tested. The sands below that depth were dry and made no conspicuous showings of oil or gas. This well is three-fourths of a mile southwest of the crest of the Preston anticline but is close enough to be a fairly good test of that part of the fold. The results are favorable for the development of small gas wells in the Trinity in this area but unfavorable for oil or gas in the underlying Paleozoic rocks.

The Paraffin Oil Co. drilled a well to a reported depth of 1,500 feet 3½ miles south-southwest of Preston, 2 miles southeast of the Lone Star Gas Co.'s well. No log or other information is available regarding this well.

Two wells were drilled close together 4 miles north-northeast of Pottsboro on the road leading to Thompson Ferry. The southern well, on the west side of the road, was drilled by the Denison Oil & Gas Co. on the Hardiman Dunning farm. It is reported that the base of the Goodland limestone was reached at 201 feet, and the hole was abandoned at a depth of 506 feet. The other well, on the east side of the road, called the Munson well, was drilled by R. H. Cook on the Fred Mueller farm to a depth of 400 feet.

The city of Denison drilled two wells at the city reservoir, 4 miles north-northwest of the city. Well No. 1, which was drilled 389 feet deep, started 5 feet above the Goodland limestone. The water from a depth of 373 to 389 feet was salt. Well No. 2 started 10 feet above the top of the Kiamichi and reached a depth of 330 feet. These wells are on the plunging axis of the Preston anticline, but as they did not reach the base of the Trinity they did not fully test its possibilities in this area.

*Driller's log of well No. 1, drilled by the city of Denison, Tex., on the west bank of Shawnee Creek ¼ miles north-northwest of Denison.*

| | Thickness. | Depth. | | Thickness. | Depth. |
|---|---|---|---|---|---|
| | *Feet.* | *Feet.* | | *Feet.* | *Feet.* |
| Mud | 5 | 5 | Lime | 10 | 270 |
| Lime (Goodland) | 18 | 23 | Sand, slate, and gravel | 40 | 310 |
| Sand and shale (Trinity sand) | 127 | 150 | Red mud | 10 | 320 |
| Lime | 10 | 160 | Red and blue | 20 | 340 |
| Sand; water within 50 feet of top | 10 | 170 | Sand and shale | 29 | 369 |
| Sand and shale | 20 | 190 | Rock | 3 | 372 |
| Lime and sand | 40 | 230 | Salt water | 17 | 389 |
| Sand and shale | 30 | 260 | | | |

A well was drilled by W. B. Munson on the G. L. Blackford farm, 2½ miles north of Denison, on the east side of the Bears Ferry road, to a depth of 2,210 feet. (See plotted log, Pl. V.) The base of the Goodland was reached at 200 feet, and the base of the Trinity at about 780 feet. Some thin beds of sand, interbedded with shale and limestone, were found from 780 to 978 feet, below which black and blue shale, with some hard shells (probably thin beds of limestone), was found to the bottom of the hole. This lower part of the section, from 955 to 2,210 feet, is probably Caney shale; the 198 feet of beds above that may belong to the Glenn formation. Some showings of gas were found from 656 to 955 feet. This well is favorably located on the plunging axis of the Preston anticline and is a good test of the beds to a depth of 2,210 feet. It indicates the possibility of developing small gas wells on this part of the anticline, but as the sands are thin and the gas is followed closely by water, a dry gas well would be difficult to complete.

The Fields well was drilled under the supervision of T. V. Munson 1¼ miles south of Colbert Bridge over Red River and 4 miles north of Denison. This well encountered the first sand at 215 feet and penetrated alternating beds of sand, limestone (?), and shale to a depth of 812 feet, where it was abandoned. The sands showed salt water. The well is now flowing salt water from a depth of 700 to 750 feet. The salt water, which is probably a brine, is charged with sufficient gas to cause it to effervesce like soda water. This well is on the north slope of the Preston anticline, about 70 feet structurally lower than the Blackford well.

The Fortuna Oil Co. drilled a well 3 miles north-northwest of Tom Bean, on the H. M. Ryan farm. According to the driller the well, which started in the upper part of the Austin chalk, reached the base of the chalk at 555 feet and encountered the first water-bearing stratum at 755 feet, probably in the Eagle Ford shale. According to the log given below the Woodbine sand was penetrated from 905 to 1,460 feet, the beds between the top of the Grayson marl and the base of the Goodland limestone from about 1,500 to 2,102 feet, and the

Trinity sand from 2,102 to 2,502 feet, the bottom of the hole. The water in the Trinity and Woodbine is fresh and stands at a depth of 200 feet below the surface. This well is near the bottom of the large Sherman syncline.

