**OKLAHOMA GEOLOGICAL SURVEY**
**Chas. N. Gould, Director**

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BULLETIN No. 40

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# OIL AND GAS IN OKLAHOMA

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Volume II

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**NORMAN**
**July, 1930**

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## FOREWORD

The present volume, Bulletin 40, Volume II, of the Oklahoma Geological Survey, includes the papers which have been published during the years 1926-1930, as separate chapters.

Bulletin 40 of this Survey is a revision of Bulletin 19, part II, entitled, "Petroleum and Natural Gas in Oklahoma," which was issued in 1917. On account of the rapid development of the oil and gas industry in this State, it has been found necessary to revise this bulletin and bring it up to date. On account of the fact that appropriaions for carrying on his work were lacking, the Director called to his aid a number of working geologists throughout the State and these individuals have contributed freely of their time and efforts to the preparation of the manuscripts, which includes about fifty separate chapters in all.

The greater numbers of the chapters are concerned with the geology and oil conditions of a single county or group of counties in Oklahoma. These are published as Volume II and Volume III of Bulletin 40, Volume II dealing with the counties in western Okahoma and Volume III dealing with the counties in the eastern part of the State.

The several papers included in Volume II, published herein, are those of a general nature dealing with certain phases of geology and of the oil industry throughout the entire State.

Both the authors of the various papers and the staff of the Survey realize very keenly that these chapters do not represent the last word on the various subjects discussed. New data are constantly coming to light, necessitating the revision of former ideas. However we believe that the facts as herein set forth represent our best information of the date of publication.

Norman, Oklahoma
July 1, 1930

CHAS. N. GOULD
Director.

Volume II

# OIL AND GAS IN OKLAHOMA

Woods, Alfalfa, Harper, Major, Woodward and Ellis Counties

By

R. L. Clifton

## WOODS COUNTY

### LOCATION

Woods County is located in the northwestern portion of Oklahoma. The 37th parallel, which is the boundary between Oklahoma and Kansas, is the northern boundary of the county. The county limits extend from Tps. 22-29 N. inclusive, and from Rs. 13-21 W. inclusive. These limits comprise 25 entire townships and the parts of 20 others, whose area is approximately 1350 square miles.

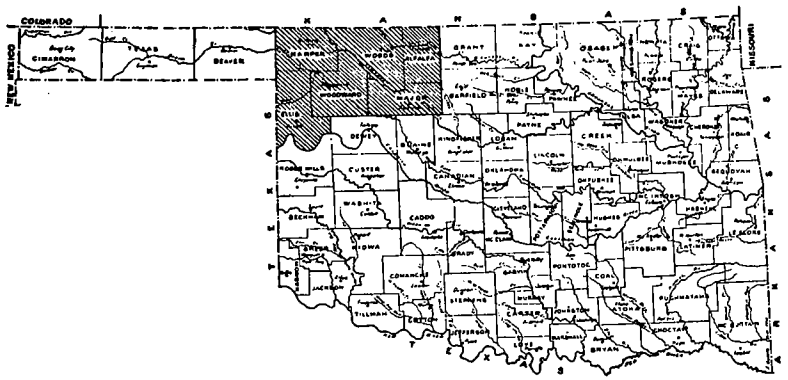



Figure 1.—Index map of Oklahoma showing location of Woods, Alfalfa, Harper, Major, Woodward and Ellis counties.

### GEOGRAPHY

#### DRAINAGE

The drainage system of the county extends in a general northwest-southeast direction. There may be variations, locally, from this generalized direction, due to the effects of differential erosion of the surface rocks.

The Cimarron and the Salt Fork rivers receive the drainage of the county. The Cimarron and its tributaries drain the southern and west-

(This report originally issued as Bulletin 40-A, June, 1926).

ern parts, while the Salt Fork and its tributaries drain the northeastern part of the county. The chief tributaries of the Cimarron River are the Eagle Chief, Dog Creek, Whitehorse, Redhorse, Anderson, Houston, Sand Creek, Mocassin, and Keno creeks. The chief tributaries of the Salt Fork are the Yellowstone, Greenleaf, Turkey and Driftwood creeks.

### TOPOGRAPHY

Woods County lies in the red beds area of the Great Plains. The surface of the county may be said to present three types of topography: red beds plains, gypsum hills, and sand and alluvium areas. The red beds plains area, which is a gently rolling prairie plain, occupies the eastern portion, and embraces more than half of the total area of the county. The gypsum hills area lies in the western part of the county and its dissected and picturesque escarpments are the chief topographic characteristics. The sand and alluvium area is found principally along the Cimarron River. In the western part of the county this area extends for some distance back from the river. Sand and alluvium beds, similar to those along the Cimarron, also occur as a narrow border along the Salt Fork River.

In general, the topography of the country in the eastern portion represents a gently rolling prairie plain of moderately low relief, while the western portion exhibits an area of moderately high relief, dominated by gypsum and sandstone escarpments that have been much dissected by stream and drainage channels.

### GEOLOGY

### STRATIGRAPHY

The rocks exposed at the surface belong to the Permian, Comanchean or lower Cretaceous, Tertiary, and Quaternary systems. For the most part the surface exposures are horizons of Permian age, although Quaternary or Recent sands and gravels constitute a considerable part of the surface beds of the county.

The Permian beds are classified as belonging to the upper Permian, or the Cimarron series.[1] Named in order from the oldest to the youngest, the Permian is represented by the following formations: the Enid,[2] the Blaine,[3] the Dog Creek,[4] the Whitehorse,[5] and the Day Creek[6] formations.

1. Cragin, F. W.: The Permian System in Kansas: Colo. Col. Studies, Vol. 6, 1896.
2. Gould, C. N.: Geology and Water Resources of Oklahoma: U. S. Geol. Survey, Water Supply Paper, No. 148, 1905.
3. Gould, C. N.: General Geology of Oklahoma: 2nd Bien. Report, Dept. of Geol. and Nat. Hist., p. 47, 1902.
4. Cragin, F. W.: The Permian System in Kansas: Loc. cit. 1896.
5. Gould, C. N.: Geol. and water Resources of Oklahoma: U. S. Geol. Survey, Water Supply Paper No. 148, 1905. Named from Whitehorse Springs, Woods County, Oklahoma. In 1900, Doctor Gould visited the sandstone exposures at this locality. In the course of his studies of the sandstone, Gould noted the presence of fossils in the indurated beds of sandstone exposed on an elevation just west of Whitehorse Springs. The significance of this discovery is that Gould called attention to the presence of fossils, for the first time in the horizons of the upper Permian, or Cimarron series of North America.
6. Cragin, F. W.; The Permian System in Kansas: Loc. cit., 1896



The exposures of the Enid formation occupy an area of about 550 square miles, lying in the eastern and central parts of the county. However, the erosional effects of the Cimarron River drainage has caused the outcrops of the Enid to extend in the county for a considerable distance to the west, thus forming an approximate east-west line of exposure along the Cimarron River across the country.

The Blaine formation occupies an area of about 150 square miles. The gypsum horizons lie in a narrow belt above the Enid in central and western Woods County. The Blaine formation, which is the chief escarpment-forming horizon in the county, consists of two massive beds of gypsum, with interbedded red clays and shales, and thin beds of dolomite and anhydrite. The lower gypsum or Medicine Lodge member of the Blaine is a massive bed whose thickness varies from 10 to 40 feet, while the upper gypsum, or Shimer member of the Blaine, has a thickness that varies from 6 to 30 feet. Both members of the Blaine are continuous throughout the county, except in those areas where subsequent erosion has removed the gypsum beds.

The Dog Creek shales, overlying the Blaine, are represented by a narrow band of red clay and shale exposures. The Dog Creek formation,[7] whose thickness is rarely more than 50 feet in the county, often includes one or more discontinuous beds of dolomite.

The Whitehorse sandstone exposures lie in the central and northern parts of the county. The thickness of this formation reaches a maximum of 265 feet, the exposed section of which is to be observed in the locally designated Cleveland Hills, ten miles north of Whitehorse Springs. The Whitehorse formation consists of a poorly-cemented, fine-grained sandstone, which is more or less intermixed with shales and clays. Locally within the formation there are indurated beds of calcareous sandstone that are fossiliferous, a chief example of which occurs at the type locality near Whitehorse Springs.

The Day Creek dolomite, which caps the latest horizons of the Whitehorse sandstone, consists of two layers of massive dolomite or magnesium-calcium carbonate. The thickness of the layers varies from a few inches to as much as four feet. The resistant nature of the dolomite to erosional forces has formed a long line or series of escarpments in northern Woods County. The Day Creek dolomite, therefore, wherever its beds have been exposed, is a marked escarpment-forming horizon, whose buttes and mesas dominate an area of high relief.

The Comanchean or lower Cretaceous rocks are represented by small and more or less isolated outliers in the northwestern part of the county, and their total area is less than 20 square miles. The Comanchean outcrops consist of shale, calcareous sands, and shell wash. The

7. Gould, C. N.: A New Classification of the Permian Redbeds of Southwestern Oklahoma. Bull. Am. Assn. Pet. Geol., vol. 8, pp. 325-326. 1924. The members of the Woodward group have been recognized as distinct formations.

age of these deposits has been correlated, on faunal evidence, with the lower Washita[8] of the Texas section.

The Tertiary rocks at the surface in the county occupy a small area in the western part. These rocks consist for the most part of calcareous sands, clays and gravels.

The Quarternary exposures occupy an area of approximately 350 square miles, lying in two separate areas within the county. One area occurs along the Cimarron River, while the other lies along the north side of the Salt Fork River. The Quaternary rocks consist of sands and gravels.

## REGIONAL GEOLOGY

A progressive well log correlation carried westward from the "Granite Ridge" uplift in the Kay County region to the eastern limits of Woods County shows that the Pennsylvanian and the Permian formations are dipping in a general southwest direction at a rate varying from zero to as much as 50 feet to the mile. Westward from the County region, where the greatest rate of dip is observed, to eastern Woods County, where the least rate of dip is found the strike of the beds shifts from a general northwest-southeast direction to an approximate east-west direction. Apparently that portion of the regional Pennsylvanian and Permian basin which embraces eastern Woods County and all of Alfalfa County is an area of flat-lying beds, whose rate of dip is zero or nearly so, except for a general south dip toward the axis of the Anadarko basin.[9]

A very different result is obtained when the progressive well log or subsurface correlation is carried westward from the Alva well, drilled in sec. 24, T. 27 N., R. 14 W., to the Cosden well drilled in sec. 8, T. 27 N., R. 16 W., and to those wells that have been drilled in Harper, Beaver and Texas counties, Oklahoma. Westward from Alva the Pennsylvanian and the Permian formations begin to rise at a rate that indicates a pronounced east component of dip. The east rate of dip increases proportionately toward the west, due to a gradual shifting of the strike of the beds. The south component of dip is still present, for correlations show that the beds dip uniformly toward the axis of the Anadarko Basin, which extends from west-central Oklahoma into the panhandle of Texas, northwestward as far as the limits of Dallam County. It should be stated in this connection that the Anadarko syncline becomes much less pronounced as a structural feature in the northwestern portion of the Texas panhandle than it does at its deepest deflection in Roger Mills County of Oklahoma, and in Lipscomb and Hemphill counties of the Texas panhandle. (See cross-sections A, B, C, and D, and Regional Map). (Map Nos. I-V, inclusive).

When the subsurface or progressive well log correlation is carried from the wells that have been drilled in adjacent areas of Kansas, past the wells drilled in Woods County, and thence to those wells

8. Clifton, R. L.; Bull. Oklahoma Acad. Sci., vol. 5, pp. 128-132, 1925.
9. Gould, C. N.; A New Classification of the Permian Redbeds: Bull. Am. Assn. Petroleum Geologists, vol. 8, pp. 322-341, 1924.



that have been drilled in western Oklahoma and the panhandle of Texas, a general—and at the same time—a fairly accurate interpretation of the regional basin in which Woods County lies is obtained. Permian formations that are represented by excellent surface exposures in the county disappear under younger beds a short distance south and west of the county. These beds dip uniformly toward the axis of the Anadarko Basin. Beyond the axis of the Anadarko syncline these same beds rise rather abruptly to reappear as surface exposures along the north flanks of the Amarillo uplift[10] in the Texas panhandle, and the Wichita Mountains of Oklahoma. Prominent exposures of the Whitehorse sandstone and the Day Creek dolomite occur along the Canadian River,[11] in Potter, Moore, and Hutchinson counties of the Texas panhandle, where the combined results of the Amarillo uplift and of erosion have brought these beds to the surface.[12] The massive dolomite strata exposed along the Canadian River in the Texas panhandle which has been called the Alibates[13] dolomite has been correlated by the writer as the Day Creek[14] dolomite instead.

## STRUCTURAL GEOLOGY

The surface rocks in the county furnish but little evidence that they have been much disturbed or folded since their deposition. Never-the-less the same forces that have produced the "Granite Ridge" of Kansas, the Anadarko Basin of Oklahoma and Texas, the buried ridge of the Amarillo uplift, the Ancestral Rockies, and later, the present Rocky Mountains, must have been reflected in tilting the beds and perhaps developing folds and arches of some magnitude. The older Paleozoic rocks underlying Woods County are most likely folded and tilted. This change in the older beds should have some reflection in the younger Pennsylvanian and Permian beds; yet the character of these younger sediments is such that anticlinal conditions, if present, would be difficult to detect in the surface rocks.

However, the presence of anticlinal folds and arches has been reported by geologists who have worked in Woods County. In 1915 the Oklahoma Geological Survey called attention to the presence of an anticline near Whitehorse Springs, eighteen miles west of Alva. The surface rocks on which this fold was mapped consisted of the Whitehorse sandstone and certain gypsum and dolomite ledges in the Blaine formation. Later, the Cosden Oil and Gas Company drilled a well on this structure, or fold, to a depth of 3,916 feet, without encountering a single important show of either oil or gas. It is quite possible that this fold is surficial, being due to solution and change in

10. Gould, C. N.; Geology and Water Resources of the Western Portion of the Texas Panhandle: U. S. Geol. Survey, Water Supply Paper No. 191, 1907.
11. Clifton, R. L.; Bull. Oklahoma Acad. Sci. vol. 5, p. 153, 1925.
12. Clifton, R L.; Areal Extent and Stratigraphy of the Whitehorse Sandstone. Unpublished Manuscript.
13. Gould, C. N.; Geology and Water Resources of the western portion of the Texas Panhandle: U. S. Geol. Survey, Water Supply Paper, No. 191, 1907.
14. Clifton, R. L.; Bull. Oklahoma Acad. Sci., vol. 5, p. 153, 1925.

the deposits of salt and gypsum in the underlying beds. At any rate the Cosden well was not drilled deep enough to test adequately the oil and gas possibilities of the structure, granting of course, that the well drilled in sec. 8, T. 27 N., R. 16 W., was located on an anticlinal fold. The base of the Permian was reached in this well at an approximate depth of 2,750 feet. Since the well was drilled only 3,916 feet in depth it is evident that the lower Pennsylvanian beds and the older Paleozoic rocks remain as yet untested on this structure.

The presence of other folds and arches has been reported from areas near the towns of Freedom and Lookout. The eastern part of Woods County has received some consideration in the effort to discover folds or structures. However, it should be borne in mind when folds and arches are found that they may be due to slumping as a result of solution and change in the salt and gypsum beds that underlie the surface rocks.

## ECONOMIC GEOLOGY

It is altogether possible that oil and gas may occur in Woods County in commercial quantities. The finding of oil in the Kingman County, Kansas well; the excellent showing of oil in the Barber County, Kansas wells; the strong gas showing in the Watchorn well in Clark County, Kansas, and the increasing production in the Texas Panhandle have given encouragement to the development for oil and gas in many parts of the regional area in which Woods County lies.

In order to warrant development for the recovery of oil and gas at least three primary geologic factors must be considered. There must be a considerable body of black shales, or shales rich in organic matter, which may serve as a source for the oil. Then there must be porous beds, such as sands and porous limestones, to serve as reservoir rocks for the oil. These reservoir rocks must be overlain by impervious layers in order that the oil may be retained in them. And lastly there must be folds or arches in the reservoir rocks to cause an accumulation of the oil in large bodies. These folds and arches may be of various forms and may be due to different geologic causes.

After considering these primary factors, it is evident that Woods County may have some importance as a prospective oil and gas area.

A study of the logs of the Alva and the Cosden wells shows that a shale of considerable thickness is present in the underlying beds. Reservoir rocks are also present for the logs show several beds of sand and sandy limestone. The presence of anticlinal folds or structures alone remains to be demonstrated according to present opinion.

## DEVELOPMENT

To date five wells have been started or drilled in Woods County to a depth of at least 700 feet. The locations and the depths of these wells are shown in the following table:

| Location | Sec. | Twp. | R. | Depth | |
|---|---|---|---|---|---|
| NE. SE. SE. | 24 | 27N. | 13W. | 3681 | (Alva Well) |
| NW. 1-4 | 1 | 28N. | 17W. | 1230 | |
| NE. NW. | 8 | 27N. | 16W. | 3916 | (Cosden Well) |
| SE. 1-4 | 19 | 24N. | 14W. | 1800 | |
| SE. SW. | 10 | 25N. | 15W. | 780 | |



In November, 1916, the Cosden Oil and Gas Company began a well, in sec. 8, T. 27 N., R. 16 W., which was not completed until January 1918. The log of this well as reported to the Corporation Commission is given in this report.

*Log of Cosden Well, Sec. 8, T. 27 N., R. 16 W.*

| | Top | Bottom |
|---|---|---|
| Soil, red | 0 | 20 |
| Red rock | 20 | 90 |
| Gyp rock | 90 | 125 |
| Red rock | 125 | 370 |
| Gyp rock | 370 | 380 |
| Red rock | 380 | 530 |
| Rock gyp | 530 | 540 |
| Red rock | 540 | 560 |
| Sand | 560 | 570 |
| Red rock | 570 | 605 |
| Gyp rock | 605 | 615 |
| Red rock | 615 | 715 |
| Red sand, soft | 715 | 765 |
| Red rock | 765 | 1020 |
| Salt rock | 1020 | 1030 |
| Red rock | 1030 | 1035 |
| Salt rock | 1035 | 1045 |
| Red rock | 1045 | 1050 |
| Salt rock | 1050 | 1170 |
| Red rock | 1170 | 1595 |
| Blue slate | 1595 | 1685 |
| Flint shell | 1685 | 1690 |
| Blue slate | 1690 | 1850 |
| Lime | 1850 | 1860 |
| Sand, salt, rock | 1860 | 1900 |
| Salt rock | 1900 | 2040 |
| Blue slate | 2040 | 2056 |
| Lime | 2056 | 2062 |
| Salt rock | 2062 | 2100 |
| Lime | 2100 | 2115 |
| Slate | 2115 | 2230 |
| Lime | 2230 | 2250 |
| Slate | 2250 | 2300 |
| Lime | 2300 | 2340 |
| Blue slate | 2340 | 2350 |
| Lime | 2350 | 2590 |
| Sand | 2590 | 2625 |
| Lime | 2625 | 2665 |
| Sand | 2665 | 2700 |
| Lime | 2700 | 2735 |
| Sand | 2735 | 2760 |
| Lime | 2760 | 2860 |
| Sand | 2860 | 2900 |
| Lime | 2900 | 2990 |
| Black slate | 2990 | 3030 |
| Red rock | 3030 | 3035 |
| Lime | 3045 | 3100 |
| Slate and shells | 3100 | 3110 |
| Lime | 3110 | 3160 |
| Sand | 3160 | 3185 |
| Lime | 3185 | 3218 |
| Slate | 3218 | 3250 |
| Lime | 3250 | 3260 |
| Black slate | 3260 | 3270 |
| Gray lime | 3270 | 3285 |
| Black Slate | 3285 | 3289 |
| Lime | 3289 | 3335 |
| Water and sand | 3335 | 3350 |
| Lime | 3350 | 3400 |
| Black slate | 3400 | 3425 |
| Lime | 3425 | 3427 |
| Black slate | 3427 | 3454 |
| Gray lime | 3454 | 3494 |
| Light slate | 3494 | 3499 |
| Gray lime | 3499 | 3503 |

| | Top | Bottom |
|---|---|---|
| Black slate | 3503 | 3550 |
| Lime | 3550 | 3553 |
| Black slate | 3553 | 3570 |
| Lime | 3570 | 3575 |
| Red rock | 3575 | 3580 |
| Black slate | 3580 | 3588 |
| Gray lime | 3588 | 3630 |
| Black slate | 3630 | 3645 |
| Gray sand | 3645 | 3650 |
| Blue slate | 3650 | 3700 |
| Slate and shell | 3700 | 3755 |
| Gray sand | 3755 | 3760 |
| Gray lime | 3760 | 3767 |
| Black slate | 3767 | 3770 |
| Gray lime | 3770 | 3773 |
| Slate, shells | 3773 | 3815 |
| Slate | 3815 | 3835 |
| Lime | 3835 | 3850 |
| Black slate | 3850 | 3885 |
| Lime | 3885 | 3895 |
| Black slate | 3895 | 3900 |
| Slate and shell | 3900 | 3910 |
| Water sand | 3910 | 3916 |

With respect to future development in the county, it should be kept in mind that the Permian beds are for the most part barren of organic or carbonaceous material. Therefore no accumulation of oil is expected in these sediments unless the oil has migrated from formations in which organic matter occurs. The Pennsylvanian formations that probably underlie the Permian beds in Woods County are the chief petroliferous horizons in Oklahoma. It is quite reasonable to expect that Pennsylvanian beds in Woods County, under favorable conditions for accumulation may produce oil and gas. However, the depth to which the drill must penetrate in order to reach productive Pennsylvanian horizons is a handicap to development in the county under present conditions of costs and returns. No prospective well should be started unless it is planned to drill to a depth of at least 4,500 feet. Even at this depth, it is not a certainty that the full thickness of the Pennsylvanian in this county would be penetrated. It is certain that any well drilled less than 4,000 feet has but very slight chances of encountering oil and gas in commercial quantities.

## ALFALFA COUNTY

### LOCATION

Alfalfa County is situated in northwestern Oklahoma, in the northernmost tier of counties. The boundary line between Oklahoma and Kansas is also the north boundary of the county. Alfalfa County includes the area extending from the middle line of Tps. 23-29 N., inclusive, and from Rs. 9-12 W., inclusive. The area of the county is 854 square miles.

### GEOGRAPHY

#### DRAINAGE

The county is drained chiefly by the Salt Fork River and its tributaries. The Cimarron River receives the drainage of the southwestern part.



The Salt Plains, occupying an area in the central portion of the county, is a saline marsh, whose barren wastes of salt and sand is the result of surface evaporation of saline solutions from the underlying salt beds in the Enid formation. The Salt Plains, while merely a local surface feature, is one of the largest saline wastes in the southwest.

#### TOPOGRAPHY

The topography of the county consists chiefly of two types—red bed plains and sands and gravel areas. The red bed plains area for the most part consists of a gently rolling prairie plain in which the tributaries of the Salt Fork River have cut narrow valleys. The sand and gravel area lies in the southern part of the county and along the Salt Fork River in the central part of the county.

### GEOLOGY

#### STRATIGRAPHY

Alfalfa County lies entirely in the red beds area and at such distance from the border of the red beds basin that the thickness of the red deposits varies from 650 feet in the northeastern portion of the county, to as much as 1,600 feet in the southwestern portion. The surface rocks belong to the Enid formation, which consists of red shales and sandstones, with some interbedded ledges of lighter colored shales and sandstones. Occasionally there are lenses of gypsum interbedded in the red shales, an example of which occurs in the roadbed approximately two miles north of McWillie, a small town in the southern part of the county.

Tertiary sand and gravel deposits occur in small areas within the county. Along the north side of the Salt Fork River stretches of sand hills cover a large area.

#### REGIONAL GEOLOGY

Alfalfa County lies in that portion of the Pennsylvanian-Permain basin, in which the beds are generally horizontal except for a uniform dip toward the axis of the Anadarko basin.[15] Progressive well logs, or subsurface correlations show that the strike of the beds extends in an approximate east-west direction (See Cross-Sections A, B, C, and D, and Regional Map).

The surface rocks do not indicate that the beds have been much disturbed since their deposition. However, it is reasonable to assume that the monoclinal, or approximately flat-lying beds of the county may be gently folded and arched.

#### ECONOMIC GEOLOGY

It is possible that oil and gas may be found in Alfalfa County. The chief essentials for the production of oil and gas are a source

15. Gould, C. N.; A New Classification of the Permian Redbeds, Am. Assn. Pet. Geol. Vol 8, pp. 322-341, 1924.

bed, as for example dark shales, a reservoir rock, an impervious bed to serve as a cap rock, and a structure of some form for the accumulation and retention of the oil and gas. The logs of those wells that have been drilled in the county show considerable thicknesses of dark shales and sands. Structural conditions or folding, apparently represent the one primary essential that has not been found to occur. While eight wells have been drilled in the county, none of these have been drilled apparently on folds, or structures, whose magnitude has been great enough to account for the accumulation of oil in pools sufficient to yield more than a showing of oil or gas. Alfalfa County should be regarded as a possible petroliferous area, and the few wildcat ventures which have been drilled in the county do not prove the complete absence of anticlinal folds or structural conditions to account for the accumulation of oil in commercial quantities.

The depth to which the drill must go in order to reach the lower Pennsylvanian and the older Paleozoic beds, is an important economic factor in the development of the county. No well should be started unless it is planned to drill to a depth of 4,500 feet. Even at this depth the drill will not test the full section of Pennsylvanian beds in the county. It is certain that any well drilled less than 4,000 feet has but slight chance to encounter petroliferous beds that are likely to produce oil in commercial quantity.

## HARPER COUNTY

### LOCATION

Harper County is located in the northwestern part of Oklahoma. It is bounded on the north by Kansas, on the east by Woods and Woodward counties, on the south by Ellis County, and on the west by Beaver County. It extends from Tps. 25-29 N., inclusive and from Rs. 20-26 W., inclusive. The county includes 22 entire townships and parts of 12 others. The area is about 1,075 square miles.

### TOPOGRAPHY AND DRAINAGE

The eastern portion of the county lies in the area of the Gypsum Hills, while the remainder of the county lies in the High Plains region.

The topography of the Gypsum Hills region has been produced by stream dissection of the Blaine formation. In general, the erosional feature of the Blaine formation is an eastward facing escarpment, whose general trend is a northwest-southeast direction, unless varied locally by narrow canyons.

The High Plains area is a rolling upland plain which is in part covered by dune sand. A large portion of the county lies in this area.



The county is drained by the Cimarron and the North Fork of the Canadian rivers and their tributaries. The Cimarron River receives the drainage of the central and northern portions of the county, while the North Fork of the Canadian receives the drainage of the southern part. The extreme southwestern part is drained by Beaver Creek, which unites with Wolf Creek to form the North Fork of the Canadian.

### GEOLOGY

The rocks at the surface in Harper County, named in order from the oldest to the youngest are Permian, Comanchean or lower Cretaceous, Tertiary and Quaternary.

The Permian formations which are represented by surface exposures are the Enid, Blaine, Dog Creek, Whitehorse, Day Creek, and Cloud Chief. The Permian formations constitute the greater part of the surface exposures in the county.

The Enid formation appears at the surface in a small area in the eastern part of the county along the Cimarron River and the valley of Buffalo Creek. The formation in the county consists of red clay and shale, and some inconspicuous ledges of soft sandstone and beds of whitish and greenish shales.

The Blaine formation occupies a narrow and irregular belt, immediately west of the Enid formation. The total area of exposures is approximately 125 square miles and lies in the eastern part of the county. The Blaine formation is here composed of two massive beds of gypsum, the Medicine Lodge and the Shimer members, with intervening shales and thin beds of dolomite and anhydrite.

The Dog Creek formation is represented by a narrow band of shale exposures west of the Blaine outcrops. The area of the Dog Creek formation is but a small total of the area of the county.

The Whitehorse sandstone appears at the surface in the northeastern portion of the county. There is a small area of sandstone exposures in the southwestern part of the county, a part of which may be referred to the Whitehorse formation. The formation consists of red shales, some clays and sandstones, and has a total area of about 40[illegible] square miles for its surface outcrops. Within the sandstone formation, there are locally lenses of calcareous and gypsiferous deposits.

The Day Creek formation has typical exposures in the northern and eastern parts of the county. The formation consists of two beds of dolomite with some thin interbedded shales. The thickness of the formation varies from one foot to as much as 10 feet. The Day Creek is an important escarpment-forming horizon in the county. Certain dolomite beds, appearing at the surface in the southwestern part of the county are referred to the Day Creek formation. The area covered by these beds is quite small.

The Cloud Chief formation appears at the surface in the southwestern part of the county. The area of the beds is about 30 square miles and the exposures consist of red shales and sandstones with occasional gypsum lenses.

In the southern portion of the county there is an area of small extent where Comanchean, or lower Cretaceous rocks appear at the surface. These small areas are outliers of former Comanchean beds and appear on the elevations near the confluence of Beaver and Wolf creeks, just inside the limits of the county.

There is an area of about 5 square miles in the extreme southwestern portion of the county where Tertiary beds appear at the surface. The rocks are for the most part shale, sand and gravel, although the beds contain deposits of calcareous clays in places.

The greater part of the Quaternary is dune sand and occurs just north of Beaver Creek in a rather wide belt extending in a northwest-southeast direction entirely across the county. Alluvium is found along the valleys of Cimarron River, Beaver Creek, and their larger tributaries. The total area of the Quaternary deposits covers about 420 square miles.

#### REGIONAL GEOLOGY

The strata in Harper County lie at low angles and the direction of dip varies. In general the regional dip is southerly, although there is a strong east component of dip present. The strike of the beds is apparently northeast-southwest. There is a general westward rise of the beds, from a point near the eastern limits of Woods County, so that by the time the limits of Harper County are reached the corresponding strata are many feet higher than in eastern Woods County. (See regional map, and the accompanying cross-sections.)

#### STRUCTURAL GEOLOGY

Surface beds in the county do not furnish any considerable evidence that the strata have been folded since the deposition of the beds. It is certain that the beds in common with beds of adjacent areas, have been disturbed and tilted. The nature of the surface exposures renders it difficult to determine structures, should they be present. No detailed work has been done in the county and specific examples which may lead to the discovery of favorable structures cannot be pointed out. There is some evidence that two of the wells drilled in the county were located on what appears as surface indications of folding.

#### SUMMARY

Since the Permian rocks are for the most part barren of carbonaceous material no production is expected in the Permian strata unless it has migrated from formations containing carbonaceous material. The Pennsylvanian rocks are the source of most of the oil and gas produced in Oklahoma. These rocks contain great quantities of carbonaceous material, and probably underlie the Permian in Harper County. The thickness of the Permian in Harper County is about 3,000 feet.



The well drilled east of Buffalo, in sec. 9, T. 27 N., R. 22 W., reached the top of the Pennsylvanian beds at a depth of 2,950 to 3,000 feet. The well now drilling at a depth of 2,900 feet in sec. 14, T. 25 N., R. 22 W., should encounter Pennsylvanian beds at approximately 3,100 to 3,200 feet.

In the area of Harper County, no well should be started unless it is planned to drill to a depth of 4,500 feet. Even a well drilled to a depth of 5,000 feet will not encounter the base of the Pennsylvanian beds unless it should so happen that the well is located upon a pronounced fold or structure, the evidence of which at this time is not known. It is certain that any well drilled less than 4,000 feet has but slight chance to find oil in commercial quantities. Development in Harper County will therefore be slow, due largely to the expense involved in drilling.

## MAJOR COUNTY

#### LOCATION

Major County lies in the northwestern portion of the state, and extends from Tps. 20-24 N., and from Rs. 19-16 W. The county includes 23 townships and parts of 8 others, and the total area is approximately 990 square miles.

#### TOPOGRAPHY

That part of Major County east of a line drawn from a point about six miles south of the northwest corner of the county, to a point on the south county line about five miles east of Homestead, lies in the red beds plains. This area is a gently-rolling prairie plain. The surface shales and thin bedded sandstones of this area disintegrate and form a very fertile soil. Many valuable farms and ranches are found here.

Bounding this area on the west is the area of the gypsum hills. The gypsum exposures occupy a strip about five miles in width, which extends across the county. The escarpments and hills of the area have been formed by the east-flowing tributaries of the Cimarron River, as these streams have extended their sources westward into the westward-dipping ledges of the Blaine gypsums.

Just west of the gypsum hills area a large sand plain occupies the remainder of the county. This sand plain has a general slope to

the southwest. In many places this general slope is interrupted frequently by sand dunes. The entire area is covered by blackjack trees and brush.

That portion of Major County which lies in the area of the red beds plains is drained by the Cimarron River and its tributaries. In this area the tributaries of the Cimarron have cut narrow valleys. In the southwestern portion of the county, the drainage channels of the North Fork of the Canadian and its tributaries have dissected the gypsum and sandstone areas forming in places deep, narrow valleys.

### GEOLOGY

The surface rocks are Permian in age, except in the valleys of the Cimarron River, the North Fork of the Canadian River and their tributaries where recent sands and gravels are found.

The Permian formations that outcrop in the county, named in order from the oldest to the youngest are the Enid, Blaine, Dog Creek and Whitehorse. The Enid formation consists of brick-red clays and shales with some interbedded layers of red and white sandstones. Some of the upper strata are highly gypsiferous and some salt springs occur in the county. The Blaine formation consists of two massive ledges of gypsum and a third sandy gypsum member. A series of shales and thin dolomite beds occur interbedded with the gypsum members.

The Dog Creek shales occur above the Blaine gypsum. In Major County the Dog Creek formation has a thickness that varies from 40 to as much as 100 feet. Often the shales grade into sandstone, and it is therefore often difficult to determine the contact between the Dog Creek and the overlying formation, the Whitehorse sandstone.

The Whitehorse formation outcrops in the southwestern portion of the county, but for the most part this formation is overlain by windblown sands. In general, the thickness of the Dog Creek shale and the Whitehorse sandstone is approximately 300 feet. A number of discontinuous beds of dolomite occur in the Dog Creek and Whitehorse section of the county. The sand hill area of the county has covered the greater portion of the Dog Creek and the Whitehorse formations.

### STRUCTURAL AND REGIONAL GEOLOGY

The general attitude of the strata in Major County is that of a gentle southwestward-dipping monocline. There may be local variations in this general dip. In the area of the Enid formation very few outcrops can be found and variations in dip, are therefore, hard to recognize. In the western part of the county, because the surface is more or less covered by dune sand, structural conditions are not apparent at the surface. The gypsum ledges in the area of the Blaine formation are well exposed and have considerable horizontal extent. A detailed



examination may find surface indications of structural conditions favorable for the accumulation of oil and gas. It is reasonable to suppose that the older Paleozoic rocks underlying the county may be folded and tilted. Yet the nature of the overlying beds are such that even pronounced folds and arches might not be reflected at the surface.

The county cannot be regarded as very favorable oil and gas area. (See cross-sections A, B, C, and D, and Regional Map.) Due to the position of the county in the regional basin, structural conditions favorable for the accumulation of oil and gas are not so likely to occur. Also, the depth to which the drill must penetrate in order to reach possible petroliferous horizons is a great handicap to development in this area. Of the five wells drilled in the county, but one of them, the Bradstreet well in sec. 9, T. 23 N., R. 9 W., has drilled deep enough to test even the upper horizons of the Pennsylvanian beds. In this well the Tonkawa sand had not been reached at a depth of 4,200 feet. In the Garber field of Garfield County, this sand is encountered at an approximate depth of 3,050 feet for those wells located on the Garber uplift.

### SUMMARY

Strata which may contain oil and gas probably underlie Major County, yet so deep as to make exploration too expensive at the present time. No well should be started in the county unless it is planned to drill to a depth of 5,000 feet. Even at this depth much of the Pennsylvanian section will remain untested unless it so happens that the well is located on a very pronounced structure, the evidence of which is not apparent in the surface rocks at the present time. It is certain that any well drilled less than 4,500 feet in depth has a very small chance of encountering oil and gas in commercial quantities.

## WOODWARD COUNTY

### LOCATION

Woodward county is located in the northwestern part of the state. It extends from Tps. 20-27 N., inclusive and from Rs. 17-22 W., inclusive. This area embraces 33 entire townships and parts of 5 others, the total area of which is approximately 1,266 square miles.

### TOPOGRAPHY AND DRAINAGE

In general the topography of the county may be considered in three classes—the gypsum hills area in the eastern and northwestern parts, the high plains area in the western part, and the sand and alluvium area, chiefly in the central part of the county, although this area appears as a mantle of sand in many parts of the county.

The county is drained by three rivers or their tributaries. The Cimarron River receives the drainage of the entire nothwestern portion

of the county, the North Fork of the Canadian River receives the drainage of the central portion, while the Canadian River receives some of the drainage of the southern part of the county.

## GEOLOGY

The rocks appearing at the surface in Woodward county are Permian, Comanchean or lower Cretaceous, Tertiary and Quaternary. The Permian rocks include the following formations, the Enid, Blaine, Dog Creek, Whitehorse, Day Creek, and Cloud Chief.

The Enid formation occupies an area of approximately 70 square miles in the northeastern part of the county. Its exposures form a narrow belt that nearly parallels the Cimarron River. The Enid, as in other areas, consists of brick-red clays and shales, with some interbedded ledges of white and red sandstones. In general, there are few sandstone lenses in the Enid in Woodward County.

The Blaine formation occupies an area of approximately 120 square miles lying as a belt southwest of the Enid formation. The Blaine consists of two massive ledges of gypsum with interbedded red shales and thin ledges of dolomite and anhydrite. The massive gypsum members of the Blaine, the Medicine and the Shimer are continuous throughout the county.

The Dog Creek is represented by a band of red clay and shale exposures which parallel the outcrops of the Blaine across the northeastern portion of the county. The Dog Creek formation, whose thickness varies from 40 to 100 feet, contains one or more discontinuous ledges of dolomite.

The Whitehorse sandstone outcrops in two areas in the county. Immediately southwest of the Dog Creek exposures there is a considerable area of this sandstone that extends across the northeastern portion of the county. The other area of the sandstone exposure lies further to the southwest along the North Fork of the Canadian River, and extends from a point 10 miles east of Woodward, thence up the river past the northwest limits of the county. Generally the formation consists of a poorly-cemented, fine-grained sandstone often intermixed with shale and clay. Locally calcareous and highly indurated beds may occur in which a few laminae are fossiliferous. The thickness of the sandstone reaches a maximum of 300 feet in the county.

The Day Creek dolomite is represented by a narrow band of exposures that cap the youngest of the Whitehorse exposures. The Day Creek in this area consists of two beds of dolomite separated by a very thin shale bed. The thickness of the Day Creek reaches a maximum of 10 feet. Due to the resistant nature of the dolomite to erosional forces, the formation has formed an extended line of buttes and escarpments across the northeastern part of the county. This topography



forms an area of considerable relief, which is much dissected by narrow and deep drainage channels.

The Cloud Chief formation is represented at the surface by a small area of exposures in the southeastern part of the county. The formation consists of gypsum, red clays and shales, and sandstones.

The Comanchean or lower Cretaceous rocks appear at the surface as limited exposures in the northwestern, eastern and southern parts of the county. These outcrops are for the most part erosional remnants or outliers of former Comanchean deposits.

The Tertiary rocks occupy an area of about 100 square miles in the southwestern part of the county. These beds are for the most part clay, sand and gravel, although calcareous beds are common.

The Quaternary rocks outcrop along the valley of the Cimarron River, along the valley of the North Fork of the Canadian River and in the southern part of the county. The total surface area of these beds is approximately 800 square miles. The Quaternary rocks are made up of alluvium and dune sand.

## REGIONAL AND STRUCTURAL GEOLOGY

In general, the beds of the county dip at low angles to the southwest. Woodward County lies well down on the monoclinal slope which extends toward the axis of the Anadarko Basin. (See regional map, and the accompanying cross-sections). These nearly flat-lying beds exhibit but little evidence that they have been much folded and arched since deposition. However, it is reasonable to assume that the Paleozoic beds have been disturbed and tilted in common with similar beds of other parts of the same regional area. Due largely to the nature of the upper beds, little evidence of folding may be expected in the surface rocks, even if present in the deeper beds. Again sufficient exposures of competent beds, upon which folding or structures may be mapped, are all but lacking in the county. Much of the area is covered with sand and gravel which adds to the difficulty of determining the possibility of structures or folding.

## DEVELOPMENT

Four wells have been drilled in the county to a depth of 800 feet or more. In so far as testing the underlying rocks that have been found productive of oil in other areas, none of these four tests have been drilled deep enough. It is reasonable to state that no oil may be expected short of the basal Permian or the upper Pennsylvanian beds. It is believed that Pennsylvanian beds of considerable thickness underly the county. The basal Permian beds may be encountered at a general average depth of 2,950 feet in this area. Since the upper section of the Pennsylvanian beds have not been found to be highly petroliferous horizons in other areas of the Mid-Continent oil fields, unless pro-

nounced folding and faulting has been a primary factor in permitting migration, it is not likely that the upper Pennsylvanian beds underlying Woodward County will be productive of much oil. Therefore no well drilled in the county may be considered a final test until the lower Pennsylvanian beds at least have been penetrated by the drill. No well should be started unless it is planned to drill to a depth of 4,500 feet. Even at this depth, much of the lower Pennsylvanian section will remain untested. This means that any well drilled less than a depth of 4,500 feet has but slight chances of finding oil or gas in this area.

### CONCLUSIONS

Woodward County lies within the area of possible oil and gas territory. Beds of dark shales for the origin of oil and sands to serve as reservoirs for oil are known to underlie this area. Given then, the necessary structural conditions or folding, to cause an accumulation of any oil that might have originated in the shale beds of the regional area in which the county lies, oil in commercial quantities may be expected. However, the depth to which the drill must go is a serious economic handicap to development in the county. The uncertainty of structures is likewise an added deterrent to development in the county.

It should be planned to carry any well started in the county to a depth of 5,000 feet or more, in order that a conclusive test of that location may be made.

## ELLIS COUNTY

### LOCATION

Ellis County is located in the northwestern part of the State. Its western boundary is a part of the Oklahoma-Texas boundary. The county extends from Tps. 16-24 N., inclusive, and from Rs. 21-26 W., inclusive. This includes 25 entire townships and parts of 16 others. The total area is approximately 1,188 square miles.

### TOPOGRAPHY

The topography is that of a high upland prairie plain, into which the streams have cut narrow valleys. The northern part of the drainage of the county is received by Beaver Creek and those streams tributary to it. The central part is drained by Wolf Creek, which is a tributary to the North Fork of the Canadian River and the southern part is drained by the Canadian River and its short tributary streams.

### GEOLOGY

The rocks at the surface in Ellis County are Permian, Tertiary, and Quaternary.



The Permian is represented at the surface in the eastern, northern and southern parts of the county by outcrops of the Whitehorse sandstone, the Day Creek dolomite, and the Cloud Chief gypsum.

The Whitehorse sandstone exposure occurs in the northeastern and eastern part of the county. The formation in this area consists of red sands, soft shales, and clays.

The Day Creek dolomite occurs in the northeastern and eastern portions of the county as remnant outcrops, appearing where erosion has removed the mantle of younger Tertiary and Quaternary beds.

The Cloud Chief gypsum occurs as surface exposures in the southern and northern parts of the county. The formation appears at the surface along the eastern, northern and southern borders of the county. The Cloud Chief formation consists of red clays, shales and sandstones, with beds of gypsum and dolomite. Gypsum, however, is the characteristic member of the Cloud Chief formation. The stratification of the formation is quite variable.

The Tertiary is exposed in the central and western parts of the county. These beds overlie unconformably the Cretaceous and Permian rocks. In the central part of the county hard calcareous deposits cap the more elevated areas, and these calcareous beds form as a result of differential erosion a topography of considerable relief. At various places in the central part of the county, the erosional buttes and escarpments of the Tertiary rocks form striking topographic features. The Tertiary consists of clay, sand, and gravel in addition to the calcareous, or "mortar bed" deposits of the central area.

The Quaternary exposures consist of two kinds of deposits—alluvium and dune sand. The alluvium deposits, consisting of sand and clay are found along the larger streams. The dune sand, a wind deposit, the source of which has been the Tertiary sands is found in the stream valleys. It is believed that the absence of dune sand deposits along the south side of larger streams, all of which flow eastward, is due to two factors, namely: the direction of the prevailing winds in this area, and to the shifting of the streams to the south, which as the stream wears and cuts its south bank more than the north, it leaves a sand deposit in its stead.

### SUMMARY

The nature of the surface rocks in Ellis County affords but small chance to find outcropping ledges on which folds, or structures may be determined. Even in those small areas where the older or Permian rocks outcrop no ledges for the determining structural relationships can be readily found. The Cloud Chief formation is so erratic in its stratification that readings on its strata cannot be trusted. The outcrops of the Whitehorse sandstone and the Day Creek dolomite are too limited to be of definite value in mapping the area.

However. it is reasonable to assume that the older rocks underlying this area are folded and tilted. Paleozoic rocks of the southernly dipping monocline, in which this area lies, are productive of much oil in other areas of the Mid-Continent field. Under proper structural conditions to account for the accumulation of oil, Ellis County may be regarded as favorable oil and gas territory, yet it should be borne in mind that the regional location of Ellis County does not offer great encouragement for the finding of much oil. (See Cross-Sections A, B, C, and D, and Regional Map). Assured of the occurrence of folds or structural conditions profitable development may result.

No well should be started in the county unless it is planned to drill to a depth of at least 5,000 feet. Even at this depth the drill will not test the full section of Pennsylvanian rocks that should underlie the area. It is certain that any well drilled less than 4,500 feet has but slight chance of encountering oil in sufficent quantity to warrant development.

# STEPHENS COUNTY

By

Frank Gouin

## INTRODUCTION

### GENERAL STATEMENT

It is the purpose of this report to present to the reader very briefly the geology of the oil and gas fields of Stephens County so that one unfamiliar with the county may get a general idea of conditions in the present producing pools and what might be expected from future pools yet to be discovered. To properly cover such a subject it is necessary not only to discuss the geology but the related subjects of drilling and production. It is much easier to evaluate a prospective area when one knows how much profit has been derived from pools in the vicinity. Thus considerable space is devoted in this report to production figures of the various pools. Much could be written on any one of several subjects covered in this report but it is hoped that the salient features of these various subjects have been mentioned. If this report results only in a little more care being taken in the drilling of wells in southern Oklahoma the writer will feel that his efforts have been amply rewarded.

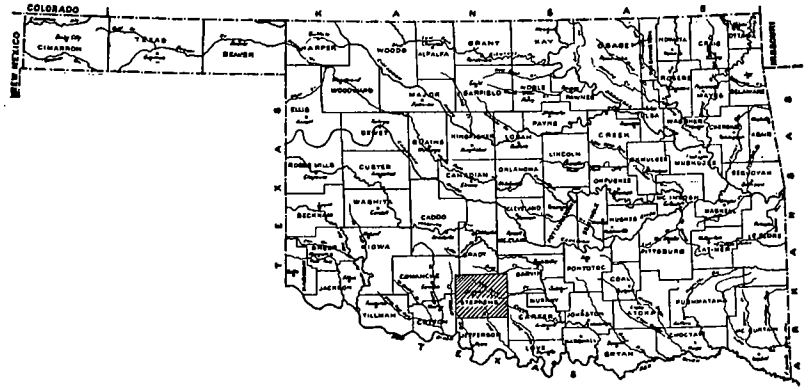



Figure 2.—Index map of Oklahoma showing location of Stephens County.

(This report originally issued as Bulletin 40-E, October, 1926).

### LOCATION

Stephens County is located in the south-central part of the State, being one of the second tier of counties north of Red River. It extends from T. 2 N., to the center of T. 3 S., inclusive and from R. 4 W. to the center of R. 9 W., inclusive, embracing an area of some 891 square miles. Duncan, the county seat, lies in the west-central part of the county. Fig. 1.

### ACKNOWLEDGMENTS

The writer wishes to acknowledge the following individuals and companies who have furnished data for this report: The Amerada Petroleum Corporation, Sidney Powers, Chief Geologist and R. A. Birk, Division Geologist, who furnished the base maps and copies of monthly pipe line runs from the producing properties listed in this report; E. D. Luman and F. A. Bush of the Atlantic Oil Producing Company, Knox Garvin and Harry Hanbury. In addition acknowledgment is due to the following fellow geologists in southern Oklahoma who have given valuable suggestions: F. W. Floyd, P. G. Russell, George Burton and Ed. W. Owen. The writer is especially indebted to Dr. Chas. N. Gould for much helpful assistance in the preparation of the manuscript.