*Driller's log of Fortuna Oil Co.'s well on the H. M. Ryan farm, about 12 miles southeast of Sherman and 3 miles north-northwest of Tom Bean, Grayson County, Tex.*

| | Thickness. | Depth. | | Thickness. | Depth. |
|---|---|---|---|---|---|
| | *Feet.* | *Feet.* | | *Feet.* | *Feet.* |
| Chalk (Austin) | 20 | 20 | Shale, blue | 20 | 1,805 |
| Shale, blue | 140 | 160 | Flint | 5 | 1,810 |
| Shale, blue | 80 | 240 | Shale, blue; 8¼-inch casing set, 1,824 feet | 10 | 1,820 |
| Yellow formation | 80 | 320 | Shale, sandy | 50 | 1,870 |
| Mud, gray | 70 | 390 | Shale, blue | 40 | 1,910 |
| Shale, gray | 70 | 460 | Shale, gray, sandy | 130 | 2,040 |
| Shale, blue; 15½-inch casing set, 742 feet | 50 | 510 | Shale, blue | 50 | 2,090 |
| Soapstone, black; 12½-inch casing set, 876 feet | 61 | 571 | Shale, blue | 5 | 2,095 |
| Slate, gray (base of Eagle Ford) | 119 | 690 | Shale, sandy: gas | 2 | 2,097 |
| Water | 110 | 800 | Mud, blue | 5 | 2,102 |
| Slate, blue | 105 | 905 | Sand (top of Trinity) | 93 | 2,195 |
| Sand, hard | 245 | 1,150 | Mud, blue | 25 | 2,220 |
| Sand; 10-inch casing set, 1,440 feet | 130 | 1,280 | Sand, water; 8-inch casing set, 2,253 feet | 30 | 2,250 |
| Hard sand | 25 | 1,305 | Sandrock | 5 | 2,255 |
| Shale, blue, and sand (base of Woodbine) | 15 | 1,320 | Sand, water | 5 | 2,260 |
| Lime, white | 60 | 1,380 | Lime | 30 | 2,290 |
| Slate, blue | 20 | 1,400 | Shale, sandy | 10 | 2,300 |
| Shale, sandy | 45 | 1,445 | Rock, red, sand | 20 | 2,320 |
| Shale, blue | 15 | 1,460 | Sand, water; 5⅝-inch casing set, 2,335 feet | 5 | 2,325 |
| Lime, sandy | 40 | 1,500 | Red bed | 10 | 2,335 |
| Shale, blue | 40 | 1,540 | Sand | 10 | 2,345 |
| Lime | 45 | 1,585 | Shale, sandy | 5 | 2,350 |
| Shale, blue | 7 | 1,635 | Sand | 10 | 2,360 |
| Lime, sandy | 10 | 1,645 | Lime, soft | 5 | 2,365 |
| Shale, blue | 20 | 1,665 | Lime, sandy | 5 | 2,370 |
| Lime, sandy | 5 | 1,690 | Red bed | 20 | 2,390 |
| Shale, blue | 35 | 1,725 | Sand, water | 45 | 2,435 |
| Lime | 20 | 1,745 | Mud, blue | 10 | 2,445 |
| Shale, blue | 25 | 1,770 | Sand, water | 35 | 2,480 |
| Lime | 15 | 1,785 | Shale, blue | 5 | 2,485 |
| | | | | 20 | 2,505 |

In two water wells drilled in Whitewright to a depth of about 1,150 feet the water stands within about 230 feet of the surface. These wells yield a good supply of potable water from the Woodbine sand.

The following wells were reported as being rigged up or drilled in Grayson County late in 1919:

E. E. Peter and others, Jackson No. 1, William Wright survey, being drilled at 753 feet.

Peters Oil & Gas Co., S. J. Campbell No. 1, Polly Anne Boone survey, rotary on location.

Preston Anticline Oil & Gas Co., Munson No. 1, Ramon Rubic survey, building standard rig.

Viola Petroleum Co., J. Exstein No. 1, David Jones survey, near Locust, northwest of Hinson, being drilled.

Westover Oil Co., Thorne No. 1, Samuel Stewart survey, present depth 2,550 feet.

Westover Oil Co., W. M. Easton No. 1, Polly Stamps survey, rotary rig.

M. & H. Drilling Co., E. C. Anderson No. 1, Joseph Bratton survey, being drilled at 635 feet.

### FANNIN COUNTY, TEX.

In 1911 the Holt Higth Waterworks Co. drilled a well 1 mile due north of Honey Grove to a depth of 1,673 feet. The well was drilled by W. E. Tomerlin, who reported shows of gas at 973 to 978 feet.

*Driller's log of Holt Higth Waterworks Co.'s well 1 mile north of Honey Grove, Fannin County, Tex.*