### EXAMINATION

Although oil and gas have been produced in the county since 1912, very little information has been published concerning the oil and gas pools within its borders. Wegemann's[1] bulletin on the Cruce and Loco fields was the only information on the county until late in 1917 when Bulletin 19, Part II. of the Oklahoma Geological Survey, entitled "Petroleum and Natural Gas in Oklahoma" was published. The Stephens County portion of this bulletin was merely an elaboration of Wegemann's earlier work for these were still the only producing pools in the county at the time the U. S. Geological Survey bulletin was written. In 1919 the U. S. Bureau of Mines published a bulletin on the Comanche pool entitled, "Underground Problems in the Comanche Oil and Gas Field," by T. E. Swigart[2]. This report was published in cooperation with the State of Oklahoma. Short sketches of the shallow pools of Milroy and Velma in the eastern part of the county by Storm[3] appeared in 1924. This is the whole of the published material to date on the county on this subject. Numerous references to the general area of southern Oklahoma are present in the literature pertaining to regional geology, stratigraphy and paleogeography.

1. Wegemann, C. H., The Duncan Gas Field, Oklahoma and the Loco Gas Field Oklahoma: U. S. Geol. Survey, Bull. 621, Part 2, pp. 31 and 43, 1915.
2. Swigart, T. E., Underground Problems in the Comanche Oil and Gas Field, Oklahoma: U. S. Bureau of Mines Bull. 1919.
3. Storm, W., The "2-4" Shallow Field and the Velma Oil and Gas Field, Oklahoma: Am. Assoc. Pet. Geol. Bull. vol. 5 No. 5, p. 626, 1924.



### TOPOGRAPHY

Stephens County is located within the red beds plains region of Oklahoma. The general nature of the surface of the ground is that of a gentle hilly country. Since all of the drainage is to the south and east the highest elevations are in the northern and northwestern part of the county—around 1,400 feet above sea level, while the lowest are in the southern part—less than 800 feet. The western half of the county is drained by Beaver Creek and its tributaries into Red River; the central portion of the county by Cow Creek, Mud Creek and their tributaries draining also into Red River, while the eastern part of the county is drained by Wildhorse Creek which drains into the Washita River.

## STRATIGRAPHY

### SURFACE GEOLOGY

### GENERAL STATEMENT

The surface rocks of the county all belong to the Permian system[4]. An areal map of the surface formations is shown in Plate I. The outcrop boundaries for this map from the Duncan sandstone up were taken from the geological map of Oklahoma by H. D. Miser, published by the U. S. Geological Survey in cooperation with Oklahoma geologists and oil companies. Those below the Duncan sandstone are by the writer. Roughly a little more than half of the southern part of the county is covered by rocks belonging to the Wichita-Clear Fork formation, while a little less than half of the northern part of the county is covered by rocks belonging to the Enid formation. The escarpment of the Duncan sandstone, which is a noticeable topographic feature, is the dividing line between these two formations.

The rocks of the Wichita-Clear Fork division consist of brick red and gray colored shales, sandstones and mudstone conglomerates. They vary locally, both as to color and character. Horizons in this division can be traced in an east-west direction across the country when followed as zones rather than by attempting to follow any particular bed. The normal dip, which is slightly east of north, is probably about thirty feet to the mile. These rocks are gently folded over their areal extent in the county. An elongated dome is the most common form of folding with a closure generally of from twenty to thirty feet.

The Duncan sandstone, rests unconformably (?) upon the top of the Wichita-Clear Fork formation. This sandstone derives its name from the city of Duncan, the escarpment being within a mile of that city. It is a heavy-bedded reddish sandstone, locally gray, having a thickness from about 75 to 150 feet. In the central portion of the county there are three main beds of sandstone interbedded with light colored shales. The top member is the most consistent throughout the

4. Gould, Chas. N., Index to the Stratigraphy of Oklahoma, Oklahoma Geological Survey Bull. 35, 1925.

county. Above the Duncan sandstone is the Chickasha formation, which is composed of vari-colored shales, red shades predominating, and lenticular reddish sandstones. These sandstones are locally gray. This formation has a thickness of about 200 feet. Horizons in this formation are difficult to trace with assurance for any distance. The Duncan sandstone dips to the northeast in the northwestern part of the county at the rate of 60 to over 100 feet to the mile. Folds on the Duncan sandstone are very steep as compared to those on the underlying Wichita-Clear Fork rocks. It is this difference in the rate of dip and type of folds which suggests an unconformity between these two formations.

Above the Chickasha formation in the extreme north-central part of the county, named in order from the oldest to the youngest formations, are the Blaine gypsum, Dog Creek shale and Whitehorse sandstone. The Blaine gypsum in the county does not contain the massive beds of gypsum and dolomite that are a part of that formation farther northwest, but is composed mainly of red clay shales and thin beds of gypsum and gypsiferous shales. This is also true of the horizon of the Dog Creek shale. The area covered by the Whitehorse sandstone can easily be identified by the high hills northeast of Marlow that are covered with loose sand weathered from this friable formation. Otherwise the description of these formations is as described in Bulletin No. 35 of the Oklahoma Geological Survey.

## SUBSURFACE GEOLOGY

### GENERAL STATEMENT

It might be in order here to set out some of the difficulties which present themselves to one who attempts to discuss the subsurface geology of southern Oklahoma and Stephens County. The foremost problem to combat is that throughout the entire Carboniferous system present in the county there is not one horizon marker which shows up in well logs by which one can correlate with assurance. The second big problem, which, if corrected might partially offset the first, comes by reason of the fact that probably over ninety-five per cent of all wells in the county have been drilled by the rotary method. This includes wildcats as well as those drilled in pools. This in itself would not be so bad were it not for the fact that in the majority of the rotary drilled wells no attention whatever seems to have been given to the cuttings except when it was thought that a sand was being drilled. In the absence of massive limestones and other definite markers which cover widespread areas in the northeastern part of the State, we lose our best point for correlation, namely, the colors of the shales. The third problem, a correction of which would entirely solve the second and which would without doubt clear up the entire situation, is that of saving cuttings as each well is drilled. When the practice of saving cuttings becomes general in this district, then will the subsurface geology and geologic history of the whole of southern Oklahoma become like an



open book and many thousands of dollars, now being expended in useless drilling, will be saved. In the discussion below, wherever correlations are mentioned that are based on identifications from well samples, this information is so stated. Where no such information is stated, it is to be assumed that the correlations are those of the writer based upon his own observations, none of which are from a paleontological standpoint. All correlations are made with the full realization that as time goes on and the saving of samples becomes a general practice, the writer will be found to be in error in many of his statements.

### PRE-CAMBRIAN

The granites and other igneous rocks of the basement complex, presumably underlie the entire county, although no well has been drilled to it. The pre-Cambrian rocks can no doubt be reached at comparatively shallow depths on some of the buried hills in the county.

### CAMBRIAN

It is also presumed that the Reagan sandstone is present on the pre-Cambrian rocks for it is exposed to the northwest on the northeast flanks of the Wichita Mountains and to the east in the Arbuckle Mountains. For a description of this sandstone, see "Index to the Stratigraphy of Oklahoma" by Chas. N. Gould, Bulletin 35 of the Oklahoma Geological Survey—page 11, 1925.

### CAMBRO-ORDOVICIAN

The Arbuckle limestone probably underlies the whole county, unless there are buried hills not yet discovered, upon which this limestone has been entirely eroded before the deposition of the younger rocks. The following is a list of wells in the county which are known to have encountered the Arbuckle limestone. Included in this list are also wells which are thought to have encountered rocks of this age. There are other wells in the county which have possibly encountered Arbuckle limestone, but the evidence is too vague to be sure of it.

1. Amerada Petroleum Corporation, Blaydes No. 10, NE.¼ NE.¼ sec. 32, T 1 S., R. 8 W. Arbuckle from 3,367 to 3,600 feet, total depth of well. Identification by Amerada geological department from samples. Personal communication from Sidney Powers.
2. Magnolia Petroleum Company, Hall No. 1, NE.¼ SW.¼ sec. 29, T. 1 S., R. 8 W. Arbuckle (?) from 3,500 to 3,860 feet.
3. Comanche Petroleum Company, Wilson No. 4, NE.¼ NE.¼ sec. 19, T. 2 S., R. 7 W. Arbuckle from 3,410 feet to 3,635, total depth of well. Identification by V. V. Waite.
4. Magnolia Petroleum Company, Brown No. 1, SW.¼ NW.¼ sec. 19, T. 2 S., R. 7 W. Arbuckle (?) from 3,505 to 3,835, total depth of well.
5. Magnolia Petroleum Company, Brooks No. 4, NE.¼ SW.¼ sec. 25, T. 1 S., R. 9 W. Arbuckle (?) from 3,017 to 3,102 feet, total depth of well.
6. Magnolia Petroleum Company, Fleming No. 1, NE.¼ NW.¼ sec. 26, T. 1 N., R. 9 W. Arbuckle (?) from 2,880 to 3,250 feet total depth of well.
   All of these wells are on the axis of the southeast extension of the Wichita uplift.
7. Lone Star Gas Company, Ida Billy No. 2½, NW.¼ SE.¼ sec. 9, T. 3 S., R. 5 W. Arbuckle (?) from 1,560 to 2,520 feet, total depth of well. Goldston[5] states that the producing section in the Loco field rests upon the Ar-

5. Goldston, W. L., Jr., Differentiation and Structure of the Glenn Formation: Am. Assoc. Pet. Geol. Bull. vol. 6, No. 1, p. 12, 1922.

buckle limestone. He probably based his evidence on this well, but he does not state upon what the identification was based or who made the identification.

8. Magnolia Petroleum Company, NE.¼ SE.¼ sec. 26, T. 2 S., R. 6 W. Arbuckle from 2,725 to 3,680 feet, total depth of well.
9. Magnolia Petroleum Company, NW.¼ SE.¼ sec. 25, T. 2 S., R. 6 W. Arbuckle from 2,700 to 3,360 feet total depth of well.

Note—Wells 8 and 9 above are located on the upthrow side of a large subsurface fault. For this reason and because of the thickness of limestone drilled, it is assumed that this is Arbuckle rather than Viola limestone. As noted below, many wells in this township have drilled ino the Viola limestone. For a description of the Arbuckle limestone, see Bulletin 35 of the Oklahoma Geolcglical Survey, p. 13.

### ORDOVICIAN

The Simpson formation is found resting upon the Arbuckle limestone with the Viola limestone occurring next above. Due to the immense amount of erosion which took place subsequent to the deposition and elevation of the Viola limestone, all of the Viola and Simpson, which at one time covered the entire county, has been eroded from the tops of many of the buried hills. This is especially true along the southeast extension of the Wichita Uplift. The following wells are known or are thought to have encountered either the Viola limestone alone or both the Viola limestone and Simpson formation.

1. Lone Star Gas Company, Martin No 1, center of the east line of sec. 7, T. 2 S., R. 6 W., Viola from 3,407 to 3,480 feet, total depth of hole. Producing a small amount of oil in breaks in the Viola.
2. Magnolia Petroleum Company, southeast corner SW.¼ sec. 14, T. 2 S., R. 6 W. Viola (?) from 3,540 to 3,710 feet. Shows of oil in this lime.
3. H. F. Wilcox Oil and Gas Company, norheast corner sec. 17, T 2 S., R. 6 W. Viola from 3,410 to 3,625. Hole full of water in top of Simpson at 3,655 feet, total depth of well.
4. The Texas Company, NW.¼ SE.¼ sec 19, T. 2 S., R. 6 W. Viola from 3,012 to 3,184 feet, Simpson formation from 3,184 feet to a total depth of 3,570 feet.
5. Magnolia Petroleum Company, northeast corner SE.¼ sec. 22, T. 2 S., R. 6 W. Viola (?) from 3,300 to total depth of well of 3,610 feet.
6. Magnolia Petroleum Company, NE.¼ SW.¼ sec. 24, T. 2 S., R. 6 W. Viola (?) from 3,473 to total depth of well of 3,692 feet. A show of oil was encountered in this limestone at 3,550 feet which was shot but failed to produce in commercial quantities. Samples of the Viola were obtained when blown out after the shot.

For a description of these two formations, see Bull. 35, Oklahoma Geological Survey, pp. 14-15.

### POST-VIOLA—PRE-PENNSYLVANIAN ROCKS

There is no evidence of any rocks of an age between the top of the Viola and the base of the Pennsylvanian in any well that has been drilled around the Wichita Mountains, or in any well which has been drilled in Stephens County to the knowledge of the writer, therefore, it is presumed that this area was a positive element during these periods and that there was no deposition representing that interval of geological time. If there are rocks representing that time interval they are present in the regionally lowest places in the county, which would be in the extreme southwestern and notheastern parts. It is also quite likely that if present at all they are extremely thin, possibly being something like the equivalent interval in the section north of the Llano-



Burnett Uplift in Texas, part of which is described by Roundy, Girty and Goldman[6].

### PENNSYLVANIAN

Up to the time of this writing geologists working in southern Oklahoma have been puzzled as to the part of the Pennsylvanian section that is represented in this county and south-central Oklahoma in general. Pennsylvanian fossils have been noted in the cuttings from various wells throughout this general district, but paleontologists have not been able to correlate such fossil horizons with a known section from some type locality. Now that the immense value of the study of micro-fossils is becoming generally known, a study is being made of well cuttings throughout the country. With the increasing importance of production from the Glenn formation in southern Oklahoma, an intensive study of the micro-fauna of that formation is now being made by microscopic paleontologists of several of the major oil companies. E. D. Luman and F. A. Bush of the microscopic division of the geological department of the Atlantic Oil Producing Company, have kindly taken the time from their work to make the correlations listed below. With just these few correlations a wonderful start is made toward the solution of the problem of the differentiation of the Pennsylvanian section in the Duncan district.

While drilling a well for the McMan Oil Company in the Empire pool in the southeast corner NW¼ sec. 33, T. 1 S., R. 8 W. some three years ago, the Garvin Drilling Company took a core of blue shale at a depth of 2,617 feet. Because the core was full of fossils Mr. Knox Garvin gave it to the writer. Luman and Bush have lately examined this core with the result that they state that it is older than the Deese member of the Glenn formation, but whether it is equivalent to the Cup Coral or Otterville limestone members their present studies of the Glenn have not progressed far enough for them to say. This core was taken 400 feet stratigraphically below the Blaydes sand.

The same men examined a full set of cuttings from the Hanbury well drilled to a depth of 2,504 feet in sec. 12, T. 3 S., R. 7 W., with the result that they place the section from a depth of 1,852 feet to the bottom of the hole as belonging to the upper-middle portion of the Hoxbar member of the Glenn. In sec. 2, T. 3 S., R. 7 W., the Kay County Gas Company drilled a well to 3,015 feet. They identified a sample from this well from a depth of 2,140 to 2,165 feet, as tying into the Glenn section at upper-middle Hoxbar. They indentified the following forms:

*Healdia* near *simplex* in abundance
*Bairdia beedei*
*Bythocypris* sp.
Two unidentified species of gastropods
*Productid* spines and crinoids.

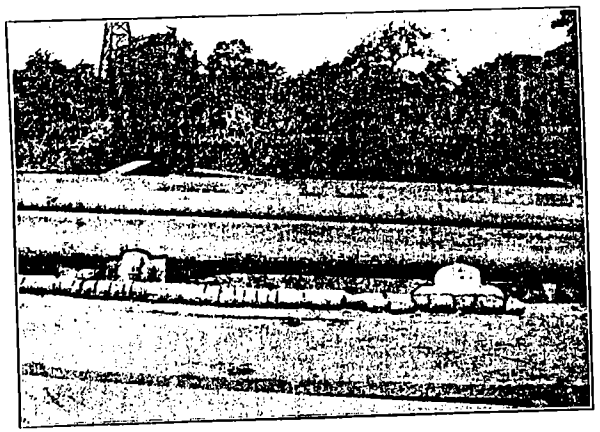
6. Roundy, P. V., Girty, Geo. H., and Goldman, M. I., Mississippian formations of San Saba County, Texas: U. S. Geol. Survey, Prof. Paper 146, 1926.

They examined the cuttings from a well drilled by the Atlantic Oil Producing Company in sec. 33, T. 3 S., R. 7 W., in Jefferson County, a little over two miles south of the Stephens County line which was drilled to a depth of 3,500 feet. The top of the Glenn was encountered slightly below 1,800 feet. The section from that depth to the total depth belonged to the Deese member of the Glenn. Two wells lately drilled in T. 3 S., R. 6 W., one in sec. 2 and the other in sec. 11, both to 2,000 feet, were identified by Carter Oil Company paleontologists, as being in the upper part of the Glenn formation from a depth of about 1,400 feet on down.

Besides the information given above, the following general information which has been determined by means of the identification of the larger fossils in cuttings from miscellaneous wells is of great help in this problem. Sidney Powers states that the cuttings from the Amerada Petroleum Company deep test Well No. 1 in sec. 32, T. 1 S., R. 8 W.,—under "Cambro-Ordovician," show that the Pennsylvanian-Arbuckle contact in this well was at a depth of 3,367 feet.

In several cases shale cores taken from around the Blaydes sand horizon (2,200 feet) in T. 1 S., R. 8 W., have been sent to various eminent paleontologists for their opinion as to the position of this horizon in the section. The general average of their opinions would favor placing this horizon not younger than middle Pennsylvanian. Their ideas were formed from comparing the larger fossils in the cores with type fossils in the section exposed in the Coalgate quadrangle.

**PLATE I**



CORE TAKEN FROM WELL IN SEC. 22, T. 1 S., R. 8 W.
Cutter head used in taking the core on left between core and drill pipe. Nine feet of core taken at one time and broken into sections for examination of the formation.



Considering all the evidence above with special emphasis being placed on the fact that the Pennsylvanian extends down to a depth of 3,367 feet in the Amerada well mentioned, the writer is inclined to place the horizon from which the McMan core was taken as belonging to the Cup Coral member. From this it is assumed that all of the producing horizons of this general district from the Surber sand zone (1,700 feet) down belong to the Cup Coral member. This would include the Empire, West Duncan, North Duncan, and the other small adjacent pools. Coupling this data with that from the Hanbury well in T. 3 S., R. 7 W., and the Atlantic et al well in T. 3 S., R. 6 W., it would seem that the amount of Glenn section now present in the county is dependent upon the relation any area has to the general highs. It is quite probable that the Glenn section in general thickens toward the eastern limits of the county in the direction of the thickest portion of formation which is in the Ardmore basin of Carter County. When the different factors which influenced the deposition and subsequent erosion of the Glenn formation prior to the deposition of the post-Glenn sediments are considered, it can easily be seen that a study of the cuttings from numerous wells scattered throughout the county will be necessary before the present distribution of the members of the Glenn formation is known.

The Glenn formation discussed in this report is the Glenn of Taff[7] and Goldston[8] as amended by Girty and Roundy[9].

Overlying the rocks of the Glenn formation over a large part of the county is a section of rocks which the writer classes as belonging to the Pontotoc group. This correlation is based on lithology alone. The correlation of the Carboniferous rocks above the Glenn is an extremely difficult problem and one that has not yet been solved in southern Oklahoma. The paucity of fossil evidence at the outcrop of these formations makes this problem difficult of solution, hence it is still more difficult when the formations are underground. The evidence for the correlation has been collected by the writer while watching the drilling and collecting the cuttings from scattered wells in this and adjoining counties, and from a study of the logs of numerous wells. In the Hanbury well in sec. 12, T. 3 S., R. 7 W., between the base of the red shales at a depth of 1,270 feet, and the Glenn formation at a depth of 1,852 ft., there is a series of thick beds of coarse sands and conglomerates with some thin beds of blue shales. The coarse sands are composed of large grains of quartz, varying from about the size of a radish seed to that of a small grain of corn. The conglomerate is made up of limestones and cherts from pre-Pennsylvanian rocks with coarse sand filling the interstices. Since the conglomerate pebbles were broken up by the drill, their size is unknown. A piece of pebble, which had been possibly an

7. Taff, J. A., Preliminary Report on the Geology of the Arbuckle and Wichita Mountains in Indian Territory and Oklahoma: U. S. Geol. Survey Prof. Paper 31, 1904.
8. Goldston, W. L., Jr., Op. cit.
9. Girty, Geo. H., and Roundy, P. V., Notes on the Glenn formation of Oklahoma: Am. Assoc. Pet. Geol. Bull. vol. 7, No. 4, p. 331, 1923.

inch in diameter, was found in the cuttings which fits exactly the description of the banded pebbles in the Hart limestone member mentioned by Birk[10]. In fact, the interval between 1,170 and 1,852 feet in this well checks very closely with Birk's description of the Pontotoc group on the west side of the Arbuckle Uplift. In a well drilled by the Atlantic Oil Producing Company in sec. 2, T. 1 S., R. 4 W., between the base of the red beds at a depth of 1,850 feet and the total depth of the well 2,520 feet, there is a very similar section, except that there is much more of the lime conglomerate present. In order to find just what this material looked like before being drilled up, the writer had a core taken at 2,520 feet. The core was found to be coarse conglomerate of unevenly assorted pebbles, varying in size from a small grain of sand to pebbles two inches in diameter. The pebbles were composed of Viola limestone and other pre-Pennsylvanian limestones and cherts. There were some beds of blue shale interbedded with the conglomerate.

This group is absent on the southeast extension of the Wichita Uplift and on the top of the other known buried hills of the county, such as Loco, Velma, Cruce and Woolsey, but is noted on the flanks of all these highs. Naturally a formation of this sort as it is derived chiefly from the Arbuckle and Wichita uplifts, would be extremely variable both vertically and laterally[11 12 13]. In the northwestern part of the county, this group is made up of arkosic sands and gravels, interbedded with brown shales. This material has been noticed in well samples as far north as the Chickasha gas field in T. 5 N., R. 8 W., Grady County. In the regional syncline in the southwestern part of the county the group has a thickness exceeding 2,000 feet, and in the southwestern part of the county a thickness exceeding 1,500 feet. The writer agrees with Birk in placing the top of the Pennsylvanian at the top of the Stratford formation, which is the base of the typical red beds, for to the northeast in Pontotoc and Seminole counties, and to the southwest in Montague and Clay Counties, Texas, the red color line crosses over the Permian-Pennsylvanian contact, taking in part of the Pennsylvanian rocks.

### PERMIAN

With the Ducan sandstone of southern Oklahoma definitely correlated with the San Angelo sandstone of Texas[14], which is the base of the Double Mountain formation, we now have a definite horizon in the Permian rocks of southern Oklahoma which can be correlated with the Texas section. Between the top of the Pennsylvanian and the base of the Double Mountain formation of west Texas, are the Wichita and Clear Fork formations. Since the escarpment of the Duncan sandstone almost isolates the older Permian rocks of southern Oklahoma from the rocks of the same age in central and northern Oklahoma, the writer here suggests that the rocks of southern Oklahoma, between the base of the Permian and the base of the Duncan sandstone, be named the Wichita-Clear Fork formation. This formation covers all of Stephens County, the upper part of it being exposed at the surface over about two-thirds of the county, it has a thickness of about 600 to 2,000 feet. The section consists of brick red shales, some thin gray shales and gray and red sandstones.

10. Birk, R. A., An extension of the Pontotoc Series around the Western end of the Arbuckle Mountains, Oklahoma, Am. Assoc. Pet. Geol. Bull. vol. 9, No. 6, p. 983, 1925.
11. Morgan, Geo. D., Geology of the Stonewall quadrangle, Oklahoma: Bureau of Geology, Bull. No. 2, Norman, Okla., 1924.
12. Morgan, Geo. D., Arkose of the northern Arbuckle area. Okla. Geol. Survey, Cir. No. 11, 1923.
13. Birk, R. A., op. cit.
14. Gould, Chas. N., The Correlation of the Permian of Kansas, Oklahoma, and northern Texas: Am. Assn. Pet. Geol. Bull. vol. 10, No. 2, 1926.



### STRUCTURE

#### WICHITA UPLIFT

The earliest period of folding for which we have definite evidence is that of the Wichita Mountain Uplift, which must have taken place not later than early Mississippian time. The fact that early Glenn rocks are resting unconformably upon the Arbuckle limestone in the Empire pool in T. 1 S., R. 8 W., in the West Duncan pool immediately west of the Empire pool, and in the North Duncan pool in T. 1 N., R. 9 W., that a well drilled in sec. 34, T. 1 N., R. 9 W., two miles west of the North Duncan Pool encountered Viola pebbles stratigraphically below the producing horizons of that pool appears to be evidence enough without citing others. This is in agreement with conclusions of Schuchert[15] Moore, Plummer[16] and others.

This uplift was a part of a movement that was of greater magnitude and more widespread than any movement which has taken place in the Mid-Continent in geologic time. Other highs which were formed at this time in Stephens County are Loco in T. 3 S., R. 5 W., Woolsey in T. 2 S., R. 6 W., Velma in T. 1 and 2 S., R. 5 W., and probably Cruce in T. 1 N., R. 5 and 6 W. To the southeast, in Carter County, Healdton and Hewitt were uplifted during this movement.

#### POST-WICHITA UPLIFT

We have no evidence of any sedimentation in the county between the time of the Wichita Uplift and the depositions of the Glenn formation, with the possible exception of the regionally lowest parts of the county, it seems that most of the county was a positive element and therefore above water during this interval of time. This is also true for the greater portion of southern Oklahoma west of the eastern part of Stephens and Jefferson counties and south of the north limits of the Wichita Mountains. The Wichita Mountains are now the last small traces of what was once a grand mountain range that extended from central Stephens County, Oklahoma, northwest across the Panhandle of Texas into New Mexico, a distance over 350 miles. They

15. Schuchert, Chas., and Pirsson, L. V., Text-book of Geology, Pt. 2, p. 343, 1924.
16. Plummer, F. B., and Moore, R. C., Stratigraphy of the Pennsylvanian formations of north-central Texas; Univ. of Tex. Bull. No. 2132, June, 1921.

were over 40 miles in width at their widest point, which is between the towns of Gotebo and Altus in Oklahoma, and the summit raised its head well over 5,000 feet above the surrounding country. Such a range of mountains must have furnished an enormous amount of material to a vast territory. By the close of Mississippian time many of the peaks in the range had been eroded down, exposing the Arbuckle limestone.

### PENNSYLVANIAN

At the beginning of the Glenn time all of the county became submerged, including that part of the southeastern end of the Wichita Mountain Range which lies within the county. This was a part of the Glenn sea which covered south-central Oklahoma. During this time a great thickness of sediments was deposited, much of the material being derived from the Wichita Mountains to the west. These sediments were deposited in fairly shallow waters, being especially shallow in the western part of the county, as evidenced by the very few thin limestones present in the section. At times much of the western part of the area must have been cut off from this main sea, as at intervals in the section there are beds of brown shale which are apparently non-marine. Girty (in a personal communication to J. V. Howell) mentions the presence of much non-marine material interbedded in the Pennsylvanian section in the Walters field in Cotton County, four miles west of the Stephens County line. The close of Glenn time was marked by the Arbuckle Mountain Uplift, at which time the eastern end if not all of the Wichita Mountain Range was again elevated, as were the other buried hills of the county.

### POST-GLENN

The history of the remainder of Pennsylvanian time after the Arbuckle Uplift is that of the removal of material from the highs with the deposition of this same material in the lows. In other words the highs were large islands in the late Pennsylvanian seas. This was largely a period of rapid erosion which was unfavorable to life, hence the scarcity of fossils in this division. Before the close of Pennsylvanian time, the Wichita Mountain Range west of the county had become eroded down to the granite core, with the result that much of this arkosic material was distributed for great distances out from the mountains. By the close of Pennsylvanian time the highs had been so worn down and the lows so filled up with material from the highs, that the area in which Stephens County lies presented a fairly level aspect.

### PERMIAN

We find with the opening of Wichita-Clear Fork time the shallow waters almost completely covering this area, with only the very tops of the buried hills above water. To the west, peaks of the now much reduced Wichita Range rose like islands out of the water, with a gradual transition between late Pennsylvanian and early Permian time, with little if any movement. The only difference was in the



source of the sediments being deposited. The Wichita-Clear Fork sediments consisting of red shales and fine-grained gray and red sandstones were evidently transported from a great distance, with most of the sediments coming from the west[17]. This resulted in the distribution of a fairly uniform thickness of sediments excepting upon the tops of some of the buried hills which were not covered until late in this interval of time. There was evidently some movement at the close of this time, for the apparent discordance in the dips on the surface rocks between the top of the Wichita-Clear Fork and the base of the Duncan sandstone is suggestive of an unconformity. The remainder of Permian time in this county is mainly a repetition of Wichita-Clear Fork time with the same source for the materials deposited. The distribution of the San Anglo-Duncan-Harper sandstone would suggest a more uniform sea.

There was a period of folding in late Permian time as evidenced by the sharp folds on the Duncan sandstone at Cruce in T. 1 N., Rs. 5-6 W. and to the northwest in Comanche County, also by the gentle folds on the surface rocks of the Wichita-Clear Fork formation. This folding evidently originated around the Central Mineral (Llano-Burnett) Region of Texas, for the north dip of the surface rocks to the north of that region continues northward into Oklahoma beyond Stephens County. This must have been a very gentle period of folding for many of the surface folds in the county are apparently not reflected in the lower rocks, in fact many of them are in areas that are regionally low. This applies to all of southern Oklahoma covered by Permian rocks. While the folding in the older rocks influenced this latter movement to the extent that there is some slight folding over the older structures in some areas, there are probably many subsurface folds which are not revealed in the surface rocks. Therefore, in all of southern Oklahoma covered by Permian rocks, the first and most important consideration, when looking for favorable areas to drill, is to thoroughly work out the regional geology. The structure of the surface rocks is the least and last important point to consider.

## PRODUCTION

### WELL SPACING

The subject of well spacing needs little attention in this county for the method of well spacing in vogue in this district seems to be satisfactory. This is discussed here in order that there will not be any radical change in the spacing in the future. In the northern part of the state the low price of oil from 1921 to 1925, together with the high costs of drilling wells, has caused the adoption of a program of spacing one well to ten acres, which spacing is too far apart for the average Pennsylvanian sands.

The chief factors, affecting the spacing of wells, in the opinion of the writer, are the pressure of the dissolved gas in the oil and the

17. Wegemann, C. H., op. cit.

viscosity of the oil, with the character and thickness of the sand and other such factors secondary matters. The general practice in western Stephens County has been to space nine wells on a forty acre tract. Where leases have been smaller than forty acres, six wells have been placed on twenty acres and four wells on ten acre tracts. In the last named arrangement, production figures prove that not only has much more oil been extracted than would have been the case were fewer wells drilled, but that more money has been made thereby. The following quotation from Swigart and Schwarzenbek[18] illustrates spacing conditions in a pool producing from the same formation as those in western Stephens County.

> "It is important to note that the actual cases used above indicate that considering average wells, four wells to ten acres is more profitable than one well to ten acres for the top Hewitt sand providing the wells average over 70 barrels per day for the first month. There is less danger from over-drilling than is commonly believed."

In the low gravity pools in the eastern part of the county wells should be spaced closer than in the western pools for the pressure of the dissolved gas is low due to the shallow depths, and the oil is quite viscous so that one well drains a very limited area.

### GENERAL DESCRIPTION OF PRODUCTION

In the discussion of the various pools in the county, which follows, an attempt is made to show what the present pools have done and will ultimately do in the way of production. The chief reason for the inclusion of this data is for their use as a "yard stick" for future producing areas in this district. For the past seven years we have been talking in terms of barrels per acre, but with differences in the cost of drilling wells in different parts of the country, together with great variations in the spacing of wells, it is necessary to know the cost per barrel produced, in order to compare one district with another. In the production tables in this report the average production per well is given. Mention is also made of the average cost of drilling a well in the various districts of the county. These give a basis of comparison with other oil producing districts that the method of per acre yields will not give.

While the average production per well in the three Stephens County pools listed in the table is about one-third less than the other pools listed, the cost of drilling the wells in the other pools would average twice the cost in the Stephens County pools, so that the net revenue per well would average higher for this county than for any of the other pools in the state listed in the table. The county has probably produced about 25,000,000 barrels of oil since the completion of the first well.

18. Swigart, T. E., and Schwarzenbek, F. X., Petroleum Engineering in the Hewitt Oil Field, Oklahoma. U. S. Bureau of Mines, Bull. Jan., 1921, p. 34.



*General Production Table*

| POOL | COUNTY | PER ACRE YIELD TO 1-1-26 | PER WELL AVERAGE TO 1-1-26 |
|---|---|---|---|
| Empire | Stephens | 9,389 | 47,356 |
| West Duncan | Stephens | 6,847 | 39,618 |
| North Duncan | Stephens | 6,826 | 40,554 |
| Healdton | Carter | | 72,273 |
| Hewitt | Carter | | 60,335 |
| Graham | Carter | | 35,134 |
| Burbank | Osage | 7,000 | 70,000 |
| Cromwell | Seminole | 5,500 | 55,000 |
| Wewoka (Lyons-Quinn sand) | Seminole | 7,000 | 70,000 |
| Papoose | Hughes-Okfuskee | 6,500 | 65,000 |

NOTE: Figures on outside pools from Krohn Oil Review and the Oil and Gas Journal.

The majority of the wells in the western part of the county flow naturally when completed. In fact, all wells excepting the edge wells that were drilled during the early development were natural producers. From two-thirds to three-fourths of the total production of all wells which were completed as natural producers has been made by flowing. For this reason the average lifting cost per barrel of oil produced is extremely low for the life of the average well in those pools. On the few leases where the lifting cost is known to the writer none have exceeded twenty-five cents per barrel after the wells were put on the pump. These are all leases having five or more producing wells. By considering the distance to the surrounding wells, a pretty fair idea of the total ultimate production any well will make can be ascertained from its initial production.

### DRILLING PROGRAM

When it is realized that in most sands more oil is left in the ground after the abandonment of the lease than has been extracted, even after the use of the vacuum and other such methods, we begin to feel that there is decided room for improvement in draining the sands. Although there is no apparent danger of an early exhaustion of our petroleum reserves, yet it is but a question of time when our national production will not supply our needs. The whole problem of getting as much oil as possible out of the sands resolves itself into a question of producing as little gas as possible for each barrel of oil produced. This is a problem on which the U. S. Bureau of Mines has been doing a lot of study and experimenting. Once the gas pressure in a sand has been dissipated, an extremely small percentage of the oil in the sand can be extracted by ordinary pumping methods even though the sand may be saturated, for the dissolved gas is the expulsive agent which forces the oil from the sand into the well[19]. Experiments on back pressure—checking the flow of oil by means of reduced openings at the mouth of the well—have not yet brought forth worth-while results as each well seems to

19. Dow, D. B., and Calkin L. B., Solubility and effects of natural gas and air in crude oils. U. S. Bureau of Mines, Serial 2732, 1926.

be a study in itself. The one system known to accomplish more than all other production methods to increase the recovery of oil from a sand, is that of rapidly drilling up a pool when first discovered. If a few wells are allowed to produce in a pool for any length of time they will so reduce the gas pressure that a large percentage of oil in the sand that should be recoverable, will be lost by present methods of production. This has been demonstrated so many times that it cannot be disputed. In many fields operators with large leases have drilled the necessary offset line wells reserving the development of the interior of the lease until a period of better market conditions, only to find that the eventual drilling up of the interior of the lease resulted in the completion of small wells. In that wonder field of the Mid-Continent, Burbank, covering thousands of acres with a sandy body from fifty to over one hundred feet in thickness, the acre yield to date has been less than in the Empire pool of Stephens County where the sand body averages less than ten feet in thickness. The extremely slow development at Burbank, together with the wide spacing of the wells, are the main factors in the difference. The yield could easily have been doubled if the development had been carried on as rapidly, and wells spaced as closely as in the Wortham or Powell fields of Texas. About the only solution to the problem of the discovery of a new pool during periods of overproduction is the shutting in of the discovery well. This is a method now being practiced in the Salt Creek field of Wyoming since the discovery of the productiveness of the Lakota sand. Operators there, in attempting to maintain a fairly consistent daily production, are drilling wells to the Lakota sand and then shutting them in.

### DRILLING METHODS

In all pools of the county, with the exception of the shallow Permian pools in the eastern part, practically all drilling is done by rotary method. Casing cemented on top of the sand after the sand has been found by means of feeling ahead with a reduced hole when the sand is thought to be near, and then taking a core when the sand is touched. Casing 8¼ inches in diameter is usually used although 6⅝ inch casing is often used on the deepest producing sands in any pool. A joint or two of 12½ inch casing is cemented for surface pipe, and an 11½ inch hole drilled when it is intended to cement 8¼ inch casing on the sand, while 10 inch surface casing is used and a 9½ inch hole drilled when it is intended to cement 6⅝ inch casing on the sand. Standard tools are rigged up while the cement is setting and the well drilled in with these tools.

It has been the practice since the first wells were completed in these pools to cement the casings and it has proved to be the most satisfactory method. The soft formations in this area do not permit of a casing seat that is permanently tight without the use of cement. Within the past two years some operators have come into the district from other places where it has not been the rule to cement casings, and have completed wells without cementing the casing by using the formation shut-off method. They have been successful in a majority of their wells in keeping a tight seat until the cream of the production was secured, but the attempts that were unsuccessful would have made it more economical to have cemented all wells, not to mention the early abandonment of those wells in which this operation was only temporarily successful. The few dollars spent in cementing is an extremely low rate of insurance to protect the investment represented by the well as a whole. In some instances the casing has not been cemented because it was not certain that the sand would produce profitably so that in this event, the casing could be recovered. However, the many sands in the Permian tend to freeze pipe in a very short time and the cases where more than one half the pipe has been recovered are very much in the minority. Also, if water is found after bailing the hole, one is never quite sure whether the water is from the sand or leaking from behind the pipe.



The best practice has been found to drill wells in with cable tools. In the early stages of development in any particular sand when the gas pressure is still high, wells can be completed with rotary tools without harm, but as soon as the gas pressure begins to decline the pressure of the column of mud laden fluid on the sand has a plastering effect on the walls of the hole in the sand that is hard to overcome by the pressure in the pay sand. Several such cases where it can be proved that this is true have happened in the Graham field of Carter County.

In the shallow pools of the eastern part of the county, all drilling to the shallow sands is done with Star machines. Wells are completed in a period of six to fifteen days at a cost of $4,000 to $6,000 for the average depth of the sands.

### WILDCATTING

Probably three-fourths of the wildcat work done in the county is by the use of the rotary. This is due to the fact that the soft formations which make up most of the section of rocks drilled in southern Oklahoma are exceedingly difficult to drill with cable tools as the casing has to be underreamed and carried to within a few feet of the bottom of the hole at all times. If much open hole is drilled the caving from the open hole usually is sufficient to prevent the continuation of the drilling. The underreaming and subsequent cleaning out necessary after each time the pipe is moved consumes over half the drilling time on the average well. Wildcatting work with the rotary has been done in a haphazard manner, in the past with no special attention paid to the formation being drilled excepting the sands. The increased knowledge of the formations in the district, together with the recent improvements in coring tools, has made it possible to do some very careful work by this method of drilling. There is still much haphazard drilling being done, but it can be said to the credit of the operators who have been in the district for some time, that this class of drilling is being done for the most part by the people rather new to the district.

Too little attention has been paid in the past to the character of the formations penetrated in wildcat wells[20][21][22]. Cuttings should be taken continuously from a point high enough above the expected base of the red beds that the actual base can be determined down to the total depth of the well. From a lithological standpoint alone one can tell the interval, if any, between the base of the red beds and the top of the Glenn formation. The thicker this intervening formation, the lower down one is regionally on the Glenn. If the first few wells drilled off the main regional highs of the county had been drilled in this manner and the formations logged as interpreted from the cuttings, it would have meant the saving of many thousands of dollars, spent later in drilling other wells and in buying leases in these same localities. More carefully watched wells recently have revealed the exceptionally steep dip to the east, northeast and southwest of the Glenn formation off the Wichita Uplift in Stephens County. After the Glenn formation is encountered, the horizons being drilled can be correlated only by a geologist familiar with the fauna and more especially the micro-fauna of this formation. By this method of keeping the cutting box in the ditch at all times, there is almost no danger of going through a sand without knowing it, for if one has inadvertently drilled through a sand the cuttings will appraise him of that fact.

The recent improvements in the patented core drills, several of which are on the market, have revolutionized rotary wildcat work. By the use of these double-barreled core drills as much as nine feet of core can be taken at one time. While the core is being taken the hole is also being drilled to guage; or if desired, the hole can be drilled so as to leave a seat for casing. The mud never touches the core, which is a wonderful aid in deciding the often difficult problem of whether a sand carries gas or salt water. When it is possible to estimate about where sands might be expected, it is well to start coring above this point and core continuously until the sand is either found or its absence determined. The old method of coring with home-made core barrel produced, on the average from four to six inches of core that was soaked with the mud in the hole. When one of these cores was brought out of the hole the guess work started. The guess really began before the core was taken out of the hole, for in many cases the core was never recovered after being cut. To properly interpret any core taken from a well, one should have a wide experience in comparing many cores from wells from which the results were later studied after casing was cemented and the wells drilled in. Too often the writer has seen pipe cemented on a sand, the core of which did not justify wasting a string of pipe to test out.

20. George, H. C., and Bunn, Jno. R., Petroleum Engineering in the Fox and Graham Oil and Gas Fields, Carter County, Oklahoma: U. S. Bureau of Mines, Bull. 1924.
21. Kraus, Edgar, Logging wells drilled by the rotary method: Am. Assoc. Pet. Geol., Bull. vol. 8, No. 5, 1924.
22. Gouin, Frank, The log of the well: The Atlantic Seal, July, 1924, Published by the Atlantic Refining Company, Philadephia, Pa.



When using the rotary it is the tendency for almost every one to "make hole". While the writer has received some wonderful cooperation from the contractor in various wildcat wells it is really more satisfactory for the wildcatter to have his own tools. Drilling, then, can be done as desired. The procedure in rotary wildcatting recommended in this chapter is the result of actual experience in drilling wells in which the writer has been interested. Wildcatting with either type of tools requires extreme care. Too many cases have been noted where cable tool tests have been unable to shut off water in order to test a sand, so drilling was contained through the sand without testing it. This method of drilling is not entirely fool proof. Cases have also been noted where the hole was caving so badly, the cavings sloughing in round the bottom of the pipe, that the operators were at a loss to know into what formation the drill penetrated.

## FUTURE POSSIBILITIES

It seems best to divide the subject of future possibilities into three radically different geological divisions in which production is being found in this county. These are (1) pre-Glenn; (2) Glenn and (3) post-Glenn.

### 1. Pre-Glenn

The future possibilities for finding production in these rocks seem rather limited. The Simpson formation is the only producing formation known below the Glenn formation and it has been removed from the tops of many of the known highs. The southeast quarter of the county should offer the best possibilities for testing to this formation. In the north half of the county, with the exception of the Cruce anticline, the Simpson is probably too deep for present drilling, although there is always the chance of discovering a buried hill not reflected on the upper formations. The southwest quarter of the county would be excluded for the same reason. The folds of these rocks are not necessarily reflected at the surface, but will coincide to some extent with Glenn folds.

### 2. Glenn

Although the Glenn formation probably underlies most of the county, it is probably too deep in the northern and southwestern parts to make drilling economically profitable under present prices of oil.

The chances are best for finding the Glenn at reasonable depths through the central and southeastern parts of the county. Surface folding is not necessarily indicative of folding in this formation.

### 3. Post-Glenn

Chances for finding producing pools in this division of rocks are favorable throughout the county. However, it should be borne in mind that the yields will average much lower than the Glenn formation production and the gravity in most cases will be much lower. What surface exposures are sufficient for control, surface folds are the primary consideration for locating wells to test this section of rocks.

## THE EMPIRE POOL

### LOCATION AND TOPOGRAPHY

The Empire pool, situated some ten miles southwest of Duncan, lies in the south-central portion of T. 1 S., R. 8 W., and in the extreme north-central edge of T. 2 S., R. 8 W. Parts or all of secs. 27, 28, 29, 32, 33, 34, T. 1 S., R. 8 W., and secs. 3, 4 and 5, T. 2 S., R. 8 W., are included in this pool.

The topography is gently rolling with a flat topographic high that is hardly noticeable except from a distance. About two thirds of the pool was at one time covered with a thick growth of scrub oak, but most of this has been cleared away on account of the development.

### HISTORY OF DEVELOPMENT

This, the banner high gravity pool of southern Oklahoma, was discovered by the Empire Gas and Fuel Company in April, 1920. The discovery well was the Surber No. 1, located in the southwest corner of sec. 33, T. 1 S., R. 8 W., which was completed with an initial production of about 1,200 barrels in a sand at 1,700 feet. Development of this sand in the pool was very rapid, for at this time oil was selling for the highest price in the history of the oil industry. By the close of the summer the pool was well defined, with virtually all locations drilled. Late in December of the same year the Climax Petroleum Company, in seeking a deeper sand completed a well to the northwest of the 1,700 foot sand development in the southeast corner of NW.¼ NE.¼ sec. 32, T. 1 S., R. 8 W., which started off at 2,400 barrels a day in a sand at 2,200 feet. Unfortunately for the producers this discovery was made on a falling oil market, but the large flush production was too great an incentive to overlook, so the same rapid development took place which was seen in the drilling to the 1,700 foot sand. By June, 1921 the main portion of the productive area of the 2,200 foot sand was developed. Development since that time has consisted of drilling to several very productive sands between these two first discovered sands which were passed up in the rush to the deeper sand, in discovering sands still deeper, and in proving up productive areas on the edge of former production. This later development has been carried on during periods when the price of oil was such that this work could be carried on profitably. During the winter of 1925-26 considerable development was made with very profitable results, this being almost six years since the pool was discovered.

### STRATIGRAPHY

The surface rocks in the pool are composed of the lenticular reddish sandstones and red shales belonging to the red sandstone group of the Wichita-Clear Fork formation of Permian age. Exposures are rather meager over most of the pool. It is thought that the base of the Permain is at a depth of between 1,100 and 1,200 feet from the surface. The writer believes that the section between this depth and the Surber sand (1,700 feet) is of post-Glenn Pennsylvanian. The only cable tool hole in this immediate area which was drilled from the top of the ground by that method of drilling, is a well drilled by the Champlin Refining Company one mile northwest of the northwest limits of this pool, being located in the southwest quarter of sec. 20, T. 1 S., R. 8 W., in the West Duncan pool. This well logs the base of the typical Permian red beds just below 1,100 feet, while the section below that down to the Surber sand consists of dark brown shales and sandstones. The section from this depth to the Blaydes sand (2,200 feet) consists almost altogether of blue shales and sandstones. From the Blaydes sand to the Arbuckle limestone, about 3,400 feet, the section is essentially the same excepting that there are occasional thin limestones. Beds of brown shale make up possibly a third of the shale section between the base of the Permian and the top of the Arbuckle limestone. This interval is the lower part of the Glenn formation as discussed under Subsurface Geology.



### STRUCTURE

The structure of the surface rocks of the pool is quite obscure, due to lack of definite control. The location of the discovery well was made due to the alignment on the supposed buried axis of the Wichita Uplift, rather than to any definite evidence of surface folding. Now that there is production in the area, it is possible to imagine that the pool is located on a surface dome, but prior to the development it is doubted if any one would get unduly enthusiastic over the area from a surface standpoint alone.

The underground structure can be worked best on the Blaydes sand for there have been many wells drilled to that sand for control. By using a combination of the structure on the Surber and Blaydes sands, excellent control can be obtained. The structure on each sand proves the presence of a very pronounced dome with some complex minor folding on the top. The center of the dome lies near the center of the east line of the SE.¼ sec. 32, T. 1 S., R. 8 E., being elongated north and southeast from this point. Minor synclines and domes on the top of the main dome add to the complexity of the whole fold. The dip to the southwest off the dome is very steep into the geosyncline of northern Jefferson County. The dip to the east is also quite steep through sec. 35, T. 1 S., R. 8 W., into a regional syncline plunging to the north through the center of T. 1 S., R. 7 W. To the northeast, due to some minor folding in secs. 15 and 22, the dip does not become steep until a point just northeast of these sections is reached where there is a sharp dip into the same regional syncline mentioned above. To the northwest and southeast, which is in the alignment of the Wichita axis upon which this pool is located, there are definite narrow synclines between this pool and those on either side, namely the Comanche pool to the southeast and the West Duncan pool to the northwest.