| | Thickness. | Depth. | | Thickness. | Depth. |
|---|---|---|---|---|---|
| | *Feet.* | *Feet.* | | *Feet.* | *Feet.* |
| Blue rock (Austin chalk), soft | 208 | 208 | Blue sandrock, hard | 2 | 985 |
| Blue sand, hard | 2½ | 210½ | Blue gumbo, hard | 6 | 991 |
| Blue sand, soft; some salty water | 30½ | 241 | Sandrock, hard | 2 | 993 |
| White soapstone, soft (probably pipe clay) | 7 | 248 | Shale and soapstone, soft | 15 | 1,008 |
| Blue sandrock, hard | 3 | 251 | Sandrock, hard | 1½ | 1,009½ |
| Shale and soapstone, soft | 23 | 274 | Blue shale, soft | 52½ | 1,062 |
| Blue sandrock, hard | 2 | 276 | White soapstone, soft | 13 | 1,075 |
| White soapstone, soft (probably pipe clay) | 8 | 284 | Blue gumbo, hard | 34 | 1,109 |
| Blue gumbo, medium (probably marl) | 28 | 312 | Blue shale, soft | 16 | 1,125 |
| Blue shale, soft, with boulders | 58 | 370 | Blue sandrock, hard | 3 | 1,128 |
| Blue sandrock, hard | 2 | 372 | White soapstone, soft | 12 | 1,140 |
| Blue shale and stone, soft | 79 | 451 | Blue gumbo, hard | 41 | 1,181 |
| Blue gumbo, hard | 29 | 480 | Blue shale, soft | 61 | 1,242 |
| Blue shale, soft, with thin layers of rock or boulders | 230 | 710 | Sandrock, soft | 5 | 1,247 |
| Blue sandrock, hard | 1½ | 711½ | Gravel, hard | 8 | 1,255 |
| Shale and soapstone, soft | 28½ | 740 | White sand, hard | 2 | 1,257 |
| Blue shale, soft; boulders and thinner layers of sand; 8-inch casing set | 233 | 973 | Red marl, hard | 24 | 1,281 |
| Blue sandrock, very hard; a slight showing of gas | 5 | 978 | Red beds, hard, laminated, with soapstone and boulders | 284 | 1,565 |
| White soapstone, soft | 5 | 983 | Blue gumbo, hard | 9 | 1,574 |
| | | | White soapstone, soft, on hard sandrock; 6-inch casing set | 9 | 1,583 |
| | | | White sandrock, hard (cap rock) | 2 | 1,585 |
| | | | White sand, soft (good coarse sand with fine red specks) | 84 | 1,669 |
| | | | Blue shale, soft | 4 | 1,673 |

A well was drilled in Ladonia 200 yards north of the public square, to a depth of 2,426 feet. The well starts near the top of the Pecan Gap chalk and reaches the top of the Annona tongue of the Austin chalk at 465 feet and the Woodbine sand at about 1,800 feet. (See plotted log, Pl. VI, in pocket.) The well stopped in a limestone that may represent the top of the Comanche series. No showings of oil or gas were reported from this well.

A deep wildcat test was drilled by the Wolfe City Petroleum Co. near the Fannin-Hunt county line, 2 miles northeast of Wolfe City, to a depth of 2,075 feet. (See plotted log, Pl. VI.) This well started in the Wolfe City sand and reached the top of the Annona tongue at 509 feet and the top of the Woodbine sand at about 1,789 feet. Salt water was found at 1,789 to 1,822 feet, which rose within 250 feet of the surface. No conspicuous showings of oil or gas were reported from this well.

A well was drilled by R. H. Dearing in Trenton to a depth of 1,123 feet. Salt water was found at 650 to 700 feet but was cased off,

and fresh water was found below, which rose within about 300 feet of the surface.

The Leonard Cotton Oil Co. drilled a deep water well in the edge of Leonard to a depth of 1,591 feet. The well starts near the top of the Annona tongue and reaches the top of the Woodbine at a depth of 1,163½ feet. (See plotted log, Pl. VI.) No showings of oil or gas were reported from this well.

The following wells were being rigged up or drilled in Fannin County during the later part of 1919:

Telephone Oil & Gas Co., W. A. Moore No. 1, Thomas W. Smith survey, being drilled; reported show of oil and gas at 660 feet.

Elkay Oil Co., Wilson Lane farm, James Boreland headright, 3 miles northwest of Ector, rigging up.

Preston Anticline Oil Co., Whiting farm, northeast corner of Jesse Wallace headright, 1 mile south of Anthony, rigging up.

Beasley No. 1, 8 miles northeast of Bonham.

The log of the Beasley No. 1 is given below, with an interpretation by L. W. Stephenson of the formations penetrated:

*Driller's log of Beasley well No. 1, 8 miles northeast of Bonham, Fannin County, Tex.*

| | Thickness. | Depth. | | Thickness. | Depth. |
|---|---|---|---|---|---|
| | *Feet.* | *Feet.* | | *Feet.* | *Feet.* |
| Clay | 35 | 35 | Gumbo and asphalt | 14 | 900 |
| Shale, blue | 230 | 265 | Sand, water bearing | 10 | 910 |
| Rock, oil and gas (top of Eagle Ford) | 10 | 275 | Gumbo, red | 135 | 1,045 |
| Shale | 55 | 330 | Shale, red and brown | 12 | 1,057 |
| Shale and boulders | 68 | 398 | Chalk rock | 8 | 1,065 |
| Rock, hard | 2 | 400 | Sand | 202 | 1,267 |
| Gumbo, hard | 46 | 446 | Gumbo | 35 | 1,302 |
| Rock | 1 | 447 | Shale, hard, blue | 28 | 1,330 |
| Shale and boulders | 41 | 488 | "Gip" (base of Woodbine sand) | 10 | 1,340 |
| Shale, sandy | 42 | 530 | Gumbo | 14 | 1,354 |
| Gumbo and boulders | 25 | 555 | Rock | 7 | 1,361 |
| Gumbo | 55 | 610 | Gumbo | 29 | 1,390 |
| Shale (base of Eagle Ford) | 200 | 810 | Rock | 5 | 1,395 |
| Sandrock | 2 | 812 | Gumbo | 42 | 1,437 |
| Sand and boulders | 3 | 815 | Rock | 3 | 1,440 |
| Shale | 25 | 840 | Gumbo | 66 | 1,506 |
| Rock | 4 | 844 | Shale and boulders | 8 | 1,514 |
| Sand, water bearing | 42 | 886 | Shale, hard, and boulders, with many fossils | 333 | 1,847 |

HUNT COUNTY, TEX.

A well was drilled in 1907 at the cotton-oil mill in Wolfe City to a reported depth of 2,240 feet. The casing in this well is supposed to have been set at 2,120 feet, and the water coming from beds below that depth is too saline for domestic use. The log of this well to a depth of 1,768 feet is available, but the descriptions are so vague that it is impossible to correlate the beds penetrated with their outcrops.

A well in Celeste reached the top of the Annona tongue of the Austin chalk at a depth of 300 feet and the top of the Woodbine at 1,535 feet, as shown by the following log:

*Driller's log of a municipal well in Celeste, Hunt County, Tex.*

[Drilled by R. H. Dearing & Sons.]

| | Thickness. | Depth. | | Thickness. | Depth. |
|---|---|---|---|---|---|
| | *Feet.* | *Feet.* | | *Feet.* | *Feet.* |
| Surface soil | 10 | 10 | Gumbo with boulders | 20 | 1,120 |
| White clay | 11 | 21 | Shale | 20 | 1,140 |
| Shale and gumbo | 279 | 300 | Rock | 5 | 1,145 |
| White rock (Annona tongue of Austin chalk) | 430 | 730 | Soapstone | 5 | 1,150 |
| Gumbo | 30 | 760 | Shale | 40 | 1,190 |
| Blue rock | 70 | 830 | Gumbo | 20 | 1,210 |
| Gumbo | 20 | 850 | Rock | 2 | 1,212 |
| Sandrock | 5 | 855 | Shale | 18 | 1,230 |
| Shale | 35 | 890 | Rock | 2 | 1,232 |
| Gumbo | 15 | 905 | Shale, very hard | 18 | 1,250 |
| Rock, very hard | 15 | 920 | Shale | 50 | 1,300 |
| Gumbo | 15 | 935 | Gumbo | 50 | 1,350 |
| Soapstone | 15 | 950 | Shale and gumbo | 50 | 1,400 |
| Sandrock | 5 | 955 | Soapstone | 12 | 1,412 |
| Soapstone | 5 | 960 | Shale and soapstone | 8 | 1,420 |
| Gumbo | 10 | 970 | Rock | 4 | 1,424 |
| Rock | 11 | 981 | Shale | 16 | 1,440 |
| Soapstone | 19 | 1,000 | Rock | 1 | 1,441 |
| Shale | 21 | 1,021 | Soapstone | 19 | 1,460 |
| Gumbo | 14 | 1,035 | Shale | 15 | 1,475 |
| Hard rock | 5 | 1,040 | Gumbo | 14 | 1,489 |
| Shale and little sand | 15 | 1,055 | Shale and soapstone | 11 | 1,500 |
| Rock | 5 | 1,060 | Soapstone, very hard | 6 | 1,506 |
| Shale | 18 | 1,078 | Shale | 29 | 1,535 |
| Rock | 2 | 1,080 | Water sand (top of Woodbine sand) | 15 | 1,550 |
| Gumbo | 10 | 1,090 | Soapstone | 4 | 1,554 |
| Shale | 10 | 1,100 | | | |

The Texas Midland Railroad Co. drilled a test well at Cash, in the southern part of Hunt County, to a depth of 2,480 feet. White limestone, which is believed to be the Austin chalk, was reached at 1,440 feet and continued to 2,065 feet. Below this limestone much sand, which may belong to the Eagle Ford, was found. (See plotted log, Pl. VI.) Showings of gas and some oil are reported from these sands.

Late in 1919 the McTon Oil Co. began drilling Ridley well No. 1, on the McKinney and Williams survey, near Kingston.

### DELTA COUNTY, TEX.

The Delta-Hunt Oil & Gas Co. drilled a well on the Monday farm, 4 miles east of Commerce and 1 mile west of Horton, Delta County, on the north side of the Texas Midland Railroad. Showings of oil, reported from 582 to 610 feet, led to the drilling of another well to test the beds at that level. The beds penetrated in these wells probably belong entirely to the Navarro formation.