### PRODUCING SANDS

Besides being the most prolific high gravity pool of southern Oklahoma, the Empire pool has perhaps more producing sands than any other pool in this section of the State. Named from the top down, with the average depth at which they are found, they are: the 1,000 foot gas sand, the Miller sand (1,500 feet), the Nigh sand (1,600 feet), the Surber sand (1,700 feet), the Cantrell sand (1,800 feet), the Shelton sand (1,900 feet), the Smith sand (2,000 feet), the Brown sand (2,100 feet), the Blaydes sand (2,200 feet), the Kagay sand (2,300 feet), and the Maloney sand (2,600 feet). Of these sands the Surber and the Blaydes have contributed the bulk of the production. The 1,000 foot gas sand is producing in one well in sec. 34, but has been noted in other parts of the field. The Miller sand is also a gas sand having been tested only in a few places in the pool on account of the deeper gassers with higher pressures in adjacent pools. The Nigh (1,600 foot) sand has produced small quantities of oil in the few wells which have been tested out at this depth. A few small wells in secs. 27 and 34 are producing from this sand. Development to the sands between the Surber and Blaydes has just been going on during the past two years resulting in wells with initial productions of from 50 to 250 barrels. However, one well was completed in the Shelton sand as early as the summer of 1920. The Kagay and Maloney sands are only productive at this time in the southwest corner of sec. 34 and the corners of the three adjoining sections. There has not been development to this sand in other portions of the pool, so one cannot say that these two sands will not produce in other areas.

All sands from the Surber sand down, are medium fine grained, sub-angular, soft sands with very little cementing material. They are surprisingly uniform throughout the pool, and are so free from cementing material that they will come out as loose sand grains when drilled slowly by the rotary with the mud pump wide open. Even when drilled fast with the pump slowed down it is often difficult to obtain clunks. The extreme porosity of these sands is further demonstrated, both by the high yields from sands which are thin when compared to the producing sands of northeastern Oklahoma, and by the fact that it is necessary to drill into only the very top of the sand to obtain all the production that it is possible to get. The sands above the Surber seem to be characteristic of most pre-Glenn sands of the county in that they are not so evenly sorted and are cemented to some extent with lime.

The Glenn sands in all of the pools of the western part of the county are sandy zones in the shales. The thickness and number of the pay streaks in the zones vary from well to well. It should therefore be borne in mind that when reference is made to any sand the sand zone is meant rather than one thin pay streak in the zone.

### PRODUCTION

The production table (see page 43) includes every producing lease in the pool proper. Several leases in secs. 27, 28, 34, and 35



which have been principally producers of gas are not included as figures are not available for the amount of gas produced although the returns from gas production from the deeper sands have been very remunerative. There were six producing wells on lease No. 9 as of January 1, 1926, but two of these wells were not completed until late in 1925 so they were not included. On lease No. 16 a second well was completed to the same sand producing in number one well long after the flush was off. Since the initial production of this well was but ten barrels it was not figured in the per-well average for it produced but a small fraction of the total production on this two and one-half acre lease. With these two exceptions, the number of producing wells in the table check with the actual number of wells on each lease.

*Production Table Empire Pool*

(Figures as of Jan. 1, 1926.)

| COMPANY | LEASE | LOCATION | Prod. Acres | Prod. | Wells | Total Prod. | Pres. Prod. | Per Acre Yield | Total Prod. Per Well |
|---|---|---|---|---|---|---|---|---|---|
| Amerada | Blaydes | 32-1-8 | 40 | 3-21 | 10 | 728,768 | 68 | 18,219 | 72,877 |
| Black et al | Blaydes | 29-1-8 | 18 | 3-21 | 5 | 292,073 | 6 | 16,225 | 58,414 |
| Brown | Voss | 28-1-8 | 10 | 5-21 | 2 | 123,408 | 40 | 12,341 | 61,704 |
| Carter Oil | Blaydes | 32-1-8 | 40 | 7-20 | 9 | 398,316 | 150 | 10,000 | 44,257 |
| Carter Oil | Forgy | 5-2-8 | 15 | 7-21 | 3 | 144,021 | 40 | 9,401 | 48,007 |
| Carter Oil | Glass | 33-1-8 | 40 | 9-20 | 5 | 388,210 | 166 | 9,705 | 77,642 |
| Climax | Smith | 32-1-8 | 30 | 1-21 | 6 | 369,244 | 40 | 12,308 | 61,541 |
| Crump et al | Smith | 32-1-8 | 40 | 2-21 | 9 | 651,781 | 114 | 16,294 | 72,420 |
| Crump et al | Shelton | 32-1-8 | 10 | 4-21 | 4 | 221,656 | 278 | 22,165 | 55,331 |
| Crump et al | Eakes | 32-1-8 | 10 | 6-21 | 3 | 59,430 | 171 | 5,943 | 19,810 |
| Empire | Burkloe | 4-2-8 | 10 | 6-20 | 2 | 39,537 | Abd. | 3,953 | 19,769 |
| Empire | Cantrell | 32-1-8 | 80 | 7-20 | 13 | 626,989 | 124 | 7,837 | 44,814 |
| Empire | Miller | 5-2-8 | 40 | 6-20 | 13 | 455,917 | 144 | 11,398 | 34,763 |
| Empire | Story | 32-1-8 | 10 | 6-21 | 2 | 54,634 | 42 | 5,463 | 27,317 |
| Empire | Surber | 33-1-8 | 120 | 4-20 | 26 | 1,129,946 | 250 | 9,416 | 43,459 |
| Gordon et al | Gin Lot | 28-1-8 | 2½ | 3-21 | 1 | 57,766 | Abd. | 23,107 | 57,766 |
| Gant et al | Shelton | 32-1-8 | 40 | 2-21 | 11 | 909,267 | 270 | 22,731 | 82,661 |
| Gant et al | Voss | 28-1-8 | 10 | 10-21 | 3 | 32,280 | 33 | 3,228 | 10,760 |
| Hamon et al | Glass | 33-1-8 | 80 | 1-21 | 10 | 317,689 | 129 | 3,971 | 31,769 |
| Healdton | Burkloe | 4-2-8 | 20 | 6-20 | 3 | 165,322 | 6 | 8,266 | 33,064 |
| Lorraine | Shelton | 32-1-8 | 30 | 3-21 | 7 | 303,028 | 64 | 10,101 | 43,290 |
| Lorraine | Potts | 32-1-8 | 10 | 9-21 | 2 | 35,788 | 40 | 3,579 | 17,894 |
| Lone Star | Bush | 3-2-8 | 10 | 1-22 | 4 | 95,250 | 18 | 9,525 | 23,812 |
| Magnolia | Glass | 33-1-8 | 20 | 1-21 | 2 | 39,124 | | 1,956 | 19,562 |
| Magnolia | Bush | 3-2-8 | 10 | 1-21 | 2 | 66,213 | 14 | 6,621 | 33,106 |
| Magnolia | Kagay | 34-2-8 | 60 | 10-20 | 10 | 362,005 | 145 | 6,033 | 36,200 |
| Magnolia | School Land | 33-1-8 | 80 | 8-20 | 11 | 982,761 | 200 | 12,284 | 89,342 |
| Magnolia | Stephens | 33-1-8 | 60 | 8-20 | 10 | 251,707 | 100 | 4,192 | 25,170 |
| McMan Oil | Blaydes | 29-1-8 | 10 | 3-21 | 2 | 31,182 | Abd. | 3,118 | 15,591 |
| McMan Oil | Pitts | 3-2-8 | 10 | 9-21 | 2 | 63,260 | 8 | 6,326 | 36,630 |
| McMan Oil | Stephens | 33-1-8 | 80 | 6-20 | 10 | 402,125 | 137 | 5,026 | 40,212 |
| Old Colony | Blaydes | 29-1-8 | 12 | 3-21 | 4 | 111,635 | | 9,303 | 27,909 |
| Old Colony | Kagay | 34-1-8 | 10 | 9-20 | 4 | 239,963 | 52 | 24,000 | 57,993 |
| Skelly | Peilsticker | 5-2-8 | 10 | 10-20 | 2 | 27,693 | 2 | 2,769 | 13,846 |
| Shamrock | Burkloe | 4-2-8 | 17 | 6-20 | 5 | 180,027 | 2 | 10,590 | 36,005 |
| Westheimer | Maloney | 4-2-8 | 35 | 6-20 | 7 | 246,712 | 12 | 7,049 | 35,244 |
| TOTALS | | | 1129½ | | 224 | 10,604,728 | 2865 | 9,380 | 47,356 |

Some very interesting information can be gleaned from a study of these production figures. Since this is a multiple sand pool, one might think at first glance that the leases which have made the highest per acre yields are those which are producing from several sands, but this is only partially correct. Of the 20 leases which have pro-

duced over eight thousand barrels to the acre, 13 leases produced from one sand only at the time of this report. Ten of these 13 produced from the Blaydes sand, while the other three produced from the Surber sand. Rapid development of leases after the discovery of each sand is mainly responsible for high recoveries from one sand. All leases which have made an average of thirty thousand barrels or less per well are edge leases. While many leases are producing from several sands, no single well is producing from more than one sand, so the total average production per well shown in the table is an average of one well from one sand. The initial gravity of the oil produced from these various sands averages between 38 and 42 degrees A.P.I. with the general average being a fraction over 39 degrees. This gravity commands a price of $2.53 per barrel at this writing (June, 1926).

Perhaps the best way to illustrate the returns which might be expected in pools in this general area of the county is to compare the cost of completing wells with the average production per well. A well to the Blaydes sand, drilled by contract, with casing cemented on the sand with rotary tools, drilled in with cable tools, will cost about $15,000 for the first well. This cost can be reduced almost one-third since the majority of operators in this district have their own tools. There are many cases where wells have been completed for less than $10,000. Naturally a completion in a shallower sand will reduce the cost. Wells can be completed in twenty days. These figures will apply equally as well for the West Duncan, North Duncan and other producing areas in this part of the county. By assuming a lifting cost of twenty-five cents per barrel, which seems to be an average figure for this district, a well which will produce a total of ten thousand barrels gross, or 8,750 barrels net, will more than repay the cost of completion at the highest figure mentioned above. A well would have only to produce a daily average of slightly less than twenty-eight barrels for a year to reach this figure. All leases in the table have made a per well average in excess of this figure. From this information it is not hard to understand why this pool is such a prolific revenue producer when crude is selling at anything like reasonable prices.

### FUTURE POSSIBILITIES

A pool, now six years old, in which wells have been completed during the past winter with initial productions of from two to three hundred barrels in sands between the Surber and Blaydes sands in the heart of the pool, and extension wells to the northeast have been completed in the shallow Surber sand with initial productions of from fifty to one hundred barrels, it can hardly be said that this pool has seen its day. There are many possibilities for the completion of paying producers in the sands between the Surber and Blaydes that were drilled through in the rush to get the flush from the Blaydes sand in 1921. The Kagay and Maloney sand zones should also offer some possibilities in various parts of the pool, although it is not thought that these sand zones can be depended upon to produce consistently throughout the pool. Between the Maloney sand zone and the Arbuckle limestone are sands which should be thoroughly tested in the more favorable areas in the pool before the pool as a whole is finally abandoned no matter how remote the chances seem for production in such sands at this time.



While the pool at this time is quite definitely defined on all sides, there is development going on to the northeast in secs. 27 and 28 where production is being obtained from the Surber sand. The early development in these two sections was for the most part done by small operators inexprienced with rotary drilling and many dry holes were drilled in territory which is now proving to be productive. Leases now producing in the pool should have an average life of at least five years more by present methods of production. With just average results from the future completions in the pool there should be an ultimate yield in excess of 12,000 barrels per acre.

## THE WEST DUNCAN POOL

### LOCATION AND TOPOGRAPHY

The West Duncan pool is located about 12 miles southwest of Duncan in the west-central portion of T. 1 S., R. 8 W., and in the east-central portion of T. 1 S., R. 9 W. The productive area covers all or a part of secs. 7, 18, 19, 20, 29, 30 and 31, T. 1 S., R. 8 W.. and secs.13, 24, 25 and 36, T. 1 S., R. 9 W. The topography is that of a slightly hilly, rolling plain. The area covered by the pool is comparatively open with very little brush in evidence.

### HISTORY OF DEVELOPMENT

This pool was first discovered in 1919 when the Ft. Ring Oil and Gas Company drilled into an oil sand slightly below 2,100 feet in the northeast corner of SE.¼ sec. 30, T. 1 S., R. 8 W., Considerable difficulty was encountered in getting the well on production, so the showing encountered failed to attract further exploratory work until after the opening of the Empire pool, just two miles southeast, encouraged the Lone Star Gas Company to drill a well a quarter of a mile to the northwest of the initial test. By that time it was apparent that a syncline existed between the Ft. Ring well and the Empire pool. The result was that the Lone Star well was completed for an initial production of over 400 barrels in the 2,100 foot sand. This well was located on the Brown farm, hence the name of the sand. Later developments proved the fact that the original well was an extreme edge well on the southeast side of the pool. The remainder of the year 1920 saw the development of the present productive portion of sec. 30 in the Brown sand. The same year a number of gas wells were completed in sec. 24, T. 1 S., R. 9 W., in various sands from the Surber sand (1,700 foot) down to the Smith sand (2,000 foot). After the discovery of the Blaydes sand (2,200 foot) in the Empire pool, this sand was drilled to in the West Duncan pool during 1921 which result-

ed in the drilling of many twin locations. By the close of 1922, most of what now constitutes the present limits of the pool were defined. Development since that time has consisted mainly in drilling inside locations, in drilling to sands not producing on particular leases and to making minor extensions. The last extention was early in 1926, when a half mile extension to the south was made in the completion of a seventy million cubic foot gas well along the center of the north line of sec. 36, T. 1 S., R. 9 W., and a hundred barrel well, producing 44 gravity oil, was discovered in the southeast corner of sec. 25 of the same township.

### STRATIGRAPHY

Practically the same section of surface rocks is exposed over the area of this pool as over the Empire pool, with the exception that some gray sandstones overlie the red shales and sandstones in the northeastern part of the pool in secs. 18, 19 and 20, T. 1 S., R. 8 W. The subsurface stratigraphy is essentially the same as in the Empire pool with the exception that the old buried hill of pre-Pennsylvanian rocks is evidently a little higher in elevation than in the latter pool, for these rocks were encountered at a depth of 3,017 feet or 1,977 feet below sea level in a test drilled by the Magnolia Petroleum Company in the southeast corner NE.¼ NW¼, sec. 25, T. 1 S., R. 9 W. This hole logs limestone from 3,017 feet to a total depth of 3,102 feet. It is the opinion of the writer that this is the Arbuckle limestone on account of the fact that the Amerada test in the Empire pool showed that the lower Paleozoics were removed down to this age of rocks before the deposition of the Pennsylvanian rocks, this pool being on the same ridge, and from the fact that several wells just northwest of this hole have encountered volumes of fresh water in presumably Pennsylvanian rocks at depths of 2,600+feet. Since fresh water is characteristic of the Arbuckle, the presence of this water in apparently Pennsylvanian sands suggests a source stratigraphically close to them.

### STRUCTURE

The structure of the surface rocks, although not quite so obscure as the structure of the Empire pool, is far from being simple to work, due to the unsatisfactory nature of the surface rocks. One can work out enough data to show the presence of a rather flat dome, agreeing to some extent with topography, with a definite east dipping nose on this dome in secs. 17 and 20, T. 1 S., R. 8 W.

It is necessary to work the subsurface structure on several sands although the Blaydes sand is the most satisfactory horizon to use, the west and northwest parts of the pool are producing from higher sands. The top of the subsurface fold is a flat dome, with the apex in sec. 19, T. 1 S., R. 8 W. A nose from this dome extends east in sec. 20 and another, north into sec. 7 of the same township. Another nose extends south into sec. 36, T. 1 S., R. 9 W. The west dip is very steep for folds in this area, attaining a rate of about two hundred feet



to the mile for a short distance in secs. 13, 24, and 25, T. 1 S., R. 9 W. There seem to be a few minor faults present.

### PRODUCING SANDS

The same series of sands present here are found in the Empire pool, the only difference being in the production from these sands. Practically the entire pool in T. 1 S., R. 9 W., produces gas only in all sands, with the exception of a few isolated wells here and there which produce small amounts of oil in sands between the Surber (1,700 foot) and the Brown (2,100 foot). This is also true of secs. 18 and 19, T. 1 S., R. 8 W. Oil production in the Surber and Brown sands is limited to sec. 30, T. 1 S., R. 8 W., while the Blaydes sand produces oil in secs. 20, 29 and 30 of the same township.

All of the sands become quite thin on top of the dome in sec 19. This has been quite a factor in the pool for, although the section is on the top of the pool structurally, due to the thinness of the sands, it has been impossible to drill to the oil level before drilling out of the sand, thereby resulting in gas production only. The Blaydes sand is the lowest producing sand in the pool.

*Production Table West Duncan Pool*
(Figures as of Jan. 1, 1926.)

| COMPANY | LEASE | LOCATION | Prod. Acreage | Beg. of Prod. | Wells | Total Prod. | Pres. Prod. | Per Acre Yield | Total Prod. Per Well |
|---|---|---|---|---|---|---|---|---|---|
| All American | Brown | 30-1-8 | 40 | 10-20 | 8 | 366,175 | 83 | 9,154 | 45,772 |
| Carter Oil | Wade | 20-1-8 | 15 | 1-22 | 3 | 53,060 | 6 | 3,537 | 17,087 |
| Champlain | Brittain | 20-1-8 | 40 | 7-21 | 8 | 297,755 | 26 | 7,444 | 37,220 |
| Hulf State | Hall | 29-1-8 | 20 | 7-21 | 3 | 121,415 | 25 | 6,070 | 40,472 |
| Lone Star | Brown | 30-1-8 | 80 | 6-20 | 18 | 791,770 | 222 | 9,896 | 55,000 |
| Magnolia | Brooks | 25-1-8 | 20 | 10-20 | 3 | 148,735 | 28 | 7,436 | 49,578 |
| Magnolia | Bartley | 20-1-8 | 40 | 6-23 | 5 | 149,420 | 125 | 3,735 | 29,884 |
| Magnolia | Hall | 29-1-8 | 20 | | 3 | 72,050 | 10 | 3,603 | 24,017 |
| Margay | Brown | 30-1-8 | 20 | 12-20 | 4 | 352,925 | 51 | 17,646 | 88,231 |
| Margay et al | Brown | 30-1-8 | 20 | 7-21 | 3 | 72,129 | 25 | 3,606 | 24,032 |
| Malernee | Brittain | 20-1-8 | 30 | 12-21 | 3 | 226,130 | 191 | 7,534 | 75,343 |
| Old Colony | Brittain | 20-1-8 | 30 | 6-21 | 4 | 188,731 | 63 | 6,291 | 47,183 |
| Roxana Pet. | Clarkson | 30-1-8 | 25 | 12-20 | 4 | 96,734 | 30 | 3,869 | 24,183 |
| Roxana Pet. | Hall | 29-1-8 | 40 | 7-21 | 6 | 226,165 | 90 | 5,654 | 38,694 |
| Safety First | Brittain | 20-1-8 | 20 | 5-23 | 4 | 65,792 | 53 | 13,289 | 16,448 |
| Skelly | Brigham | 30-1-8 | 6 | 5-21 | 1 | 26,370 | 13 | 4,411 | 26,470 |
| Wallace et al | Clarkson | 30-1-8 | 20 | 5-21 | 4 | 92,470 | 3 | 4,623 | 23,118 |
| TOTALS | | | 486 | | 84 | 3,327,926 | 1034 | 6,929 | 39,618 |

The production table of this pool does not reveal the yields that are obtained in the Empire pool. There are several contributing factors for this variance. The chief reason is due to the fact that the fold is so much higher than the average for this district that the top sands contain gas only. The area covered by the gas filled sands includes a large part of the producing area, thus leaving a fairly narrow belt of oil containing sands between the gas and water levels. Another very important reason is the fact that the pool as a whole was drilled much more slowly than the Empire pool. The three leases which have produced in excess of nine thousand barrels to the acre were drilled up

rapidly after the opening of the pool. All three of these leases are in sec. 30, T. 1 S., R. 8 W. Development has been especially slow in sec. 20, T. 1 S., R. 8 W.

It is unfortunate that a compilation cannot be made of the total amount of gas produced from this pool since the first gas well was discovered in 1920, however, it can be safely said that there has been more gas produced from this pool than from any other pool in the county. After the decline of the Walters field in Cotton County and the Fox field in Carter County in 1920, this pool was the main standby and for three years supplied the Lone Star Gas Company line to Ft. Worth and Dallas and the Oklahoma Natural Gas Company line to Oklahoma City. Initial production of the gas wells range all the way from five to seventy million cubic feet a day. These wells are drilled, casings cemented on the sand and drilled in, all with a rotary. This can be done at a total expense of from five to ten thousand dollars per well, depending upon the depth and the kind of casing used (new or second hand). With gas selling at ten cents per thousand cubic feet at the well, and the twenty-five percent of the total volume —the maximum allowed to be taken at any one time by state law— often being taken during the coldest months of the winter, it can be seen that the total revenue which has been derived from the output of gas in this pool has been a considerable sum.

#### FUTURE POSSIBILITIES

At this time most of the west side of the pool, that part in T. 1 S., R. 9 W., has been pretty thoroughly drilled and most of the present producing horizons pretty well explored with the exception of a very small area at the south end. In the east half of the pool, that part which lies in T. 1 S., R. 8 W., secs. 30 and 29, has been rather thoroughly drilled into the present producing sands. There is room for many more locations in sec. 19 and for some in sec. 18, but these will probably be good for gas only. The pressure would be quite low this late in the development, unless stray lenses of sand not connected to any outside source now producing are found. That part of sec. 20 which is productive, lies almost altogether below the gas level and it is in this section that development has been quite slow. On June 4, 1926 a well was completed in what is probably the equivalent of the Smith sand in the SW.¼ sec. 20 T. 1 S., R. 8 W., for an initial production of 590 barrels of 44 gravity oil. Coming almost exactly six years since the discovery of the pool such a well indicates that there are still possibilities for worth while development in sands between the Surber and the Brown in this section as well as in secs. 29 and 30.

While at the present time there are no sands producing in this pool below the Blaydes sand zone with the exception of sec. 31, T. 1 S., R. 8 W., numerous sands have been logged by wells which have been drilled below this horizon in scattered portions of the pool. In all cases these wells were carried below the present producing levels after they had failed to encounter production in the regular pay horizons. A well drilled by Westheimer and Daube just below the water level for the Blaydes sand in the NW.¼ NE.¼ sec. 29, T. 1 S., R. 8 W., cored what appeared to be a series of gas sands below three thousand feet, but the hole was lost while running a measuring line inside the drill pipe preparatory to running casing. A well drilled at the extreme north end of the pool at the south line of sec. 7 in the same township had showings of oil and gas below 2,700 feet. It is not at all impossible when considering the age of the section between the Blaydes sand and the top of the Arbuckle limestone and the fact that sands are known to be present in this interval, that producing sands could be discovered when the testing to these sands is done at favorable places on the fold. This pool should have a future life of about the same duration as the Empire pool so that the ultimate yield recoverable from present methods should exceed eight thousand barrels per acre.



### THE NORTH DUNCAN POOL

#### LOCATION AND TOPOGRAPHY

The North Duncan pool is located about ten miles northwest of Duncan in the southwest part of T. 1 N., R. 8 W., and in the southeast part of T. 1 N., R. 9 W. All or part of secs. 19, 29, 30, 31, 32 and 33, T. 1 N., R. 8 W., and secs. 14, 23, 24, 25, 26 and 36, T. 1 N., R. 9 W., cover the productive area of this pool. The pool is located in a rolling open country.

#### HISTORY OF DEVELOPMENT

The Parsons-Gant Oil Company completed the discovery well of this pool in November, 1920, with a twenty million cubic foot gasser in sand at 2,070 feet near the center of sec. 32, T. 1 N., R. 8 W. At that time, there was so much gas being produced in the general district this did not cause any undue excitement until the same company completed a well making 1,600 barrels a day in the SE.¼, sec. 25, T. 1 N., R. 9 W., on the Thomas farm in sand at 2,000 feet, during January of 1921. By the end of that year the pool was defined in a general way and most locations drilled up. The only noteworthy extension since that time has been the development of an oil sand found at a depth of 2,300 feet in the east portion of sec. 26 and the extreme west line of sec. 25, T. 1 N., R. 9 W.

#### STRATIGRAPHY

The surface rocks over this pool are a portion of the red sandstone horizon of the Wichita formation of the Permian. They consist of gray to reddish calcareous sandstones and reddish shales, the whole horizon consisting of lenticular beds of these formations. The Permian and post-Glenn Pennsylvanian extends to an average depth of about 1,600 feet. Below this depth the section consists of blue shales with some brown shales, sandstones and thin bedded limestones. The Ordovician has been encountered in only one well in the pool, this being

a well drilled by the Magnolia Petroleum Company on the northwest edge of the pool which had limestone from a depth of 2,880 feet to a total depth of 3,250 feet. It is the opinion of the writer that the section between the base of the red beds and the top of this limestone is of Pennsylvanian age, the section so represented probably being the age equivalent of the section of rocks between the base of the red beds and the top of the limestone in the Empire and West Duncan pools. This limestone is thought to be the Arbuckle, for the reason that the pool is on the buried portion of the southeast extension of the Wichita Uplift and is closer to the exposed part of the Uplift than is the Empire pool where the lime has been proved to be Arbuckle in age.

### STRUCTURE

There is an indication of wrinkling of the surface rocks in the eastern part of the pool, but the lack of exposures in the alluvial bottom of Beaver Creek and its tributaries prevents satisfactory mapping of the structure. However, in the west half of the pool there is a high in the surface rocks in the center of the NW.¼ sec. 24, T. 1 N., R. 9 W., with a very flat nose to the south through sec. 25 into sec. 36 of the same township.

The structure on the main producing sand, the Thomas, is that of a low flat dome, elongated in a northwest-southeast direction. On the top of this dome are many irregularities in the form of minor domes and lows. The major features in general conform remarkably well to the structure of the surface rocks where the surface structure can be interpreted. The highest part of the dome is in sec. 24, T. 1 N., R. 9 W., The tops of other highs on this dome are in the easternmost portion of sec. 25 of the same township and the western most portion of sec. 30, T. 1 N., R. 8 W., and in the NW.¼, sec. 32.

Dips off of the main structural high are very gentle to the south and to the southeast which is the direction of the regional line of folding upon which this pool is located. The dip to the west is also quite gentle, since this pool is just to the east of the axis of the Wichita Uplift. The dip to the northeast is exceptionally steep, probably continuing with but very little interruption into a southward synclinal reentrant of the Anadarko Basin.

### PRODUCING SANDS

While there are a few wells producing from a sand zone at a depth of 1,800 feet or some 800 feet below sea level, the first main producing sand is found at a depth between 2,000 and 2,125 feet, depending upon the surface elevation. This is the Thomas sand in which the water level during the early development of the pool was found at an average elevation of 1,000 feet below sea level. This sand produces over the entire productive area of the pool, with the exception of secs. 14, 23 and 26, T. 1 N., R. 9 W., where it becomes very tight and shaly. In this portion of the pool the main production, until the summer of 1925, was a gas sand found some forty feet stratigraphically below the Thomas



sand. The only other sand of any consequence in this portion of the pool is a sand producing oil at a depth of slightly below 2,300 feet, which would be a subsea elevation of about 1,200 feet. One hundred feet below the Thomas sand in the main portion of the pool is a sand which has produced considerable quantities of oil in scattered wells. Another sand two hundred feet below the Thomas sand has produced large volumes of gas in a few wells.

The Thomas sand is probably the stratigraphic equivalent of the Brown sand in the Empire and Oil City pools. The Thomas sand is producing from two small isolated oil wells in the northwest corner, sec. 15, T. 1 S., R. 8 W. In this last named area the top of the fold is so low and the water level is so close to the top that the productive area is extremely limited.

*Production Table, North Duncan Pool*

(Figures as of Jan. 1, 1926)

| COMPANY | LEASE | LOCATION | Prod. Acre | Beg. of Prod. | Wells | Total Prod. | Pres. Prod. | Per Acre Yield | Total Prod. Per Well |
|---|---|---|---|---|---|---|---|---|---|
| Carter Oil | Dew | 30-1-8 | 20 | 7-21 | 4 | 151,147 | 82 | 7,556 | 37,787 |
| Carter Oil | Funk | 30-1-8 | 20 | 7-21 | 5 | 294,934 | 84 | 14,746 | 58,987 |
| Carter Oil | Morgan | 32-1-8 | 15 | 2-22 | 2 | 49,918 | 12 | 3,381 | 24,959 |
| Coline Oil | Harris | 25-1-9 | 12 | 12-21 | 3 | 76,811 | 59 | 2,134 | 25,604 |
| Coline Oil | Malicky | 31-1-8 | 6 | 2-21 | 1 | 50,510 | 36 | 8,418 | 50,510 |
| Coline Oil | Slaving | 29-1-8 | 10 | 3-22 | 3 | 37,858 | 19 | 4,786 | 23,929 |
| Gypsy Oil | Brown | 24-1-9 | 30 | 4-21 | 4 | 231,680 | 19 | 7,823 | 58,670 |
| Gypsy Oil | Maxey | 30-1-8 | 30 | 8-21 | 5 | 284,490 | 49 | 9,483 | 56,898 |
| Gypsy Oil | McPa ge | 24-1-9 | 10 | 2-51 | 2 | 30,690 | Abd. | 3,969 | 19,845 |
| Haynes et al . | Funk | 30-1-8 | 10 | 4-21 | 3 | 68,450 | Abd. | 6,845 | 22,817 |
| Homa-Okla. | Spears | 32-1-8 | 20 | 1-22 | 3 | 131,089 | 23 | 6,184 | 43,696 |
| Harrigan et al. | Burns | 31-1-8 | 20 | 4-21 | 3 | 179,899 | 13 | 8,994 | 59,963 |
| Humble Oil | Ko'chum | 25-1-9 | 30 | 5-21 | 5 | 120,619 | 31 | 4,021 | 24,124 |
| Magnolia Pe'. | Cook | 30-1-8 | 80 | 6-21 | 11 | 818,417 | 230 | 10,230 | 74,401 |
| Magnolia Pe'. | Funk | 30-1-8 | 35 | | 9 | 317,265 | 95 | 9,065 | 35,252 |
| Magnolia Pe'. | Harris | 25-1-9 | 30 | | 4 | 182,743 | 65 | 6,091 | 45,686 |
| Magnolia Pe'. | Sch. Morg | 32-1-8 | 12 | 6-21 | 2 | 111,140 | 7 | 9,262 | 55,570 |
| Magnolia Pe'. | Thomas | 25-1-9 | 40 | 2-21 | 10 | 341,403 | 7 | 8,535 | 34,140 |
| Magnolia Pe'. | G. Young | 29-1-8 | 12 | 4-21 | 2 | 139,125 | 40 | 11,600 | 69,562 |
| Magnolia Pe'. | S. Young | 29-1-8 | 20 | 6-21 | 6 | 162,680 | 35 | 8,134 | 27,113 |
| Moran-Fuller | Sch. L. | 36-1-9 | 10 | 5-21 | 2 | 43,679 | Abd. | 4,368 | 21,839 |
| Priddy | Cook | 30-1-8 | 40 | 6-21 | 5 | 217,458 | 13 | 5,436 | 43,492 |
| Priddy | | 25-1-9 | 15 | 4-21 | 2 | 62,894 | 6 | 4,192 | 31,447 |
| Priddy | Sch. L. | 36-1-9 | 6 | 7-21 | 1 | 24,736 | 10 | 4,122 | 24,736 |
| Priddy | Sch. L. | 36-1-9 | 10 | 4-21 | 3 | 65,035 | 5 | 6,503 | 21,678 |
| Priddy | McFatge | 24-1-9 | 30 | 6-21 | 3 | 121,145 | 6 | 4,038 | 40,382 |
| Roxana | Cook | 30-1-8 | 80 | 5-21 | 7 | 162,470 | 5 | 2,031 | 23,210 |
| Smith-Law | Spears | 32-1-8 | 20 | 7-21 | 4 | 124,121 | 34 | 6,206 | 31,030 |
| Texas Drug Co. | Spears | 32-1-8 | 40 | 9-21 | 6 | 242,501 | 10 | 6,041 | 40,417 |
| TOTALS | | | 713 | | 120 | 4,867,017 | 995 | 6,826 | 40,554 |

Comparing the production table of this pool to that of the Empire pool, it is seen that there is considerable difference in the yields. This is almost entirely due to the fact that on most leases in the North Duncan pool only one sand is producing. Comparing the average production per well it is also seen that these also are lower for the North Duncan pool. This is no doubt due to the low structural position of the south end of the pool where the water level was but a few feet below the top of the sand in many of the wells. Many wells were

drilled too deeply into the sand when completed. The gravity of the oil is on a parity with that produced in the Empire pool averaging above 39 degrees A.P.I.

### FUTURE POSSIBILITIES

There is still a chance in scattered portions of the pool for the completion of small wells in the sand now producing but with the exception of the northwest portion of the pool these chances are few in number. All wells which have been drilled below the present producing horizons have logged sands with the exception of the one hole carried to the Arbuckle (?) limestone, none have gone much deeper than 3,000 feet and all of these without exception were carried on down after failing to get production in the regular producing horizons. While results so far in this and other pools producing from the same horizons have been anything but encouraging for deeper production, it cannot be said that there is no chance at all for deeper production.

## THE COMANCHE POOL[23]

### LOCATION AND TOPOGRAPHY

The Comanche pool is located in secs. 17, 18, 19 and 20, T. 2 S., R. 7 W., and in secs. 11, 12, 13, and 24, T. 2 S., R. 8 W., being situated immediately north and northwest of the town limits of Comanche in the south-central portion of the county.

The topography gradually rises to the northwest from the southeast part of the pool with a maximum relief averaging 100 feet. The pool is wooded with black jacks in the northwest but open to the southeast.

### HISTORY OF DEVELOPMENT

The Comanche pool was discovered when the Comanche Petroleum Company completed their Clara Wilson No. 1, located in the center of the west line, NW.¼ NW.¼ sec. 20, T. 2 S., R. 7 W., as a twenty million cubit foot gas well in sand from 1,286 to 1,324 feet in August of 1918. The well was located just to the north of the top of the surface dome upon the strength of which the well was drilled. The next test was made by the same company on the south side of the dome in the SE.¼ NE.¼ sec. 30, being abandoned after getting a hole full of water in sand at 1,937 feet in December of the same year. The first oil well completed was the third test, also being drilled by the same company, located in the center NE.¼ NW.¼ sec. 19, with an initial production of 30 barrels in sand at 1,390 feet. This well was completed late in December, 1918. The completion of this well started several other tests in the vicinity to the same sand.

In October, 1919 the Comanche Petroleum Company discovered the 1,800 foot sand when their John Wilson No. 1 in the NW.¼ NE.¼ sec. 19 was completed as a 15 barrel pumper in sand from 1,780 to 1,810 feet. The small initial production of this well deterred

23. Swigart, T. E. Underground Problems in the Comanche oil and gas field, Stephens County, Oklahoma: U. S. Bureau of Mines in cooperation with the State of Oklahoma, 1919.



operators from any further exploration of this zone until January, 1920, when the Comanche Petroleum Company completed their J. O. Wilson No. 3 in NE.¼ sec. 19 with an initial production of 350 barrels natural. The active development in the county dates from the completion of this well as it demonstrated the potential possibilities of the district to the producing fraternity. By the close of 1920 the completion of several dry holes, together with the sharp decline in the price of crude oil put a stop to further development in the pool. During 1923 and 1924 the 1,400 foot sand was extended to the east in secs. 17 and 20, and to the north into sec. 18, while in 1925 both the 1,400 foot and 1,800 foot sands were extended to the northwest into secs. 11, 12 and 13, T. 2 S., R. 8 W. This latter area is still being developed at this writing (June, 1926).

### STRATIGRAPHY

The surface rocks exposed over the pool are reddish sandstones and red clays and shales lying within the red sandstone series of the Wichita-Clear Fork formation of the Permian. The Permian extends from the surface to an average depth of 1,400 feet, or to the Wilson sand. From this sand to a depth of about 3,400 feet the section consists of blue shales, some brown shales, sandstones and thin bedded limestones. Just below 3,400 feet the section consists of massive limestone. The writer tentatively places the base of the Permian at the Wilson or 1,400 foot sand, in keeping with his correlations in the other pools on the line of folding upon which this pool is located. In the Comanche Petroleum Company's deep test, located in the southeast corner NE.¼ NE.¼ sec. 19, T. 2 S., R. 7 W., drilled to a depth of 3,635 feet, the Arbuckle limestone was encountered immediately below what appears to be Pennsylvanian rocks at a depth of 3,410 feet or a subsea elevation of 2,427 feet. A test drilled in the southwest corner NW.¼ sec. 19 had a similar section so it is presumed that the limestone encountered at a depth of 3,505 was also the Arbuckle limestone. The writer, therefore, presumes that the section between the Wilson sand at 1,400 feet and the top of the Arbuckle at 3,400+feet is of Pennsylvanian age. All of the pre-Pennsylvanian section that was originally deposited down to and including some of the Arbuckle limestone was evidently eroded before the deposition of the Pennsylvanian rocks.

### STRUCTURE

The surface structure of the Comanche pool is that of an elongated dome with a northwest-southeast axis, the top of which is located at about the center of the east line of sec. 19, T. 2 S., R. 7 W. The reverse dip is very noticeable from the main paved highway on the southern limits of Comanche where the rocks can be seen dipping to the south and southwest at the rate of about fifty feet to the mile. Going north from the town of Comanche on the paved highway to Duncan, the road goes down a dip slope between the northwest quarter

of sec. 17 and the NE.¼ sec. 18, T. 2 S., R. 7 W. The east dip can be seen in secs. 21 and 28 east of Comanche.

The underground structure on the Wilson sand is very similar to that of the surface structure excepting that the axis has shifted about a quarter of a mile to the north. The pool does not produce southwest of the axis of the surface fold.

### PRODUCING SANDS

There are three producing sands in the Comanche pool. The highest sand in the section is one that is encountered between 800 and 900 feet which produces gas. The next lowest sand is the Wilson or 1,400 foot sand which produces oil in most cases. The lowest producing sand is the 1,800 foot sand which produces oil in all cases.

The 800 foot gas sand is present throughout the field. It originally had a pressure of over 300 pounds per square inch with volumes of from one to five million cubic feet per day. This pressure is now lowered appreciably because of the withdrawal of the gas from the sand since it was first discovered in 1919. Of the two oil sands the Wilson sand seems to be the most consistent over the area of the pool. While the initial production for wells in this sand has been as high as 160 barrels, the general average is closer to 30 barrels. Production in the 1,800 foot sand is limited to sec. 19 of T. 2 S., R. 7 W., and to small areas in secs. 12, 13 and 24, T. 2 S., R. 8 W. Initial production of wells in this sand has been as high as 400 barrels with several making around 300 barrels. The remainder of the Pennsylvanian section has been explored, with one exception, only down the flanks of the dome after the present producing sands had been encountered too low to produce, so it cannot be said that the pool has been explored for producing horizons below those now producing.

The following table gives production data on the principle producing leases in the pool. Leases in the northwest end of the pool which have just been producing for a year or less are not given in this table.

*Production Table, Comanche Pool.*

| COMPANY | LEASE | LOCATION | Prod. Acre | Wells | Total Prod. | Prod. Pres. | Per Acre Yield | Per Well Average |
|---|---|---|---|---|---|---|---|---|
| Mid-Kansas | Barnett | 19-2-7 | 20 | 3 | 116,835 | 80 | 5,842 | 38,945 |
| Mid-Kansas | Bristow | 18-2-7 | 18 | 3 | 25,613 | 20 | | 8,538 |
| Mid-Kansas | I. Thomas | 19-2-7 | 25 | 5 | 249,790 | 75 | 10,000 | 49,958 |
| Mid-Kansas | C. Wilson | 20-2-7 | 25 | 4 | 187,890 | 70 | 7,516 | 49,222 |
| Mid-Kansas | P. D. Wilson | 19-2-7 | 50 | 8 | 413,935 | 78 | 8,278 | 51,742 |
| Mid-Kansas | Andrea | 24-2-8 | 5 | 1 | 13,520 | 5 | 2,704 | 13,520 |
| Magnolia | Carter | 17-2-7 | 10 | 2 | 107,025 | 30 | 10,702 | 53,512 |
| Magnolia | Redick | 13-2-8 | 5 | 1 | 22,710 | 5 | 3,785 | 22,710 |
| Magnolia | F. Wilson | 17-2-7 | 30 | 5 | 159,870 | 70 | 5,329 | 31,972 |
| Magnolia | | | | | | | | |
| TOTALS | | | 188 | 32 | 1,297,188 | 433 | 6,900 | 40,537 |

These figures would indicate that the pool will ultimately produce between 8,000 and 9,000 barrels per acre, or somewhere around 50,000 barrels per well.



### FUTURE POSSIBILITIES

Small minor extensions to the sands now producing are possible along or close to the axis of the fold. A small amount of development lately has been with the idea that the Empire pool would connect with this pool, but there is apparently a flat saddle in between with the water level near the top of the sand. A well in the center of sec. 2 and another in the NW.¼ sec. 11, T. 2 S., R. 8 W., are both producing small quantities of oil from the Blaydes sand zone. Two dry holes drilled offsetting the well in sec. 2 demonstrates the uncertainties of drilling this saddle. Better possibilities would seem to be in trying for production from sands known to be present below the 1,800 foot sand zone. As to whether any of these sands will produce is difficult to say in advance of drilling.

## THE LOCO POOL

### LOCATION

The Loco Pool located in the southeastern part of the contry, in secs. 4, 9, 10, 14, 15 and 16, T. 3 S., R. 5 W.

### HISTORY OF DEVELOPMENT

According to Wegemann[21], the first development in this pool resulted from the asphalt deposits, which are present in the southeastern part of this township, as well as in the southwestern part of T. 3 S., R. 4 W. He states that in 1903 a refinery was built to develop these asphalt deposits. However, the refinery was burned down soon afterwards, so that nothing more was done with this venture. Soon after this, some shallow dug wells were put down, but these operations were not successful in securing oil in sufficient quantity for economic production. Drilling was begun in the pool by the Oklahoma Diamond Oil and Gas Company, early in 1913 in secs. 10 and 14, resulting in the completion of several gas wells of capacity ranging up to twenty million cubic feet, in sand at an average depth of around 700 feet. Oil in commercial quantities was first obtained late in 1915 by the Owl Oil Co., in sec. 9. These wells produce from a sand found between 850 and 900 feet, with initial production from 10 to 25 barrels per day of 24° A.P.I. gravity. Due to the low price of crude oil, development was very slow until the high prices of 1919. In 1919 the pool received renewed development and from that time until the close of 1923 development was rather active. During the last named period, the Owl Oil Co., completed quite a number of oil wells in the 850 foot sand in secs. 9, 14 and 15. Development in the pool has been slow since that time due principally to the low initial production of the wells and to the extremely low gravity of the oil.

21. Wegemann, C. H., The Loco gas field, Stephens and Jefferson counties, Oklahoma: U. S. Geol. Survey, Bull. 621-C., pp. 31-42, 1915.

### STRATIGRAPHY

The surface rocks in the Loco pool are part of the Wichita-Clear Fork formation of the Permian, consisting of red shales and sandstones. These rocks are a part of the calcareous shale group shown on the Oklahoma geological map and mentioned in Bulletin 35 of the Oklahoma Geological Survey. The Permian has a thickness of about 600 feet on the axis of the fold, with increasing thickness to the northeast and southwest down the flanks. The thickening is very rapid to the southwest, toward the regional basin of central Jefferson County.

The Pennsylvanian rocks begin at a depth of about 600 feet from the surface, consisting of blue shales, sandstones and thin limestones. It is in the upper part of this section that the producing sands are present. The thickness of the Pennsylvanian section depends upon the position on the fold, for there is no doubt but that this pool is located on one of the many buried hills of southern Oklahoma. Unfortunately, as in most of southern Oklahoma one has to rely upon drillers logs for the stratigraphy as samples of cuttings are rarely saved. The Lone Star Gas Co., in Ida Billy No. 2½ in the SE cor., NW.¼ SE.¼ sec. 9, T., 3 S., R. 5 W., drilled into lime at 1,550 feet and abandoned the well while still in the lime at 2,520 feet. The section of rocks penetrated between these depths, evidently is of pre-Pennsylvanian age. This buried hill is as steep as the average, as is shown by the fact that a well drilled to 2,250 feet in the SW. cor. sec. 4, a well drilled to 2,149 feet in the NW.¼ sec. 15 and one drilled to a depth of 2,150 feet in the NW.¼ sec. 16, were apparently still in Pennsylvanian rocks when finished.

The main producing horizons are the 700 foot gas sand and the 850 foot sand. These sands are probably in the upper part of the Glenn formation. Showings have been found in the deeper sands, but the results have been very discouraging. A sand between 950 and 1,000 feet has produced oil in small amounts. Another just above 1,500 feet has done likewise.

A sand at 1,910 feet in the southwest corner of sec. 11, produced 15 barrels initial, but the increasing depth hardly makes such production commercial.

### STRUCTURE

The structure of the surface rocks has been so well described by Wegemann that no attempt will be made to discuss it here.

The structure of the 850 foot oil sand, in the light of development which has taken place since Wegemann's report, is the same with reference to the axis, in the southeast part of the pool. However, development in secs. 4, 5 and 9, shows that the fold closes to the northwest, with the SE.¼ sec. 5 being lower structurally than the top of the fold in sec. 9. The structure on the base of the Pennsylvanian has been described under Stratigraphy. The northwest-southeast axis



of this fold is in keeping with the direction of most of the producing pools of Stephens County. There are several subsurface faults on this fold.

### PRODUCTION

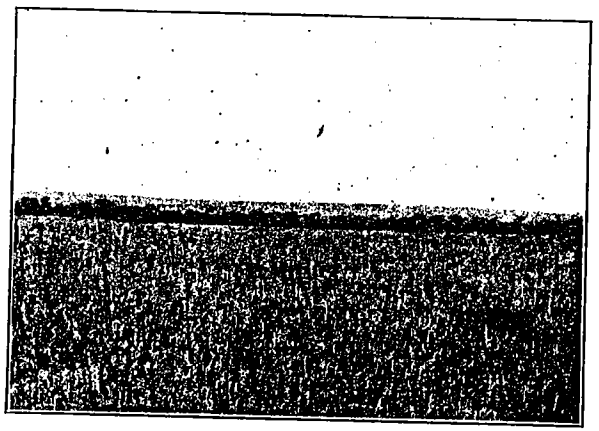
The oil produced in the pool averages around 24° A.P.I. The initial production of wells has been from five to twenty barrels. Both of these factors has made development work in the pool very unattractive. Some little gas has been piped from the field but the pressure is now so reduced that this is no longer renumerative. The faulting in the pool is no doubt an explanation of the low gravity of the oil. The pool does not seem to have a very bright future for in order to get a thicker section of Pennsylvanian rocks one would have to go down the flanks of the fold where the sands would probably be encountered too low to produce.

## THE CRUCE POOL

### LOCATION AND TOPOGRAPHY

The Cruce pool is located in sec. 12, T. 1 N., R. 6 W., about two miles north of the post ofice of Cruce, in the east-central part of the county. The relief in the pool itself is not over fifty feet, but escarpments to the east and west of the pool have a relief of from fifty to one hundred feet.

**PLATE II**



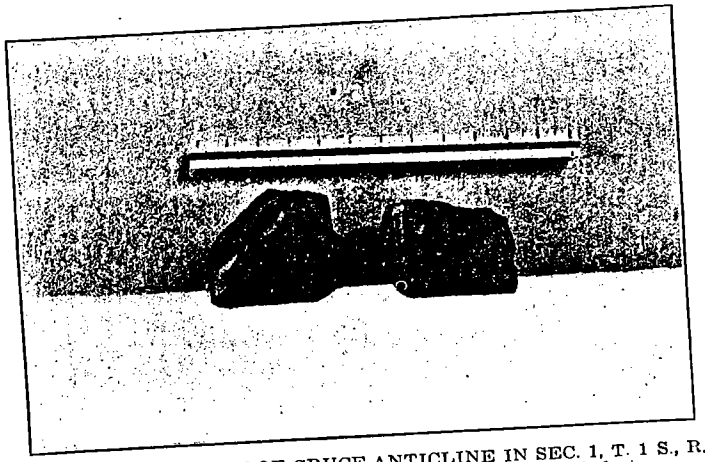
EAST FACING ESCARPMENT OF DUNCAN SANDSTONE ON WEST SIDE OF CRUCE ANTICLINE.

### STRATIGRAPHY

The surface rocks exposed in the pool are of the gray shale horizon of the Wichita formation, while the escarpments to the east and west are composed of the sandstones and shales making up the Duncan sandstone section. Here the rocks of the Duncan sandstone are essentially gray in color. The Permian and post-Glenn Pennsylvanian

extends to a depth of some 1,900 feet from the surface. All of this section is made up almost entirely of red and brown shales and gray sandstones. The only deep test drilled in the pool went to a depth of 2,750 feet. From a depth of about 1,900 feet to the bottom of the hole the section penetrated was composed entirely of a hard, black calcareous shale which is probably the equivalent of the Pennsylvanian portion of the Caney shale. The logs of the few deep tests on the west flanks of the fold suggest a normal Pennsylvanian section present on the flanks.

**PLATE III**



CORES FROM WELL WEST OF CRUCE ANTICLINE IN SEC. 1, T. 1 S., R. 6 W.
Well drilled by the Garvin Drilling Company. Cores from top and base of a sand found at 3,100 feet 50 degress. Note the dip which exceeds

### STRUCTURE

The description of the surface structure together with a map of this area has been so well described by Wegemann[25] that it will be discussed only briefly here. The Cruce anticline, on which the Cruce pool is located, is a northwest plunging anticline. The Duncan sandstone series is exposed on the flanks but has been truncated along the axis. The open nature of the country, together with the relatively steep dips for the Permian rocks makes this fold the most prominent of any Permian fold in southern Oklahoma. Lack of good control on the surface rocks makes the southeast end of the anticline indefinite, but it is quite likely that this end of the anticline may be as far south as sec. 5, T. 1 S., R. 5 W. The anticline begins to plung quite rapidly to the northwest in the NW.¼ sec. 12, T. 1 N., R. 6 W.

The underground structure based on the 850 foot gas sand suggests a dome in the NE.¼ sec. 12, on the anticline. The probable

25. Wegemann, C. H., The Duncan gas field, Stephens County, Oklahoma. U. S. Geol. Survey, Bull. 621-D, pp. 43-50, 1915.



absence of most of the Pennsylvanian section on this dome is proof of another buried hill.

It is quite likely that there is a deep seated fault parrallel to the axis of the anticline and very close to the axis. The truncation on the axis of the fold is suggestive of this. In addition all sands penetrated in the deep test in sec. 12 metioned above, were filled with a dead oil, the higher hydrocarbons having evaporated long since.

### DEVELOPMENT AND PRODUCTION

According to Wegemann, the first gas wells were not completed until 1912, although drilling in the pool took place as early as 1907. After that several gas wells were drilled in the 850 foot gas sand with initial production of from three million to almost eighteen million cubic feet per day. These wells supplied the towns of Duncan and Marlow with gas for a number of years. The wells are now almost completely exhausted and some of them are used at present for fuel in nearby farm houses. Southeast of this pool along the axis a well was drilled in 1919 which had a volume of twenty million cubic feet of gas at 1,720 feet, but was drilled into water. This well was located near the center of sec. 19, T. 1 N., R. 5 W. In the southwest quarter of this section a well was completed with an initial production of 10 barrels of low grade oil at 883 feet in 1924. Farther southeast toward the south end of what is probably the axis of this same anticline a well was completed in April, 1926 with an initial production of 25 barrels of 28 gravity oil at a depth of 1,700 feet. This well is located in sec. 32, T. 1 N., R. 5 W.

### FUTURE POSSIBILITIES

With most of the Pennsylvanian section absent on the axis of the fold, aside from the possibility of getting very small wells of low grade oil in the red bed section, the only other chance seems to be for a Simpson test, providing the Viola limestone has not been eroded. The subsurface fold is apparently so steep that one would be too low structurally if a well were drilled on the east or west flank low enough to encounter some additional Pennsylvanian section.

## THE DOYLE POOL

### LOCATION AND TOPOGRAPHY

The Doyle pool lies in the northeastern part of the county, just southwest of the post office of Doyle in secs. 2, 11 and 12, T. 1 N., R. 5 W. The pool is located on a topographic high with considerable relief to the east and northeast.

### HISTORY OF DEVELOPMENT

The discovery well was completed in september, 1922 in sec. 11, T. 1 N., R. 5 W., by Clark and Cowden, with an initial production of 75 barrels at 1,090 feet. Most of the development work in the pool was completed during the following year.

### STRATIGRAPHY

The surface rocks over the pool belong to the Duncan sandstone series of the Enid formation of the Permian. The section down to the producing sands at 1,200 feet consists of red shales and sandstones, with some gray shales. The section below the sands to a depth of about 1,500 feet is essentially the same. The section below the producing sands to a depth of at least 2,500 feet and possibly to a greater depth, consists of the typical brown shale section of the post-Glenn Pennsylvanian of this area.

### STRUCTURE

The structure of the surface rocks in the pool is that of a small flat dome, the apex of which is in the center of sec. 11. The reverse dip (south) amounts to some 20 to 25 feet, while the dips to the north-east, north and northwest are quite steep. The flat portion of the top of the dome is almost entirely contained within the north half of sec. 11. The structure on the producing sands is very similar to that on the surface rocks with the sand dipping about the same rate as the surface rocks.

### PRODUCING SANDS

There are three main sands in the pool found between 950 and 1,250 feet. There is only about two hundred feet of interval between the highest and lowest sand but the differences in surface elevation accounts for the extra hundred feet.

### PRODUCTION

On May 1, 1926 there were 24 producing wells in the pool making a total daily production of 150 barrels which is about six barrels per well. The pool had produced up to January 1, 1926 a total of 197,924 barrels or 8,247 barrels per well.

## THE VELMA FIELD[26]

### LOCATION AND TOPOGRAPHY

The Velma field is located in the southeastern part of the county, lying principally in the south part of T. 1 S., R. 5 W., and the northeast quarter of T. 2 S., R. 5 W. All or parts of the following sections form the present producing area of the field; sec. 22, 23, 25, 26, 27, 34, 35 and 36, T. 1 S., R. 5 W., secs. 1, 2, 3, 10, 11, and 12, T. 2 S., R. 5 W., sec. 31, T. 1 S., R. 4 W., and secs. 6, 7, and 8, T. 2 S., R. 4 W. This field derives its name from the village of Velma which is located some two miles east of the north end of the field.

26. Storm, W., The "2-4" shallow field Oklahoma, and the Velma oil and gas field: Am. Assoc. Pet. Geologists, Bull., vol. 5, No. 5, p. 626, 1924.



## PLATE IV

TOPOGRAPHIC HIGH OF THE VELMA FIELD LOOKING SOUTHWEST.

This field has the highest topographic elevation of any area in the Addington quadrangle, attaining an elevation of 1,300 feet at its highest point. A northwest-southeast ridge through the center of the field which has a relief of about 250 feet in less than a mile is, in many places, a feature which is very noticeable for miles from all directions. The field is heavily covered with brush and jack oaks.

### STRATIGRAPHY

The surface rocks exposed are a portion of the red sandstone series of the Wichita-Clear Fork formation, consisting of gray to brown calcareous sandstones and vari-colored shales. The base of the red beds, which is possibly the base of this formation, is reached at a depth of from 850 to 1,000 feet from the surface on the axis of the fold with increasing thickness down the flanks. The section below this consists of blue shales, sandstones and a few thin limestones, presumably of Pennsylvanian age, the thickness of the Pennsylvanian section being dependent upon the position on the fold. A deep test on the top of the fold encountered what may be Ordovician rocks at a depth of 1,745 feet, while a test down the west flank about two miles from the axis was still in Pennsylvanian rocks at a depth of 3,340 feet where it was abandoned.

### STRUCTURE

The surface structure of the field consists of a long northwest-southeast anticline, the axis of which coincides to a remarkable extent with the topography. The steep side of this anticline is to the northeast, while the southwest flank slopes off gently into the syncline between this fold and the Loco anticline. Several surface faults can be traced while the presence of others is suggested in places, but due to

the nature of the surface rocks these latter can not be definitely tied down. Since most of the production is from the Permian section, there is definite control only for subsurface structure on this age of the rock section present. Naturally the subsurface on the lower portion of the Permian section merely substantiates the surface structure, excepting that the faulting is more definite. A well drilled by the Huntley Company in the SW. cor. NE.¼ sec. 1, T. 2 S., R. 5 W., encountered the base of the red beds at a depth of 900+feet. This well drilled into what may be Ordovician limestone at a depth of 1,745 feet to 1,920 feet with a possible Simpson section to a total depth of 2,509 feet, thus suggesting that the core of this anticline is another of the many buried hills of southern Oklahoma, for wells drilled much deeper farther down the flanks of the fold failed to drill entirely through the Pennsylvanian section.

#### DEVELOPMENT

The Texas Company completed the discovery well of the field in their Frensley No. 1 in the SW.¼ SE.¼ sec. 26, T. 1 S., R. 5 W., in July, 1917 with an initial production of 20 barrels. Lack of pipeline transportation retarded development until late in 1920 when the first pipeline was built into the field. Since that time the development of the field has spread rapidly to its present limits.

#### PRODUCING SANDS

The producing sands in the field proper are found at depths from about 350 feet to 900 feet. Oil wells are completed in these sands with an initial production of about five to twenty-five barrels with the majority at the present time having an initial production more closely approximating the lower figure. Gas wells are completed with a volume of from one to five million cubic feet but with pressures of a hundred pounds to the square inch or less. The average gravity of the oil is about 28° A.P.I., commanding a price of $1.65 per barrel. Per acre yields will probably not exceed two to three thousand barrels for the field as a whole. During the year 1925 several wells were completed down the southwest flank of the fold in secs. 33 and 34, T. 1 S., R. 5 W., and sec. 3, T. 2 S., R. 5 W., producing from Pennsylvanian sands at depths of from 2,200 to 2,600 feet with initial productions of 25 to 50 barrels per day. Similar tests in secs. 10 and 11, T. 2 S., R. 5 W., have failed to find production in paying quantities although at about the same structural position. While there appears to be a chance for Pennsylvanian production along the southwest flank of the fold at points near where the lower beds abutt against the buried hill the successful completions to date in such formations do not have an initial production sufficient to compensate for the failures that are inevitable in the lenticular sands of this age of rocks. The best chance for deeper production would seem to be in thoroughly testing the Ordovician core on the axis of the fold.



All shallow drilling in the pool is done with Star machines. Drilling to the Pennsylvanian sands has been done with cable tools, which is an expensive operation when considering the production obtained. The pool is now producing about 2,000 barrels per day from about 450 wells. To January 1 of this year (1926) it had produced a total of about 2,500,000 barrels. There is still considerable development work to be done before the field is entirely drilled up.

### THE MILROY POOL[27]

#### LOCATION AND TOPOGRAPHY

The Milroy pool is located in the extreme southeast portion of the county in secs. 13, 14, 23 and 24, T. 2 S., R. 4 W. The topography is very rugged with considerable relief as a fork of Caddo Creek traverses the center of the pool with a hill some 150 feet higher immediately to the south in section 24. The pool is quite thickly wooded with jack oaks.

#### STRATIGRAPHY

The surface rocks consist of gray sandstones, brown mudstones, and pink to reddish shales, all of which are a part of the sandstone horizon of the Wichita formation. The underground portion of the Wichita-Clear Fork formation is composed essentially of rocks of the same character. This formation extends to a depth of some 900 feet from the surface. Below the Wichita-Clear Fork rocks is a section of the Pennsylvanian rocks. Too little drilling has been done into these rocks in this pool for discussion.

#### STRUCTURE

The surface structure is that of a dome elongated east and west, truncated by a fork of Caddo Creek. The dip to the north and to the south is unusually steep for Permian rocks of southern Oklahoma, which, with the truncation makes the folding very apparent from a distance. As in the case of the Velma field the subsurface folding is merely a substantiation of the surface for the production is from Permian horizons.

#### DEVELOPMENT

Development in this pool took place from 1916 to 1920 with little if any development work going on since that time. Depths to sands and production of the wells are both similar to the Velma field. The pool at this time is producing about 200 barrels per day from about 70 wells. The chances for production in Pennsylvanian sands are probably slight, due to the extreme sharpness of the fold and the limited area that it covers.

27. Storm, W., Op. cit.

## MISCELLANEOUS SMALLER POOLS

### MAGNOLIA POOL

In T. 1 S., R. 9 W., there is a small pool which extends from the southeast corner of sec. 16, through the center of sec. 22 and thence almost due east into the west-central edge of sec. 23, being hardly more than two locations wide. It was discovered by the Magnolia Petroleum company in July, 1918 when they completed a well in sec. 22 with an initial production of about four hundred barrels in the Blaydes sand. Later completions made from 25 to 100 barrels initial. There are now some 12 producing wells in the pool making a total daily production of about 150 barrels. Due to the rather small initial production of the wells the total production probably will not average over 20,000 barrels per well.

### RAINOLA POOL

In sec. 22, T. 1 S., R. 8 W., there is a small pool, the center of which is, just to the north of the center of the section. This pool was discovered late in 1921 by the Rainola Oil Company when they completed a well with an initial production on the pump of 20 barrels in what is probably the horizon of the Smith sand found here at slightly below 2,000 feet. This happened to be an edge well on the fold. Later wells completed first made gas until the pressure was reduced, after which they produced oil. Initial production of the wells has been from 20 to 100 barrels on the pump. There are now some 10 producing wells in the pool making a combined daily production of about 150 barrels. The total average production per well in this pool will probably not exceed 15,000 barrels although several of them paid for themselves out of the gas produced before going to oil.

### WOOLSEY POOL

In secs. 23 and 26, T. 2 S., R. 6 W., there is a small pool which was discovered by the Magnolia Petroleum Company in 1922. The discovery well made about 75 barrels natural from sand at 1,750 feet. Later completed wells averaged about the same amount. There are at this time about 14 wells making a total daily production of about 130 barrels. The producing horizon is no doubt in the Glenn formation but just what part is unknown. The base of the red beds is encountered at a depth of about 1,300 feet. Below this depth and above the producing sand numerous fossils have been reported in the drill cuttings.

*Production Data on the Woolsey Pool.*

| COMPANY | Lease | Sec. | Wells | Tot. Prod. | Pres. Prod. | Per W ll Av. |
|---|---|---|---|---|---|---|
| Magnolia | Ferris | 23 | 5 | 149,120 | 40 | 29,824 |
| Pan-Am | Wills | 23,26 | 1 | 87,585 | 32½ | 21,896 |
| Magnolia | James | 23 | 5 | 200,510 | 40 | 40,102 |
| TOTALS | | | 14 | 437,215 | 112½ | 31,320 |



### NELLIE GAS AREA

Late in 1925 two gas wells were completed in the southeast corner of T. 1 N., R. 9 W., one in sec. 25 with an initial production of about 5,000,000 cubic feet per day in a sand at 1,840 feet, the other in sec. 36 with an initial production of about 15,000,000 cubic feet per day in sand at 1,840 feet. This horizon is post-Glenn, in what the writer would correlate as the Pontotoc group. A well lately abandoned at 4,550 feet just east of the gas well in sec. 25 was still in post-Glenn rocks at a depth of 4,100 feet where a sample was obtained. The section down to the latter depth consisted chiefly of the brown shales and coarse arkosic gravels typical of the locality in which the well is located.

### LAWTON-HANBURY AREA

An area that is just outside the county, but which is mentioned here, both because it will probably not be covered by the report on any of the other counties, and because of its unique interest as to producing horizons, is the Lawton-Hanbury area of Comanche County. The production at present in this area lies in sec. 30, T. 2 N., R. 9 W., and in secs. 24 and 36, T. 2 N., R. 10 W. The easternmost producing well is some two miles west of the western line of Stephens County. The area lies some ten miles due east of the town of Lawton. The surface rocks in the area belong to the red sandstone group of the Wichita-Clear Fork formation of the Permian.

#### DEVELOPMENT

In the summer of 1920 the Gladys-Belle Oil Company completed a well at a depth of 1,530 feet, which made an initial production of something over one hundred barrels of 42 gravity oil, in the southwest corner of NW.¼ sec. 32 T. 2 N., R. 9 W. Three offsets were drilled to this well, one of them producing from the same sand, while the other two produced from a sand at about 1,640 feet. These wells all declined very rapidly so that within two years they had all been abandoned. Other wells drilled during this time to the northeast, east and south, but none closer than half a mile to the discovery well were all unsuccessful. In August, 1925, Mr. Hanbury completed a well in the NE¼ sec. 30, in sand at 2,010 feet which made an initial production of about four hundred barrels. This was the only direction that had not previously been condemned. This started a development which is now going on.

#### STRATIGRAPHY

The Wichita-Clear Fork formation extends to an average depth of about 1,400 feet. The section below this is probably the equivalent of the Pontotoc group. It consists of blue and brown shales, thin sands and gravels. The thickness of this group depends upon the position any well bears to the Wichita Uplift, varying from zero in the western part of T. 2 N., R. 10 W., where the Permian rocks are rest-

ing directly upon the Arbuckle limestone, to a thickness of at least 3,000 feet in the eastern part of T. 2 N., R. 9 W., with the base not yet reached. No well in this area has gone into the Glenn formation. The gravels in this formation are composed of fragments of all rocks from pre-Cambrian granites to and including the Viola limestone.

### STRUCTURE

The surface structure in this area is a flat dome with the apex about the center of the west line of sec. 19, T. 2 N., R. 9 W. Control for subsurface structure is not yet sufficient to delineate, but production to date is agreeing remarkably well with the surface fold.

### PRODUCTION

The unique feature of this area is in the character of the producing sands. The sands are numerous from a depth of 1,500 feet to below 2,500 feet. Present producing sands are at 1,530 feet, 1,610 feet, 1,860 feet, 2,000 feet, and 2,100 feet. With one exception, every well completed to date has declined to a daily production of less than twenty-five barrels in about two weeks' time. Many have thought that the producing horizon was a gravel, hence the cause of the rapid decline but the evidence seems to be conclusive that there is a thin sand at every producing horizon which contains the oil and gas and that immediately below the sand is a dry gravel. The pay sand drills hard as if one were drilling a "shell", while the tools drop when the gravel is being drilled which is the reason that many have believed that the gravel is the pay. It is now the opinion of many who have studied the area that the dry gravel takes up a large part of the production from the sand, thus explaining the extremely rapid decline of the wells. The one exception noted above is a well which was completed before the gravel was penetrated. This well pumped an average of fifty barrels a day soon after completion last September and is today pumping about forty barrels. The correct procedure would seem to be to cement casing with the rotary before the sand is reached and then to complete with cable tools by drilling as little of the real sand as possible, making sure that the gravel is not penetrated. By this method there is quite an area which should evidently make possible the completion of some fair wells. While the initial production will not be high, the sand should be rather long-lived. The fact that the oil is over 40 gravity is an asset to the area.

### FUTURE POSSIBILITIES

With this area in its infancy there is room for many more locations. The area to develop would be a strip paralleling the Wichita axis in the eastern part of T. 2 N., R. 10 W., probably not farther west than a north-south line through the center of the second tier of sections from the east line of the township, and the extreme west tier of sections in T. 2 N., R. 9 W. Starting at the west line of this zone of play one would have to shift slightly east for each successive deeper sand sought. As to how deep one could expect to continue to find producing sands it is impossible to state this early in the development.

# KAY, GRANT, GARFIELD AND NOBLE COUNTIES

By

G. C. Clark and C. L. Cooper

### ACKNOWLEDGMENTS

The material for the compilation of this report was obtained largely from the Geological Department of the Marland Refining Co. The data on the Tonkawa and Thomas fields was used as it is found in the Bulletin of the American Association of Petroleum Geologists. For these articles, and for much additional help and criticism of the report in manuscript form, the authors are indebted to F. L. Aurin, S. K. Clark, and J. I. Daniels of the Marland Company.

Much of the early history of the fields was obtained from Ira Reinhart's report on the northern Oklahoma oil fields. The American Association of Petroleum Geologists has kindly loaned the cuts of the illustrations for the Tonkawa and Thomas fields.

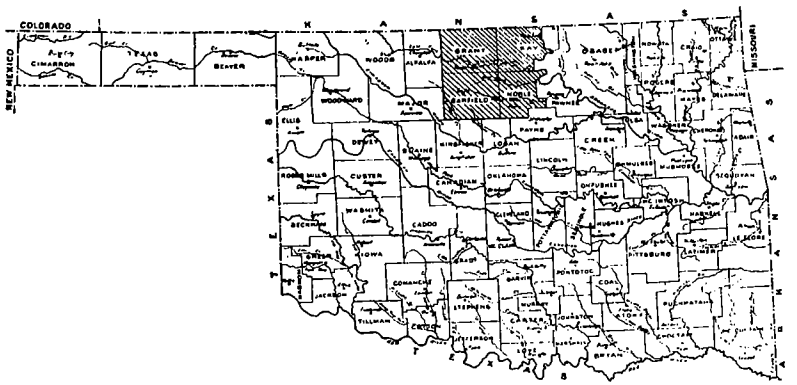



Figure 3.—Index map of Oklahoma showing location of Kay, Grant, Garfield and Noble counties.

## STRATIGRAPHY

### SURFACE FORMATIONS

The rocks exposed on the surface in the four counties under discussion include formations of late Pennsylvanian and lower Permian age, the oldest being exposed in east-central Kay County in T. 27 N., R. 5 E. The Pennsylvanian formations consist of numerous beds of drab colored limestones interbedded with drab to red colored

(This report originally issued as Bulletin 40-H, March, 1927).

shales. The limestones range from a few inches to 15 feet or more in thickness. The Neva limestone, believed by Beede to mark the Pennsylvanian-Permian contact, seems to define to a certain extent the change of color of the rocks other than the limestones; the shales and sandstones above the Neva are predominately red while those below are the typical drab color of marine sediments. The limestones without exception thin out to the south and are replaced by red shales and sandstones.

The following table shows a generalized section of the Pennsylvanian rocks in eastern Osage and western Kay counties:

*Pennsylvanian section in T. 22 N., Rs. 2 W.-5 E.*

| | | Feet |
|---|---|---|
| | Limestone, Neva | |
| | Sandstones, shales, and some limestones, alternating red and gray | 65 |
| | Shales, red and gray, Red Eagle | 19 |
| | Limestone | 3 |
| | Shale, mostly red | 9 |
| | Limestone, Cushing | 7 |
| | Shale, mostly red | 37 |
| | Limestone | 3 |
| | Shale, gray | 7 |
| Foraker | Limestone | 5 |
| Foraker | Shale, gray, with red streaks | 10 |
| Foraker | Limestone | 7 |
| Foraker | Shale, gray, with red streaks | 12 |
| Foraker | Sandstone, non-red | 13 |
| Foraker | Shale, gray, with red streaks | 9 |
| Foraker | Limestone | 5 |
| Foraker | Shale, gray | 8 |
| | Limestone | 4 |
| | Shale, gray | 164 |
| | Concealed | |
| | | 450 |

The Permian section is made up of a few thin non-red limestones, red and non-red shales and sandstones near the base with an increasing thickness of red shales and sandstones as one goes higher in the section. In this area are found most of the non-red Permian rocks of the State, the color change line[1] crossing the Pennsylvanian Permian contact in T. 18 N., R. 4 E.

The Permian section as exposed at the surface is shown in the following table:

1. Aurin, F. L. Officer, H. G., and Gould, Chas. N., The subdivisions of the Enid formation: Bull. Am. Assoc. Pet. Geol., Vol. X, No. 8, 1926.



*Permian section in T. 24 N., Rs. 3 W.-2 E.*

| | Feet |
|---|---|
| Shales, red with some sandstones to top | 210 |
| Shales, purple | 55 |
| Shales, red | 42 |
| Shales, mostly non-red, some sandstones and limestones | 252 |
| Shales, red and non-red, sandstones, and gypsum alternated | 267 |
| Gypsum | 5 |
| Shales and sandstones, red and non-red, some gypsum | 130 |
| Gypsum | 8 |
| Shales, mostly red | 37 |
| Limestone, Herington, shale partings near top | 26 |
| Shales, red | 50 |
| Limestone, Winfield, thin shale parting in middle | 13 |
| Shales, red, some sandstones and thin limestones at base | 153 |
| Limestone, Fort Riley | 10 |
| Shales, mostly red, some sandstones | 101 |
| Limestone, Wreford | 16 |
| Shales, red and non-red, some sandstone | 68 |
| Limestone, Crouse | 2 |
| Shales, red and non-red, some sandstone | 67 |
| Limestone, Cottonwood | 6 |
| Sandstone and shales, non-red | 75 |
| Limestone, Neva, alternating limestone and shale | 34 |
| | 1,627 |

## NEVA LIMESTONE

The lowest formation exposed in this area is the Neva limestone. It is found outcropping at the surface in east-central Kay County in sec. 27, T. 27 N., R. 5 E. The Neva is composed of four thin beds of limestone separated by beds of gray shale. The formation thins to the south, but in T. 26 N., R. 5 E., has an aggregate thickness of 35 feet. The following section by Bowen[2] shows the detailed character of the formation:

*Section of Neva limestone near Burbank*

| | Feet |
|---|---|
| Limestone, gray, somewhat cherty, soluble; chert commonly lying loose on the surface | 2 |
| Shale | 6+ |
| Limestone, containing large, gray, nodules of chert; both chert and limestone full of large Fusilina, chert nodules white on freshly broken surface; weathers brown with a sandy appearance | 2 |
| Shale | 8 |
| Limestone, gray; weathers white; contains no fossils or chert; weathers into large, thin, sharp-edged slabs; forms prominent rim | 4 |
| Shale | 12 |
| Limestone, dense, non-crystalline; has straw-yellow color streaked with maroon; contains pelecypods; rarely well exposed | 2½ |
| | 36½ |

2. Bowen, C. F., Oil and gas resources of Osage Reservation, Oklahoma: U. S. Geol. Survey, Bull. 686, p. 140, 1922.

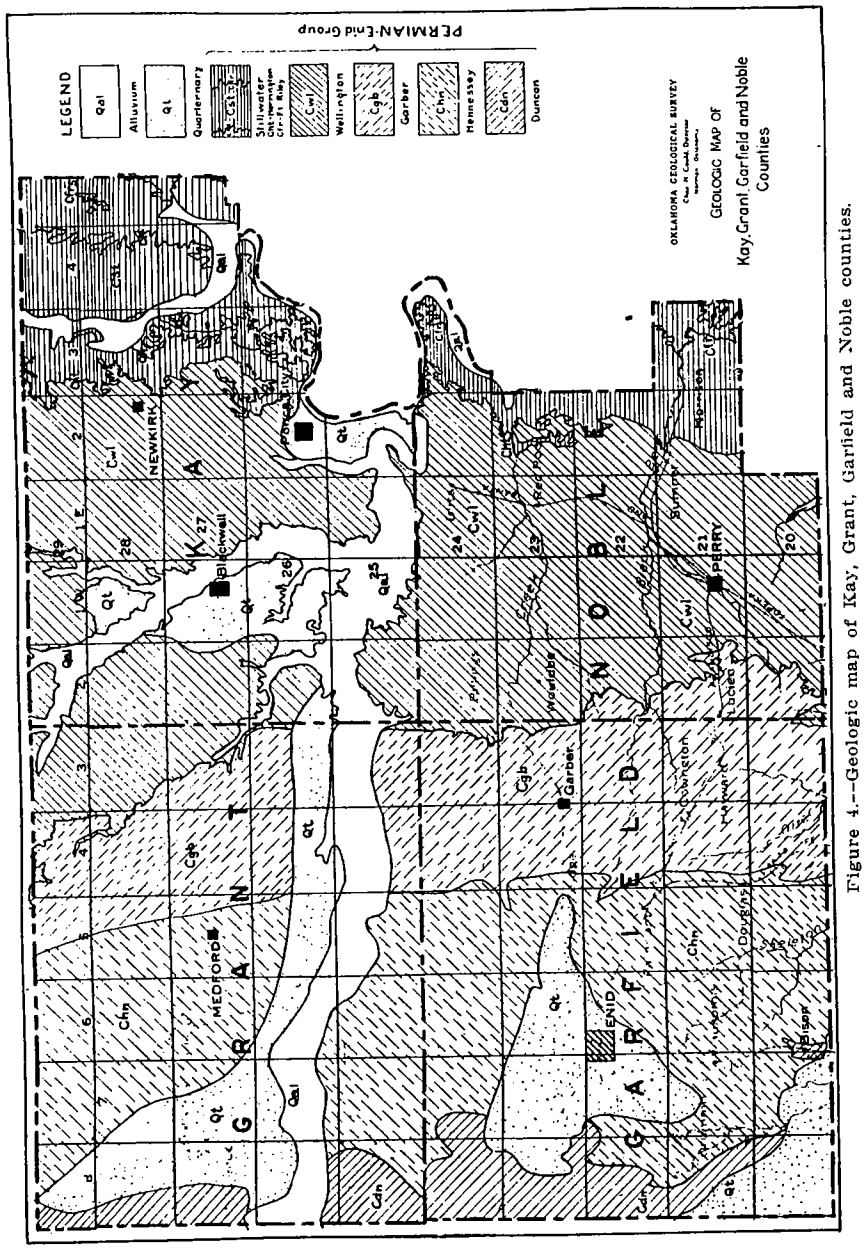



Figure 4.—Geologic map of Kay, Grant, Garfield and Noble counties.



### COTTONWOOD LIMESTONE

The Cottonwood limestone is about 6 feet thick in this area. It is a white to light gray hard, crystalline limestone, slightly oolitic and fossiliferous in places. The only exposure of the Cottonwood in this area is found along Beaver Creek in Tps. 27 and 28 N., R. 5 E.

The following section, by Heald[3], was measured in Osage County.

*Section of Cottonwood limestone in SW.¼ sec. 21, T. 29 N., R. 6 E.*

| | Ft. | In. |
|---|---|---|
| Limestone, massive, bluish white on weathered surface, light gray to buff on fresh surface; surface uneven and full of round holes as much as 2 in. in diameter, but it is not as rough as the Neva; occasional rough places have dark surfaces; no chert | 2+ | |
| Shale, thin; and oolitic limestone | 11 | 0 |
| Limestone conglomerate, blue, gray to yellowish; made up of rolled pebbles of limestone, shell fragments, and some little hematite pebbles; degree of cementation varies; a good deal of crystalline calcite; many fossils; coiled shells **(Schi ostoma)** and fluted long-nosed brachiopods **(Meekella)** most characteristic | | 6 |
| Shale, olive-drab, clay | | 20 |
| Limestone conglomerate as above, except that it contains more pebbles and less lime; fossiliferous, **(Myalina)** productids; cross-bedded largest pebbles seen about half an inch in diameter | 2 | 0 |
| Shale or marl, pink, greenish gray, and white, bedding irregular; beds form overlapping lenses; contact with overlying conglomerate very irregular | 2 | 6 |
| | 20+ | |

### CROUSE LIMESTONE

The Crouse limestone[4] is a very thin limestone about two feet thick in this area, lying 100+ feet above the Cottonwood limestone. The Crouse outcrops in east-central Kay County in T. 28 N., R. 5 E. It is commonly a light-gray thin-bedded limestone, but in places is massive throughout its entire thickness. The limestone is very porous and in places very fossiliferous. The formation has not been traced farther south than sec. 5, T. 27 N., R. 5 E. At this place the interval between the Crouse and the underlying Cottonwood is 64 feet.

### WREFORD LIMESTONE

The Wreford limestone is exposed in northeastern Kay County in Tps. 27-29 N., R. 5 E. and generally consists of two beds of limestone separated by a shale of variable thickness. The lower limestone is a bedded, buff to gray limestone averaging 8 feet thick and forms

3. Heald, K. C., Oil and gas geology of the Foraker Quadrangle, Osage County, U. S. Geol. Survey, Bu'l. 641-B, p. 23, 1917.
4. Heald, K. C., The oil & gas geology of the Foraker quadrangle, Osage County, Okla.; U. S. Geol. Survey, Bull. 641-B, pp. 21-22, 1917.

broad sloping terraces terminated on the east by a high scarp. The lower bed, averaging two feet thick, is a yellowish fossiliferous limestone. The interval between the Crouse and the Wreford is 86 feet. The Wreford is the basal member of the Chase group of Kansas. The following section[5] was measured in Osage County.

*Section of Wreford Limestone, Osage County, Oklahoma.*

| | Feet |
|---|---|
| Limestone, blackish gray on weathered surface, light buff to brownish gray on fresh surface; in several slabby beds 2 to 6 inches thick; top bed is massive, 12 to 16 inches thick, hard and dense; lower beds break into slabby, lenticular pieces. Fossiliferous; considerably limonitized; has many echinoid spines; is in places full of smooth cylindrical holes half an inch to 3 inches in diameter. Above this is a mass of shale and limestone | 4 |
| Limestone, buff, hard, dense, massive; full of chert; yellowish brown on weathered surface, blue-gray on fresh surface. About 25 per cent of the rock is chert, in irregular nodules and layers, lens-shaped concretions roughly parallel to bedding most common; chert is fossiliferous | 3 |
| Shale, limy, yellow-gray to green-gray; looks sandy but no grains distinguishable; bedding regular; fossiliferous | 2 |
| Limestone, light buff on both weathered and fresh surfaces, dense, hard, compact; full of fossils, which are locally replaced by glassy or milk-white calcite; in two beds with a 1-inch shale parting; the many crystalline fossils give the rock a spotted appearance | 3 |
| | 12 |

### FORT RILEY LIMESTONE

Between the Fort Riley limestone and the Wreford there occurs a series of red shales and sandstones having a total thickness of 100 feet in sec. 5, T. 27 N., R. 5 E. To the north thin limestones appear, the red sands disappear and the section changes to one of drab limestones and shales. The Fort Riley is a massive buff limestone averaging 10 feet thick, exposed in a broad band of irregular outcrops in Tps. 25-29 N., R. 4 E., and crossing into T. 25 N., R. 3 E., in section 21. An exposure of this formation is also found in the large bend of the Arkansas River northeast of Bressie.

### WINFIELD LIMESTONE

Between the Fort Riley and the Winfield there is a thickness of 150-160 feet of red shales with some non-red shales, sandstones and a few thin limestones in the lower half of the interval, corresponding to the Doyle shales of the upper Chase group of Kansas. These non-red beds increase to the north and decrease to the south in the

5. Heald, K. C. The oil and gas geology of the Foraker Quadrangle, Osage County, Oklahoma: U. S. Geol. Survey, Bull. 641-B, p. 22, 1917.



section. The main outcrop of the Winfield is found in eastern Kay and Noble counties, southeast of Ponca City and east of Newkirk. Three outliers occur in the eastern part of T. 27 N., R. 3 E., just east of Mervine. The Winfield in this area varies from 9 feet in sec. 18, T. 22 N., R. 3 E., to 18 feet at the Kansas line, and continues to thicken to the north in Kansas. It cannot be definitely recognized any considerable distance south of the exposure in sec. 18, T. 22 N., R. 3 E. where the limestone is separated into two beds by a parting of red shale 3 feet thick.

### HERINGTON LIMESTONE

The Herington limestone is separated from the Winfield by an interval of 50-60 feet of beds, which, like the beds described above, consist of drab to gray limestones and shales at the Kansas line, changing to red shales and sandstones to the south. These shales are the equivalent of the Enterprise shale in Kansas. The Herington is composed of one to three members of light buff-colored limestone which thins to the south, where there is found a massive sandstone just below the limestone. The Herington has an aggregate thickness of 26 feet near the Kansas line. The outcrop of this limestone closely parallels that of the underlying Winfield limestone in east-central Kay and Noble counties, and can be definitely traced as far south as sec. 14, T. 22 N., R. 2 E.

The rocks which lie above the Herington are made up almost entirely of typical red beds formations as shown in the section on p. 77. These beds occur in an alternating series of red sandstones and shales, with numerous gypsum beds, interspersed throughout the section. The series as a whole, from the base of the Neva up, are included in the Stillwater, Wellington and higher formations of the Enid group, and correspond to the Flint Hills, Wellington, Harper, Salt Plains, Cedar Hills and Flower Pot formations of Kansas.

The following description of Aurin, Officer, and Gould[6] gives, in a general way, the characteristics of these formations.

### STILLWATER FORMATION

> Throughout a considerable part of the area of the outcrop of the Stillwater in central Oklahoma the exact location of neither the base nor the top of the formation has been accurately mapped at this time. The equivalents of the Stillwater in southern Kansas and in Osage and Kay counties, Oklahoma, consist of a series of limestones and shales which constitute the Flint Hills named, in ascending order, as follows: "Cottonwood limestone and Garrison shale of the Council Grove group, the Wreford limestone, Matfield shale, Florence flint, Fort Riley limestone, Doyle shale, and Winfield limestone of the Chase group, and the Luta limestone, Enterprise shale, and Herington limestone members of the Marion formation of the Sumner group.
>
> As one passes south these various beds begin to lose their identity in the region of the Arkansas River in southern Osage,

6. Op. cit. pp. 792-799.

northeastern Noble, and Pawnee counties. By the time the color change line has been reached the limestones are thinning rapidly and are being replaced by sandstones, while the shales begin to change their color from gray to red. Still farther south the limestones disappear and the entire formation is found to consist of alternating beds of red shales and red and gray sandstones. This is typical Stillwater, as exposed at the type locality, Stillwater, the county seat of Payne County.

The combined thickness of the various Kansas formations making up the Stillwater as exposed on the surface in southern Kansas and northern Oklahoma approximates 540 feet[7]. In general, these beds are believed to thicken to the south. A fair estimate for the thickness of the Stillwater in east-central Oklahoma would probably be about 800 feet.

## WELLINGTON FORMATION

The Wellington formation, first described by Cragin[8], consists of gray to bluish and drab shales with numerous thin beds of gray "Mud-stone." The same general conditions also obtain in a considerable part of Kay County, Oklahoma. At the color-change line, however, beds of red sandstone appear, and the color of the shales changes from gray and drab to red. The characteristic "mud-stones" persist, however, to the latitude of Perry, and the Wellington type of topography is still found as far south as Mulhall. South of Cimarron River practically all the original Wellington characteristics have been lost.

The Wellington formation in Kansas rests on the Pearl shale member of the Marion formation, but since the Pearl shale member cannot be readily differentiated from the Wellington in Oklahoma it is mapped with the Wellington and, for purposes of mapping, the boundary is placed at the top of the easily recognized Herington limestone. The top of the Wellington is the base of the lowest heavy sandstone of the Garber formation.

The thickness of the Wellington, including the Pearl shale in northern Oklahoma, is approximately 670 feet.

## GARBER SANDSTONE

The name Garber, which for several years has been employed by local geologists in the region under discussion, is here proposed to include a series of red clay shales, red sandy shales, and red sandstones lying above the Wellington. The name is from the town of Garber, in eastern Garfield County, Oklahoma, where the formation is well exposed.

Geologists working in the field have learned to distinguish in a general way a lower shaly phase and an upper sandy phase of the Garber formation, and these phases are sometimes spoken of as the "lower Garber" and "upper Garber." In order to avoid the use of the terms "lower" and "upper" the following classification is used.

### Lucien shale member

The lower part of the Garber sandstone exposed throughout a considerable part of eastern Garfield, western Noble, and western Logan counties is composed largely of red, more or less fissile or laminated clay shales with several ledges of red sandstone.

7. Gould, Chas. N., Index to the Stratigraphy of Oklahoma, Oklahoma Geol. Survey, Bull. 35, pp. 80-85, 1924.
8. Cragin, F. W. The Permian system of Kansas: Colorado Coll. Studies, Vol. 6, pp. 18-26, 1896.



One of these ledges generally occurs at the base of the Lucien member, otherwise the base of the Garber sandstone. Other beds of red sandstone, more or less lenticular in nature, occur at higher levels, but the Lucien member as a whole is made up chiefly of red shales which are generally easily distinguishable from the blocky, red clay-shales of the younger Hennessey formation.

The thickness of the Lucien member approximates 250 feet. The beds are well exposed at the village of Lucien, in western Noble County.

### Hayward sandstone member

The upper part of the Garber sandstone is named the "Hayward sandstone member" from a village in southeastern Garfield County.

This member consists for the most part of heavy ledges of massive red sandstone, more or less lenticular, generally cross-bedded and not uncommonly conglomeratic, interstratified with beds of fissile shale and sandy shale. The sandstones, in many places, weather into conspicuous cliffs. The thickness of the member approximates 350 feet.

## HENNESSEY SHALE

The Hennessey is throughout a clay-shale formation, and as such is easy to differentiate from the sub- and superjacent formations which consist chiefly of sandstone. Its lower limit is the heavy sandstone at the top of the Garber, and its upper limit the base of the Duncan sandstone.

The shales of the Hennessey differ from other red shales in the lower part of the Enid group in that they are rarely fissile or laminated, but are more commonly blocky and break with a conchoidal fracture having the appearance of "joint clay". The Hennessey as a whole is also characterized by numerous bands or streaks, white or light green in color, varying in thickness from a few inches to 4 feet or more. These bands may be persistent for many miles and, in the absence of better material, serve as convenient data of reference for instrument work by geologists.

As in the case of the Garber, the Hennessey has also been divided by men familiar with its stratigraphy into lower and upper beds or members. For these members the authors here propose the names "Fairmont shale member" and "Bison banded member."

## DUNCAN SANDSTONE

Cragin[9] first described the Harper sandstone in Harper County, Kansas, as follows:

"The Harper sandstones * * * * * comprise several hundred feet of more or less mottled, but prevailing dull red, or brownish-red argillaceous and arenaceous shale and sandstones, above the Wellington shales and below the Salt Plain measures."

The Harper sandstones of Kansas have been carried southward into Oklahoma where they are found to constitute the formations which in this paper are called the Garber sandstone, the Hennessey shale, and the Duncan sandstone. The uppermost of these formations, here called the Duncan has been traced south crossing Grant, Garfield, Kingfisher, Canadian, and McClain counties, where it appears to be the same as the Duncan sandstone.

9. Op. cit.

As exposed in northern Oklahoma, the Duncan consists of rather soft, friable or shaly, red sandstone. It is commonly crossbedded, locally conglomeratic, and not uncommonly interstratified with red shales. This shaly phase of the Duncan has sometimes given rise to confusion regarding the location of the contact between the Duncan and the sub-and superjacent formations, and upon this subject the authors are not yet in complete agreement. The base of the Duncan is the line of contact between the lower sandstone bed and the top of upper blocky shale bed of the Hennessey. The top of the formation in some places is difficult to locate, on account of the gradual change of the sandy phase of the Duncan into the shale beds constituting the Chickasha, as will be set forth later.

The thickness of the Duncan appears to be variable, averaging perhaps 100-300 feet. Throughout its outcrop in Kansas and Oklahoma the Duncan is generally a persistent scarp-maker, forming a row of low hills overlooking the plain to the east, formed by the Hennessey shale and equivalent formations.

### CHICKASHA FORMATION

In northern Oklahoma the Chickasha is composed chiefly of gypsiferous red clay shales and thin sandstones, the clays greatly predominating. The clays contain many bands or streaks, from a few inches to several feet in thickness, of white and light-green clay. The formation is also characterized by the great abundance of "polkadot" balls, or concretions, of white and green clay, the origin of which has been the subject of much comment, but which is still obscure. The upper part of the Chickasha contains much satinspar, selenite, or concretions of gypsums.

The upper limit of the Chickasha is the base of the Blaine gypsum of the Gypsum Hills, but, as stated many years ago:[10] "The top of this formation (the Enid) is not a plane, since the gypsum beds, which mark its uppermost limits, are found to be more or less lenticular when traced for long distances."

### SUBSURFACE FORMATIONS

An exceedingly complete section of the subsurface formations is available for Kay and Noble counties, but only in the eastern margin of Grant and Garfield counties has there been drilling to the Ordovician (Wilcox sand and "Siliceous lime") rocks. This horizon has been reached in a well as far west as sec. 29, T. 23 N., R. 4 W., which reached what is probably the Viola limestone at 5990-95 feet. Beyond this no data is available.

The subsurface horizons are comparatively easy of correlation because of the regularity of occurrence of a number of persistent key beds. The present practice of keeping accurate logs by means of cuttings taken at frequent intervals during the drilling of the well, augmented by core drill records in a number of areas, has given a very complete and accurate knowledge of subsurface conditions. Very accurate correlations are now possible from the time the well has reached the Foraker limestone until the "Siliceous lime" is penetrated.

10. Gould, Charles N., U. S. Geological Survey, Water-Supply Paper No. 148, p. 39, 1905.

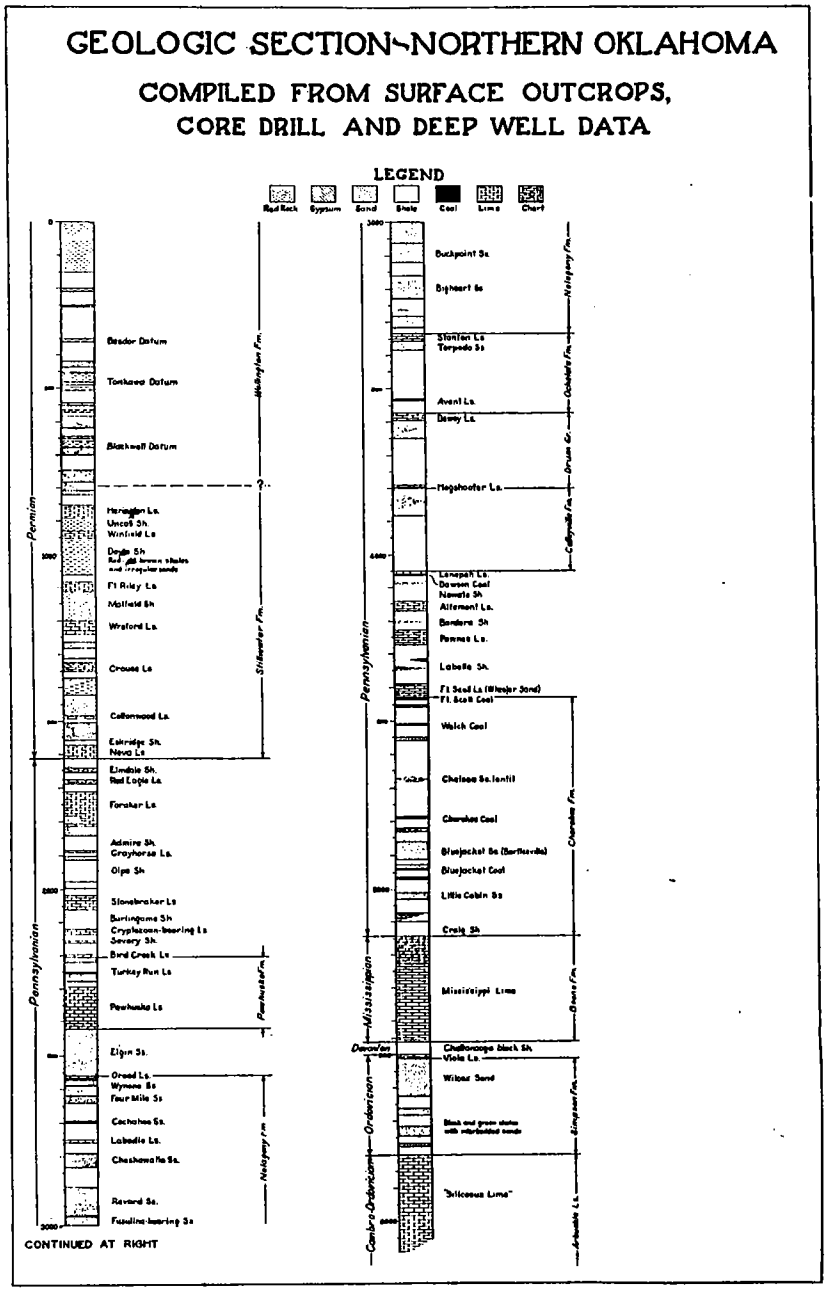



Figure 5.—Geologic Section—north-central Oklahoma.

Not all of the actual subsurface formations will be described. Those formations which outcrop in the eastern part of the area (Stillwater formation) and which have been described under "surface formations" are beneath the surface farther west in Grant and Garfield counties, and will not be described here. The discussion of subsurface formations will include rocks of Pennsylvanian to Ordovician age inclusive.