*Driller's log of Delta-Hunt Oil & Gas Co.'s well, 1 mile west of Horton, Delta County, Tex.*

[Drilled by Sayle & Credille.]

| | Thickness. | Depth. | | Thickness. | Depth. |
|---|---|---|---|---|---|
| | *Feet.* | *Feet.* | | *Feet.* | *Feet.* |
| Sand | 5 | 5 | Clay | 34 | 374 |
| Clay | 5 | 10 | Birdseed shale | 6 | 380 |
| Sand | 25 | 35 | Clay | 5 | 385 |
| Pack sand | 10 | 45 | Sand and carbonaceous deposits | 10 | 395 |
| Shale | 135 | 180 | Massive yellow lime | 5 | 400 |
| Limy sandstone | 6 | 186 | Sand and shale alternating | 144 | 544 |
| Blue water sand | 14 | 200 | Massive blue lime | 6 | 550 |
| Sandy shale | 45 | 245 | Gypsiferous limestone and sand | 16 | 566 |
| Slate shale | 15 | 260 | Limy sandstone | 5 | 571 |
| Boulders and shale | 30 | 290 | Blue water sand | 4 | 575 |
| Birdseed shale | 10 | 300 | Gumbo or clay | 7 | 582 |
| Clay | 5 | 305 | Sandy limestone; oil | 8 | 590 |
| Soft birdseed shale | 15 | 320 | Sandy shale and clay; oil | 20 | 610 |
| Shale and marine she'ls | 20 | 340 | | | |

The Klondike Oil & Gas Co. drilled a well on the Geary farm, 2½ to 3 miles southeast of Klondike station, on the north bank of South Fork of Sulphur River. Limestone, which may be the Pecan Gap chalk, was encountered at a depth of 922 feet. The well was abandoned in shale at a depth of 1,987 feet. (See plotted log, Pl. VI.)

A number of moderately deep wells that have been drilled in and near Cooper yielded some gas along with salt water. A well drilled one block north and one block west from the city square flows a 1½-inch stream of salt water, not a brine, with considerable gas. The water is used in a bathhouse, and the gas is burned for light and heat. A well 1 mile east-northeast of Cooper, on the J. M. Haygood place, flows a strong stream of water and some gas, which is said to come from a depth of 1,200 or 1,300 feet. The gas, which has an estimated volume of 400 cubic feet an hour, is collected over the water and used in about a dozen houses. A well of unknown depth on the Scott Getton (?) place, half a mile northwest of Cooper, is said to have shown some gas. Two wells have been drilled on the Crowson & Townsend (formerly J. W. Wallis) farm, eight blocks south of the city square, on East First Street. One was drilled by Claude Witherspoon in 1914 (?) to an unknown depth. In 1916 Sayle & Credille drilled another well about 100 feet distant to a depth of 707 feet.

*Log of city well on East First Street, Cooper, Delta County, Tex.*

[Drilled by Sayle & Credille.]

| | Thickness. | Depth. | | Thickness. | Depth. |
|---|---|---|---|---|---|
| | *Feet.* | *Feet.* | | *Feet.* | *Feet.* |
| Surface | 10 | 10 | Shale | 53 | 380 |
| Yellow clay | 30 | 40 | Gumbo | 25 | 405 |
| Blue shale | 10 | 50 | Birdseed shale | 35 | 440 |
| Yellow clay | 10 | 60 | Chalk or lime (top of Pecan Gap member) | 30 | 470 |
| Blue clay and nodules | 30 | 90 | Shale and lime | 38 | 508 |
| Clay and shale | 10 | 100 | Cement sand or arenaceous chalk | 2 | 510 |
| Shale and marine shells | 30 | 130 | Shale | 2 | 512 |
| Blue shale | 30 | 160 | Chalk (some grit) | 6 | 518 |
| Gumbo | 20 | 180 | Blue shale | 94 | 612 |
| Blue shale | 20 | 200 | Yellow clay and soapstone | 6 | 618 |
| Gumbo | 23 | 223 | Shale and marine shells | 16 | 634 |
| Blue shale | 57 | 280 | Soapstone, soft | 73 | 707 |
| Shale and marine shells | 26 | 306 | | | |
| Clay | 11 | 317 | | | |

Another well 1 mile southwest of the railway station at Cooper, 100 yards east of the Texas Midland Railroad, on the P. W. Miller farm, was drilled by Fred Chappell in 1914 to a depth of 900 to 1,000 feet. Chalk (Pecan Gap member) is reported at a depth of 470 feet, and a show of gas at about 840 feet.

A well on the James Jones farm, about 2½ miles north-northeast of Enloe, on Sulphur Creek, was drilled in 1918 by the Gumbo Oil & Gas Co. to a depth of 2,665 feet. The well started 28 feet above the top of the Pecan Gap chalk, reached the top of the Annona tongue at a depth of 605 feet, and was drilled to about the base of the Woodbine sand. (See plotted log, Pl. VI.) A showing of gas was reported from the 925-foot level. If the elevation of this well is the same as that of the well drilled by Sayle & Credille at Cooper, the dip would be approximately 70 feet to the mile south-southwest from Enloe to Cooper, a relatively high dip.

The Thirteen Oil Co. drilled a well near Cooper to a reported depth of 3,002 feet and abandoned it as dry in October, 1919.

### LAMAR COUNTY, TEX.

The town of Paris drilled a well 2½ miles east of the town square to a depth of 1,965 feet.[9] The well started in the Blossom sand and penetrated the Eagle Ford clay from 80 to 600 feet, the Woodbine sand from 600 to 1,420 feet, and the Comanche series from 1,420 to 1,965 feet. The water found in the Woodbine was briny and unfit for use.