### PENNSYLVANIAN

The Pennsylvanian is represented by a great thickness of alternating sandstone, shales, and limestones. This series is approximately 2,500 feet thick at Braman, 2,700 feet at Garber, 3,050 feet at Ponca, 3,100 feet at Tonkawa, 3,250 feet on normal west dip just west of Ponca field and 2,800 feet at the Thomas pool. These formations thicken to the east, as is shown by a thickness of approximately 4,400 feet of Pennsylvanian shown in a general section of northern Oklahoma taken from surface and core drill data, (see Figure 5).

The Pennsylvanian represented in well logs of this area include all of the formations from basal Cherokee to the base of the Neva limestone. These need not be described here since an adequate description has been given by Gould.[11]

The common driller's names of the important horizons in the Pennsylvanian series from the base up are:—Cherokee shales, Oswego "Big lime" group, Layton sand, Tonkawa sand, Endicott sand series, Hoover sand series, Pawhuska limestone, and Foraker limestone. These will be taken up in detail under the description of the various fields. There is an erosional unconformity at the base of the Pennsylvanian.

### MISSISSIPPIAN

The Mississippian series is represented by an average of about 300 feet of Mississippi lime, which grades from a gray to a dark brown and black cherty limestone, with a variable thickness of residual chert at the top. Two, and sometimes three, horizons are recognizable. In going from the Ponca City field to the Blackwell field the interval between the Oswego and the Mississippi lime increases to about 450 feet midway between these fields. A little production has been obtained in the upper chert horizon of the Mississippi lime.

### DEVONIAN

The Chattanooga shale, here placed in the Devonian, has been placed in the Mississippian by some writers. The formation in this area is composed of black carbonaceous shale containing a considerable amount of pyrite.

### ORDOVICIAN

This system includes about 15 feet of "white lime," which has been correlated with the Viola limestone, and the Simpson formation. Most

11. Gould, Chas. N., Index to the Stratigraphy of Oklahoma: Oklahoma Geol. Survey, Bull. 35, 1925.



of the wells that have gone through the Simpson find it to be on an average, 300 feet thick. The upper member of the Simpson, known as the Wilcox sand, is made up of pure sand with well rounded and frosted grains, and a few scattered thin partings of green shale. It is distinguished from the Pennsylvanian sands by the total absence of mica which is present in all the higher sands, and the character of the sand grains. The remainder of the Simpson is made up of alternating beds of black and green shale and sandstone, the sands being much thinner than the Wilcox but of a similar character.

### CAMBRO-ORDOVICIAN

Below the Simpson formation there is an unknown thickness of "Siliceous lime," or Arbuckle limestone. This formation has not been penetrated deeper than 1,000 feet in this area.

The name Siliceous limestone was applied by F. L. Aurin[12] to the massive beds or bed of dolomite of Ordovician age, found immediately underlying the sands and shales of the Simpson formation in northern Oklahoma.

This formation varies from white to brown in color and from dense to coarsely crystalline in texture, as found in drill cuttings and in occasional fragments obtained when a well is shot. No quantitative analyses are available but from rough tests made on samples from various wells the magnesium content is estimated to be somewhere between 20 and 40 per cent and wherever tested is consistent throughout the entire thickness of the formation.

Chert nodules of various sizes are scattered irregularly through this dolomitic mass. In most cases this chert is composed of a mass of oolites, which in cross section generally show radiating and branching channels rather than the concentric layers of common oolites. In a few cases, zones are found in the Siliceous lime which are composed of fine, perfectly formed crystals of brownish dolomite in a white, porcellanous chert matrix. These fine crystals and the oolites are most abundant in the "pay zones" in certain fields, while in other localities the drill cuttings show only a fissured or channeled condition where oil is encountered in the dolomite. These fissures are lined with perfectly formed crystals of dolomite showing that solution and deposition has taken place after the deposition of the beds and it is this secondary solution which is probably responsible for the porosity of the "pay zones."

The drill cuttings of this dolomite have a characteristic sugary appearance which frequently leads the drillers to log it as sand or sandy lime. This misconception is apparently confirmed by the fact that the chert content is usually sufficient to "cut" the bit, and also by the fact that the dolomite effervesces only slightly in cold acid.

12. Aurin, F. L., Pre-Pennsylvanian oil and gas horizons in Kay County, Okla.: Bull. Amer. Assoc. Pet. Geol., Vol. 4, No. 2, 1920.

However, in hot acid it effervesces rapidly and under a glass of 15 power or higher the typical rhombohedral cleavage blocks of the dolomite are easily seen. The chert is also easily differentiated from sand by the conchoidal fracture and the fact that it is opaque or nearly so.

### STRUCTURE AND GEOLOGIC HISTORY

Oil accumulation in this area, with one or two minor exceptions, is associated with distinct structural features in contrast with some of the fields in eastern Kansas and the Okmulgee and Osage districts of Oklahoma which produce from lenticular sands not associated with structure.

Our knowledge of the geologic history of the subsurface formations of this area, as furnished by well cuttings and records, extends back to early Ordovician. With one exception wells have not gone deeper than the upper 300-400 feet of the Siliceous lime (Cambro-Ordovician). This exception, a well in T. 28 N., R. 3 E., reached the arkose at approximately 4,800 feet, after penetrating 1,010 feet of Siliceous lime.

The deposition of the first sediments laid down upon the granite occurred from Cambrian to the close of Hunton time, and includes the upper Arbuckle, Simpson, Viola, Sylvan, and Hunton formations. This period of sedimentation was followed by a period of emergence when the above formations were tilted and eroded.

The next structural movement affecting the formations occurred in the pre-Chattanooga time and is thought to have been caused by the Ozark uplift and as a result the pre-Chattanooga formations were tilted in a southwest direction. This uplift was followed or accompanied by erosion which truncated the upfolded formations from the Simpson to the Sylvan (and possibly Hunton), leaving their surfaces exposed in broad belts. This uplift has caused a regional dip of 55 feet per mile through the Ponca City field and 42 feet per mile through the Garber area. It is possible that there was some movement in the granite basement before this time, but there is not sufficient evidence available at the present time to discuss this phase of the problem.

Following the pre-Chattanooga period of uplift the formations from the Chattanooga black shale to the top of the Mississippi lime were deposited, after which there was another period of emergence accompanied by folding, faulting and erosion.

This structural movement, from present available data, occurred at the close of Mississippian time. There is no doubt as to the pre-Pennsylvanian age of the movements. There are two distinct faults, one in the Thomas pool and one in the Tonkawa area, that have involved the pre-Pennsylvanian rocks. In these pools there is also evi-



dence of erosion at the close of the Mississippian time which has in most cases concentrated the upper chert member of the Mississippi lime on the flanks of the folds. On the crests of the Thomas and Tonkawa folds the drill passes from the Cherokee shales into the "white lime" (Viola limestone) or Wilcox sand.

These movements have resulted in two major lines or trends of folding in this region. The more positive one (here named the Blackwell Anticline) includes from north to south, the Dilworth, Blackwell, Retta, Thomas and Garber pools. This trend of folding is believed to be an extension of the granite ridge or Nemaha Mountains of Kansas. With one exception, as already mentioned, granite has not been encountered in any of the wells in this area. The other line of folding (named the Ponca Anticline on Map No. VIII), believed to be an extension of the Beaumont and Dexter folds of Kansas, passes through the Mervine and Ponca pools. The Tonkawa and Billings pools seem to lie on a separate trend from these folds. This ridge is terminated by the fault on the north edge of the Tonkawa field, and if extended to the north, encounters the large syncline which lies between the Ponca and Blackwell folds. It is probable that the Ponca anticline is younger than the Blackwell anticline because erosion has not here removed the Mississippi lime.

An interesting feature involving structure is found in a line of domes found between Tonkawa and Peckham. These folds are situated in the regional syncline between the Ponca and Blackwell anticlines and are not connected with the Tonkawa structure. These structures have practically no production while production is found in the fields to the east and west.

All of the folds in this area were eroded contemporaneous with or subsequent to uplift, which resulted in the exposure of the older formations on the crests of the anticlines. The amount of strata removed varies from a part of upper Mississippian to the entire section from the top of the Mississippi lime to the upper Siliceous limestone, the amount of removal depending upon the amount of the structural relief (see table, page 82). The whole section has been eroded from the crest of the Garber structure, where approximately 750 feet of sediments have been removed.

The character of the rocks at the surface during this pre-Pennsylvanian erosion interval was such that anticlinal valleys were not formed. Had the Mississippian been composed of thick shales and interbedded hard, resistant limestones and sandstones it is probable that anticlinal valleys would have resulted. The section, being made up of large thicknesses of resistant beds and a few thin beds of the less resistant shales resulted in anticlinal hills. These hills in turn reflected themselves in the subsequent formations resulting in the present surface structures. The possibility of subsequent folding in the formation of surface structure should be considered, as it is not probable that all of

the surface structure is due to the reflection of these buried hills. There is Permian or post-Permian faulting in the Retta area, and some indications of post-Permian faulting is found in the Braman area. However, the most important factor in the formation of surface structure is the differental deposition and settling of the Pennsylvanian and younger sediments on this old topography.

*Effects of pre-Pennsylvanian uplift and erosion.*

| Pool | Structural Relief of Ordovician | Present Topographic Relief of Pre-Pennsylvanian Surface | Difference, or Thickness Removed by Erosion | Interval Between Base of Oswego and top of Pre-Penn-Surface |
|---|---|---|---|---|
| GARBER | 1750 | 1000 | 750 | 50 |
| RETTA | 1000 | 550 | 450 | 50 |
| OTSTOT | 1000 | 650 | 350 | 75 |
| DILWORTH | 950 | 600 | 350 | 100 |
| DEER CREEK | 1250 | 800 | 450 | 100 |
| TONKAWA | 900 | 500 | 400 | 185 |
| S. BILLINGS | 1100 | 750 | 350 | 100 |
| PONCA | 500 | 375 | 125 | 325 |
| MERVINE | 525 | 400 | 125 | 150 |
| THOMAS | 1000 | 600 | 400 | 50 |

Following this hiatus came the period of deposition during which all of the Pennsylvanian and Permian sediments were deposited. In Cherokee time a mantle of shale containing some fine grained sands (Burbank) was spread over the entire area. It attained considerable thickness in the valleys and was very thin on top of the highest hills which were at times islands in this early Cherokee sea. Before the close of Cherokee time all the pre-Pennsylvanian islands had been completely submerged, as evidenced by the fact that the Oswego-Big lime series extends without interruption over the entire area. The minimum shale interval between the base of the Oswego and the erosion surface on top of the highest pre-Pennsylvanian hill is about 50 feet.

In this area there was a period of practically uninterrupted deposition from Oswego to the youngest Permian beds. The structure of these beds is a modified impression of the underlying pre-Permian topography. Little is known in detail of the history of the region after this time, except that the area has been distinctly positive and undergoing erosion. It may be that the Tertiary alluvial fan, which spread eastward from the Rocky Mountains once covered this region, and was removed by subsequent erosion. Structurally there has been some faulting of the Permian beds, as in the Retta area, of which little is now known.



## PONCA FIELD

The Ponca field is located in secs. 4, 5, 7, 8, 9, 17, 18, and 19, T. 25 N., R. 2 E., Kay County.

### HISTORY

This was the first field to be discovered in the north-central Oklahoma district. In December, 1907, E. W. Marland, a Pennsylvania oil operator, with others visited Kay County to investigate the possibilities for oil. He was impressed with the Ponca area, and after securing a lease from Miller Brothers started a well in February, 1909. This was the first well west of the Osage, consequently many difficulties were encountered in moving in material. The nearest supply house was located at Tulsa, 120 miles distant, and from there the heavy material was transported. The initial well never reached the producing sand, was abandoned, and another started five miles distant. This second well, a gasser, came in in the spring of 1910. At this time the 101 Ranch Oil Co. was organized by Marland and his associates, which continued operations until 1917. This company developed the "1,500 foot" sand, drilling eight gas wells before oil was found. The first oil well in the field was brought in as the Willie Cry No. 1, SE.¼, sec. 8, T. 25 N., R. 2 E. and made 120 barrels in the "1,500 foot" sand after being shot.

In 1917 the Marland Refining Co. took over the entire acreage of the field and developed the "2,100 foot" sand, and next year the "3,800 foot" sand.

### STRUCTURE

The oil accumulation in the Ponca field is found in a pronounced anticlinal fold (Map No. X) trending northeast-southwest. The surface structure is somewhat obscure, but the folding becomes more pronounced with depth. The approximate structural relief on the Wilcox is 500 feet. The east dip from the crest of the structure is extremely steep, approximately 400 feet for the first half mile on the Mississippi lime and 150 feet on the "1,300 foot" sand. The interval between the base of the Oswego and the top of the pre-Pennsylvanian surface is 325 feet which is probably the greatest to be found in the entire area.

### PRODUCTION

There are a number of producing horizons in the Ponca field. The following table shows the various sands.

*Producing sands in the Ponca field.*

| Depth | Thickness | Production | Horizon |
|---|---|---|---|
| 500 | 20 | *10 | Basal Permian |
| 900 | 18 | *8-10 | Grayhorse(?) |
| 1,300 | 30 | *10 | Bird Creek, Turkey Run |
| 1,500 | 18 | 40-150 | Ponca (U. Hoover). |
| 1,600 | 15 | Good Show | L. Hoover |
| 1,800 | 16 | 30-200 | Endicott |
| 2,100 | 40 | 30-200 | Bigheart |
| 3,600 | 50 | 75-150 | Mississippi Lime |
| 3,900 | 40-90 | 100-800 | Wilcox |

Average gravity 40.6 *Million feet of gas.

## NEWKIRK-MERVINE FIELD

The Mervine field is located in secs. 2, 3, 10, 11, 14, and 15, T. 27 N., R. 3 E. and sec. 35, T. 28 N., R. 3 E., Kay County.

### HISTORY

The first important oil well was drilled in this field in 1913 on the Murdock farm in the NE. cor. SE.¼ sec. 2, T. 27 N., R. 3 E. and had an initial production of 100 barrels. This is the first oil well to be drilled on a published structure, which was made by the Oklahoma Geological Survey in 1913. The discovery well was followed by a number of good wells which made from 500 to 1,000 barrels each from the "1,000 foot" sand. These wells did not hold up their production, and interest in the area lagged until July, 1918, when the Carter Oil Co. and the Southwestern Petroleum Co. drilled a well on the McClasky farm in NW. cor. SW.¼, NE.¼ sec. 15, T. 27 N., R. 3 E. which made a good producer in the "3,200 foot" sand. In December of the same year the Carter-Hays No. 3, in sec. 15, made an initial production of 2,000 barrels from around 3,100 feet. The production of this well has held up remarkably considering the rapid decline of wells subsequently drilled.

Late in 1916 Marland opened the North Newkirk field with a 28,000,000 foot gas well on the McMichael farm in sec. 17, T. 28 N., R. 3 E. The gas from this well was used to supply the towns of Ponca City, Newkirk, Kildare, and Tonkawa for about three years. The finding of gas lead to further drilling and in July, 1919, Marland's No. 1 Hieberson made 200 barrels in the top of the Mississippi lime. The same year Marland drilled a 500 barrel well in sec. 16, T. 29 N., R. 3 E. in the Chilocco district.

### STRUCTURE

The structure of the Mervine is a continuation of the Ponca fold and lies on the main line of folding extending south from the Beaumont and Dexter folds in Kansas. See Map No. VIII and Fig. 6). This structure was mapped in 1912 by Ohern and Garrett of the Oklahoma Geological Survey after being discovered by Gould in 1901, while making a reconnaissance of this general area. The fold has a structure relief of 535 feet on the Wilcox and an east dip of 220 feet in a half mile on the "1,000 foot" sand in sec. 2, T. 27 N., R. 3 E. The axis of this fold trends about N. 20° E., with the crest in the center of section 2.

Northeast of Newkirk in secs. 8 and 17, T. 28 N., R. 3 E., is a small dome about a mile in areal extent and which is also a topographic high, being almost coincident with the highest hill in the region.



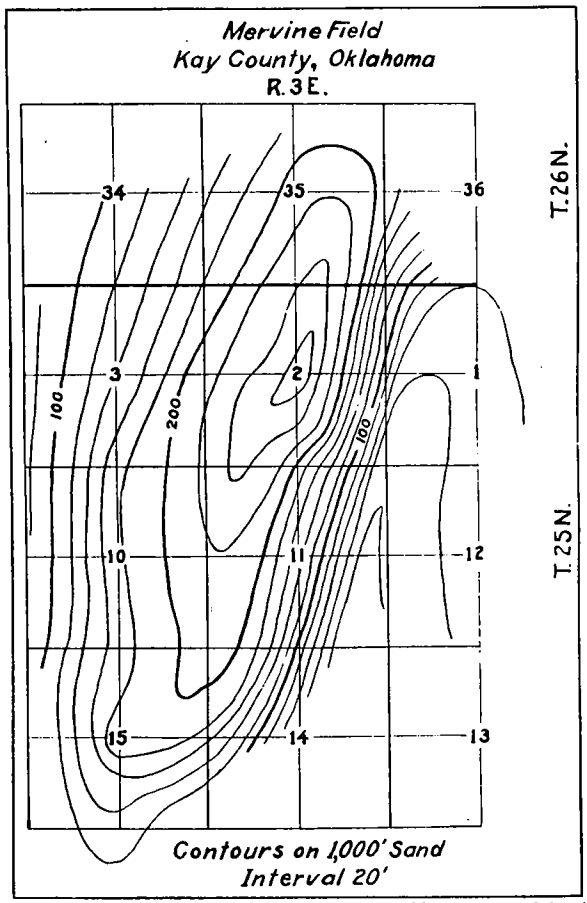



Figure 6.—Structure map of Mervine field (1,000 foot sand horizon).

### PRODUCTION

There are five producing sands in the Mervine pool. The "1,000 foot" or Mervine sand is continuous over the pool and produces on the highest part of the structure. The next three sands are productive

only locally. The deep sand, 3,100 feet, is the equivalent of the Burbank (?) and produces in the southern part of the field.

*Producing sands in the Mervine pool*

| Depth | Thickness | Production | Horizon |
|---|---|---|---|
| 1,000 | 26 | 20-400 | Newkirk |
| 1,250 | 15 | 10-41 | Hoover |
| 1,500 | 15 | 50-250 | Endicott(?) |
| 1,800 | 22 | 5-40 | Stalnaker(?) |
| 3,100 | 50 | 50-400 | Burbank |

Average gravity 40.6

## BLACKWELL FIELD

The Blackwell field is located in secs. 29, 30, 31, and 32, T. 29 N., R. 1 E., secs. 5, 6, 7, 8, 17, 18, 19, 20, 29, and 30, T. 28 N., R. 1 E., and in secs. 1, 12, 13, 23, 24, 25, 26, 35, and 36, T. 28 N., R. 1 W., Kay County.

### HISTORY

In 1912 the north end of this field was developed by Marland and others which resulted in 21 gas wells out of 37 completions. Previous to this there had been some development by local people, but much difficulty was experienced in drilling through the red beds. Real interest in the field started in 1914, when one oil well making 600 barrels and a number of good gas wells were drilled. This first oil well was located in NE. cor. sec. 29, T. 29 N., R. 1 E. and since then the field developed to the south with the bringing in of a number of good wells. The Duluth-Oklahoma Company drilled a well in sec. 1, T. 28 N., R. 1 W. which started off with a 2,000 barrel production and which produced a half million barrels within a year. The field was finally extended five miles south of the first well. It is not known who discovered the field, but it was mapped by L. E. Trout for the Oklahoma Geological Survey.

### STRUCTURE

The surface structure is very hard to map because of the indefinite nature of the outcrops of shale occurring in the area, and the complex nature of the fold as shown by subsurface work. The structure (Fig. 7) is made up of two highs in north-south alignment, separated by a saddle. The fold is an extension of the granite ridge of Kansas and is on the Garber, Thomas, Otstot line of folds in Oklahoma.

### PRODUCTION

There are at least two producing horizons in this field, ranging from lower Permian to Ordovician (Wilcox) in age.



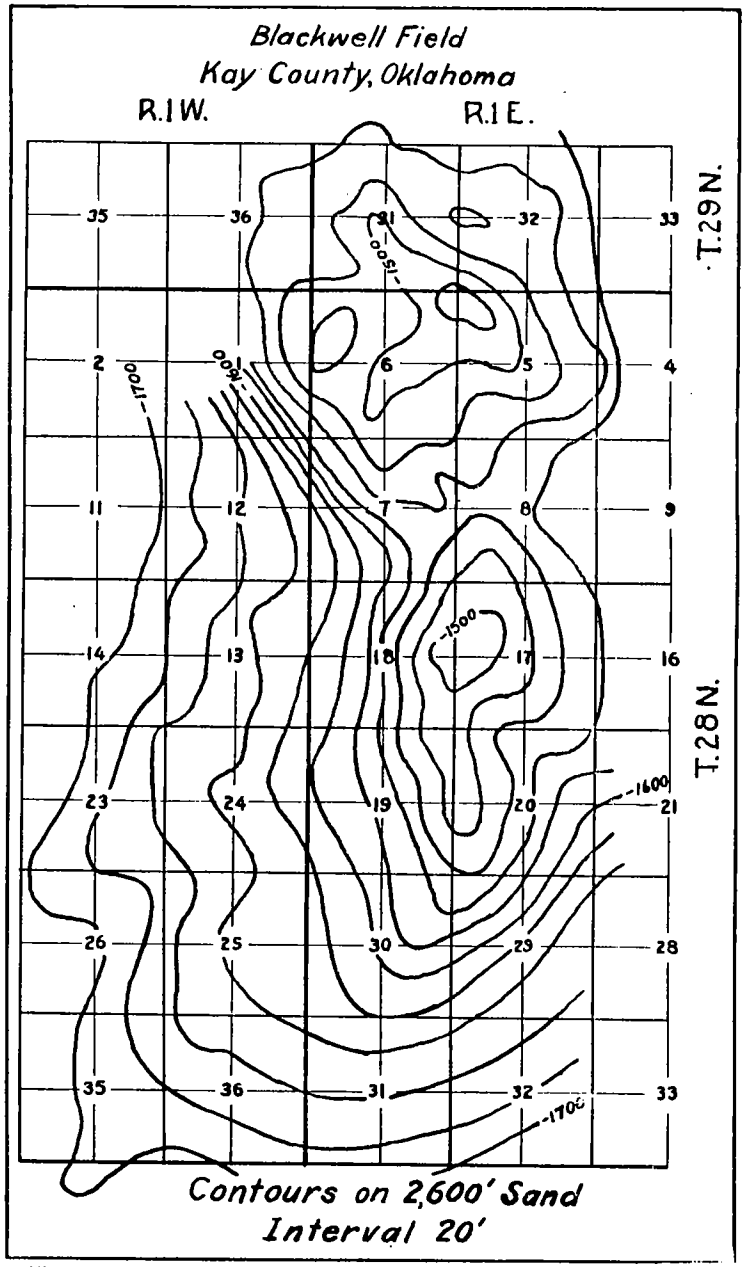



Figure 7. Structure map of Blackwell field (2,000 foot sand horizon).

*Producing sands of the Blackwell field.*

| Depth | Thickness | Production | Horizon |
|---|---|---|---|
| 700 | 6 | *10 | Just above Neva |
| 1,400 | 20 | *2-35 | Newkirk (?) |
| 1,600 | 10 | 100-450 | Ponca (Upper Hoover) |
| 1,750 | 15 | 100-1,350 | Lower Hoover |
| 1,900 | 20 | 20-1,200 | Endicott (?) |
| 1,950 | 13 | to 1,000 | Revard (?) |
| 2,200-2,300 | 32 & 23 | *5-20 | Stalnaker (Tonkawa) |
| 2,600 | 75 | *5-20 | Layton |
| | | 100-2,000 | |
| 3,300 | 100 | *3-45 | Wilcox |

Average gravity 38. *Million feet of gas

### BILLINGS FIELD

The Billings field is located in secs. 15, 16, 21, and 22, T. 23 N., R. 2 W., Noble County.

#### HISTORY

This field is the result of drilling in NE. cor. NW.¼ secs. 22 and 23, on a structure mapped by geologists of the Midco Petroleum Co. of Tulsa. It produced 250 barrels from a sand at 2,136 feet. In June, 1919, this well was deepened and produced 50 barrels at 2,351 feet, and in September it was deepened a third time to 5,031, where it was abandoned. A show of oil between 4,100 and 4,200 feet caused the drilling of another well which produced 35 barrels at 4,176 feet. Two wells to the Wilcox made small amounts of oil. The pool covers a small area and development was slow.

#### STRUCTURE

A subsurface contour map of this field shows a well defined dome, which, unlike most fields in this area does not have a tendency to elongate in any direction. The closure of the dome amounts to approximately 500 feet covering an area of 10 square miles, but the producing area is limited to about one square mile with a closure of about 250 feet.

#### PRODUCTION

Oil and gas are found at a number of horizons in this field. Many of the wells had a large initial production, but speedily declined to a settled production averaging 15 barrels per well.

*Producing sands in the Billings field.*

| Depth | Thickness | Production | Horizon |
|---|---|---|---|
| 450 | 20 | | Herington |
| 625 | 10 | *1-3 | Above Fort Riley |
| 725 | 5 | | Matfield Shale |
| 950 | 6 | *1-6 | Below Crouse Limestone |
| 2,050 | 30 | 100-1,500 | U. Hoover |
| 2,200 | 50 | 3-10 | Lower Hoover |
| 2,400 | 25 | 50-100 | U. Nekagony formation |
| 2,750 | 75 | 50-100 | Tonkawa |
| 4,100 | 65 | 35 (1 well) | Mississippi lime |

Average gravity 43. *Million feet of gas



Dry holes have been drilled on all sides of production so that the prospects for extensions of this pool are not good. The fact that the two Wilcox wells did not yield production of any consequence shows that the field has been completely developed.

### GARBER FIELD

The Garber field is located in secs. 18 and 19, T. 22 N., R. 3 W. and secs. 13 and 24, T. 22 N., R. 4 W., Garfield County.

#### HISTORY

The discovery well on the Hoy farm in the NE. cor. sec. 25, T. 22 N., R. 4 W., was brought in by the Sinclair interests in September, 1917 shortly after the discovery of the Billings field. The "Hoy" sand named after the owner of the farm, produced 100 barrels at 1130-56 feet. The development proceeded fairly rapidly following the completion of the Sinclair well. The Roxana Petroleum Corpora-

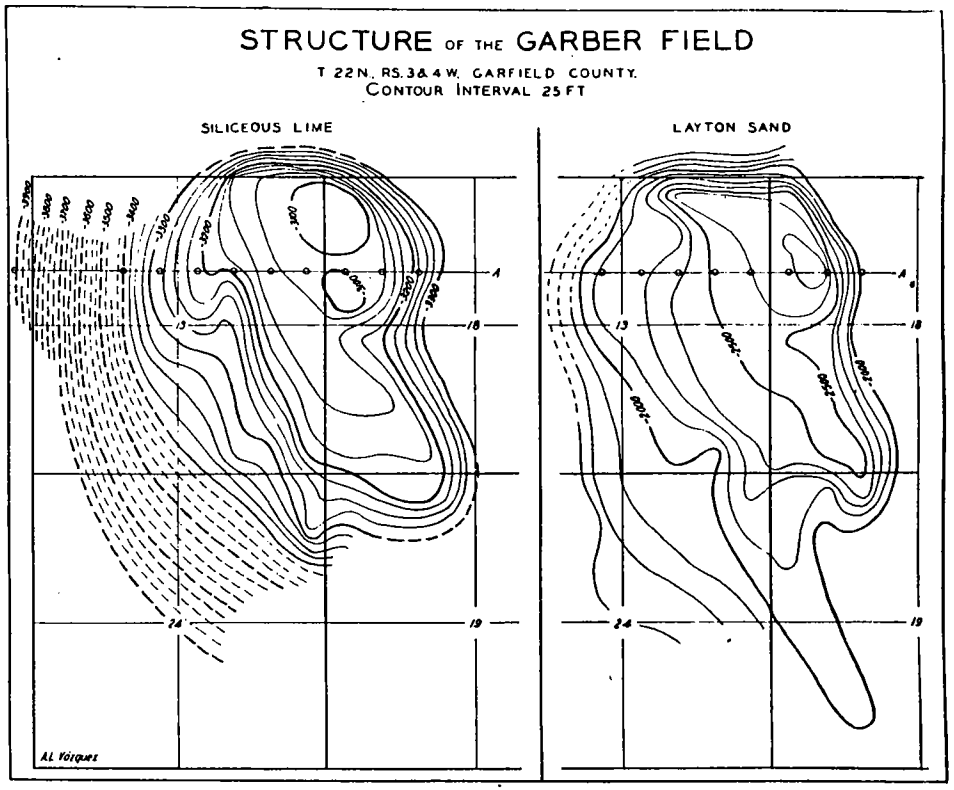



Figure 8.—Structure maps of Garber field (Layton and Siliceous lime horizons).

tion, Healdton Oil & Gas Co., Cosden Oil & Gas Co., Marland Refining Co., and Atlantic Petroleum Co., all had tracts close to the discovery well and immediately started drilling.

### STRUCTURE

The location of the first drilling in the Garber area was the result of the indication of subsurface structure mapped on the surface formations. The outcrops are in cross-bedded sandstones with intervening shales, which vary greatly in horizontal extent. However, it was possible to map the presence of the structure in a general way, but its extent was unknown before drilling. Subsurface structure (Fig. 8 and Map No. XI) in the shallow zones is extremely difficult of solution because of the irregular and lenticular character of the sand bodies. Perhaps the true interpretation of the Garber structure can be obtained only from data gathered from the deeper sands.

The structure as worked out on the top of the Siliceous lime is apparently a topographic high on which the geologic section, from just below the Oswego-Big lime horizon to and including some of the Siliceous lime, is absent. The Mississippi lime, Chattanooga shale, Viola limestone, Simpson formation, and a part of the Siliceous lime were removed during this erosion interval. The thin section of Cherokee shales present is due to the fact that this old hill was an island, which was not submerged until late Cherokee time, giving about 60-75 feet of Cherokee shale over the crest of the high. This results in the contact between the Siliceous lime and the Cherokee shale. The geologic history of the Garber area is much the same as that of the Thomas and Tonkawa areas. The Wilcox is present only on the flanks of the fold. This contact between the Wilcox and the Siliceous lime roughly follows the 3,275 foot contour line, as shown on the accompanying cross-section (Map No. XI).

### PRODUCTION

The wells in the shallow lenticular sands decline rapidly to about 15 barrels per well while the production in the deeper and more regular sands is more steady. The field has been a profitable one because of the shallowness of the sands and the large number of producing horizons.

The largest initial production of any well in Oklahoma is the Sinclair Oil and Gas Co.'s Hartley No. 27 in the NW.¼ NW.¼ sec. 18, T. 32 N., R. 3 W. This well reached the Siliceous lime at 3,085 feet and produced as high as 27,000 barrels daily during its early history.



*Producing sands in the Garber field.*

| Depth | Thickness | Production | Horizon |
|---|---|---|---|
| 825 | 8 | | Winfield |
| 1,050 | 20 | 20-150 | Hoy sand |
| 1,360 | 10 | | |
| 1,470 | 15 | 20-150 | Above Foraker |
| 1,740 | 10 | | |
| 2,020 | 12 | 15-100 | U. Pennsylvanian |
| 2,100 | 12 | | |
| 2,200 | 5 | 25-200 | |
| 2,315 | 20 | | U. Hoover |
| 2,500 | 15 | | M. Hoover |
| 2,560 | 35 | | L. Hoover |
| 2,750 | 45 | | Endicott |
| 3,025 | 25 | | U. Tonkawa |
| 3,070 | 50 | | L. Tonkawa |
| 3,600 | 90 | | Layton |
| 4,160 | 20 | | Oswego—Big Lime |
| 4,250 | ? | | Wilcox on flanks of fold |
| 4,260 | 50+ | 5-10,000 | Siliceous lime |

## EAST BILLINGS FIELD

The East Billings field is located in secs. 20, 29, 30, 31, and 32, T. 24 N., R. 1 W. in Noble County. This field is sometimes known as the North Billings field.

### HISTORY

In 1916, shortly after the discovery of the Billings pool, operations were started on what was believed to have been a continuation of the line of folding running northeast. The U. S. Geological Survey had mapped a structure of sections 17 and 20, and the Humphreys Petroleum Co. started several wells which failed to produce, although some gas was encountered.

The Midco Petroleum Co. in November 1919, drilling in the SE. cor. sec. 30, brought in a 150 barrel well from a sand at 2,000 feet, which was the discovery well of this field. The pool is small, about one square mile in area, and is completely developed.

### STRUCTURE

The Billings production is on a small dome, less than a square mile in area, situated on the major fold running through the Tonkawa and South Billings fields. There are sufficient surface dips to show the presence of the reversal.

### PRODUCTION

Most of the production is obtained from the Upper Hoover sands just below 2,000 feet. Some gas has been found at 600 and 2,675 feet, and only a show of oil in the Mississippi lime at 4,300 feet.

## DEER CREEK FIELD

The Deer Creek field is located in secs. 14, 15, 22, 23, 26, and 27, T. 27 N., R. 3 W., Grant County.

### HISTORY

The discovery well is in NE. cor. SE.¼ sec. 22, completed in July, 1920 and produced about 18 million feet of gas from a sand at 2,440 feet. This well was later deepened to 3,350 feet and made 10 barrels of oil. The first oil produced came from the Western State's No. 1, Swaggert in SW. cor. SE.¼ SE.¼ sec. 15, which made 450 barrels at 2,950 feet. The Prairie Oil & Gas. Co. offset to this sand made 960 barrels at 2,925 feet.

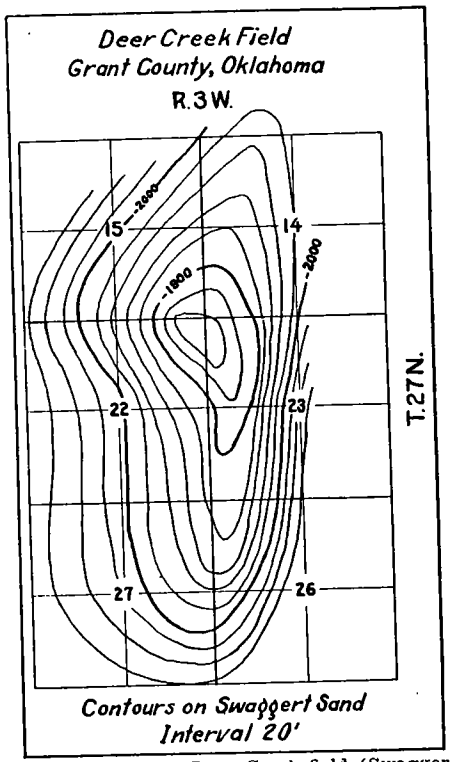



Figure 9.—Structure map of Deer Creek field (Swaggert horizon).

### STRUCTURE

The Deer Creek structure (Fig. 9) is a small elongated dome, about three times as long as wide, with the axis extending almost directly north and south. This structure is one of the most sharply folded in the entire area having 1,250 feet of structural relief on the



Ordovician, which is probably the cause of the large amounts of gas and small amounts of oil produced.

*Producing sands of the Deer Creek field.*

| Depth | Thickness | Production | Horizon |
|---|---|---|---|
| 1,300 | 23 | * 5-15 | Above Neva |
| 2,000 | 10 | *12-15 | Newkirk (?) |
| 2,400 | 20 | *10-15 | Lower Hoover |
| 2,900 | 30 | 960 | Swaggert (Tonkawa) |
| 3,000 | 10 | 15 | Layton |
| 3,900 | 20 | Gas | Wilcox |

*Million feet of gas.

## TONKAWA FIELD

The Tonkawa field is located in Tps. 24 and 25 N., R. 1 W., Kay and Noble counties.

### HISTORY

The Tonkawa field dates from June, 1921, when school land well No. 1, in NE. cor. sec. 16, T. 24 N., R. 1 W., was completed at a depth of 2,661 feet with an initial production of 850 barrels. The second well was completed three months later with an initial production of 3,300 barrels. These wells were in the Tonkawa sand. The fourth completion was a dry hole which was due to a tightly cemented sand. Dry holes were also drilled in NW.¼ sec. 10 and SW.¼ sec. 3, and the real importance of the field was not apparent until almost a year later when Carmichael No. 1, SW. cor. NE.¼ sec. 3 was brought in for 850 barrels in the Lower Hoover sand.

Development proceeded at a rapid rate during the latter part of 1922 and the first half of 1923. All of the wells at this time were producing from Pennsylvanian formations.

Development of the deeper sands in this general area began with the completion of Slick No. 1A, SW. cor. sec. 35, T. 25 N., R 1 W. in April, 1924. Well log correlations with deep tests placed the producing horizon in basal Cherokee or near the top of the Mississippi lime. Evidence later has led to the conclusion that the Mississippi lime is absent and that the Wilcox is found directly beneath the Pennsylvanian shales, as is the case in such fields as Eldorado (Kansas), Cushing and Blackwell.

In the following paragraphs by Glenn C. Clark[13], the stratigraphy and structure of this field is very clearly given.

13. Clark, Glenn C., Wilcox sand production, Tonkawa Field, Oklahoma: Bull Amer. Assoc. Pet. Geol., Vol. 10, No. 9, pp. 885-891, 1926.

## STRATIGRAPHY

Production at Tonkawa above the Wilcox sand is from five sand horizons included in a zone 750 feet in thickness, the top of which is 900 feet below the Pennsylvanian–Permian contact and the base about 1,450 feet above the base of the Pennsylvanian. This zone of producing sands is correlated with that part of the Osage County surface section between the Big Heart and Elgin sandstones. An average thickness of Permian over the higher part of the structure is 950 feet.

The Tonkawa sand, found at a depth of 2,450 or 2,500 feet, is the deepest producing horizon of the Pennsylvanian sands. The only prominent sand between the Tonkawa and Wilcox is the "3,100-foot" sand, which may be correlated in a general way with the Layton sand of the Cushing district.

The Oswego-Big Lime series is about 200 feet thick and is made up of prominent limestone beds. The individual members, however, are not easily correlated from well to well. The Cherokee shale is approximately 265 feet thick, with a persistent red shale bed about 215 feet below the base of the Oswego-Big Lime series. This red shale lies some 50 feet above the unconformity between basal Cherokee shale and the older formations.

The Mississippi lime on top of the structure is absent and increases in thickness toward the sides up to 150 feet in wells along the western edge of the field. The normal thickness in this general area to the east, where not influenced by folding, is about 300 feet. The upper 50 to 75 feet are light-colored chert, commonly called the "chat" producing horizon; the remainder is dark gray to dark limestone.

Underlying the Mississippi lime is about 30 feet of black shale, generally recognized as Chattanooga. This shale does not cave like the dark shale found just above the Mississippi lime.

Overlying the Wilcox sand and just below the Chattanooga shale is a light-colored, crystalline limestone about 30 feet in thickness. This limestone has the same characteristics as its equivalent in the Okmulgee district, the "White lime," and is so called at Tonkawa. It is correlated with upper Viola of the Arbuckle section. The lower part of this formation produces some oil. In some cases the upper part carries water.

The Wilcox sand varies from the tight quartzitic type to the loosely cemented, clear, well-rounded sand, characteristic of Wilcox over Kansas and Oklahoma. As found in the few wells that have been drilled into the Siliceous lime below, the Wilcox has a thickness of 280 feet. No attempt is made to subdivide the Wilcox except in a general way, based partly on producing zones. Due to the difficulty in securing samples from flowing wells, little is known as to whether correlations may be made from well to well on lithologic characteristics of horizons within the upper, productive part of the Wilcox. As in many other fields, the green shale formation divides the upper and lower Wilcox but, in the writer's opinion, this is the only means of subdivision at the present time.

The first pay zone includes about 40 feet of sand immediately below the "White lime" and the second includes that between 60 to 120 feet in the sand. There seems to be a non-productive zone of 20 to 30 feet in thickness between these two pay horizons. The upper 100 to 120 feet of Wilcox sand have no shale breaks of consequence. Immediately below this is found a dark shale bed about 30 feet thick. In general appearance this shale is not unlike the Chattanooga, but upon careful examination shows a certain resemblance to the green shale associated with the Wilcox sand. Included between the base of this shale and the top of the Siliceous lime are interbedded sand and dark shale beds. No increase in production has been found in this lower phase of the Wilcox.



The uncommon amount of shale associated with the Wilcox sand probably is an important factor in the high oil recovery at Tonkawa. The fact that this shale is much darker in color than the ordinary green shale of this horizon is also significant in this respect.

The Siliceous lime has proved productive in two wells, Gaume 14 W, and C. C. Endicott 8 W, but the results have indicated that large production is not to be expected from this horizon. Experience in other fields has been that where either the Wilcox sand or the Siliceous lime is highly productive little may be expected from the other.

## STRUCTURE

The Tonkawa structure lies between the alignment of granite-ridge structures including Eldorado, Oxford, Blackwell, Retta, Thomas, and Garber and the less prominent line of folding through the Beaumont, Dexter, Newkirk, and Ponca fields. Though apparently not connected with either of these, it has a close resemblance to the typical granite-ridge structures. (See Map Nos. VIII, XII and XIII).

The major part of the folding connected with the Tonkawa structure must have taken place at the close of Mississippian or during early Pennsylvanian time. The presence, in the immediately surorunding area, of Mississippi lime in approximately full thickness would indicate that conditions were stable during the time of its deposition. This folding and the faulting along the northeastern edge of the field were probably a part of the same general movement. Subsequent erosion removed the Mississippi lime from the higher part of the fold and the white lime from the extreme peak. After this period of erosion, followed by submergence, Pennsylvanian sediments were deposited over the truncated edges of the pre-Pennsylvanian formations.

The topography of this erosion surface was reflected in diminishing degree as deposition continued. A structure map contoured on any Pennsylvanian horizon would represent, in a general way, this topography. A comparison of the structure map contoured on the lower Hoover sand (Map No. XII) with that contoured on the white lime (Map No. XIII) is, excepting in degree of dip, essentially a comparison of the pre-Pennsylvanian topographic map with the structure map of the pre-Pennsylvanian formations. Attention is called to the difference in size and apparent difference in lateral position of the area inclosed within the highest contour in the comparison of the two structure maps. As seen in the cross-sections (Map No. XIII), the wedge-shaped remnant of Mississippi lime along the western flank of the fold has been largely responsible for these differences. Such influence on the east side is removed by the fault of over 300 feet throw. It seems that the white lime "high" lies east of the lower Hoover "high," thus indicating a shifting eastward with depth. It will be noted, however, that the east dip of each begins at practically the same point, and the difference in appearance is due to width and degree of dip.

The dip of Pennsylvanian and Permian formations along the southeast side of the field is more pronounced than that along the northeast side. This steep southeast dip into a prominent

syncline is continuous along the east side of the pool in secs. 29 and 30, T. 24 N., R. 1 W., and the old Billings pool in T. 23 N., R. 2 W. These three pools are located on the same general line of folding, but extensions north and south are not evident. Unfortunately, drilling has not given sufficient information on the east dip to disclose whether or not this is due to faulting.

The limit of Wilcox sand production on the southwest side of the field is defined by a contour approximately 300 feet lower than the top of the structure. The position of this contour is followed by contours on shallow sands from 50 to 80 feet downdip. The northwest extension is the only part of the field in which the limit of Wilcox production equaled or exceeded that of the shallow sands.

### PRODUCTION

Total Wilcox sand production to January 1, 1926, was 28,305,000 barrels, an average of 21,443 barrels per acre over the 1,320 acres that produced oil from this horizon. Similar production from shallow sands to the same date was 49,258,000 barrels, an average of 18,729 barrels over 2,630 acres.

*Producing sands of the Tonkawa field.*

| Depth | Thickness | Production | Horizon |
|---|---|---|---|
| 725-825 (5 sands) | 5-10 | *5-12 | Above Neva (Hotson?) |
| 1,350 | 6 | (small) | |
| 1,500 | 17 | | Bet. Foraker and Elgin |
| 1,750 | 18 | *10-30 | (Newkirk) |
| 1,800 | 16 | (small) | Upper Hoover |
| 1,825-75 | 48 | | Middle Hoover |
| 1,950 | 25 | *6-12 | Lower Hoover |
| 2,025 | 5 | 50-250 | Carmichael |
| 2,100 | 6 | 100–600 | Endicott |
| 2,400-2,500 | 100 | 1,000-3,000 | Tonkawa |
| 4,100 | 285 | Av. 250 | Wilcox |

*Million feet of gas.

## THOMAS FIELD

The following discussion by Stuart K. Clark[14] gives an excellent idea of the peculiar conditions encountered in the Thomas Pool.

### LOCATION

The Thomas field is located in the center of T. 25 N., R. 2 W., Kay County, Oklahoma, about 6 miles northwest of the Tonkawa oil field.

### HISTORY

The discovery well of the Thomas field, Marland Oil Company's Thomas No. 1, was drilled on the strength of structural information obtained by core drilling. It was completed in May, 1924, as a 250 barrel well in sand encountered at a depth of 2,055 feet, which is hereafter called the Thomas sand.

The drilling campaign which followed this discovery was short-lived. Only two additional producers, Twin State Oil Company's Siler No. 1, in the NW. cor. sec. 22, and Carter Oil Company's Turk No. 1, in the NE. cor. sec. 21, were found at this horizon. The other drilling wells either missed the sand entirely or found it carrying water. All of them, except Marland's Thomas No. 2, in the SE. cor. SW. ¼ SW. ¼ sec. 15, were shut down. It was drilled deeper, and in May, 1925, was completed as a 3,600 barrel well in the Wilcox sand. The top of the sand was found at 3,955 feet, and the well, as finally completed, penetrated the sand 91 feet.

A second drilling campaign was immediately begun. It resulted in the finding of eleven producing wells in the Wilcox sand, and three additional producing horizons. In the order of their discovery these horizons were: the chert at the top of the Mississippi lime, with four producing wells, the 2,600-foot, or Turk sand with two wells and a 1,900-foot sand with one well. The development of the field at the present time is practically complete.

### PRODUCTION

The Thomas field has produced to date 3,000,000 barrels of oil. Its present daily average is 7,000 barrels, and its ultimate total production is estimated at approximately 4,500,000 barrels.

The major portion of the oil has come from the Wilcox sand. The initial production of the wells in this horizon ranged as high as 6,500 barrels per day. The maximum initial production of wells producing from the chert at the top of the Mississippi lime was about 250 barrels. The Turk sand wells produced about 75 barrels per day. The largest initial production from the Thomas sand was 350 barrels. The one well in the 1,900-foot sand started at 400 barrels a day but declined very rapidly.

The oil produced is the high gravity (42°-44° Baume) green oil which is characteristic of this general district. Open flows of from 10,000,000 to 30,000,000 cubic feet of gas were encountered by several wells in a sandy lime in the Permian rocks at a depth of 1,200 feet.

### STRATIGRAPHY

Rocks of Permian age are found from the surface to a depth of 1,200 to 1,300 feet. They include a series of alternating gray and red shales about 450 feet thick at the top; a series of thin gypsums or anhydrite beds (logged as limestone by the drillers) separated by gray shales, with a total thickness of 150 feet; and a series of alternating limestones and red shales about 600 feet thick, with the Herington limestone at the top and the Neva limestone at the bottom.

The Pennsylvanian system includes a maximum thickness of 2,800 feet of blue and gray shales, limestones, and sandstones. The prominent limestones include the Foraker, Pawhuska, Oread, and the Oswego-Big lime group. The most prominent sandstones include the Hoover sand series, the Endicott sand series, and the Layton sand. The Tonkawa sand is represented only by a sandy shale zone over the top of the fold. Thin beds of red rock are found at the top of the Endicott sand zone and a short distance above the base of the Pennsylvanian.

The Mississippian system is represented by the Mississippi lime, with a maximum thickness of 300 feet. It varies from a gray to dark brown or black cherty limestone, with a variable thickness of residual chert at the top.

The Chattanooga shale, a black carbonaceous shale containing a considerable amount of iron pyrites, has in the past been referred to the Devonian system, but some recent workers are in-

14. Clark, Stuart K. Thomas Oil Field, Kay County, Oklahoma: Bull. Amer. Assoc. Pet. Geol., Vol. 10, No. 7, pp. 643-653, 1926.