The following wells were reported as being rigged up or drilled in Lamar County late in 1919:

Blossom Oil & Development Co., Lenoir No. 1, Sherman Rowland headright, 11 miles east of Paris, rigged up.

[9] Gordon, C. H., Geology and underground waters of northeastern Texas: U. S. Geol. Survey Water-Supply Paper 276, pp. 45–46, 1911.

Texas Crude Oil Co., Justice No. 1, Wesley Askins headright, 3 miles northeast of Paris, being drilled.

Tri-sands Oil & Development Co., Ford No. 1, P. S. Doss headright, 15 miles north of Paris, being drilled.

Lamar Petroleum Co., J. H. Hastett headright, 17½ miles northwest of Paris, derrick.

Maurice Burton and others, Berry No. 1, R. Dunlap headright, near Brookston, 7 miles southwest of Paris, being drilled.

Auds Creek Oil Co., Barr No. 1, A. Hampton headright, 7 miles south of Paris, being drilled.

Lamar Development Co., Alex Graham headright, 10 miles southeast of Paris, derrick.

Mustang Oil & Gas Co., L. Roberts headright, 15½ miles southeast of Paris, derrick.

### HOPKINS COUNTY, TEX.

The town of Sulphur Springs drilled a water well to a depth of 1,515½ feet.[10] The beds in the upper 810 feet are referred to the Wilcox formation, those from 810 to 1,134½ feet to the Midway, and those from 1,134½ to 1,515½ feet to the Navarro and Taylor (?).

*Record of city well at Sulphur Springs, Tex.*

| | Thickness. | Depth. | | Thickness. | Depth. |
|---|---|---|---|---|---|
| Wilcox: | *Feet.* | *Feet.* | Midway: | *Feet.* | *Feet.* |
| Surface soil | 1 | 1 | Blue shale | 90 | 900 |
| Red clay | 8 | 9 | White clay | 20 | 920 |
| Lignite | 2 | 11 | Blue shale | 80 | 1,000 |
| White sand with water; source of supply for most of the wells of the region | 4 | 15 | Hard sandstone | 4 | 1,004 |
| | | | Blue shale | 30 | 1,034 |
| | | | Fine sand; some water | 2 | 1,036 |
| Blue sandy shale | 18 | 33 | Soft white clay | 15 | 1,051 |
| Buff sandstone | 2 | 35 | Gray sandstone | 40 | 1,091 |
| "Pipe clay" | 2 | 37 | White "pipe" clay | 2 | 1,093 |
| Black shale with mica | 15 | 52 | Sandstone | 15 | 1,108 |
| Sand with water; furnishes city supply | 16 | 68 | Hard blue shale | 2 | 1,110 |
| | | | Soft sandstone | 15 | 1,125 |
| Shale | 59 | 117 | Hard sandstone | 2½ | 1,127½ |
| Limestone | 1 | 118 | Hard blue shale | 5 | 1,132½ |
| Black shale interlaminated with lighter-colored shale; contains iron concretions, iron pyrites, and mica | 565 | 683 | Fine gray sand | 1 | 1,133½ |
| | | | Very hard sandstone | 1 | 1,134½ |
| | | | Navarro and Taylor (?): | | |
| Hard limestone | 1 | 684 | Hard blue shale | 171 | 1,305½ |
| Black shale in thin layers with fossils | 20 | 704 | Sand with some water | 14 | 1,319½ |
| | | | Blue shale and sand | 95 | 1,414½ |
| Light-colored shale | 8 | 712 | Blue shale; some sand with mica | 101 | 1,515½ |
| Blue shale | 88 | 800 | | | |
| Black shale with iron concretions and fossils; *Venericardia planicosta* | 10 | 810 | | | |

## OIL AND GAS POSSIBILITIES.

### TRINITY SAND.

The Trinity sand underlies the entire area under consideration and, so far as known, is structurally conformable with all the overlying Cretaceous formations. This being the case, a fold that shows in

[10] Gordon, C. H., Geology and underground waters of northeastern Texas: U. S. Geol. Survey Water-Supply Paper 276, p. 61, 1911.

the surface beds in this area must also be present in the Trinity sand. As oil and gas most commonly occur in anticlines, the folds here outlined from the study of surface formations present favorable structural conditions for oil and gas accumulation in the Trinity sand. Structure is, however, only one of the factors governing the occurrence of oil; there must be a source of oil, favorable sand conditions to permit its migration, and an impervious cap to prevent its dissipation.

The high grade of the oil now found in the Trinity, the absence of organic matter in the formation, and the distribution of the oil in it prove fairly conclusively that the oil has migrated into the Trinity from the underlying Paleozoic formations, either from the Caney shale or from the Glenn formation, both of which are believed to underlie this area. Thus, wherever the Trinity is in contact with either of these formations an adequate source of oil is probably available. But they are in contact with the Trinity only under abnormal structural conditions, where they have been folded or faulted and deeply eroded before the Trinity was deposited. Such a condition is not likely to exist in this area except near the crests of major anticlines like the Preston, Madill, and Oakland folds. Accordingly, it is unlikely that oil will be found in paying quantities in the Trinity anywhere in this area except on those folds, a conclusion that is corroborated in a measure by the drilling that has been done.