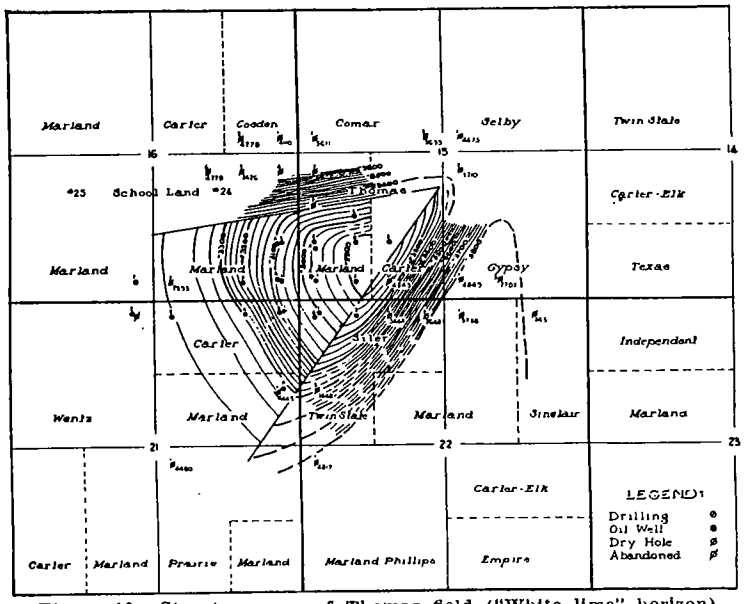



Figure 10.—Structure map of Thomas field ("White lime" horizon).

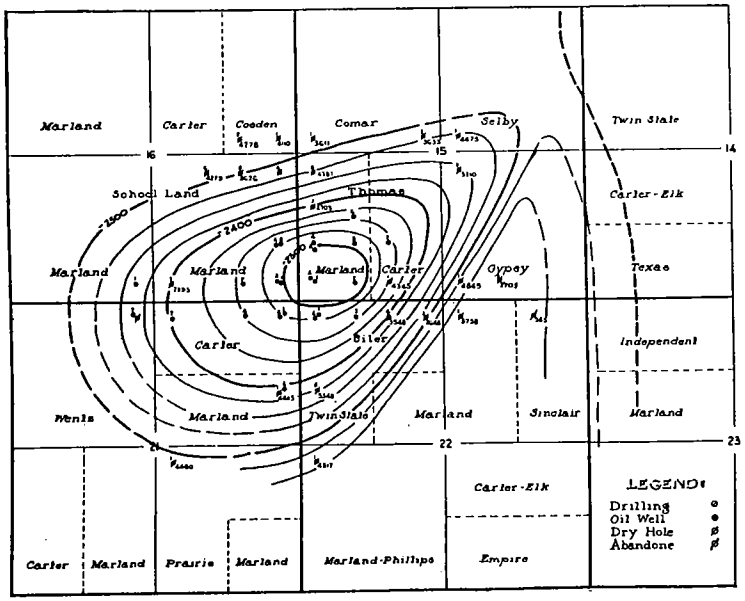



Figure 11.—Structure map of Thomas field (Layton horizon).



clined to place it in the Mississippian. It has a uniform thickness of about 30 feet.

Rocks of strictly Ordovician age in this area include the "white lime" and the Simpson formation. As the name implies, the "white lime" is a white to putty-colored limestone about 15 feet thick, which is believed to be the equivalent of the upper part of the Viola limestone.

In the Tonkawa field the thickness of the Wilcox member is about 120 feet. The remainder of the Simpson section there consists of alternating beds of black and green shale and thinner beds of sandstone similar in character to the Wilcox sand.

Below the Simpson formation is an unknown thickness of the "Siliceous lime" of Cambro-Ordovician age.

## STRUCTURE

The Thomas field lies on a major line of folding passing through the Blackwell, Otstot, Retta, and Garber fields. The structure and geologic history of all these fields are closely related. (See Figs. 10, 11,12 and 13).

From the evidence now available it appears that the first local structural movement affecting this area came at the close of Mississippian time. As a result of this movement a wedge-shaped segment of the pre-Pennsylvanian rocks was elevated approximately 1,000 feet above the adjoining area. The structure developed by this movement is indicated on the structure map by contours drawn on top of the "white lime" (Fig. 10).

During, and subsequent to the elevation of this wedge, erosion altered its topography by removing from its crest between 300 and 400 feet of sediments, including all the Mississippi lime, the Chattanooga shale, the "white lime" and part of the Wilcox sand, thus leaving an inlier of Wilcox sand exposed at the top and the truncated surfaces of the "white lime," Chattanooga shale, and Mississippi lime successively exposed on the flanks. Beds of residual chert, presumably resulting from the concentration of the silica originally present in the eroded portion of the Mississippi lime, accumulated on the slopes of the hill.

The original form of the hill was further modified by a reduction in the height of the fault scarps; that is, the areas immediately adjacent to and on the upthrown sides of the faults, being more exposed, were reduced more by erosion.

The two cross-sections, A-A and B-B (Figs. 12 and 13), show in vertical section the relation between the pre-Pennsylvanian structure and topography, and give an accurate impression of the amount of material removed by erosion.

Following this period of erosion the pre-Pennsylvanian hill was gradually submerged and eventually buried under several thousand feet of sedimentary rocks. For a time, however, the top of the hill formed an island in the Pennsylvanian sea. This is indicated by the fact that the first beds deposited on the flanks of the hill do not extend over its crest; and also by the fact that the crest of the hill contributed some material in the form of Wilcox sand grains and small fragments of green shale to the earliest Pennsylvanian bed, the shale between the red rock and the top of the Mississippi lime.

But even after this hill was completely buried its presence influenced the entire subsequent geologic history of the area. In fact, the structure of the younger rocks is simply a modified likeness of the topography of the buried hills. The degree of likeness decreases steadily upward; that is, the folding of the successive beds becomes less pronounced, the dips becoming more

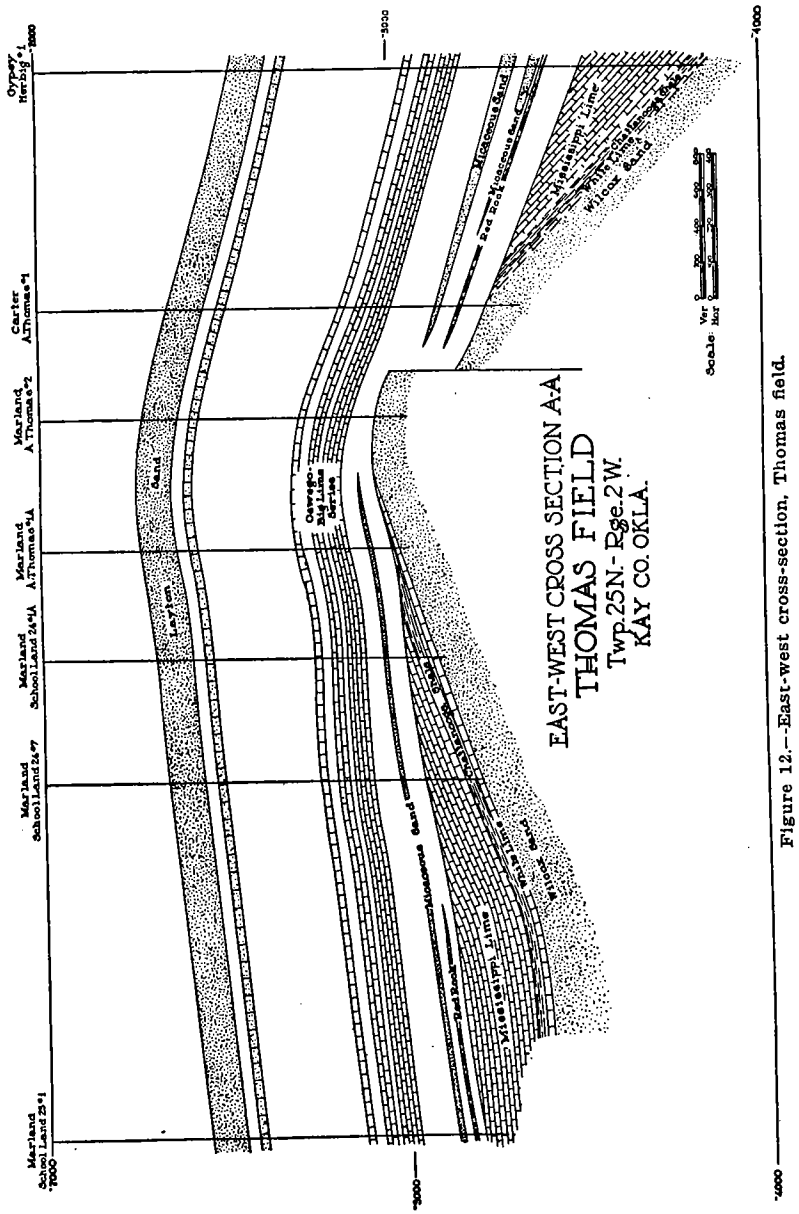



Figure 12.--East-west cross-section, Thomas field.



and more gentle as the thickness of intervening strata increases. These features are illustrated in the accompanying maps, (Figs. 8 and 11), showing the structure of the Layton sands and the "white lime" horizons.

## OTSTOT FIELD

The Otstot field is located just north of the center of T. 27 N., R. 1 W., just west of the town of Blackwell, Kay County.

### STRUCTURE

The Otstot field lies on the general trend of folds, called the Blackwell Anticline in this report.

Production is obtained from a pre-Chattanooga terrace which has been dissected by streams of that age. This terrace is almost level on top, and the edge wells which define the field are found two to three hundred feet lower than those in the producing area. The Mississippi lime and the Chattanooga shale are not present on the top of this old topographic high, having been removed by the pre-Cherokee interval of erosion.

### PRODUCTION

The defined producing area is about four square miles in extent. The wells on the highest part of the structure produce large quantities of gas, the average production of which is 50 million cubic feet. The oil producing wells are located principally on the northern and northeastern edge of the field and produce from the same horizon from which the gas is obtained. Some of these wells when brought in produced gas, later making oil. Average production for the oil wells is 100 to 500 barrels. The shallowest production is found in the Stalnaker sand in a few wells on the eastern edge of the field. Average production from this sand is 100 to 200 barrels. An irregular sand found at 3,100 feet, which is a sandy phase in the upper part of the Oswego-Big lime series, produces in a few wells in sec. 16. Some of these wells have shown an initial production as high as 2,900 barrels but their decline was very rapid.

## RETTA FIELD

The Retta field is located in secs. 1 and 12, T. 26 N., R. 2 W., Kay County.

### HISTORY

The discovery well of this pool is the Hubbard No. 1, NW.¼ sec. 12, T. 26 N., R. 2 W. This well had no production in the Wilcox sand but found oil in the Siliceous lime at a depth of 2,760 feet, which is 150 feet below the top. This production is deeper in the Siliceous lime than in any other well in the district.

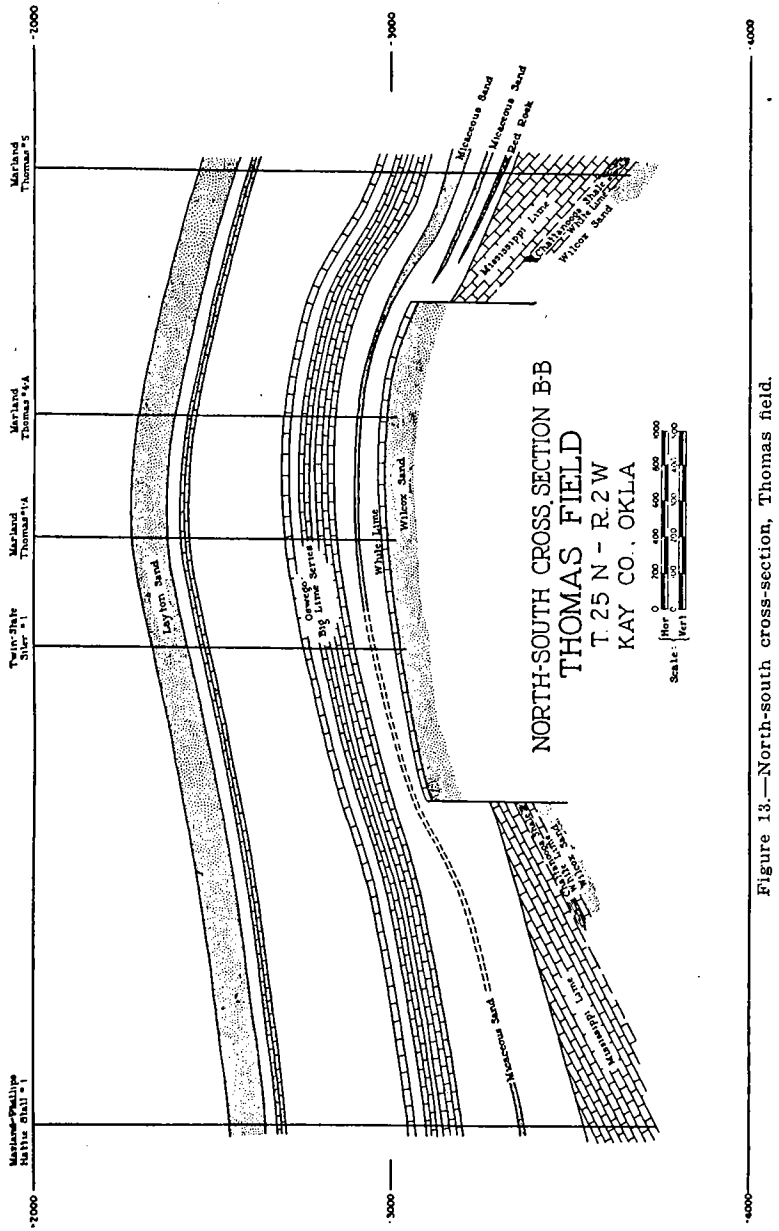



Figure 13.—North-south cross-section, Thomas field.



### STRUCTURE

The Retta structure is a small irregular, well defined dome, cut by a normal fault on its western side. This fault dips approximately 45° west, has 150 feet of displacement and is one of the few faults in this general region which is reflected in the Permian rocks on the surface. There is no evidence to check the presence of this fault in the Wilcox sand and deeper formations because of lack of drilling, but it is entirely probable that the fault extends through all of the sedimentary rocks to the granite below.

### PRODUCTION

There are four producing horizons in the Retta field. The shallowest production is from the Stalnaker sand at an average depth of 2,500 feet. These wells produce mostly gas but some produce oil with an average production of 100 to 800 barrels. The wells decline rapidly, so that many of the Stalnaker sand wells are later deepened to the Layton horizon which is the next producing sand below the Stalnaker. The Layton is found, on an average, at a depth of 2,950 feet and produces 100 to 200 barrels. The Layton sand wells hold their production much better than the Stalnaker wells. The Wilcox sand is found at an average depth of 3,600 feet and makes from 300 to 1,300 barrel wells. The Siliceous lime at 3,700 feet has furnished a few small wells.

The first Wilcox well began producing in September, 1926, making about 600 barrels of oil. In January, 1927, eight wells in the Wilcox sand produced an aggregate of 4,000 barrels per day. The five wells in the Siliceous lime are all small producers and water trouble is general at this horizon. This field is not yet defined and at this date there are fifteen drilling wells, all of which are to be drilled to the Wilcox sand which is the important producing horizon.

## VERNON FIELD

The Vernon pool is located in secs. 16 and 17, T. 29 N., R. 1 E., Kay County. The pool is just southwest of the shallow gas area in sec. 15, T. 35 S., R. 2 E., in Kansas which has been producing for several years.

### STRUCTURE

The Vernon structure is a small dome lying on the Blackwell Anticline and is probably cut off from the Blackwell field structure by a small syncline or saddle.

### PRODUCTION

The discovery wells produced gas at 2,000 feet which is equivalent to the Endicott horizon of the Tonkawa field. Later wells which averaged from 100 to 300 barrels produced from the Stalnaker sand at 2,300 feet. The chat at the top of the Mississippi lime (3,350 to 3,400 feet) produces 50 to 250 barrels.

## BRAMAN FIELDS

### NORTH BRAMAN

The north Braman field is located in sec. 21, T. 29 N., R. 1 W., in Kay County. The entire field covers approximately 600 acres with the deeper production confined to an area of about 80 acres.

The structure is a flat-topped hill which rises gradually from the east, is fairly level at the top, and dips steeply to the west. The highest part of the structure produces from the Siliceous lime with a maximum of 2,500 barrels, while to the east production is obtained from the Wilcox sand which has produced wells as big as 8,500 barrels. Shallow production is found in the Lower Hoover (1,900 feet) and the Upper Endicott (2,100 feet). The Hoover shale sands occur above the Oread lime (in the shale interval between it and the Pawhuska); whereas, according to some correlations the 1,900 foot sand lies above the Oread and the 2,100 foot sand below it in the Braman field, putting the latter in the Endicott zone. The initial production from these wells is about 1,800 barrels which decline to an average production of 175 to 500 barrels. These sands do not produce in the southern Braman area because they are practically absent there.

### SOUTH BRAMAN

The South Braman pool is located in secs. 5 and 8, T. 28 N., R. 1 W., Kay County.

### STRUCTURE

The South Braman structure is a sharp fold (200 feet of dip in one-fourth mile) on the lower horizons. This fold is probably faulted on the west in much the same way as the Retta structure. The Mississippi lime, Chattanooga shale and a part of the Wilcox sand are not present on the top of this fold.

### PRODUCTION

The discovery well of this pool is located in the center of the south line of the SE.¼ SW.¼ sec. 5, very near (600 feet) the corporate limits of Braman. This well produced over 5,000 barrels of oil in the Stalnaker sand at 2,387 feet. The excitement caused by this discovery well resulted in 33 locations on the Braman townsite of which three were brought in as small producers. This feverish development has resulted in the loss of thousands of dollars and in much destruction of property in the town due to drilling activities. The Stalnaker sand (2,300 feet) and the Layton sand (2,800 feet) make wells with an average production of 100 to 5,000 barrels, while some have reached a maximum of 5,000 to 6,000 barrels. These sands are non-productive in the north Braman area. Most of the deep producers are from the Siliceous lime (3,300 to 3,400 feet) and are included within an area of about 80 acres.

There is some Wilcox production in both pools.

# CADDO COUNTY

By

Clyde M. Becker

## GEOGRAPHY

Caddo County, Oklahoma, comprises the following area: Tps. 5 to 10 N., Rs. 9 to 13 W., also Tps. 11 and 12 N., Rs. 11, 12, and 13 W. The total area covers 35 townships or 1,296 square miles.

### TOPOGRAPHY AND DRAINAGE

The topography of this region has been developed by the erosion of a high sandy plateau. The minor streams of the area are intermittent and descend rapidly toward the major streams. Their banks are steep and canyon-like and the general topography indicates that the drainage is recent in development.

Two major streams drain this area. The South Canadian River bounds the county on the north, and the Washita River crosses near the center of the county from east to west. The valley of this river is from 2 to 4 miles wide and its soil is very fertile. A peculiar feature of the drainage of the region is that nearly all the creeks run south. The Washita River drainage system extends almost to the South Canadian, but creeks which have their source south of the Washita also run south and finally find their way into Red River. Examples of this are Medicine and Cache creeks, both of which have their source within a few miles of the Washita and flow directly away from that stream and cross the Wichita uplift on their way southward. The course of streams has little or no relation to structural conditions.

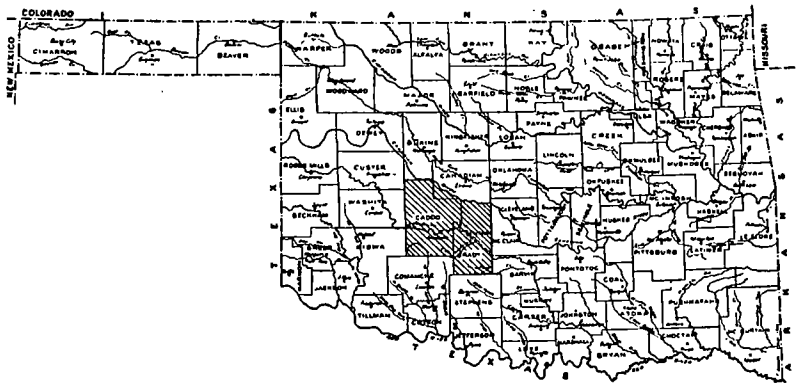



Figure 14.—Map of Oklahoma showing location of Caddo and Grady counties.

(This report originally issued as Bulletin 40-I, March, 1927).

## GEOLOGY

### STRATIGRAPHY

The exposed formations in Caddo County range in age from Cambrian to latest Permian. They are, in descending order, as follows: Day Creek dolomite and Cloud Chief gypsum, thought by some to occupy the same stratigraphic horizon, and from 5 to 35 feet thick; Whitehorse sandstone, soft red poorly cemented sand, 200-275 feet thick; Dog Creek-Blaine, red gypsiferous shales and gypsum, 125-150 feet thick; Chickasha sandstone, dark red and lenticular, with frequent clay partings, probably 150 feet thick in southeastern Caddo County, but thinning to not more than 75 feet where it crosses the western boundary of the county south of Carnegie; Duncan sandstone, loose uncemented sand, 30-50 feet thick; Clear Fork formation, 400-600 feet of red banded shales; and approximately 6,000 feet of Arbuckle limestone.

The major portion of Caddo County is covered by the Whitehorse sandstone of the Permian, but along the east side of the county the Dog Creek and Blaine shales are exposed. Along the north flank of the Wichita uplift, the Dog Creek, Blaine, Chickasha, Duncan and pre-Permian formations are exposed in narrow steeply dipping outcrops.

The Duncan standstone, in southeastern Caddo County is separated from the Chickasha above by 30 to 50 feet of almost uncemented sand. Below this sand is 20 to 30 feet of dark red sandstone similar to the Chickasha. Northwest of Apache the loose upper sand disappears and the lower beds of the Duncan come up into contact with the base of the Chickasha. This lower bed becomes more and more shaly to the northwest until it is difficult to follow the contact beyond the western boundary of the county.

Below the Duncan is a series of red banded shales 400 to 600 feet thick as shown in well logs. These shales, like the formations immediately above them, appear to thin to the northwest, and the big white sandstone series which underlies these shales is found not far below the dolomite previously referred to in the northern part of T. 7 N., R. 16 W., north of the town of Gotebo. This white sandstone series is the same sandstone referred to by Wegemann and Howell[1], whose description is as follows:

> The most prominent bed or group of beds in the Lawton field structurally and stratigraphically is the sandstone that forms the low rounded hills east and north of the gas wells. Its outcrop may be traced for 12 to 15 miles northwest of the Lawton pool and probably much farther along the north flank of the Wichita Mountains. The individual beds of sandstone are lenticular being interbedded with shales but the group as a whole seems to be continuous over a large area in this part of the State. It occupies about the same stratigraphic position as the high ridge 6 miles north of Loco in which grahamite was at one time mined in sec. 6, T. 2 S., R. 4 W., and also the prominent wooded ridge extending across T. 1 S., R. 5 W., in the direction of the Duncan gas field. **This sandstone is about 200 feet thick. Some 400 or 500 feet above it lies the sandstone that forms the escarpment about the Duncan gas field, as well as the line of hills 6 miles northeast of the Lawton field. The rocks between these two sandstones are predominately shales.

1. Wegemann, C. H., and Howell, R. W. The Lawton oil and gas field, Okla.: U. S. Geol. Survey, Bull 621 G., 1916.



The sandstone scarp referred to, as well as the area 6 miles north of the Lawton gas field, is the Duncan sandstone. The author has detailed most of the area discussed in the preceding paragraph and is in complete accord with Wegemann's conclusions.

The above described Permian formations are in contact with the Arbuckle limestone in the southeastern corner of the county, and is approximately 6,000 feet thick in this area. The Reagan sandstone is not exposed below the Arbuckle in Caddo County. The Reagan is found below the Arbuckle and above a porphyritic granite south of the county line in T. 4 N., R. 12 W., and is approximately 100 feet thick. This porphyritic granite is similar to the Colbert porphyry of the Arbuckle Mountains and is exposed in contact with the Arbuckle limestone in the southwest portion of Caddo County in T. 5 N., R. 13 W.

### STRUCTURAL GEOLOGY

The major structural features of this area are the Wichita uplift and the Anadarko basin. Minor structural features so far as known are the Cement anticline and a structural terrace northeast of the Anadarko basin.

The Wichita uplift is believed by Taff to have occurred in early Pennsylvanian times and was greatly eroded between the time of uplift and the beginning of the Permian. The detrital material consisting of both clastic and non-clastic sediments was dumped as deltaic deposits around the base of the older truncated formations. The area was reduced to the proportions of a peneplane at the close of the Pennsylvanian by the lowering of the uplift by erosion and the filling in of the deep basin by the eroded material. The Permian beds were laid down upon this surface and covered both the eroded uplift and the deltaic material around its base. Later when the entire area was re-elevated the eroded material below the Permian settled much more than the resistent beds of the truncated uplift, resulting in the Anadarko basin. The Permian beds show steep dips at the perimeter of the old uplift, and range from 3 to 7 degrees but the dips are 20 to 40 feet per mile where they actually overlie the uplift.

Because of the character of Pennsylvanian deposits below the Permian in the Anadarko basin it is almost impossible to correlate well logs after they pass through the Permian and it is also impossible in most

instances to tell exactly when the drill passes from the Permian into Pennsylvanian formations. Wells drilled near the buried uplift usually find granite wash just below the Permian while out a little farther a sand and sandy shale series appears, and still farther out in the basin the section shows almost no sand, the entire log consisting of shales and a few thin limestones. Therefore there are two distinct types of Pennsylvanian sediments in the Wichita region. First, those laid down as horizontal strata before the uplift, and deposited as was the Glenn of the Arbuckle Mountains; second, the eroded deltaic material similar in character to the so-called Permon-Pennsylvanian Pontotoc series.

### ECONOMIC GEOLOGY

At the present time the Cement anticline is the only oil and gas producing structure in Caddo County. This structure was first mapped by D. W. Ohern and Frank Buttram in 1916. The history of the early development and a description of sub-surface geology and discussion of drilling conditions are fully described in Frank Reeves, U. S. Geol. Survey, Bulletin 726-B, "Geology of the Cement Oil Field, Caddo County, Oklahoma."

At the present time, according to the best data available, there are 175 oil wells and three gas wells producing in the Cement field, 95 of which are owned by independent producers, and produce at the present time approximately 1,000 barrels per day. Much of this oil is handled by the Anderson Pritchard Refining Co. of Cyril. The Magnolia Petroleum Company is operating 80 wells which produce 700 barrels daily. Mr. C. P. Parsons of the Magnolia Petroleum Co., has furnished for use in this report a graph of the production decline curve of a type lease of the Cement field. It will be noted that production holds up exceedingly well, which has been the chief characteristic of all the wells which have been properly cared for.

The principal operators of the field are as follows: Magnolia Petroleum Corporation, Homaokla Oil Co., Lone Star Gas Co., Gorton Trust Co., Hall and Briscoe, Louisiana Oil and Refining Co., Florokla Oil Co., English Drilling Co., Clyde Kale, Achme Development Co., Prairie Oil and Gas Co., Wampum Oil Co., and W. H. Livermore, Inc.

### FUTURE DEVELOPMENT

The development of oil and gas fields in Caddo County in the future will probably be confined to two areas, the terrace-like structures along the north slope of the truncated Wichita uplift and the terrace-like structure northeast of the Anadarko basin in the northern part of the county. In the northern area the productive horizon, if found, will probably be near the base of the Permian. In addition to the possible horizon at the base of the Permian, the Glenn and deeper strata as low as the Simpson may produce oil in the southwestern part of the county.



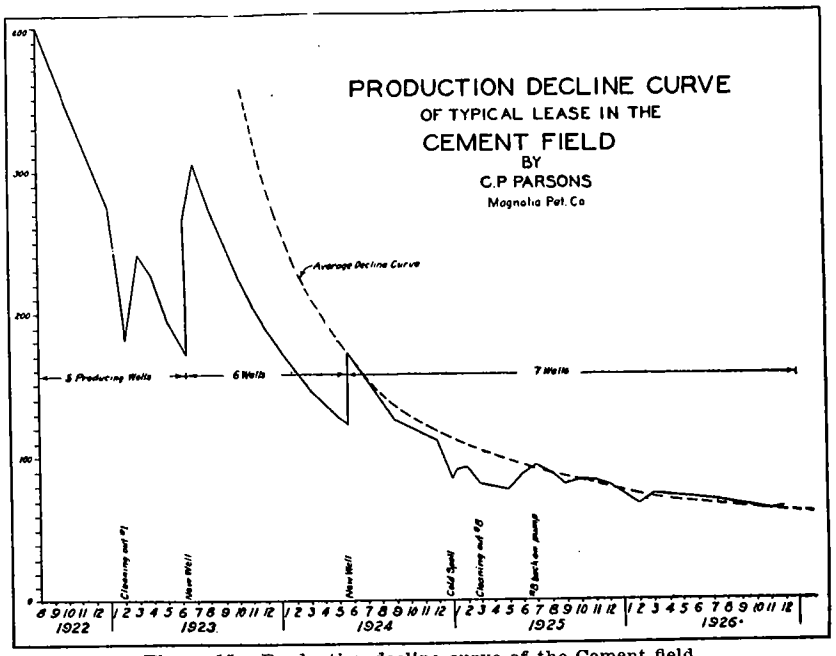



Figure 15.—Production-decline curve of the Cement field.

## GRADY COUNTY

By

Clyde M. Becker

### INTRODUCTION

#### LOCATION

Grady County, Oklahoma comprises the area south of the Canadian River between Rs. 4 and 9 W., and extends south to the north line of T. 2. N. The county is 24 miles wide, east to west, and the mean of the north and south dimension is approximately 46 miles. The total area is a little over 1,100 square miles.

#### ACKNOWLEDGMENTS

The following men have been of great assistance with advice and data; Chas. N. Gould[1], J. V. Howell, F. W. Floyd, Joseph B. Umpleby, C. D. Stephenson, Rudolph Brauchli, and in the actual mapping of

1. Gould, Charles N., A new classification of the Permian red beds of southwestern Oklahoma: Bull. Amer. Assoc. Pet. Geol., Vol. 8, pps. 322-341, 1924.

structure, Allan B. Gray, and Waldemar M. Ervin. Reports by Sawyer[2] and Clifton[3] have furnished additional material.

### GEOGRAPHY

The South Canadian and Washita rivers drain Grady County. Only two small streams run northward into the South Canadian, all other streams running southward into the Washita River. The valley of the South Canadian is sandy and unproductive, while the valley of the Washita is one of the most fertile in the State.

### TOPOGRAPHY

The topography of Grady County consists of high sandy hills, cut by deep drainage channels where erosion has attacked the Whitehorse and Chickasha sandstone formations, and rolling plains where the Dog Creek and Blaine shales are exposed.

Surface elevations range from 975 feet to 1,100 feet along the valley of the Washita, to slightly above 1,400 feet along the high sandstone hills north of Rush Springs in T. 4 N., R. 7 W. It is probable that the sand hills 7 to 10 miles northwest of Pocasset attain nearly the same elevation.

## STRATIGRAPHY

### CLOUD CHIEF GYPSUM

The Cloud Chief gypsum is a stratum of crystalline gypsum 10 to 20 feet thick where exposed in Grady County.

### WHITEHORSE SANDSTONE

A loose almost uncemented red sandstone 225 to 325 feet thick, the lower 100 feet containing much gypsum and is more cemented than the upper portion.

### BLAINE AND DOG CREEK FORMATIONS

Red soft banded gypsiferous shales, 120-130 feet thick. Included in these formations are two sandstone members, the upper 30 to 40 feet below the base of the Whitehorse, is 20 to 25 feet thick, brownish red in color and contains considerable gypsum. It is frequently confused with the base of the Whitehorse. This bed is exposed in a long ledge in the hills south of Verden, and extends eastward to a point three miles west of Chickasha. The other sandstone member is approximately 40 feet below the formation just described, and 30 feet above the base of the Blaine formation. It is a dark red coarse grained somewhat conglomeratic sandstone averaging 10 feet in thickness, and is frequently mistaken for the upper portion of the Chickasha formation. This bed is well exposed in a scarp south of the Little Washita River near the center of Sec. 4, T. 5 N., R. 7 W. It is also ex-

2. Sawyer, R. W., Areal geology of a part of southwestern Oklahoma: Bull. Amer. Assoc. Pet. Geol., Vol. 8, pp. 317-321, 1924.
3. Clifton, R. L., The Whitehorse sandstone: Unpublished thesis, University of Oklahoma.

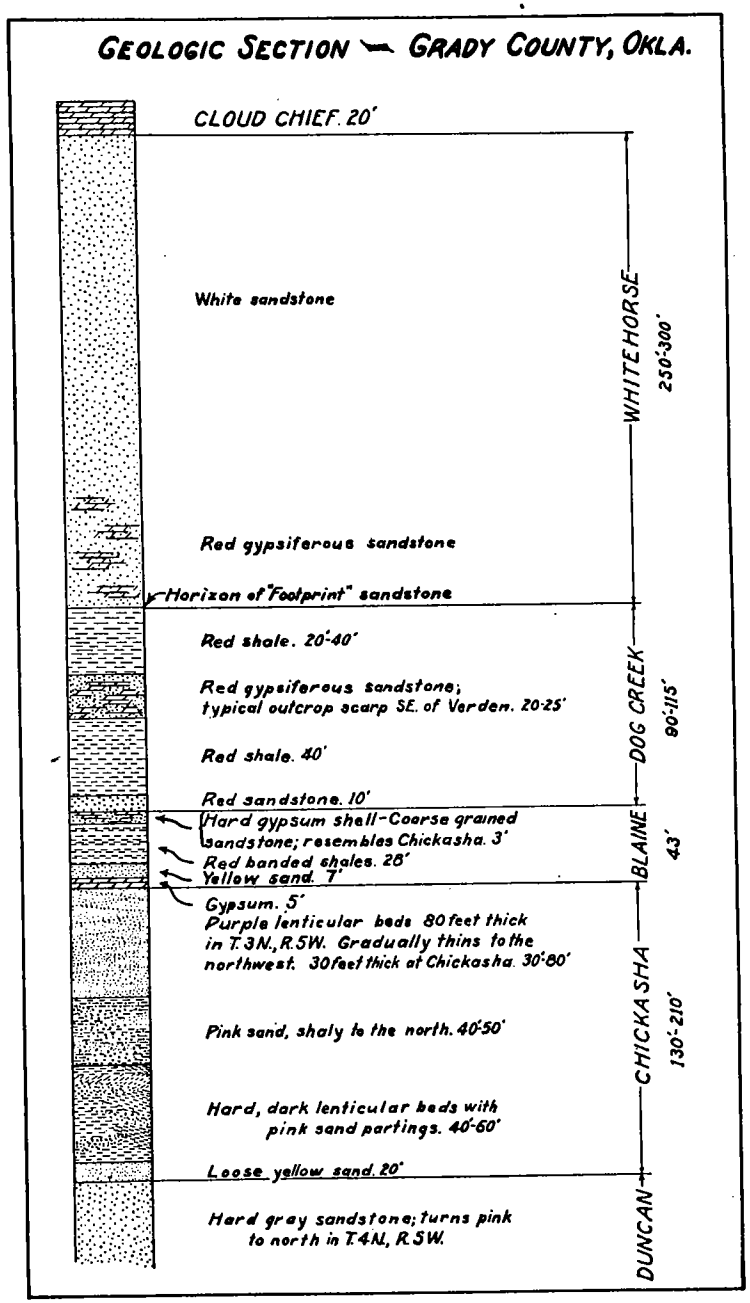



Figure 16.—Geologic section of Grady County.

posed west of Chickasha in secs. 25 and 36, T. 7 N., R. 8 W., and in sec. 31, T. 7 N., R. 7 W.

### VERDEN CHANNEL SANDSTONE

The so-called Verden sandstone occurs between the base of the Whitehorse and the top of the Dog Creek formation. It is a long channel-like deposition which has been described by Stephenson[4], and Reed and Meland[5]. The latter suggested the name of the Verden sandstone.

The lower sandstone member of the Dog Creek formation extends over a very wide area, and has been found mappable as far southwest as sec. 21, T. 4 N., R. 10 W., southwest of the town of Fletcher, Comanche County.

### CHICKASHA FORMATION

Sometimes locally called the "Purple sandstone." There are three distinct divisions of the Chickasha formation, which will be referred to as the upper Chickasha, middle Chickasha, and lower Chickasha. The upper Chickasha is from 45 to 80 feet thick and consists of a series of deep red to purple mudstone conglomerate lenses, separated from each other by very fine grained pink, uncemented sand. The type section is located in the southwestern part of T. 4 N., R. 5 W., and the southeastern part of T. 4 N., R. 6 W. The lenses in this formation become less massive and more shaly to the northwest until it is little more than a banded gypsiferous shale in the northern part of the county. The middle Chickasha, 40 to 50 feet thick, is a stratum of pink unconsolidated fine grained sand in which no massive lenses of any kind occur. The type section is found in the central and southwestern portion of T. 4 N., R. 5 W. Like the upper Chickasha this formation becomes more shaly and gypsiferous to the northwest. The lower Chickasha, 50 to 100 feet thick, consists of a series of massive dark red mudstone lenses separated by red shales and an occasional sandy shale. This lower horizon is the most persistent part of the Chickasha formation.

### DUNCAN SANDSTONE

The upper portion of this formation is a well cemented sandstone from 10 to 50 feet thick. Like the Chickasha the thickest, most massive portion is in the southeastern part of the county. In this area its color is almost white, but going northward it changes to a buff, and from buff to a pink or light red color.

Below this upper sandstone are alternate beds of very soft green and red shales, and thin sandstones. The total thickness of the Duncan formation, where exposed in southeastern Grady County, and northern Stephens County, is approximately 150 feet. Inasmuch as the Duncan and Chickasha formations both grade from coarse to fine material from southeast to northwest, it appears certain that the material for these formations was eroded from the Arbuckle uplift.

4. Stephenson, D. D., Observations on the Verden sandstone of southwestern Oklahoma: Bull. Amer. Assoc. Pet. Geol., Vol. 9, No. 3, pp. 626-631, 1925.
5. Reed, R. D. and Meland, N., The Whitehorse sandstone: Jour. of Geol., Vol. 32, pp. 150-157, 1924.



### GEOLOGIC HISTORY

All the formations described above belong to the late Permian. The entire area was probably submerged, but at very shallow depths, until the close of the Permian period. During the period of emergence, or subsequent to it, important crustal deformations occurred. The result is at least two known major structures; first the Grady County anticline a map of which accompanies this report, and the Chickasha gas structure. Both of these structures are mappable in Permian beds. A number of other structures in southern Oklahoma prove that major folding occurred at least very late in the Permian period. The best known of these folds is the Cruce structure in northern Stephens County. Both limbs of this great anticline show dips as high as 200 feet to the mile on the Duncan sandstone.

The Cement anticline in Caddo County, just west of the Chickasha gas field was mapped by Buttram and Ohern on the Day Creek dolomite above the Whitehorse and near the top of the Permian. Not only do the surface beds give evidence of post-Permian foldings, but several faults have been found and mapped in southeastern Grady County, which are shown on accompanying Grady County structural map.

### ECONOMIC GEOLOGY

The economic possibilities of Grady County from the standpoint of development of oil and gas lie in the development of structures previously referred to, and to the remote possibilities of the discovery of structures unknown. The production of oil and gas in Grady County is confined to two well-defined major structures, previously referred to as the Grady County anticline and the Chickasha gas structure. The Grady County anticline enters the southeast corner of the county, the axis being in the western portion of sec. 34, T. 3 N., R. 5 W., and has been mapped for a distance of 25 miles northwest to the Washita River. This anticline is possibly the northwest extension of the Arbuckle uplift. The other producing structure is the elongated dome in Tps. 4 and 5 N., R. 8 W., upon which the Chickasha gas field was developed. This structure together with the history of development, producing sand horizons and drilling conditions is fully described in a paper of the U. S. Bureau of Mines, May 1, 1923, revised March, 1926.

A new development which may be of importance is the well of Gant and Garvin, sec. 19, T. 5 N., R. 7 W., which found oil sand at 1,955 feet and drilled in sand to 1,968 feet. A recent report of this well gives the daily production as 35 barrels of 36° gravity oil. No surface structure is evident, and more drilling is necessary before subsurface conditions can be determined.

A structure indicating a regional high has been mapped by the Becker-Reed Oil and Gas Company along the east line of Grady County, as shown on the accompanying map, but this company's well drilled in sec. 19, T. 6 N., R. 4 W., near the Grady-McClain County line was dry. No showings of any kind were encountered to a depth of 3,011 feet. This well was drilled with cable tools.

### PRODUCING HORIZONS

There is probably some difference of opinion as to the geologic age during which the producing sands of Grady County were deposited, but after several years of study it is believed that the chief horizon of production lies at or near the base of the Permian, probably in a slight unconformity between the Permian and Pennsylvanian formations. Whether the sands are Permian or Pennsylvanian in age can only be determined by paleontologic study, but up to the present time this method has not been attempted. It is certain that the producing horizons of the Cement field from 2,000 to 2,400 feet, the Ramsey gas horizon of the Chickasha Gas field, 2,050-2,500 feet, the Harness field gas production, and the oil and gas production of the important Carter-Knox area between 1,600 and 2,000 feet, and the north end field over 1,200-1,650, correlate very closely. The tremendous importance of the base of the Permian and upper Pennsylvanian as a producer of oil is now recognized in the Texas Panhandle, West Texas, and New Mexico, but it is not believed that it has been fully recognized that this same horizon is the zone of major production in the fields of Grady and Caddo counties. This fact gives importance to the great undeveloped area between the fields of this area around the north flank of the Wichita Mountains and to the fields of the Texas Panhandle. The only commercial production that has been found above this contact zone is in the Nichlos gas sand of the Chickasha gas field, and in the Carter-Knox area in which two wells are producing below this horizon. The Hawkins No. 1 SE.¼ SW.¼ SW.¼ sec. 5, T. 3 N., R. 5 W., is producing 20 barrels of 41° gravity oil from sand found at 2,785-2,800 feet. The Horton No. 1, SW.¼ SE.¼ sec. 8, T. 3 N., R. 5 W., is producing 60 barrels from sand at 2,600-2,623 feet. The oil is the same gravity as the Hawkins No. 1. These wells indicate that there is possibility of deeper production for the area. This sand is about 800 feet below the top of the upper producing horizon.

In the Chickasha gas field, the Magnolia Petroleum Company found gas production 875 feet below the top of the Ramsey horizon at a depth of 3,178 feet in its No. 1 Irwin in sec. 15, T. 5 N., R. 8 W.

Drilling in the area is chiefly with rotary tools. The physical conditions of the Permian red beds make the operation with cable tools too expensive to be practical.

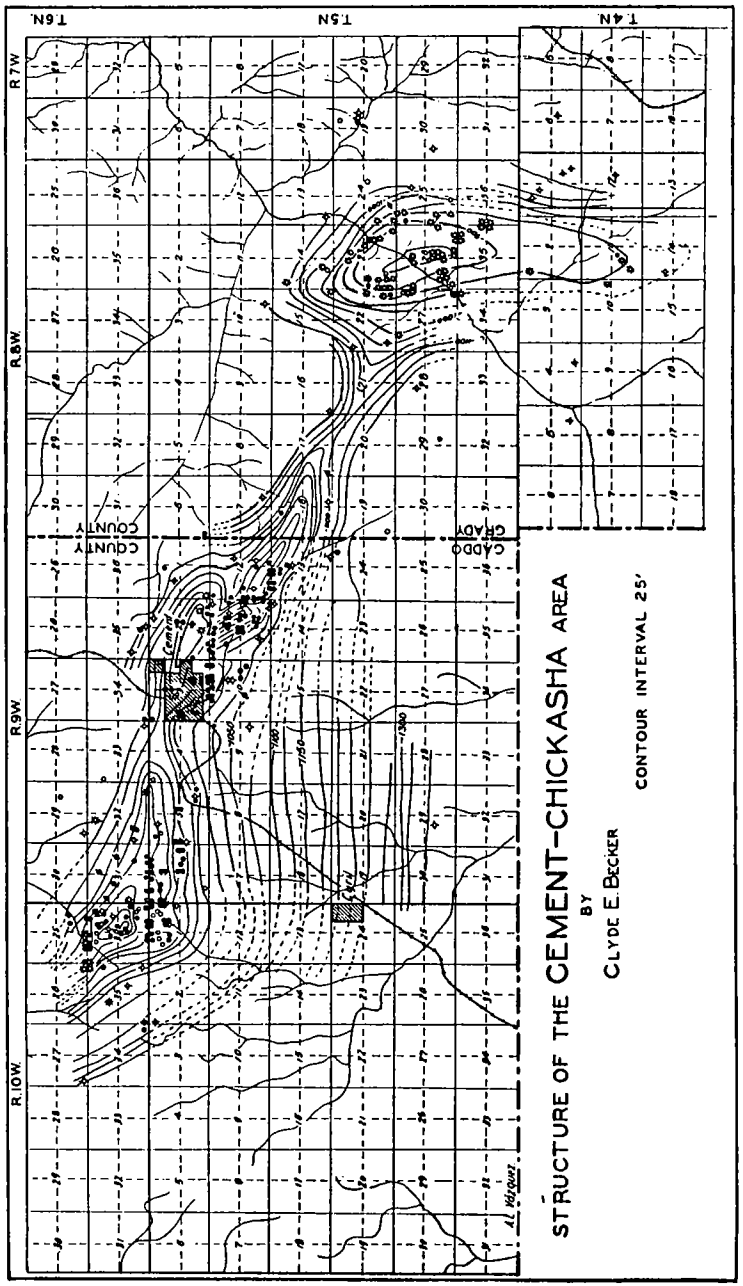



Figure 17.—Structure of the Cement-Chickasha area. Contours on top of the Ramsey sand horizon.

## HISTORY

### CARTER-KNOX OIL FIELD

About 1916 Clyde T. Griswold, under the direction of Frederick G. Clapp, mapped the south end of the Grady County anticline for the A. T. & S. F. Ry. Company. This company drilled several wells along the Grady-Stephens County line, getting showings in at least three of their tests. The distance from pipe lines prevented development, as the wells were not of the gusher type, although the showings were very promising.

In 1921 Sm. Abshire for the Goldelline Oil Corporation and Dr. Cox for the Josey Oil Company mapped the northern part of T. 3 N., R. 5 W., the southwestern portion of T. 4 N., R. 5 W., and the southeastern part of T. 4 N., R. 6 W. While they both mapped a pronounced high, their work was not followed immediately by drilling. The same year the author mapped the southern portion of T. 3 N., R. 5 W., and made a location for Sorrells and Ellis in the NW.¼ SW.¼ NW.¼ sec. 27, T. 3 N., R. 5 W., near what is believed to be the top of the structure. Because of financial difficulties this company was unable to complete the well. In 1924 Walter Critchlow of Ardmore completed a 42 million foot gas well on this location. In 1922 the Marland Oil Company, directed by Dr. J. V. Howell and assisted by C. L. Stephenson, mapped T. 4 N., R. 6 W., and re-checked the work of other geologists in Tps. 3 and 4 N., R. 5 W. Their location in the NE.¼ SE.¼ sec. 17, T. 4 N., R. 6 W., was completed in June 1923 as an 11 million foot gas well in a sand found at 1,990 and drilled to 1,998 feet. In November 922, the Becker-Reed Oil and Gas Company started a well near the top of the structure as mapped by Abshire and Cox. This well was completed in July 1923, as an 18 barrel oil well in a sand from 1,798 to 1,820 feet. In 1923 the author, assisted by Allan B. Gray, made a connected map of this great structure, from the southern portion of T. 2 N., R. 5 W., Stephens County, to the north line of T. 4 N., R. 6 W., and in 1924, assisted by Waldamer M. Ervin, completed this work to the Washita River in T. 7 N., R. 8 W., as shown on the structural map. The production farthest north on this structure is the Harness gas field in secs. 15 and 22, T. 5 N., R. 7 W. The first well in this field was drilled by the English Drilling Company in 1920 on the Harness farm and was completed as a small oil well at a depth of about 2,100 feet. This was the first producing oil well in Grady County. Later completions in this field have all been gas wells. No actual gauge can be had on the volume as there is no line to the field.