The Trinity has yielded prominent showings of oil and gas in this area only on these anticlines. Because of the intensity of the pre-Cretaceous folding and the depth to which these folds were eroded before the deposition of the Trinity, it is rather unlikely that much oil will be found in that formation, even under favorable structural conditions. Over a broad area in Texas the Trinity constitutes an enormous reservoir of fresh, potable water; in the area here considered the Trinity contains a large supply of water, but the water is more or less salty, doubtless owing to its stagnant character.

The Trinity sand contains many pervious sand beds through which the oil is free to migrate to localities where conditions favor its accumulation. In the area of the Preston, Oakland, and Madill anticlines, however, the Trinity is exposed at the surface and in places deeply eroded, offering a means of escape of the oil to the surface. Surface seeps of oil are found on the Bill Easton place, 1¼ miles south of Rock Bluff on Red River, in the Enos gas pool, and near Madill. The exposure near Enos consists of more than 6 feet of typical oil sand, from which dark-yellow oil of paraffin base may be extracted. That the Trinity has sufficiently thick clay beds at many places to prevent the escape and dissipation of all the oil and gas it contains is indicated by the presence of these substances

in the Enos gas pool and Madill oil pool and in a broader area where favorable showings have been found. Under the existing conditions, however, only small wells may be expected.

## PALEOZOIC ROCKS.

The Paleozoic rocks of this immediate area are entirely concealed; information regarding them is obtained from a study of records of deep wells that have reached them and from their exposures in the region north and west of Madill, where they unconformably underlie the Trinity sand.

A generalized section of the Paleozoic rocks in the Arbuckle Mountains, to the northwest, is given in Plate II (p. 2). None of these formations have been definitely recognized in well borings in the Madill-Denison area, as no fossils have been obtained from them; on the basis of lithologic similarity, however, it is possible to recognize, with more or less certainty, the Glenn and Caney formations. The nearest exposure of the Glenn is 2 miles northeast of Durwood, or 11 miles northwest of Madill. There it consists of red to pale-yellow shales and sandstones that strike northwest and dip 20°–60° SW. Similar rocks are found in the Dulsa Askew well, in sec. 5, T. 7 S., R. 4 E., Okla.; in the C. V. Westover well, in the northwest corner of Grayson County, Tex.; and in the Indian Chief well, in sec. 19, T. 7 S., R. 4 E., Okla. It is probable that the Owens well, in the syncline between the Preston and Madill anticlines, encountered the Glenn formation, and that the Munson well, north of Denison and south of the Preston anticline, passed through the basal part of that formation and entered the underlying Caney shale.

The Caney shale, characterized by its black color in fresh cuttings and dark-gray color in weathered cuttings, was probably found in the Mattie Sacra wells, in sec. 17, T. 5 S., R. 5 E., Okla.; in the Dundee Petroleum Co.'s well, in sec. 9, T. 6 S., R. 6 E., Okla.; in the Waite well, in sec. 23, T. 7 S., R. 5 E., Okla.; and in the Munson and Campbell wells, in Grayson County, Tex. The Waite well, which encountered below the Trinity more than 1,000 feet of black shale, probably the Caney, is less than 4 miles from the Indian Chief well, which encountered below the Trinity only red and brown shale and sandstone, probably belonging to the Glenn formation, to a depth of 2,540 feet. As the Caney is below the Glenn, the Caney must be more than 1,900 feet lower at the Indian Chief well than at the Waite well, whereas the dip in the Cretaceous between the two places amounts to only about 100 feet. The conclusion seems to be justified that along the Madill, Oakland, and Preston anticlines the dark shales, probably the Caney shale, were folded or faulted up and the overlying formations eroded before the Cretaceous was laid down,

and subsequent folding along the old line of uplift has gently arched the Cretaceous formations. The wide area over which the black shale is found and the steep dip determined from well logs and from exposures in the area to the northwest suggest that the old rocks may be complexly folded and faulted, so that there is a repetition of the beds below the gentle arches in the Cretaceous. The structure of the underlying rocks may thus be too complicated to favor commercial accumulation of oil in them.

Indications of petroleum in the Caney shale are rare. There is a seep of light-green oil, which is reported to make 1 or 2 barrels of oil daily, on Oil Creek, northwest of Berwyn, at the outcrop of vertical Caney shale and Sycamore limestone. The oil found in the Caney (?) in the Mattie Sacra well is in part of 66° and in part 72° Baumé gravity and is an abnormal oil resulting from natural filtration or distillation. The oil in the Waite wells is also of high gravity. No normal oil has been found in the Caney shale.

Petroleum is known to occur in the Glenn formation in the Ardmore region, and asphalt has been extensively quarried in it east of the Criner Hills. It has been thought that the oil and gas of southern Oklahoma are derived from beds of Glenn age and that the oil in north Texas is derived from the Cisco formation. More recently it has been suggested that on account of the steep tilting of the Glenn formation in the Criner Hills and of the almost horizontal Pennsylvanian sands in the similar buried Healdton Hills, the producing sands at Healdton and elsewhere may be in a formation that lies unconformably above the Glenn, which is cut off by progressive overlap around the Arbuckle Mountains and Criner Hills. Such a formation as the one here suggested may or may not underlie the Cretaceous beds in the Madill-Denison area.