Late in 1923 the Joe Ray Oil Company had completed a small oil well at a depth of 955 feet and a gas well gauging 15 million cubic feet at a depth of approximatey 1,350 feet in the NE.¼ sec. 28, T. 3 N., R. 5 W. The purchase of this property by the Magnolia Petroleum Company was the first evidence of interest shown by any major company since the leasing campaign of the Marland Oil Company the previous year. In 1924, Walter H. Gant and associates began the development in sec. 2, T. 2 N., R. 5 W., just across the Stephens County line which resulted in the finding of a 7 million foot gas well from a sand drilled from 1,210 to 1,213 feet. This well soon began showing oil. This favorable showing resulted in the Carter Oil Company, who already had acquired holdings in the field, buying a half interest in this property and the result was the Carter-Knox Petroleum Company's development which finally brought the field into prominence. The Knox Petroleum Company is Mr. Gant's company, so named for his partner, Knox L. Garvin. Associated with Gant and Garvin in this company are Judge Dolman of Ardmore, Earl C. Frates of Tulsa and the Becker-Reed Oil & Gas Co.



In addition to the names mentioned there are several whose courage and foresight were largely instrumental in the pioneering of a field which now promises to attain major proportions. The firm of Shipp, Nash and Josey were among the first to recognize the possibilities of the field. Although their wells did not produce, they were well located. John Bryan, land man and F. W. Floyd, geologist for the Carter Oil Company, through their faith and effort brought the Carter Oil Company into the field. Joe Ray, a farmer until his first oil venture in 1923, has been a most potent factor in the development of the field. The Walker Drilling Company, which drilled the first wells for Mr. Ray, took stock in this company for a large part of its pay for the drilling of the wells.

Major operating companies in the Carter-Knox field are as follows: Carter Oil Company, Magnolia Petroleum Company, Marland Oil and Refining Company, Sinclair Oil and Gas Company, Amerada Petroleum Corporation and the Gypsy Oil Company. There are 75 producing oil and gas wells in the field; the daily production is approximately 5,000 barrels and there are 63 locations and drilling wells.

The Chickasha gas field, Tps. 4 and 5 N., R. 8 W., was discovered in July, 1922 by John B. Nichlos, who drilled the discovery well in the NE.¼ sec. 26, T. 5 N., R. 8 W. This well gauged approximately 48 million cubic feet of gas coming from a shallow Permian sand found at a depth of approximately 1,350 feet. This sand is known as the Nichlos sand. By the end of the first year ten wells had been drilled to this sand and were delivering over six million cubic feet of gas per day to the Oklahoma Natural Gas Company. By the end of the second year 55 wells had been completed and were delivering from 4 to 19 million feet per day. In March 1923, W. R. Ramsey passed the shallow sand and drilled to a deeper pay horizon, in the SW.¼ sec. 23, T. 5 N., R. 8 W. A series of sands was found at a depth of from 2,029 feet to a total depth of 2,500 feet. The result was a 52 million cubic foot gas well, and the deveyopment of the true pay horizon in the Grady-Caddo County area.

### HARNESS GAS FIELD

Development in this field is being carried on by Robert Sultan of Walters, Oklahoma and his associates, Badgett Bros., and Hughes. There are now six producing wells in the field.

### SUMMARY

Development of oil and gas in Grady County to date is confined to two structures; the Chickasha gas field structure, and the Grady County anticline. A third structure may be developed through the development of Gant and Garvin, sec. 19, T. 5 N., R. 7 W.

The Chickasha gas field appears to be fully developed unless deeper sands are found.

The most important development on the Grady County anticline is the Carter-Knox oil field which, although in the early stage of development, is known to extend from sec. 2, T. 2 N., R. 5 W., northwest for a distance of nearly nine miles.

Experience thus far shows that the major zone of production is the same where oil or gas has been found, but the surface beds do not indicate that any structures of major proportions are yet to be found. The thickness of the principal producing horizon indicates that the total oil recovery per acre will be large.

## GARVIN COUNTY

By

Robert H. Dott

### ACKNOWLEDGMENTS

Many of the details in Part I were worked out while the writer was in the employ of the Carter Oil Co. This opportunity is taken to thank L. Murray Neumann, chief geologist of the Carter Oil Company, and A. L. Beekly, chief geologist of the Mid-Continent Petroleum Corporation, for their kindness in permitting this publication.

The writer wishes also to thank E. C. Case, of the University of Michigan, Sidney Powers, Frank C. Greene, A. L. Beekly, George S. Buchanan and H. W. Peabody for valuable suggestions and criticisms.

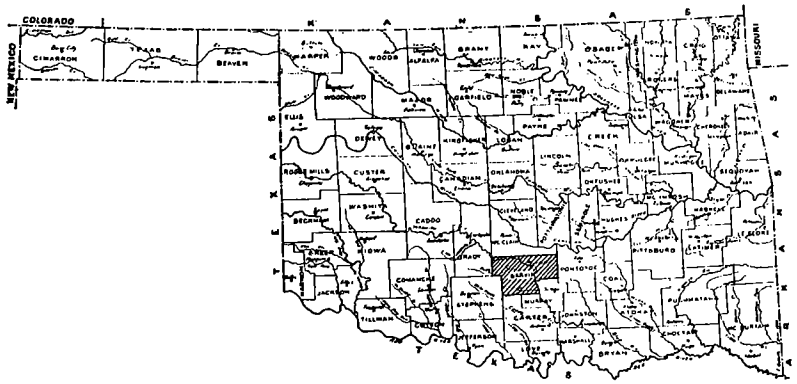



Figure 18—Index map of Oklahoma showing location of Garvin County.

### STRATIGRAPHY

#### BEDS EXPOSED AT THE SURFACE

Red beds, generally regarded as of upper Pennsylvanian and Permian (Permo-Carboniferous of Case) age crop out in Garvin County. Case[1] uses the term "Permo-Carboniferous conditions" as practically synonymous with "red bed conditions" and shows that such conditions were first initiated in eastern North America well

1. Case, E. C., Permo-Carboniferous conditions versus Permo-Carboniferous time: Jour. of Geol., vol. XXVI, No. 6, pp. 500-506, 1918.

(This report originally issued as Bulletin 40-K, May, 1927).

down in the Pennsylvanian[2]. The upper Pennsylvanian of Garvin County was deposited largely under red bed conditions, and passes with no apparent break into the overlying Permian (Permo-Carboniferous).

These red beds have been designated Pontotoc terrane and Enid or Clear Fork-Wichita group, respectively. They are overlain by Cretaceous (?) shales and sandstone, by Tertiary gravels and river sands, and by recent alluvium. The areal distribution of the various formations is shown on the accompanying areal geologic map. Map No. XVII.

## PALEOZOIC FORMATIONS

### PONTOTOC TERRANE

This name was given by George Morgan[3] to a series of red beds, arkosic sandstones, limestone conglomerates and limestones which crop out in western Pontotoc, eastern Garvin and northern Murray counties. He subdivided the terrane into three units which he designated Vanoss formation, Stratford formation and Konawa formation. The principal lithologic characteristic of the rocks of this terrane is the presence of arkosic material, which is virtually absent from the overlying and underlying formations.

#### VANOSS FORMATION

Only the uppermost part of this formation is exposed in Garvin County. It is found in the southeastern part of T. 3 N., R. 3 E. and in the eastern and central part of T. 2 N., R. 3 E.

Near the top of the Vanoss formation occurs a 10 to 20 foot, persistent bed of gray, coarse-grained, arkosic sandstone, which can be traced with considerable certainty from the vicinity of Vanoss to and across T. 2 N., R. 3 E. This and a small thickness of underlying shales and sandstones comprise all of the formation exposed in Garvin County.

#### STRATFORD FORMATION

According to Morgan[4] "the base of the Stratford formation is a series of limestones which constitute the Hart limestone member." From a rather detailed study of the area, the writer is inclined to the opinion that the base of the limestone series does not occur at the same stratigraphic position in all outcrops, but that from Hart northward this base seems to progress upward across the bedding plane.

At Hart the arkosic sandstone which lies at the top of the Vanoss formation is succeeded directly by limestone. In the escarpment

2. Case, E. C., Environment of vertebrate life in Paleozoic in North America: Carnegie Inst., Washington, Pub. 283, 1919.
3. Morgan, George D., Geology of the Stonewall quadrangle: Bu. of Geol., Bull. 2, p. 132, 1924.
4. Op. cit., p. 137.



one and one-half miles west of Vanoss[5] the following section was measured:

*Section 1½ miles West of Vanoss.*

| | Feet |
|---|---|
| Hard, white limestone, rich in arkosic materials. | |
| Buff, cellular limestone, probably of septarian origin | 2 |
| Arkosic sandstone | 2 |
| Red shales with gray sandstone streaks | 25 |
| Arkosic sandstone (considered by the writer to be the same bed as found at Hart). | |

The cellular limestone listed above occurs over several sections in the western part of T. 3 N., R. 4 E., and makes a very satisfactory marker. Other buff, cellular beds occur in the stratigraphic column further south, but this particular bed is quite persistent and the interval between it and the arkosic sandstone at the top of the Vanoss formation is fairly constant.

In section 29, T. 4 N., R. 4 E., according to the writer's interpretation of local structure and stratigraphy, the lowermost bed of limestone is some 150 feet higher, stratigraphically, than the base of the limestones at Hart. The underlying material is red shale with some limestone concretions and occasional arkosic sandstone beds.

Morgan describes an inlier of Hart limestone[6], surrounded by Guertie sand, in the bed of a creek in the eastern part of sec. 2, T. 4 N., R. 3 E., which the writer correlates with the bed occurring in sec. 29, T. 4 N., R. 4 E. Loomis[7] in 1922 described this occurrence as a Pennsylvanian limestone surrounded by Permian red beds. No Hart limestone can be found north of this point.

The Hart limestone proper is a grayish-white, chalky to hard, in part chemically precipitated limestone, interbedded with and grading laterally into red shales and gray arkosic sandstones (Plate V, A, B, C). The lower foot or so of limestone ledges, where they lie in contact with shale, locally shows a cellular structure (Plate V, D), and single beds of this cellular material occur in the shale in many places. This material probably owes its origin to vein-filling in the shale by deposition from percolating calcareous waters.

The shales are all highly calcareous, and often contain beds of limestone nodules. Calcium carbonate seems to be the principal cementing material in the sandstones.

The Stratford formation might be roughly divided into two units on the basis of the greater percentage of limestones in the lower part. The contact lies some two miles west of Stratford. The upper part of the formation consists of a series of predominately red

5. Morgan, Geo. D., Op. cit., p. 138, Plate XX.
6. Op. cit., p. 139.
7. Loomis, Harve, Geologic Note: Bull. Amer. Assoc. Pet. Geol., vol. 6, p. 54, 1922.

shales with a few beds of gray to brown arkosic sandstones, limestone nodules and beds of limestone. Individual beds are locally quite thick and laterally persistent.

The Stratford formation covers the eastern third of Garvin County, and also crops out in a small exposure south of Wildhorse Creek, in T. 1 N., Rs. 1 E. and 1 W. The total thickness of the formation is approximately 450 feet.

### KONAWA FORMATION

Morgan[5] applied this name to a series of red shales and sandstones cropping out just north of the Garvin County line, in McClain, northwest Pontotoc and southern Pottawatomie counties, which he regarded as younger than, and overlapping upon the Stratford formation, though he could never find the two in contact.

Such an interpretation has some merit, because of the lithologic difference between the Stratford and Konawa formations, and the similarity between the Konawa and the overlying Enid beds. It is not impossible that the Konawa formation represents the basal Enid of this region, older than the Enid group of Garvin County. The writer, however, is inclined to look upon the Konawa formation as merely a lateral phase of the Stratford formation, due to depositional factors. This will be discussed more at length under "deposition."

### ENID GROUP

The series of red shales and sandstones, approximately 1,100 feet thick, which lie between the top of the Pontotoc terrane and the base of the Duncan sandstone is now generally regarded as equivalent to most of the Enid group of northern Oklahoma, and to the Clear Fork-Wichita group of Texas.

The writer was able to subdivide this group into eight fairly distinct lithologic units, based on the predominance of sandstone in some of shale in others. (See Fig. 19). Though in places obscure and difficult to recognize, these subdivisions seem sufficiently definite to make practicable their isolation and mapping. The areal extent of these units was checked by detailed structure mapping with a plane table. Some of the sandstone units cap escarpments which can be readily followed considerable distances. As this is the first

*Explanation of Plate V*

A. Massive Hart limestone along east line of sec. 7, T. 3 N., R. 4 E.
B. Looking north from the slope of hill in C. The same series of beds is exposed, with limestone making the bulk of the thickness.
C. Shales and limestone rubble of middle part of Hart limestone in high hill in the south half of sec. 18 T. 3 N., R. 4 E.
D. Buff, cellular bed of limestone which is a good marker in the western part of T. 3 N., R. 4 E. Other similar beds occur and all are usually found at the base of a limestone series where in contact with shale.

5. Op. cit., p. 140.

PLATE V. THE HART LIMESTONE MEMBER OF THE STRATFORD FORMATION, IN WESTERN PONTOTOC COUNTY.

attempt to subdivide this series, these units are provisional only, and will be designated by numbers rather than by geographic names.

The sandstones vary from rather hard, thin, gray and black ledges to massive, soft, red, yellow and brown series, with occasional thin, white beds. The sand grains are small and of uniform size. Arkosic material is entirely absent, except perhaps, for a very slight amount in the base of the group. The sandstones are all more or less cross-bedded. They are quite similar in general appearance, and were it not for the shale intervals, could be distinguished only with great difficulty, except that the sandstones of Unit 1 are not red, while those in Unit 3 and above, are, in most places, distinctly red. The presence of the intervening shale units, however, permits of very satisfactory subdivision.

The shales are for the most part maroon, and are rather calcareous, with many zones of limestone rubble and calcareous nodules, locally with cellular structure. There are no distinct beds of limestone such as appear in the Stratford formation. Beds of barite rosette concretions occur at some horizons. (Fig. 19).

### Unit 1

The Enid group in Garvin County begins with a group of beds consisting of two massive sandstones separated by a shale interval. This group is well developed in the vicinity of Civit, Pauls Valley and Wynnewood. A generalized section is as follows:

*Generalized Section of Unit 1, Enid Group, in Garvin County.*

| | Feet |
|---|---|
| (Upper)—Sandstone, massive to thin-bedded, mineral-stained yellow to black | 35 |
| (Middle)—Shales, red with thin brown and white streaks of sandstones | 65 |
| (Lower)—Sandstone, massive, brown and black | 40 |
| | 140 |

On the whole, the sandstones of the lower part of Unit 1 are massive, of medium hardness, black and brown in color. The middle member is mainly red shale, with a few dark sandstone ledges and one or two bands of white sand, a foot or two thick. In the western part of T. 4 N., R. 2 E. the latter make very good markers for determining local structure. The sandstones of the upper member are harder, thinner-bedded, and are most commonly yellow to dark brown, gray or black in color.

All sandstones of the upper part, and some of the shales of Unit 1 are said to be mineralized. Birk[9] ascribed the black color of the

9. Birk, R. A., An extension of the Pontotoc series around the western end of the Arbuckle Mountains, Oklahoma: Bull. Amer. Assoc. Pet. Geol., vol. 9, No. 6, p. 983, 1925.

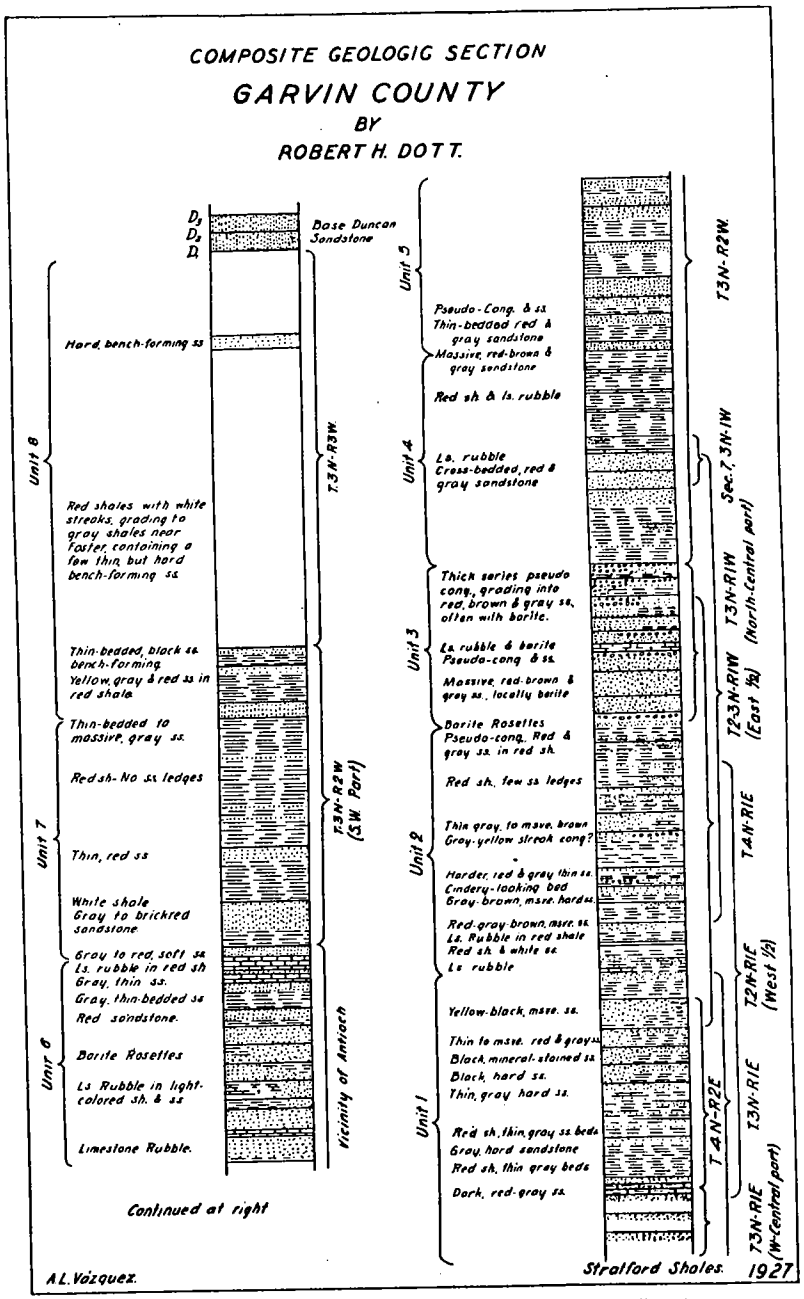



Figure 19.—Composite geologic section of Garvin County

sandstones of this unit to the presence of a manganese mineral. An abandoned mine in section 4, T. 4 N., R. 2 E. is reported to have produced silver and copper from the sandstone and shale of the upper part of the unit.

From the old mine in section 4, T. 4 N., R. 2 E. southwestward to the Washita Valley, the upper part of this unit caps a noticeable escarpment. South from Pauls Valley to the mouth of Wildhorse Creek, the high bluffs on the west side of Washita River are capped by these same beds, with the lower ones near the base of the hills. A particularly good section may be seen at the west end of the highway bridge, about 3 miles southwest of Wynnewood. A small exposure of what the writer regards as Unit 1 is to be found overlying the Strafford shales and limestones, on the south side of Wildhorse Creek, in sections 27, 28 and 34, T. 1 N., R. 1 E.

Unit 1 probably corresponds to Morgan's Asher formation[10] and to the lower part of the calcareous sandstone member of the Clear Fork-Wichita group as designated by Miser on the new Oklahoma geological map.

#### Unit 2

Unit 2 is composed largely of shale, with thin, laterally disappearing sandstones, a few locally massive. The topography is in general rounded, and the surface is largely prairie land. The thickness of the unit is about 145 feet.

The outcrop of Unit 2 parallels that of Unit 1, from the north county line to Wildhorse Creek, and some part of the unit very likely crops out south of Wildhorse Creek.

Unit 2 corresponds to the upper part of the calcareous sandstone division of the Clear Fork-Wichita group, as shown by Miser[11].

#### Unit 3

Unit 3 is predominantly a massive sandstone group, about 8[illegible] feet thick. The sandstones are red to brown in color and are quite massive, though locally they grade laterally into shale with thin gray dark brown and black sandstone ledges. The red color, when present helps to distinguish these sandstones from those of Unit 1.

At the base of the series, in T. 4 N., R. 1 E., a bed of barite rosette concretions occurs. This can be traced several miles southwest from section 4, T. 4 N., R. 1 E. Other, similar beds occur near the middle of the unit, near Whitebead. These concretions make fair local markers, although they sometimes have as much as 50 feet of vertical range, and are therefore confusing. Another occurrence of these rosettes was noted in Unit 6, near Antioch.

10. Op. cit., p. 141.
11. Miser, H. D., Oklahoma Geological map: U. S. Geol. Survey, 1926.



Associated, interbedded, and often intergrading with the red sandstones at the top of Unit 3 are beds of what at first glance appear to be conglomerates, but what seem rather to be sandstone with small concretions or nodules of lime, arranged in such a manner as to appear like pebbles up to three-fourths inch in diameter. These psuedo-conglomerates are fairly persistent and make good local markers. One of these beds can be found in several places in secs. 5, 6, 7, and 8, T. 4 N., R. 1 E., and near Whitebead.

Several outcrops in the vicinity of Paoli show traces of copper, and copper ore is reported to have been mined from an abandoned pit one mile east of Paoli.

Like most of the Enid sandstones, those of Unit 3 are poorly bedded. They are hard enough to make rather prominent ridges, and make up the second escarpment-forming sandstone series in the Enid group.

The outcrop of this unit can be followed with reasonable certainty from the NW. cor. sec. 4, T. 4 N., R. 1 E., southwest to the Washita Valley, then from the vicinity of Whitebead south, past Brady in T. 2 N., R. 1 W., to old Fort Arbuckle (Hoover), south of Wildhorse Creek.

Westward from Hoover to Hennepin (sec. 31, T. 1 N., R. 2 W.), occur some fine-grained, red and brown sandstones, overlying limestone conglomerate, limestone and shales of probable Stratford age. From their appearance, these beds must belong to the Enid group, and from their stratigraphic and structural relationships, to Unit 3. The dip seems to be to the north or northeast.

Good exposures of Unit 3 are to be found in the vicinity of Paoli and Whitebead, in an escarpment 1½ miles west of the SE. cor. sec. 36, T. 3 N., R. 1 W., in the ridge east and north of Brady, and in sec. 13, T. 1 N., R. 1 W.

This unit forms the lower part of Miser's red sandstone member of the Clear Fork-Wichita group.[12]

#### Unit 4

Unit 4 is composed of three members, two of shale separated by a sandstone member which is locally massive, but grades laterally into thin-bedded sandstones with shale partings.

A generalized section is as follows:

*Generalized Section of Unit 4, Enid Group, Garvin County.*

| | Feet |
|---|---|
| Shale, some sandstone ledges | 55 |
| Sandstone, massive, grading to thick shale with thin sandstones | 40 |
| Shale, some sandstone ledges | 30 |
| | 125 |

12. Op. cit.

The shales are essentially similar to those of other units of the Enid group, and need not be discussed further. The sandstones of the middle member are red, gray and black in color, and are in places, much cross-bedded. They are locally massive, or with only thin shale partings. Elsewhere the member is predominantly shale, with thin sandstone ledges. Like most of the Enid sandstones, the massive beds are rather soft, while the thinner ones are harder. Small escarpments are capped by beds of this middle member, though it can hardly be called an escarpment-forming sandstone. Near the southwest corner of sec. 34, T. 2 N., R. 1 W., a ledge shows an occurrence of what appear like rain drop impressions.

In sec. 7, T. 3 N., R. 1 W., some red and gray sandstones are so cross-bedded that local east dips seem to be evident, whereas a series of elevations on a bed of limestone rubble indicates normal west dip.

The outcrop of Unit 4 trends south through R. 1 W., from the north line of the county to Wildhorse Creek, thence west up Wildhorse Valley.

West of Paoli, the unit is composed largely of shale. The sandstones of the middle member are well developed in sec. 7, T. 3 N., R. 1 W., and sec. 12, T. 3 N., R. 2 W., where they cap escarpments. From sec. 24, T. 3 N., R. 2 W., southward, these beds can be traced, but they are thinner and less prominent, except locally, as in the northeast quarter of sec. 15, T. 2 N., R. 1 W., where sandstones are massive enough to support timber. They form a pronounced westward-dipping slope in the southwest part of T. 2 N., R. 1 W. In the south-central part of T. 2 N., R. 1 W., small escarpments are capped by several beds of this unit. On the south side of Wildhorse Creek, on top of a hill in sec. 32, T. 1 N., R. 1 W., are beds which probably belong to this unit, resting upon conglomerates of probable Stratford age.

Unit 4 is part of Miser's red sandstone member.[13]

#### Unit 5

Unit 4 is succeeded by a series of fairly persistent, massive, escarpment-forming sandstones, overlain by shales with a few sandstone beds, belonging to Unit 5. A generalized section is as follows:

*Generalized Section of Unit 5, Enid Group in Garvin County.*

| | Feet |
|---|---|
| Shale, red with some sandstone beds | 50 |
| Sandstones, massive, red-brown with some shale, grading into shale with thin sandstones | 40 |
| | 90 |

The sandstone member caps an escarpment on the east side of Washita River, in the northwest part of T. 4 N., R. 1 W. On the

13. Op. cit.



south side of the river, in the southeast part of T. 4 N., R. 2 W., the sandstones are thin and soft. In T. 3 N., R. 2 W., however, several of the sandstones become more massive, notably in section 2, and from section 14, southeast to the southeast corner of the township, a prominent escarpment is capped by this bed. Thence the outcrop trends southward to Katie with recognizable, though not prominent ledges.

Nearly half of T. 1 N., R. 2 W. is covered by what are considered beds of Unit 5. Rock Creek lies in the axis of the Anadarko Basin, and the beds dip northeast and southwest into it. The upper member is there composed of more massive sandstones than in the area to the north. The uppermost ledges extend up the bed of Rock Creek as far as Elmore City.

This unit belongs to Miser's red sandstone member.[14] The lower part is the third escarpment-forming sandstone in the Enid group.

#### Unit 6

Overlying the shale of Unit 5 occurs another prominent sandstone series, Unit 6. The lithology of this unit varies in different parts of its outcrop. In the vicinity of Antioch, in the center of T. 3 N., R. 2 W., the unit is essentially a 120 foot bed of red sandstone. To the north and south, beyond the limits of the township, the lower 50 feet grade into shale.

The upper part of the unit caps the escarpment on the south side of Washita River, two miles east from Maysville, and also the high bluffs on both sides of Rush Creek, near Antioch. In the latter locality, the lower part of the unit is composed of bluff-forming ledges, and in several localities, of a massive bed some 30-40 feet thick. A bed of barite rosette concretions occurs at the middle of this unit, near Antioch. One outcrop was noted in the road one-fourth mile north of the Antioch store. The shales contain beds of limestone nodules.

Southward from Antioch this unit can be traced with reasonable certainty to Elmore City, retaining the massive development of the upper part all the way. Some gray beds are interspersed with the red. West of Elmore City both the sandstones and shales of the unit become gray.

Unit 6 forms the top of Miser's red sandstone member. It is the fourth escarpment-forming sandstone of the Enid group.

#### Unit 7

Unit 6 is succeeded by a series of shales with a few persistent sandstones comprising Unit 7, totalling some 130 feet in thickness.

14. Miser, H. D., Op. cit.

The shales are mainly red, with a few white streaks. The sandstones are thin and soft and of brick-red color. The topography is rounded, with no prominent escarpments, and the outcrop is barren of timber, except in stream courses.

The hills on the south side of Washita River from Lindsay and Erin Springs, eastward to Maysville are capped by beds of this unit. From Maysville, the outcrop trends southward, west of Antioch, to Foster in the southeast part of T. 2 N., R. 3 W., thence westward along the south line of that township, to the county line. It outcrops in a belt from 2 to 4 miles wide.

From the vicinity of Foster, westward, the color changes to gray, and the material is well-bedded. This unit is probably the base of Miser's gray sandstone member.[15]

### Unit 8

Following Unit 7 occurs the uppermost member of the pre-Duncan Enid. It is composed of shale, but contains several hard sandstone ledges which cap definite escarpments, capable of being traced considerable distances. The unit is approximately 300 feet thick.

This unit begins with three hard and persistent sandstones, the upper of which caps a prominent escarpment situated in the northwest part of T. 2 N., R. 2 W., which can be traced or readily recognized as far south as Foster, and as far north as Wallville. This top bed is some 30 feet above the base of the lower one, and forms the fifth escarpment-forming sandstone in the lower part of the Enid group, and the first important one below the Duncan sandstone.

The upper part of this unit is predominantly shale, with one or two persistent, hard, well-bedded sandstones near the top. Mr. Frank C. Greene called the writer's attention to one of these beds which lies about 50 feet below the base of the Duncan sandstone. It is well-exposed in T. 2 N., R. 3 W., and makes an excellent marker.

North of the center of T. 2 N., R. 3 W., the beds of this unit are distinctly red. South of this point, and west to the county line, they all appear to be gray and form the upper part of Miser's gray sandstone member[16]. The gray color seems to be localized in the axis of the Anadarko basin. Associated with this gray color, the bedding is more regular than where the beds are typically red.

### Duncan Sandstone

This bed, which is one of the best markers in the red beds series, has already been described by various authors.[17 18 19 20 21]

15. Op. cit.
16. Miser, H. D., Op. cit.
17. Wegeman, C. H., The Duncan gas field, Stephens County, Okla.: U. S. Geol. Survey, Bull. 621, II, pp. 44-45, 1915.
18. Sawyer, R. W., Areal geology of a part of Oklahoma: Bull. Amer. Assoc. Pet. Geol., vol. 8, pp. 322-341, 1924.
19. Gould, Chas. N., A new classification of the Permian red beds of southwestern Oklahoma: Bull. Amer. Assoc. Pet. Geol., vol. 8, pp. 317-321, 1924.
20. Gouln, Frank, The geology of the oil and gas fields of Stephens County, Oklahoma: Oklahoma Geological Survey, Bull. 40-E, pp. 16-17, 1926.
21. Aurin, F. L., Officer, H. G., and Gould, Chas. N., The subdivision of the Enid formation: Bull. Amer. Assoc. Pet. Geol., vol, 10, pp. 786-799, 1926.



In Tps. 2 and 3 N., R. 3 W., the Duncan sandstone is a hard, reddish-gray, well-cemented sandstone, and as it overlies the soft shales of the upper part of Unit 8, it makes a remarkable topographic feature in western Garvin County by capping an escarpment 150 feet high. This is known as Table Mountain.

The Duncan sandstone trends from southwest of Erin Springs, east to near Wallville, thence south to Foster, thence westward up the Anadarko basin. The formation is at least 100 feet thick.

It is worthy of note that near the axis of the Anadarko basin, the sandstone is well cemented and well bedded, is hard, and forms a prominent escarpment. Out of the basin, however, north of Rush Creek in Garvin County, and north of Washita River in McClain County, it is softer, poorly bedded and does not make a clean-cut escarpment. To the north, the color is more nearly red and less gray than in the vicinity of Foster and in practically all respects, the Duncan sandstone north of Rush Creek more closely resembles the sandstone beds of the lower Enid than the bed which caps Table Mountain.

This is the highest of the Paleozoic rocks exposed in Garvin County. It has been correlated with the middle and upper Harper sandstones of Kansas, and with the San Angelo sandstone of Texas.

## CORRELATIONS

The possible correlations of the Pontotoc terrane[22] and of the subdivisions of the Enid group[23] with their equivalents in northern Oklahoma and Southern Kansas, are shown in Table I, page 132.

## DEPOSITION

The Pontotoc and Enid sediments were deposited under peculiar conditions. Conglomerates and fossils suggest marine or fresh water deposition for part of the Pontotoc beds, and red beds suggest terrestrial deposition for others. The red color, prevalence of cross-bedding in the sandstones and the presence of bones[24] suggest a terrestrial origin for the Enid beds.

In the Pontotoc terrane, the water-lain deposits occur nearest the mountains, where conglomerates and limestone are found in contact with the lower Paleozoic formations, They grade northward into synchronous red beds away from the mountains.

The writer has suggested in another paper[25] that the Arbuckle uplift formed a narrow, deeply down-folded and faulted syncline,

22. Gould, Chas. N., Index to the stratigraphy of Oklahoma: Okla. Geol. Survey, Bull. 35, 1926.
23. Aurin, F. L., Officer, H. G., and Gould, Chas. N., Op. cit.
24. Dr. Case states in a personal communication, that he found in an exposure at the north edge of the cemetary, just south of Pauls Valley "two fragments of bone, water worn * * * * *. The fragments were unidentifiable." Unit 1 as defined in this paper is exposed in that locality.
25. Dott, Robert H., Notes on Pennsylvanian Paleogeography: Oklahoma Geological Survey, Bull. 40-J, 1927.

*Table I. Correlations of the Pontotoc terrane and Enid group.*

| | | Garvin County | Northern Oklahoma | | Kansas |
|---|---|---|---|---|---|
| Permian (Permo-Carboniferous) | Enid Group (Clear Fork-Wichita) | Duncan sandstone | Duncan sandstone | Enid Group | Upper Harper<br>Middle Harper |
| | | Unit 8-500' | Hennessey shale | | Lower Harper |
| | | Unit 7-130'<br>Unit 6-120' | Garber sandstone | | |
| | | Unit 5-90'<br>Unit 4-125'<br>Unit 3-85' | Wellington fm. | | Wellington shale, Pearl shale member of Marion fm. |
| | | Unit 2-145'<br>Unit 1-140' | Stillwater fm. | | Marion fm.<br>Chase fm.<br>Council Grove fm. |
| Pennsylvanian | Pontotoc Terrane | Stratford fm.<br>Vanoss fm. | Eskridge shale<br>Neva limestone<br>Elmdale shale<br>Sand Creek fm.<br>Buck Creek fm. | | Wabaunsee fm. |

(known in the outcrops of lower Pennsylvanian and lower Paleozoic formations, as the Mill Creek syncline), with relative uplifts north and south of this trough. That this was deep is indicated by the fact that Pennsylvanian formations have been brought in contact with the Arbuckle limestone and it is conceivable that it was invaded by a shallow arm of the Pontotoc sea or contained fresh or brackish water lakes which received part of the Vanoss and Stratford deposits.

In a recent publication[25] the writer referred to the finding of some undetermined gastropods in the Hart limestone in sec. 31, T. 3 N., R. 4 E. These were shown to D. K. Greger, who suggested they might be fresh water forms. Later Raymond C. Moore expressed a similar opinion.

In Vanoss time, the streams were tapping the newly exposed Tishomingo granite. During this time and to a greater extent in Stratford time, large quantities of calcium carbonate were being dissolved from the exposures of Arbuckle, Simpson, Viola and Hunton limestones, carried by streams and precipitated with the muds and sands after the manner suggested by Clarke[26].

Of such probable origin were the lime nodules in the shales, the cementing material in the arkosic sandstones and the Hart and

26. Clark, F. W., The data of geochemistry: U. S. Geol. Survey, Bulletin 770, p. 555, 1924.



other limestones, though the presence of fossils in the Hart limestone indicates that it was formed in part, under normal conditions of limestone deposition. Algae may also have preciptated the calcium carbonate to form limestones, as suggested by Clarke[27]. Birk[28] found algae in some of the Pontotoc limestone.

The above interpretation would account for the presence of the water-lain deposits of Vanoss and Stratford age so close to the mountains, and the localization of the limestones in a belt not far distant from the outcrops of lower Paleozoic limestones, and the change, away from the mountains in so short a distance, to contemporaneous continental deposits like the Konawa formation in northern Pontotoc and southern Pottawatomie counties.

That at least a minor unconformity occurs between the Stratford formation and the base of the Enid group is shown by the writer's interpretation of areal geology on the south side of Wildhorse Creek, where successively younger units of the Enid group rest upon Stratford shales, conglomerates and limestones. This is further suggested by a small occurrence on the Sulphur-Stratford highway between the S. L. & S. F. Railroad tracks and the north edge of Sulphur. Red shales with limestone rubble wholly unlike the Pontotoc beds, and resembling those of the Enid group, rest upon massive limestone conglomerates of Vanoss age.

The writer has seen evidence in the dips east of Davis to show that the Mill Creek syncline and the Anadarko basin are co-extensive in this locality. The gray color and even-bedding of the shales and sandstones of Units 7 and 8, of the Enid group, and the greater hardness, gray color and even-bedding of the overlying Duncan sandstone in the Anadarko basin, near Foster, suggest that they are water-lain. If so, then it is likely that the Anadarko basin contained an arm of the sea, or fresh or brackish water lakes during part of Permian time, while terrestrial conditions prevailed elsewhere.

## MESOZOIC (?) FORMATIONS

### CRETACEOUS (?)

Capping the hills on the north side of Wildhorse Creek, in T. 1 N., R. 1 E. and R. 1 W., and on the hills south of Salt Creek in T. 1 N., R. 2 W., are patches of loose sand, covering outcrops of several units of the Enid group. This sand is quite unlike any of the Paleozoic deposits, though it does resemble the Tertiary Guertie sand.

In a small creek near the east line of the northeast quarter of section 16, T. 1 N., R. 1 E., this loose sand is underlain by a well cemented yellow sandstone which seems to be entirely foreign to the Enid group, and to more nearly resemble the Trinity sand as exposed south of Atoka. This sandstone is in turn underlain by blue-gray

27. Clarke, F. W., Op. cit., p. 557.
28. Birk, R. A., Op. cit.

shale, likewise different from the Enid shales, and similar to the Trinity shales as described by Bullard[29].

Just north of Whitebead, at the NE. cor. sec. 4, T. 3 N., R. 1 W., is a small exposure of well cemented, yellow sandstone conglomerate which resembles in color and cementation the Trinity (?) sandstone as exposed in sec. 16, T. 1 N., R. 1 E.

The Cretaceous age of these deposits is highly conjectural, but they seem to be distinctly different from and younger than the beds of the Enid group, and they do resemble some of the Trinity deposits.

## CENOZOIC FORMATIONS

### TERTIARY GRAVELS

Scattered over most of the higher hills in Garvin County, and in fact over a large part of Oklahoma, are thin deposits of smooth, rounded pebbles associated with red to brown clay and fine sand. In places, as along the highway between Stratford and Sulphur, thick beds of similar gravels occur. These deposits are usually sufficiently widespread to conceal large areas of Paleozoic outcrops. The writer has found this material covering as much as 60 per cent of the area of some townships in Garvin County.

Often small fragments of silicified wood are associated with these clays and gravels. In one locality, near the east quarter-corner of section 14, T. 2 N., R. 3 E., parts of a large tree were found. Superficially, the wood resembles that of a modern tree.

These deposits were described by Gould[30], and assigned to the Tertiary. His remarks were summarized by Bailey Willis[31].

### GUERTIE SAND

In the northeast corner of Garvin County occurs an area of loose sand, overlying unconformably, beds of the Stratford formation. This was mapped by Morgan[32], and has been described by Taff[33] and Morgan[34]. It is considered an old stream deposit of Tertiary age. Similar material is found in patches from this locality, eastward as far as Pittsburg County, in a belt roughly parallel to and not far distant from the course of Canadian River. The loose sand in the southern part of Garvin County may be of similar age and origin.

29. Bullard, Fred M., The geology of Love County, Oklahoma: Okla. Geol. Survey, Bull. 33, p. 17, 1925.
30. Gould, Chas. N., Geology and water resources of Oklahoma: U. S. Geol. Survey Water-Supply Paper, No. 148, 1905.
31. Willis, Bailey, Index to the stratigraphy of North America: U. S. Geol. Survey, Prof. Paper 71, pp. 813-814, 1912.
32. Op. cit.
33. Taff, J. A., Geology of the McAlester-Lehigh coal field, Indian Territory: U. S. Geol. Survey, 19th, Ann. Rept., Part III, 1899.
34. Op. cit., p. 142.



### ALLUVIUM

Recent alluvium fills the valleys of Washita River and its larger tributaries.

### WIND BLOWN SAND

A deposit of fine sand can be found capping some of the bluffs on the east side of Washita River covering and concealing Paleozoic outcrops. The material is red in color, of loessial texture, and was obviously blown to its present position from the Washita flood plain, by the prevailing southwesterly winds.

Considerable areas are covered by this material north of Pauls Valley, and between Pauls Valley and Wynnewood, on the east bank of Washita River.

Similar deposits can be found in the city of Tulsa, and elsewhere along the banks of Arkansas River, as well as along the banks of all east-flowing streams in Oklahoma.

## SUBSURFACE FORMATIONS

### LOWER PALEOZOIC

In Pontotoc and Murray counties, east and south of Garvin, nearly all of Oklahoma's lower Paleozoic formations are exposed, including two important oil producing horizons. Here may be found the Arbuckle limestone, Simpson formation (to which belongs the Wilcox sand), Viola limestone (a minor producer), Sylvan shale and Hunton limestone (an important producer in Seminole County).

Subsurface mapping on this latter formation has shown the existence of a plunging arch[35] [36] whose axis lies in western Pontotoc County. By virtue of this Hunton Arch, the lower Paleozoic formations dip westward beneath Garvin County, and a few wells in the extreme eastern part, and in adjacent parts of Murray, Pontotoc and Pottawatomie counties have penetrated them, as shown in Table II.

In the Robberson field, T. 1 N., R. 3 W., lower Paleozoic rocks have been found beneath the red beds, dipping at high angles, on the westward extension of the Arbuckle anticline. This is fully discussed by Robert Roth (See pp. 144-164).

### MARINE PENNSYLVANIAN

Structurally conformable with the lower Paleozoic formations in the Robberson field, and likewise overlapped by the red beds, occur a thick series of Pennsylvanian sediments belonging to the Glenn

35. Morgan, George D., Op. cit., p. 43.
36. Dott, Robert H., Op. cit.

*Table II. Subsurface formations in eastern Garvin County*

| COMPANY OR FARM | LOCATION | DEPTHS | | | |
|---|---|---|---|---|---|
| | | PENN. PERM. TO | LOWER PALEOZOIC FORMATIONS | | |
| | | | Formation | From | To |
| Lewis | 29-T 3 N., R. 4 E. | 1127 | Hunton | 1127 | 1247 |
| | | | Sylvan | 1247 | 1300 |
| | | | Viola—[37] | 1300 | 1435 |
| Dixie, Fillmore | 33-T. 3 N., R. 4 E. | 830 | Simpson | 830 | 1320 |
| Gilcrease | 16-T. 4 N., R. 4 E. | 1280 | Hunton | 1280 | 1450 |
| | | | Sylvan | 1450 | 1600 |
| | | | Viola | 1600 | 1990 |
| | | | Simpson | 1990 | 2267 |
| Wrightsman | 24-T. 4 N., R. 4 E. | 1240 | Hunton | 1240 | 1325 |
| | | | Sylvan | 1325 | 1500 |
| | | | Viola | 1500 | 1930 |
| | | | Simpson | 1930 | 2756 |
| Stuyvesant | 7-T. 1 N., R. 3 E. | 1380 | Simpson | 1380 | 2525 |
| Goldeline | 11-T. 2 N., R. 3 E. | 760 | Simpson | 760 | 1720 |
| | | | Arbuckle | 1720 | 2006 |
| Manahan | 5-T. 3 N., R. 3 E. | 2075 | Hunton | 2075 | 2250 |
| | | | Sylvan | 2250 | 2370 |
| | | | Viola | 2370 | 2920 |
| | | | Simpson | 2920 | 2924 |
| J. S. Cosden | 32-T. 3 N., R. 3 E. | 1690 | Simpson | 1690 | 2005 |
| Day Oil Co. | 9-T. 5 N., R. 3 E. | 3330 | Hunton | 3330 | 3466 |
| | | | Sylvan | 3466 | 3605 |
| | | | Viola | 3605 | 4018 |
| | | | Simpson | 4018 | 4021 |
| Gibson | 29-T. 2 N., R. 2 E. | 2205 | Simpson | 2205 | 2945 |
| Texas-Pacific | 35-T. 3 N., R. 2 E. | 1985 | Simpson | 1985 | 2480 |

formation as defined by Taff, Goldston, Girty and Roundy[38]. The possible correlations of these beds with their equivalents in other areas may be seen in Table IV. These same formations probably extend northward into Garvin County, though no drilling in the central or western part has as yet been deep enough to prove their presence.

Just east of Garvin County, in western Pontotoc, equivalents of the Glenn formation are very thin or entirely absent from the top

37. The Viola limestone listed in these tables probably includes magnesian limestone of upper Simpson age, which Luther White has designated "Post Wilcox Simpson." They are indistinguishable in well logs from the Viola limestone.

38. Taff, J. A. U. S. Geol. Survey, Geol. Atlas, Tishomingo Folio (No. 98), 1903.
Goldston, W, L,, Jr., The differentiation and structure of the Glenn formation: Bull. Amer. Assoc. Pet. Geol., vol. 6, 1922.
Girty, George H., and Roundy, P. V., Notes on the Glenn formation of Oklahoma with consideration of new paleontologic evidence: Bull Amer. Assoc. Pet. Geol., vol 7, pp. 331-349, 1923.



of the Hunton Arch[39]. Where present, they rest unconformably on the lower Paleozoic formations. They are in turn disconformably overlain by a thin layer of fossiliferous shale thought to belong to the Ada formation (of Wabaunsee age), which overlaps still further toward the top of the Hunton Arch, covering still older formations. This is immediately succeeded by the conformable beds of Pontotoc age.

In Garvin County, marine Pennsylvanian strata have been found beneath the red beds in the following wells, in addition to those listed in Table No. II:—

*Table III. Wells in Garvin County and vicinity which have passed through red beds into marine Pennsylvanian strata.*

| Company | Location |
|---|---|
| Detert | Sec. 10, T. 6N., R. 2 E. [40] |
| Texas Pacific | Sec. 5, T. 1 N., R. 1 E. [40] |
| Sinclair | Sec. 23, T. 4 N., R. 1 E. |
| Thompson | Sec. 36, T. 5 N., R. 1 E. |
| Empire | Sec. 27, T. 2 N., R. 1 W. [41] |
| Barber | Sec. 30, T. 2 N., R. 1 W. [41] |
| Nelson et al | Sec. 21, T. 4 N., R. 1 W. [40] |

The fact that some of these wells are over 3,000 feet deep and show a considerable thickness of material below the red beds, without having reached lower Paleozoic formations, indicates that in Cherokee, Marmaton and Kansas City time, a basin similar to the Coal Basin existed to the west of the Hunton Arch and received sediments of similar thickness. These thick Pennsylvanian sediments must therefore be present beneath central and western Garvin County.

The above is the extent of our present knowledge of the subsurface stratigraphy of Garvin County, outside the Robberson field. It is to be hoped that in future deep drilling, cuttings will be carefully taken and examined microscopically, in order that some definite information may be obtained.

Table No. IV lists the formations thought to be present beneath the surface of Garvin County, and their probable equivalents in other areas.

39. Dott, Robert H., Op. cit.
40. The writer saw fossils from these wells.
41. There is some doubt as to the identity of the lowest formations.

*Table* IV. *Subsurface stratigraphy of Garvin County with correlations.*

| Age | Northern Oklahoma and Kansas | | Garvin County and vicinity | Carter County | |
|---|---|---|---|---|---|
| Permian | Enid group | | Enid group | Enid group | |
| Pennsylvanian | Wabaunsee | | Pontotoc terrane<br>Ada formation | Pontotoc | |
| | Shawnee | | Vamoosa | Break ? | |
| | Douglas | | Break ? | Break ? | |
| | Lansing | | Break ? | Break ? | |
| | Kansas City | | Francis | Hoxbar | |
| | Marmaton | | Wetumka-Seminole | Deese | Glenn [42] |
| | Cherokee | | Thurman-Calvin<br>Savanna-Boggy | Cup Coral | Glenn [42] |
| | Winslow | Absent (?) in Garvin Co. | McAlester<br>Hartshorne | ?<br>? | |
| | ? | Absent (?) in Garvin Co. | Atoka | ? | |
| | Morrow formation | | Wapanucka<br>Upper Caney | Otterville<br>Springer | |
| Mississippian | | | Lower Caney<br>Sycamore | Caney<br>Sycamore | |
| Devonian | | | Woodford<br>Upper Hunton | Woodford<br>Upper Hunton | |
| Silurian | | | Lower Hunton<br>Sylvan | Lower Hunton<br>Sylvan | |
| Ordovician | | | Viola<br>Simpson<br>Upper Arbuckle | Viola<br>Simpson<br>Upper Arbuckle | |
| Cambrian | | | Lower Arbuckle<br>Reagan | Lower Arbuckle<br>Reagan | |

42. True Glenn, according to Girty and Roundy. Goldston would include the Springer, Otterville, Cup Coral, Deese and Hoxbar.