What underlies the black shale tentatively referred to the Caney formation is in doubt. The Pennsylvanian rests on Ordovician beds in the Healdton, Loco, and Petrolia fields, whereas farther south, between Fort Worth and Weatherford, the Pennsylvanian overlies pre-Cambrian rocks. In the Petrolia field and near St. Jo, in Montague County, Tex., the Ordovician is underlain by pre-Cambrian rocks. It is possible that in the Madill-Denison area the Pennsylvanian will be found to rest on the pre-Cambrian.

The carbon ratios of the Pennsylvanian coals of north Texas indicate, according to Fuller,[11] the absence of commercial accumulations of oil in the Pennsylvanian and underlying rocks of this area. No determinations of the carbon ratios are available for the Madill-Denison area, but the increase of the carbon ratio to the east prob-

[11] Fuller, M. L., Relation of oil to carbon ratios of Pennsylvanian coals in north Texas: Econ. Geology, vol. 14, pp. 536–542, 1919.

ably justifies this conclusion, which is also suggested by the light gravity of the oil found here.

Oil in commercial quantities is not expected in the Caney shale, which is believed to underlie the Trinity along the high parts of the anticlines in this area, because of the absence of suitable reservoirs, the highly folded character of the rocks, and the intense metamorphism which they have undergone as inferred from the carbon ratios of the Pennsylvanian coals in the area to the west. The Glenn formation, which probably occurs below the Caney on the anticlines in this area, does not seem to offer any more favorable source of oil, because of its structural position and the probability that it has been strongly metamorphosed. Attempts to drill deeper than the Caney involve great hazards because of the unknown but probably complex structure of the Paleozoic rocks, because the succession of beds below the Caney is not known, and because of the high degree of metamorphism which the rocks have probably undergone.

## SUGGESTIONS REGARDING FURTHER PROSPECTING.

### PRESTON ANTICLINE.

A review of the facts so far set forth suggests the possibility of developing on the Preston anticline small gas wells with a maximum daily volume of 5,000,000 cubic feet and oil wells with a maximum initial daily production of 20 barrels in the Cretaceous beds at depths of 400 to 700 feet. The wells will have to be carefully drilled so as not to penetrate the water-bearing sand, which immediately underlies the oil and gas sand. The most promising area for such development is near the crest of the anticline in the vicinity of Enos, Okla., and to the southeast across Red River, near Preston, Tex. Development, however, should not be attempted in areas where the top of the Goodland limestone lies below the 560-foot contour, as shown on Plate IV.

So far the results of deep drilling on this anticline have been discouraging. The drilling of additional deep tests is not recommended, because of the lack of structural conformity between the Cretaceous and the Paleozoic rocks and the probable absence of sands at a moderate depth in the underlying Paleozoic rocks.

### OAKLAND ANTICLINE.

The wells drilled on the Oakland anticline have not made particularly favorable showings in the Trinity sand, and as a number have been drilled, chiefly in the vicinity of Madill, production from that formation is not expected. Reports of showings of oil and gas in the underlying Paleozoic rocks on this anticline, especially in

the Ardmill Oil & Gas Co.'s well No. 3 on the Sacra farm, indicate that the chance of finding oil in those rocks is more encouraging than on the Preston anticline. It is reported that Sacra well No. 3 could have been completed as a commercially productive well. Drilling here is attended with the same uncertainty as on the Preston anticline and should not be undertaken without due consideration of the risk involved.

### MADILL ANTICLINE.

The small Madill oil pool lies at the northwest end of the Madill anticline. The territory near this pool has been so completely drilled (Pl. IV probably does not show all the wells that have been drilled) that there is little chance of its extension. There is, however, a possibility that additional small pools may be discovered to the southeast along the axis of this anticline. Any tests on this anticline should be located near its crest and drilled only to the top of the underlying Paleozoic rocks, which will not be more than 700 feet below the surface.

### OTHER AREAS.

The Madill, Oakland, and Preston anticlines constitute the only part of the area shown on Plate IV that is structurally favorable for the accumulation of oil or gas. Plate I shows part of this area and in addition a considerable area to the southeast, over much of which the structure has not been outlined in detail. The only upfold of note in that area, so far as known, is the Leonard-Celeste monoclinal nose. This is a gently arched plunging anticline and does not offer particularly favorable structural conditions for oil accumulation. The chance of finding oil on that fold in the Trinity sand is poor for the reasons set forth on preceding pages. The Woodbine sand offers the best possibility for oil development on this fold. This sand was probably reached in a well at Celeste at a depth of 1,535 feet, from which water, presumably fresh, was obtained. As this well is probably several miles east of the crest of the anticline and did not reach the base of the Woodbine, it can not be considered an adequate test of the structure. However, the chance of obtaining oil on this anticline is not very promising.