### THICKNESS OF RED BEDS

Plate III shows the thickness of the red beds in Garvin County and parts of adjacent counties. Included in these "red beds" are the "red Pennsylvanian" (Pontotoc terrane) and the Permian (Enid group). Whether the base of these red beds represents the same stratigraphic horizon in all cases is conjectural.

Most of the wells in this vicinity were drilled with rotary tools, and many of the logs are so poorly kept that only a few selected ones could be used for this map. Many logs of deep wells report no "red beds" at all.

It is interesting, though beyond the scope of this paper, that in many of the Carter and Stephens County pools, the red beds are thinner than outside the pools, indicating that these fields overlie buried hills which were islands during part of red bed deposition. As this map is generalized, these features are not well shown. Burton[43] has worked out the details of this relationship for several fields.

## STRUCTURE

### SURFACE STRUCTURE

Two major structural features occur in Garvin County, the Anadarko basin and the Arbuckle anticline. The short south limb of the former is also the north limb of the latter, whose extension in Garvin County is largely buried beneath red bed deposits. The Anadarko basin is a depositional feature, resulting largely from settling into a pre-existing trough. The Arbuckle anticline is clearly the result of horizontal movement.

Since Garvin County is topographically a dissected plateau with the tops of the hills always at about the same level, the areal geologic map serves also to show the regional surface structure.

A number of small apparent domes and anticlinal noses can be worked out in various parts of the county, but from the nature of the beds and the absence of good markers, such mapping is attended with considerable uncertainty.

### SUBSURFACE STRUCTURE

Outside the Robberson field, our knowledge of the subsurface structure of Garvin County is limited to the extreme eastern part where wells have passed through red beds and marine Pennsylvanian strata into lower Paleozoic formations. These data indicate only that eastern Garvin County lies on the steep west flank of the Hunton Arch, as shown by figure 20.

The Texas Pacific Coal and Oil Company well in sec. 5, T. 1 N., R. 1 E., (T. D. 3,476 feet, in Pennsylvanian) and the Sinclair Oil

43. Burton, George E., Relation of red beds to the oil pools in a portion of southern Oklahoma: Bull. Amer. Assoc. Pet. Geol., vol. 5, p. 173, 1921.

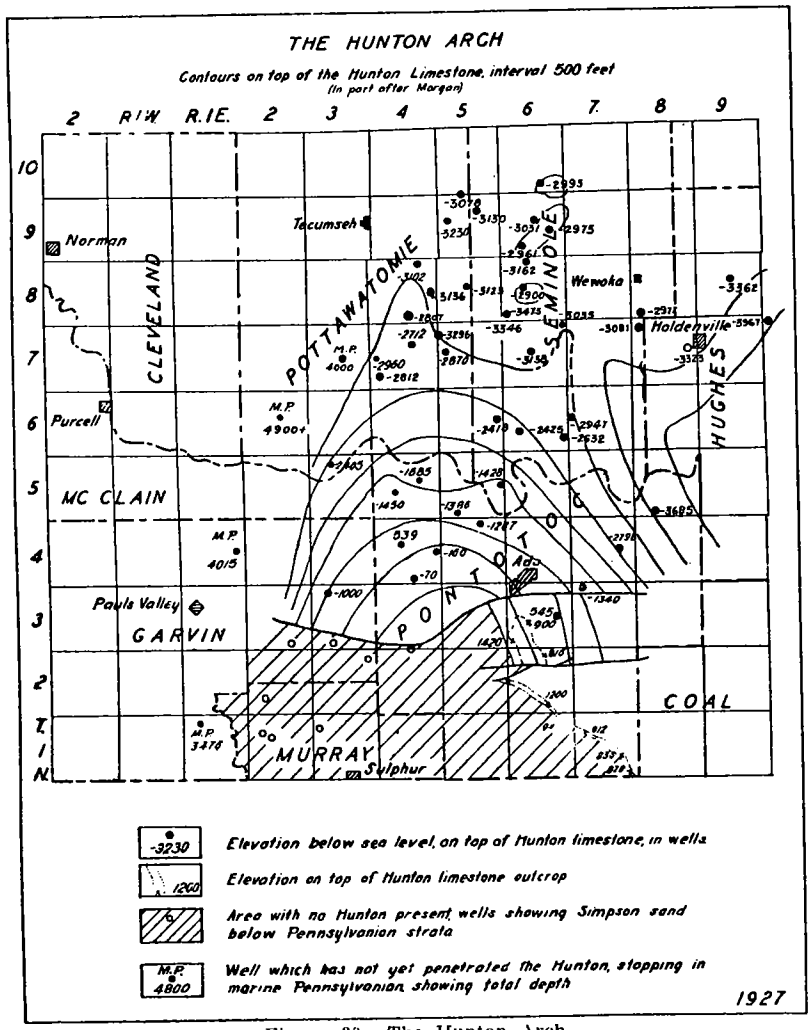



Figure 20.—The Hunton Arch.

N. B. for well in sec. 10, T. 6 N., R. 2 E., read 4,900 instead of 4,015.
Well shown in sec. 33, T. 5 N., R. 9 E., should be in 33, T. 5 N., R. 8 E.

and Gas Company well in sec. 23, T. 4 N., R. 1 E. (T. D. 4,015 feet, in probable Pennsylvanian) indicate that the lower Paleozoic formations are dipping rapidly to the westward. The Texas Pacific well showed upper Pennsylvanian at an elevation of 2,480 feet below sea level at the bottom of the hole, whereas the Gibson well seven miles east showed the top of the Simpson sand at 1,417 feet below sea level. The Sinclair well showed Pennsylvanian at about



3,015 feet below sea level at the bottom of the hole, whereas the G. A. Manahan, well nine miles east, showed the Hunton limestone at 994 feet below sea level.

The top of the Hunton Arch has been broken by a fault parallel to the Arbuckle anticline and the Mill Creek syncline, through the southern part of T. 3 N. The upthrow is to the south, bringing the Simpson formation in contact with the Hunton limestone. This fault is shown on Fig. 20. Table V shows several wells in which the Simpson formation was found to be overlain by marine upper Pennsylvanian strata. Wells drilled north of this fault found these younger deposits to be overlying the Hunton limestone.

*Table V. Wells showing Simpson sand to be overlain by marine Pennsylvanian strata.*

| Company | Location | Depth to Simpson Sand |
|---|---|---|
| Dixie Oil Co. | sec. 33, T. 3 N., R. 4 E. | 830 feet |
| Goldeline Oil Co. | sec. 11, T. 2 N., R. 3 E. | 725 feet |
| J. S. Cosden | sec. 32, T. 3 N., R. 3 E. | 1,690 feet |
| Texas Pacific | sec. 35, T. 3 N., R. 2 E. | 1,985 feet |

The fault block described above probably extends westward for some distance, but the relation of the subsurface formations in the Gibson well in sec. 29, T. 2 N., R. 2 E., and the Texas Pacific well in sec. 5, T. 1 N., R. 1 E., indicates that it is plunging rapidly to the west.

## FUTURE POSSIBILITIES

In the present state of our knowledge, the future of Garvin County as an oil producer is an enigma. In January, 1927 a new pool was opened south of the Robberson field, and others may yet be found in that vicinity. Outside the Robberson field drilling to date has proved but little beyond the thickness of the red beds and the certain fact that any future production will be deep.

It seems reasonable to expect that any possible production should be found under conditions similar to those existing in neighboring oil fields. Five sets of such conditions are known:—

1. Pennsylvanian production near Ada.
2. Hunton and Wilcox production in Seminole County.
3. Production in Carter and Stephens counties.
4. Ordovician production at Robberson.
5. Permian (?) production in T. 3 N., R. 5 W.

### PENNSYLVANIAN PRODUCTION

Wells have produced small quantities of oil from the Boggy shales (Cherokee) or adjacent formations in the vicinity of Ada and Allen. This production occurs in small flexures of otherwise gently dipping beds.

Similar beds, probably under similar structural conditions occur in Garvin County, though at prohibitive depths unless larger wells can be found than those in the Ada and Allen fields.

### HUNTON AND WILCOX PRODUCTION

A small amount of production is found in the Hunton limestone near Beebe, Pontotoc County, and a commercial well was completed in January, 1927, producing from this horizon, in sec. 19, T. 7 N., R. 4 E. The discovery wells in the Seminole field produced from the Hunton horizon, and numerous Hunton wells are still being operated.

Scores of wells in Murray and Pontotoc and a few in Garvin County have passed through the Hunton limestone with no more than small showings of oil.

In eastern Garvin County on the west flank of the Hunton Arch, the Simpson formation of which the Wilcox sand is a member, contains sulphur water. Numerous wells in Pontotoc and Murray counties prove that this formation will not be likely to contain oil in areas where artesian water is present.

Since the Hunton limestone and older formations are dipping so steeply to the west on the flank of the Hunton Arch, they are not likely to contain oil nor to be within reach of the drill unless folding of great magnitude has elevated them, a condition for which there is not the slightest suggestion of evidence.

### PRODUCTION IN CARTER AND STEPHENS COUNTIES

South of the Arbuckle anticline occur a number of oil fields, whose production seems to have originated in Carboniferous (Caney and Glenn) and older formations, from which it has migrated along highly tilted bedding planes, to accumulate in sands of the unconformably overlying red beds, which were flexed over topographic highs in the older formations, during or following deposition.

Wells drilled into the Carboniferous formations where they are flat-lying and not covered by red beds have produced little or no oil, suggesting that tilting and red beds overlap are responsible for the accumulation.

Such conditions cannot be found in Garvin County, outside the vicinity of the Robberson field, and the finding of Pennsylvanian shales beneath red beds in all wells west of R. 2 E., where any sort of determination can be made, and the lack of success in drilling indicate that they do not exist.

### ORDOVICIAN PRODUCTION AT ROBBERSON

It will be shown in Mr. Roth's paper that in the Robberson field the Ordovician formation seems to be the most logical source-rock for the oil which has accumulated in the axis of the Arbuckle anticline.



Reasons have already been given to show that Simpson production cannot be expected in eastern Garvin County, at least unless folding of great magnitude exists both to form a suitable trap, and to bring the formation to within reach of the drill. Similar objections may be raised concerning the duplication of Robberson conditions, and there is even less reason to believe that suitable structural conditions exist north of the Arbuckle anticline.

### PERMIAN (?) PRODUCTION IN T. 3 N., R. 5 W

In the Carter-Knox pool, in T. 3 N., R. 5 W., and elsewhere in that vicinity, oil is found at about 1,500 feet, in a sand which probably belongs to the red beds series. The Chickasha gas sand may occur at about the same horizon. Above this producing horizon, in T. 3 N., R. 5 W., occur several hundred feet of gray shale. Below the gray shale, and including the producing sand, red beds continue to the bottom of the deepest wells, some 3,500 feet in depth.

Obviously the oil is well up in the series and not at the base of the red beds. It may have originated in the gray shale, which appears to be an intercalated marine formation, or it may have been of deep-seated origin, having found its present accumulation by upward migration along fault planes. Neither hypothesis is supported by very strong evidence.

If the former explanation is correct, some hope might be held for similar production in Garvin County, though it seems that sufficient wells have been drilled to prove its non-existence. There is some reason to believe that the gray shale outcropping near Foster is equivalent to the gray shale found in wells.

If the latter hypothesis truly explains the accumulation, similar conditions might be found in Garvin County, after a thorough study of the Carter-Knox pool has shown what those conditions actually are.

# THE ROBBERSON FIELD, GARVIN COUNTY

By

Robert Roth

## INTRODUCTION

The Robberson oil field with an average daily production in June, 1923, of 6,482 barrels per day from 148 wells, ranked fifth among the producing fields of southern Oklahoma. Since then it has steadily declined, even though there has been an increase in the number of producing wells, until its average daily production for the month of December, 1926, is 2,976 barrels per day from 232 wells.

The pool has been very extensively drilled, but in spite of this fact, very little is known of the sub-surface conditions below the base of the Permo-Pensylvanian red beds, due without a doubt. to the fact that well cuttings were not saved except in a few rare occasions. However, a few more facts have been brought to light from the drilling records of the past three years which may be of some interest and which will be set forth in this paper.

### ACKNOWLEDGMENTS

The writer wishes to express his thanks to the Atlantic Oil Producing Company for the liberal use of their samples, maps and production reports and to E. D. Luman for many helpful suggestions and for critically reading the manuscript. He is also indebted for many helpful suggestions to Frank C. Greene, of the Skelly Oil Company, George S. Buchanan, of the Carter Oil Company, and Sidney Powers, of the Amerada Petroleum Corporation.

The author finally records his grateful appreciation of the help of A. R. Denison in reading the manuscript and for the use of several samples of well cuttings which Mr. Denison obtained from the Amerada Petroleum Corporation. In this is included Robert H. Dott of the Mid-Continent Petroleum Corporation, who suggested many corrections and to whom the author is indebted for the inception of the manuscript.

## LOCATION

With the exception of several small wells which are distant outliers of the pool, the main field lies in sections 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18 and 20, T. 1 N., R. 3 W., of the southwest corner of Garvin County. It is 28 miles southwest of Pauls Valley, 30 miles east of Duncan, and 10 miles northwest of the western end of the Arbuckle Mountains. Robberson field may be reached by roads from

1. Presented before the Tulsa Geological Society, February 19, 1927.



Pauls Valley, Wynnewood, and Duncan. The nearest railroad point is Wynnewood, 22 miles northeast, on the main line of the Gulf, Colorado and Santa Fe Railway.

## HISTORY

This region about Robberson field has been considered to have petroleum possibilities for the past twenty-six years. Mr. G. H. Eldridge[2] noted several occurrences of asphalt and a number of oil seepages in water wells, springs and prospect holes from the western end of the Arbuckle Mountains out as far as the Robberson field as it is now located.

Mr. Joseph A. Taff[3] has described the geography, physiography, and general relations of the Pre-Cambrian igneous rocks, Cambrian, Ordovician, Silurian, Devonian, Carboniferous, Cretaceous rocks and Quaternary deposits. He also gives the geologic structure of the Arbuckle Mountains and their mineral resources.

Mr. Chester A. Reeds worked in the Arbuckle Mountains after Joseph A. Taff. The results of this research was published as Bulletin No. 3 of the Oklahoma Geological Survey in 1910. It is entitled "A Report on the Geological and Mineral Resources of the Arbuckle Mountains, Oklahoma." In this paper Mr. Reeds describes the physiography, stratigraphy, structure and mineral resources of the region.

Another article published by Mr. Chester A. Reeds, upon the Arbuckle Mountains is to be found in Natural History, Vol. XXVI, No. 5, for September-October, 1926, and Oklahoma Geol. Survey, Circ. No. 14, 1927. This article deals principally with reminiscenses of the author while collecting in the area. The article is well illustrated and contains a good stratigraphic column which has several new revisions as well as a new formation; i. e. the Frisco limestone, which lies above the Bois D' Arc limestone and below the Woodford chert.

Taff[4] describes the physiographic features and the history of the region; the occurrence, character, and relations of the pre-Cambrian igneous rocks, and Cambrian, Ordovician, Silurian, Devonian, Carboniferous, and Cretaceous sedimentary rocks, and the geological structure of the Arbuckle and Wichita Mountains.

In 1913, L. C. Snider[5] wrote a report giving a brief discussion of all the larger deposits of asphalt found in the state of Oklahoma, which included character, size, age of containing rocks and location.

2. Eldridge, G. H., U. S. Geol. Survey, 22nd Annual Report, 1901.
3. Taff, Jos. A., U. S. Geol. Survey, Geol. Atlas, Tishomingo Folio (No. 98), 1903.
4. Taff, Jos. A., Preliminary report on the geology of the Arbuckle and Wichita Mountains, in Indian Territory and Oklahoma: U. S. Geol. Survey, Prof. Paper, 31, 1904.
5. Snider, L. C., Rock Asphalts of Oklahoma and their use in Paving: Oklahoma Geol. Survey, Circ. No. 5, 1913.

Several deposits in counties surrounding the Robberson field were mentioned.

In 1915 Pierce Larkin confirmed the presence of oil and gas in shallow water wells at Robberson, two of which are in the NE. ¼ sec. 16, T. 1 N., R. 3 W. He also found evidence of favorable structure in local dips. On his recommendation a block of acreage was secured by the McMan Oil Company, who sold their holdings to the Magnolia Petroleum Company before the leases were prospected. It is probably due to his work that the field was discovered.

Moore[6] gives a general discussion of all the principal producing fields of southern Oklahoma, south and west of the Arbuckle Mountains which contains a study of the subsurface conditions of the fields and their intimate relationship to the Arbuckle uplift.

A brief discussion of the geological history of the region and facts regarding the origin of the oil are put forth. It is believed that most of the oil in southern Oklahoma is derived from the Ordovician.

No further work was published on the area in general until Mr. W. L. Goldston, Jr.[7] described the Glenn formation as including the Hoxbar, Deese, Cup Coral, Otterville and Springer members, also giving character, areal extent, faunal lists and a correlation with north-central Texas and with the formations north of the Arbuckle Mountains.

Following this article Girty and Roundy[8] published an article giving faunal lists of all the members of the Glenn formation as well as some members northeast of the Arbuckle Mountains with which the Glenn has been correlated. From these results and by taking the original definition of the Glenn as given by Taff in the Tishomingo Folio, they believe they have grounds for delimiting the Glenn formation to the Deese, Cup Coral and possibly the Otterville members.

A report by A. R. Denison[9] summarizes all the data that was known about the Robberson field up to that time.

The last publication on the area in general is in the Bulletin of the American Association of Petroleum Geologists, Vol. IX, Number 6, for September, 1925.

Ralph A. Birk[10] traced the limestones near the base of the Stratford formation of the Pontotoc series around the west end of the

6. Moore, R. C., The relation of mountain folding to the oil and gas fields of southern Oklahoma: Bull. Amer. Assoc. Pet. Geol., Vol. 5, No. 1, 1921.
7. Goldston, W. L. Jr., Differentiation and structure of the Glenn formation: Bull. Amer. Assoc. Pet. Geol. Vol. VI, No. 1, 1922.
8. Girty, Geo. H. and Roundy, P. V., Notes on the Glenn formation of Oklahoma, with consideration of the new paleontologic evidence: Bull. Amer. Assoc. Pet. Geol., Vol. VII, No. 4, 1923.
9. Denison, A. R., The Robberson field, Garvin County, Oklahoma: Bull. Amer. Assoc. Pet. Geol. Vol. VII, No. 6, 1923.
10. Birk, R. A., The Extension of a portion of the Pontotoc Series around the western end of the Arbuckle Mountains: Bull. Amer. Assoc. Pet. Geol., Vol. IX, No. 6, 1925.



Arbuckle Mountains, and then southeast to a point near Ardmore. The mapping was done before George D. Morgan's report on the geology of the Stonewall quadrangle was published. Since the top, rather than the bottom, of the limestone series was followed the line shown on the map does not coincide with the one of Morgan's formation boundaries. The base of the Asher formation, which is next above the Pontotoc series, was also traced around the mountains and found to overlap the shale in the upper part of the Stratford formation. The west end of the Asher formation rests directly on the limestones in the lower part of the Stratford formation, which are in contact with the upturned edges of the Ordovician limestones. All lower members of the Pontotoc series are absent. The conglomerates near Berwyn, formerly called Franks, are assigned to the Pontotoc series, and a correlation is made across the mountains by J. T. Richards on the basis of some concentric-ringed pebbles which have been banded by algae. It is suggested that the uncertain boundary between the Permian and Pennsylvanian be placed at the base of the Asher formation.

Gas was discovered in April, 1920, by the Magnolia Petroleum Company, Cowan No. 1, NW.¼ SW.¼ NW.¼ sec. 16, T. 1 N., R. 3 W., and became exhausted before the well was completed. The first big well to be brought in was the Mauldin No 1, which came in on June 9, 1920, estimated at 40,000,000 cubic feet from a total depth of 1,386 feet.

Following this an active campaign was started on adjacent property and during the next thirteen months many gas wells were completed in sections 15 and 16. Most of them reached the gas sand of the Mauldin No. 1.

Oil was discovered in Magnolia's Hart-Newberry No. 1 in the NW. cor. section 14 on July 16, 1921, more than a year after the discovery of gas. This well was estimated to have yielded 200 barrels per day and stimulated a drilling campaign which led to the finding of oil in section 16, and in the vicinity of the discovery well in section 15. Development progressed around these centers of production until they were connected by producing oil wells.

The first large producer was the Texas-Pacific Coal and Oil Company's Pearce No. 1, NE.¼ SW.¼ sec. 13, which came in on August 16, 1922, producing 1,000 barrels daily (initial yield). This well gave the field its greatest impetus and there soon followed two other wells, each making more than 8,000 barrels daily. From that time on the production increased very rapidly, reaching its peak in less than a year from the initial discovery. Since then the field has steadily declined to its present production.

## STRATIGRAPHY

### SURFACE

The surface exposures of the Robberson field are all of Permian age. They consist of alternating shales and sandstones, the latter sometimes grading into conglomerates, and one or two thin limestone beds. The shales are largely brown and red with an occasional blue or gray bed which rapidly grades into the characteristic red-brown shales. The sandstones frequently contain crystals of pink potash feldspar, and when these sandstones are weathered they have a spotted appearance due to the oxidation of the iron pyrite which they contain. The conglomerates contain fragments of granite porphyry and a very coarsely crystalline granite made up of quartz and the above mentioned pink orthoclase. This igneous material has been derived from granite porphyry and Tishomingo granite, which is now cropping out about 12 miles to the southeast, and is probably of Archean age. In Denison's report on the area mention is made of a bituminous sandstone cropping out in section 24 and another in the SE. cor. section 16.

### SUBSURFACE

#### Permian

In general the first 1,200 feet encountered by the drill are in part red beds called gumbo, gravel composed of arkosic material, and several limestone beds, one of which, occurring from 950 to 1000 feet, is recorded in most of the early wells drilled. This series has been named the Garvin beds by Mr. Denison. The Garvin beds carry a few water sands near the surface and these sands have a good supply of meteoric water. The lower sands of the Garvin beds contain little water, but they do have an occasional show of heavy oil. At the base of this formation is a fairly continuous limestone bed which serves as a cap rock to the producing horizon and it is upon this limestone that the contours have been made which served as the datum plane from which the profile in Figure 21 was drawn.

This figure is drawn through the high in section 14, and shows the relative accumulation of oil and gas in the Newberry sands and in the Ordovician. The formations penetrated are drawn with a scale of three on the vertical to one on the horizontal.

From 1,200 to 1,600 feet occur a series of gas sands alternating with red, brown and blue shales, which in Denison's report are called the Mauldin producing horizon after the original large gas well, Mauldin No. 1. The sands are quite lenticular which makes correlation almost impossible, even in offset wells. This apparent lenticular character of the gas sands may in part be due to faulting or slumping in the Permian. Wells to the west of the discovery well encounter three gas sands which are fairly continuous; however, the lowest is the most prolific and is the one to which most of the later wells have been drilled. In the eastern part of the field adjacent to the dis-

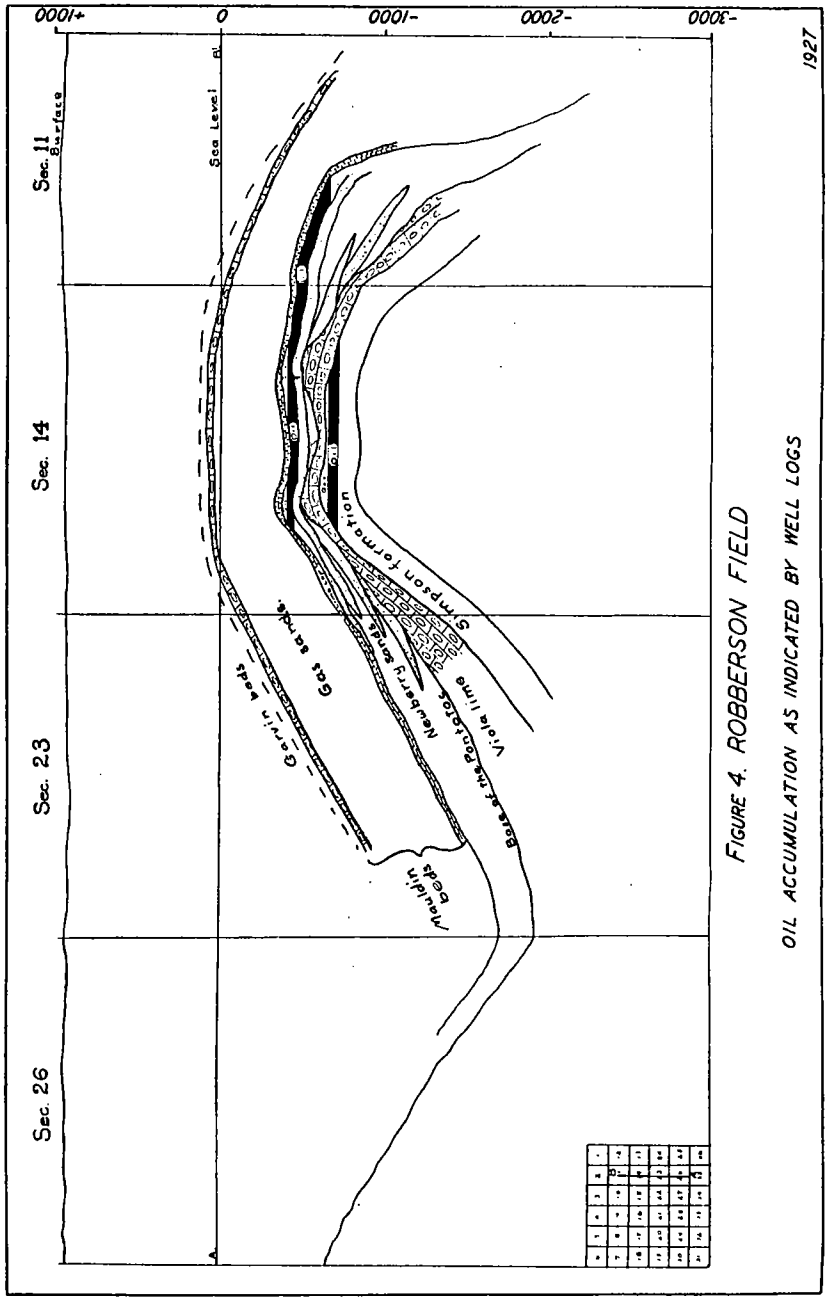



Figure 21.—Cross-section of the Robberson field.

covery well only one gas horizon has been recognized. It is quite persistent and can be roughly contoured within the limits of its production. Samples of this sand show it to be composed of well-rounded quartz grains which are frosted. They are identical with the Ordovician sands and have been derived from the Simpson formation cropping out in the Arbuckle Mountains to the southeast.

### PENNSYLVANIAN

The Garvin and Mauldin beds are of Permian age and both rest with great unconformity upon the Ordovician sediments below, since all the Silurian, Devonian, Mississippian, and most of the Pennsylvanian have been removed, as well as a part of the Ordovician. In the old ravines and gullies of these buried hills, and also spread over the hills themselves at a depth varying from 1,375 to 1,877 feet is found a sand series called in Denison's report the Newberry sands after the discovery well, Newberry No. 1. These sands are undoubtedly an erosional residue and probably represent an overlap of the last of the Pennsylvanian seas in the area prior to Permian deposition, as they may be correlated with the Pontotoc cropping out to the southeast. Certainly there can be but little doubt that they represent a formation older than the Permian.

### ORDOVICIAN

The buried hills are composed of a series of limestones and sandstones with a limestone layer of varying thickness over the top. These formations are resting at a high angle probably as a monoclinal fold with the steepest dip to the north and, without a doubt, are faulted. A steep dip on the north would account for the undue thickness of limestone encountered in some of the wells drilled on that flank.

Well samples of this limestone have been examined with the microscope and were found to vary in color and lithographic character from a dense light brown to a dark gray limestone containing some crystalline calcite stringers of almost microscopic dimensions. Larger fragments show many calcite stringers running through the mass and this is also well brought out in thin sections of the limestone. No dolomite has been identified in this limestone. These well samples were compared with outcrop samples of Viola and Arbuckle limestones and seem to agree in every way with the characteristics of the Viola limestone as examined, but do not seem to check with the Arbuckle limestone. Furthermore, the section below the limestone in question is comparable to the Simpson formation. Typical Simpson sands which are present would exclude the probability of the limestone beds as being a part of the Arbuckle limestone. From these facts it seems that the limestone is Viola and the alternating sands and dolomitic limestones are Simpson and that the Arbuckle limestone has probably never been penetrated by the drill in the Robberson field.



In Mr. Denison's report two wells in particular were stated to have penetrated granite. One of these wells is the R. Newberry No. 2, Acc. No. 2 of the Texas-Pacific Coal and Oil Company, 150 feet from the SE. line SW.¼ NE.¼ SW.¼ sec. 13, T. 1 N., R. 3 W., in which the granite was logged by the drillers as red and black limestone from a depth of 1,801 to 2,119 feet.

The other well which reported igneous material is the Weaver No. 1, NE. cor. W.½ SE.¼ SW.¼ sec. 13, T. 1 N., R. 3 W., Texas-Pacific Coal and Oil Company. This well was shut down at 1,805 feet in what was logged as black limestone. Samples of this black limestone are described as dark porphyry in Denison's report.

Figure 22 is a contour map based upon the contact between the Pontotoc and the Ordovician. The contours in this map are quite accurate as there is no doubt as to the formation when the drill strikes the Viola limestone. The probable faulted zone is indicated by one line. Contour intervals are 100 feet, and areas which have an accumulation of oil and gas are indicated. The dark circles are wells penetrating the Ordovician and the depths at which the Ordovician was encountered is given, taken from sea level as a base. The light circles are some of the deeper wells in the red beds. Shallow depths are not given but were used as control points in making sub-surface contours.

In referring to Figure 22 it will be noted that the Viola limestone has been found within a quarter of a mile on all sides of these two granite wells. Furthermore, it can be noted that the total depth of these wells is about where the base of the Pontotoc should be as there is a small depression found at this place.

Samples of the granite found in the R. Newberry No. 2 were examined by the writer and found to be arkose. Since the arkose found in this area resembles a granite to such an extent that when it is drilled up, it is impossible to differentiate it from a true granite without the aid of a microscope, hence it is very possible to mistake this arkose for a granite. Samples of the Weaver No. 1 were not obtainable, but Sidney Powers states that the material is a diorite or a related rock. If this is so and if the writer's determination of the Viola limestone is correct, then it is the first instance of igneous activity later than the pre-Cambrian so far found in the Arbuckle Mountains.

The areal geologic map (Fig. 23) shows the Arbuckle uplift and its relationship to the pools southwest of the Arbuckle Mountains. The condition at Robberson is indicated as being a continuation of the Arbuckle uplift beneath the red bed overlap, and it will be noted that the other pools have a tendency to be en echelon and parallel to the main uplift. The subsurface formation contacts are indicated and are quite accurate, except northeast and due east of the Robberson field as no deep wells have been drilled in this area. The formation

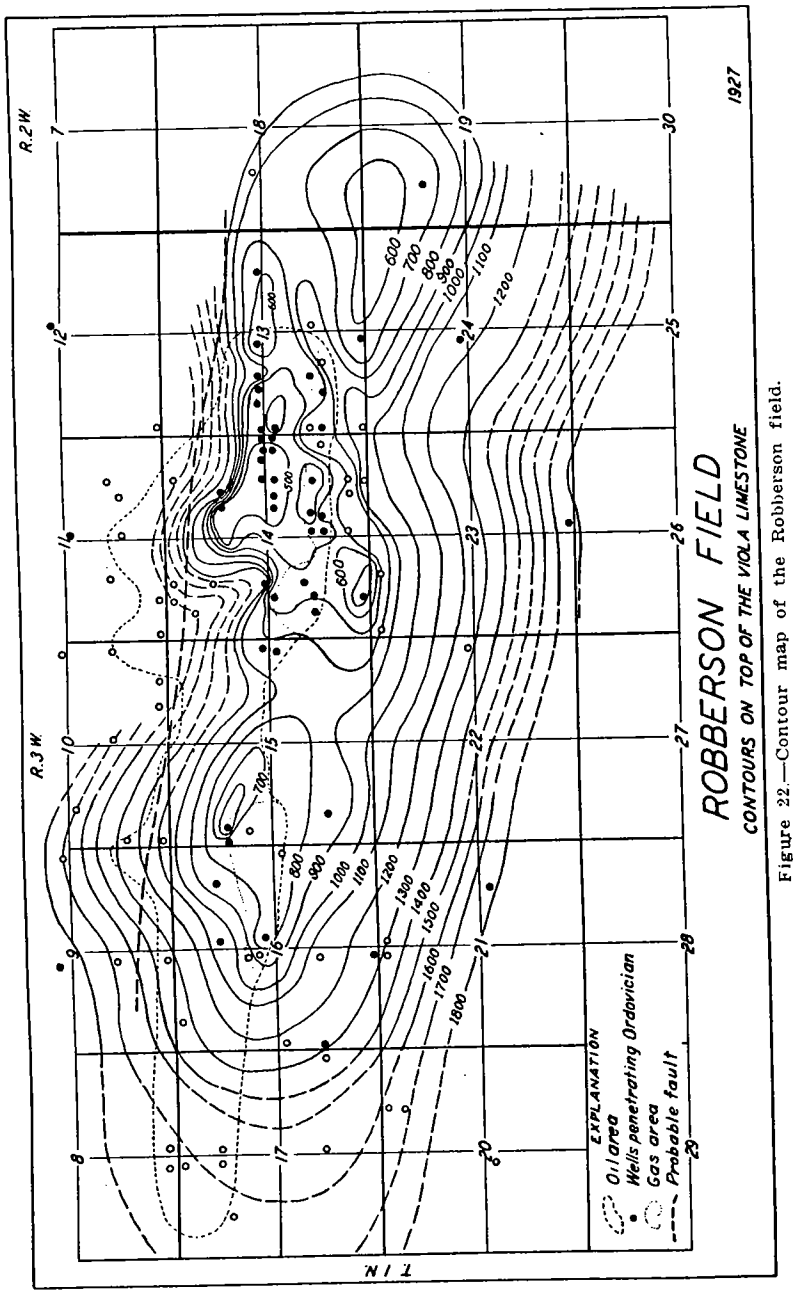



Figure 22.—Contour map of the Robberson field.



contacts south and southeast of Robberson beneath the red beds overlap are based upon sample determinations of the following wells.

Samples obtained from the wells drilled on the south flank of the pool were examined with a microscope and these determinations were made with the aid of microscopic fossils. Broadgate's Abram No. 1, SW.¼ SE.¼ sec. 23, T. 1 N., R. 3 W., passed through the red beds at 1,295 feet and entered into a formation that is Springer or older, and encountered the Viola limestone at 2,910 feet. The well was abandoned at 3,016 feet, still in the limestone. Magnolia's Downey No. 1, NE.¼ NE.¼ sec. 22, T. 1 N., R. 3 W., found the base of the red beds at 1,825 feet and penetrated the Springer to 2,480 feet, the total depth. Another well, W. H. Riddle No. 1, Texas-Pacific Coal and Oil Company, SW.¼ SW.¼ NW.¼ sec. 35, T. 1 N., R. 3 W., had the base of the red beds at 584 feet and then went to 2,630 feet, ending in definite Springer. The Magnolia Burr No. 1, sec. 31, 1 N., R. 3 W., produced 75 barrels per day (initial production) after being drilled in late January, 1927. Samples were examined from a depth of 3,390 feet and the fauna which they contained indicated that the production was coming from the Cup Coral.

On the west side of the pool the section is best represented by the Edwards No. 1, Grimes and Russell, sec. 23, T. 1 N., R. 4 W. This well found the base of the red beds at 1,968 feet. It drilled to a total depth of 3,525 feet, ending in the Deese member of the Glenn formation.

On the north side of the pool, the well in the NW.¼ SE.¼ SE.¼ NW.¼ sec. 9, T. 1 N., R. 3 W., found the base of the red beds at 2,745 feet. It then penetrated the Viola limestone to a total depth of 4,275 feet. Other wells to the north of the pool have very unsatisfactory logs and interpretation is impossible. One log, however, is fairly good. It is that of the Bell No. 1 Shaffer, located in the SE.¼ SE.¼ SE.¼ NW.¼ sec. 33, T. 2 N., R. 3 W., in which the red beds were penetrated to a depth of 2,005 feet. The base of the red beds north of the field is below 3,000 feet.

On the east and southeast all the older formations gradually come to the surface until they crop out about twelve miles distant from the field in the Arbuckle Mountains.

## OIL PRODUCING SANDS

### PONTOTOC

Samples from the Newberry sands with few exceptions are shown to be but loosely consolidated sediments, composed of conglomerates, containing some fragments as large as hazel-nuts, and consisting of chert, limestone, crystalline quartz, and pink potash feldspar. Some fragments are angular and others well rounded. In general, the limestone is well rounded, while the chert and larger

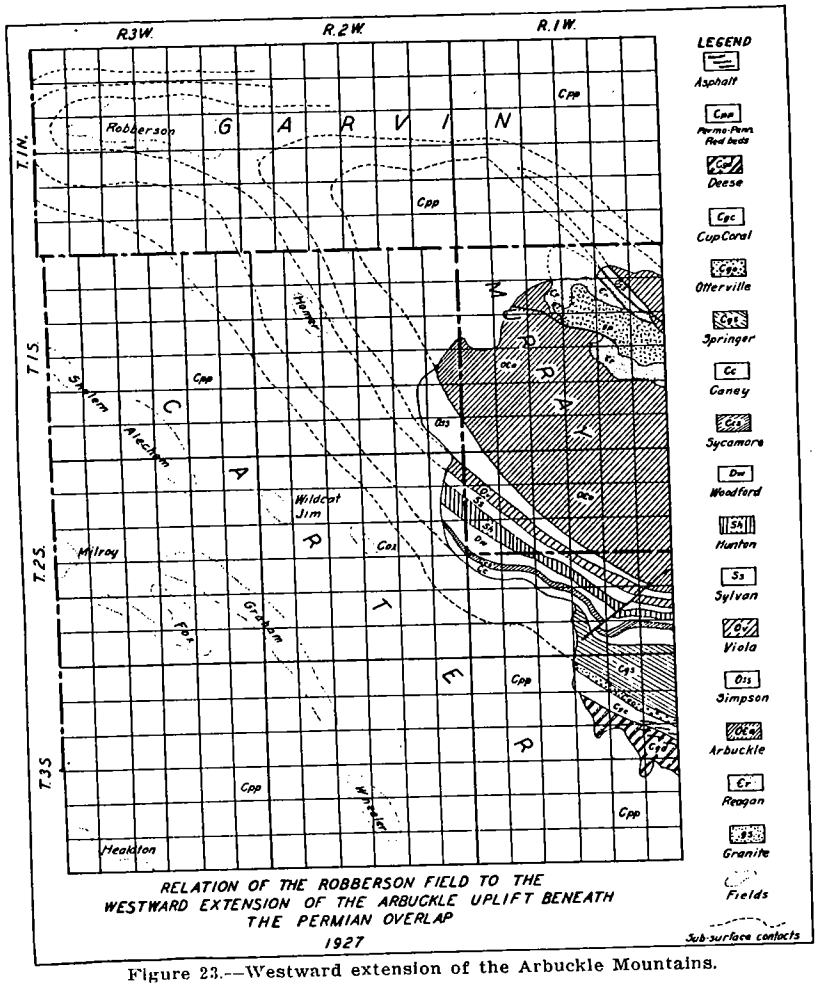



Figure 23.—Westward extension of the Arbuckle Mountains.

grains of quartz are angular. The smaller grains of quartz are frosted and well rounded, while the feldspars are only slightly rounded. The condition of the particles indicates short transportation and rapid erosion from a nearby land mass. The frosted grains are from the eroded Simpson formation. These sands are found from the top far down the flanks on all sides of the buried hills but they do not seem to extend as producing sands beyond the immediate vicinity of these hills. They are productive of much gas and can be correlated over the whole field though not equivalent in age, as those at the bottom are older than those at the top of the hills. The upper members of this sand series which are found on the flanks of the buried hills are probably equivalent in age to the gas sands occurring on top of these hills. The Homaokla Hervey No. 1 SW.¼ NE.¼ NW.¼ NW.¼ sec. 14, T. 1 N., R. 3 W., produced 20,000,000 feet of gas and 60 barrels of oil initial yield. This well is down the north slope of the buried hills. None of the other wells producing oil from these sands has sufficient gas to make them flow longer than a few days. Two members of the Newberry sands, near the top of the buried hills, have a constant interval over local areas but vary greatly over different parts of the field. The discovery well produced from the upper sand, but many later wells found this sand barren and were drilled to the lower horizon.



In other parts of the field only one of these sands is found to be productive. It is considered to be the lower member as this sand is more persistent and is a better producer than the upper one. Below these two sands numerous shows of oil and gas are found, but only one commercial producer, Hart Ringer No. 4, SE. cor. SW.¼ SW.¼ sec. 11, has been completed. Deeper drilling in other parts of the field have found not further encouragement.

### ORDOVICIAN

The big pay horizon in the buried hills ranges from 4 to 402 feet below the base of the Pontotoc. The biggest wells have found the oil only a short depth in the hills as Nelson Brothers' Jones No. 5 was drilled 22 feet into the limestone, Humble's Powell No. 1 four feet in, and Texas-Pacific's Pearce No. 2, ten feet in. These wells are located in sections 13 and 14. The depth of production varies, due to the folded and faulted conditions existing in the buried hills and to the amount of the Viola limestone eroded. Samples indicate that the production all comes from one horizon below the Viola limestone.

An interesting fact is that offsets to the biggest wells in the field did not make more than 150 barrels per day initial production, although in some cases the offset was producing from the same or greater depths before the "gusher" well came in. This shows that the oil has accumulated in pockets and lenses of the pay horizon, which is probably due to faulting and to the degree of cementation of the sand.

## STRUCTURE

### SURFACE

The surface structure is very difficult to work because of unreliable exposures. Even when good exposures are found they are very difficult of interpretation due to the slumping and probable faulting to whch they have been subjected, both from actual movement and from differential settling of the Permian beds on all sides of the Robberson buried hills. Several things, however, are quite

evident from the outcrops: there is a definite south dip in sections 23 and 24; also a southwest dip in section 16. A west dip may possibly be recognized in section 17.

Pierce Larkin in working over the Robberson area recognized what he thought to be an anticline.

## SUBSURFACE

### Permian

Any interpretation of the subsurface conditions in the Permian formations is extremely difficult due to the lenticular character of the beds and to the great unconformity between the Permian and the older sediments. However, fairly good results may be obtained by contouring on the lime cap above the Newberry pay horizon.

A contour map on the Permian pay zone, which is not included in this report, shows a great many irregularities in sections 13, 14, and 16. This may be due in part to local faulting. Also, the domes or highs found in the Permian are in every case the direct reflection of corresponding highs in the buried hills, and therefore, the contour map in Figure 22 may be taken as the same for the Permian, except that the relief of the Permian is not so pronounced.

### Pontotoc

The same difficulty that one has in contouring the Permian is encountered when he tries to contour the Newberry sands, as they are definitely known to be very lenticular.

### Ordovician

The contours in Figure 22 do not represent the attitude of the strata in the older formations, but they do represent the topography of these hills as they were gradually buried by the advancing seas before the Permian and Pennsylvanian deposition The contours show an irregular range of hills striking to the west and rapidly dying out in that direction, as the last notable peak is to be found in section 16. Samples from various wells penetrating the older sediments show that the dips in the formations are quite high, in some cases above 45°, especially on the northern flank.

## ORIGIN OF STRUCTURE

The Robberson buried hills are composed of sedimentary rocks and are the northwest continuation of the Arbuckle Mountains. The older sediments and igneous rocks composing the Arbuckle Mountians plunge under the Permian and Pontotoc in the eastern part of T. 1 S., R. 2 W., the Permian sediments overlying the Robberson hills have, since their deposition, been subjected to all later movements that may have occurred in the Arbuckle Mountains. Also these sediments have undergone a certain amount of differential settling after deposition which allowed them to settle on all sides of the buried hills. Differential settling accompanied by possible movements in the



Arbuckle Mountains will account for the 200 feet of closure which is found in the Permian and Pontotoc pay horizons.

The structure permitting the accumulation of oil in the Robberson field differs from most of the other structures of southern Oklahoma, in that the latter are buried truncated folds parallel to the main Arbuckle uplift. These truncated folds are not continuous, but have a tendency to be en echelon with each other. They may in some cases have a structure similar to that of the Criner Hills which are a series of fault blocks, while on the other hand the Robberson Hills are a direct continuation of the Arbuckle Mountains beneath the Permian and Pontotoc overlap.

The production of the Robberson field comes from the Permian, Pennsylvanian and Ordovician.

## RELATION OF STRUCTURE TO PRODUCTION

Oil and gas occur on the northern flank of the pool, but not on the southern and southwestern flanks, except in very few isolated places, and then only in small amounts. The producing sand is continuous over the south side in spite of this segregation of the production on the northern flank.

The production on the north sides seems to be limited by the pinching out of the sands, as many dry holes in the area record no "pay" sand at the regular horizon. These sands are, no doubt, very lenticular in character, as indicated by the logs and records of producing wells, because a dry hole is often offset by a 1,000 barrel gusher. The gas wells are mostly in the Permian and Pontotoc, though many of the wells in the Ordovician produce a great amount of gas with high pressure. This is probably the cause of the emulsion of oil and connate water which was found so hard to break when the wells were brought in from below the Viola limestone, and which caused a great loss of oil. The gas pay is also very lenticular in character. It occurs on the summit and well down on all flanks of the Robberson hills. The gas wells are located over the peaks of the Ordovician in sections 13 and 14, as well as in sections 15 and 16. The saddle between sections 14 and 15 is productive of oil.

All the peaks of the buried hills shown in Figure 19 are productive of oil and gas. The highest peak in sections 13 and 14, however, has had the largest wells in the older sediments.

## ORIGIN OF OIL AND GAS

Chemical analysis of the oil in the Pontotoc as compared with the analysis of the oil in the Ordovician shows both oils to be identical. This would preclude the possibility of the oil in the Pontotoc and the Mauldin beds from having a different source than that found in the Ordovician.

The following discussion in which three theories will be presented is made with the supposition that the oil is derived from a single source.

The first theory is that the oil and gas may have had their origin in the Permian sediments surrounding the buried hills. In the Carter-Knox field in T. 3 N., R. 5 W., about ten miles to the northwest of Robberson, the oil may have originated in a gray shale intercalated in the red beds which occurs at a depth of about 1,000 feet. The Permian origin for this oil is doubted by several geologists, as they recognize a fault in the field which may have allowed the oil to migrate upwards from below. However, there are several facts which militate against the acceptance of this theory in the Robberson field. In Figure 21 the accumulation of the oil and gas is shown to be on only one side of the pool, namely the north flank. This segregation of the oil and gas on the north flank of the pool is not due to the pay sand occurring only there, since the same porous sand may be found on the south flank and at the same relative horizon. This accumulation would lead one to believe that the oil was derived from some place to the north of the pool. If the oil were derived from the Permian it should occur on all flanks of the buried hills.

Other facts which do not argue in favor of the oil and gas coming from the Permian are as follows: In the Mauldin beds the sands are more or less connected and they have produced most of the gas from the field. In a few places a very heavy asphaltic oil is found in these sands. In the Newberry sands a general connection is also found. Most of the oil produced from this series of sands, is a lighter gravity oil and is associated with considerable gas. These sands are notably free of water, as when a well producing from them is abandoned water does not flow in to take the place of oil. In the Ordovician all the production was of the gusher type and of very short duration. This oil was under hydrostatic head and had a very high gas pressure. There seemed to be very little connection between the producing wells, as gushers were frequently offset by wells producing only 150 barrels per day. All of these wells were drowned out by connate water.

In the light of these facts and supposing the oil and gas to have migrated up the north flank of the pool through the course Pontotoc sands a fault must be postulated in order to allow accumulation in the Ordovician. It seems highly improbable that the oil and gas should have migrated downwards along these fault planes into the Simpson, and against the connate water which it contains, and after arriving there, to have accumulated in lenses and pockets which were subsequently sealed off sufficiently to prevent further connections. Furthermore, this migration is contrary to the generally accepted theory regarding an interchange of oil and water, as we have a sand in the Pontotoc and in the Simpson, yet the Pontotoc sands are



free of water. It will also be noted that the gravity of the oil and the relative amount of the gas increases the farther it is removed from the Ordovician, which would not indicate a migration from the Permian into the Ordovician. This will be explained in the third hypothesis.

A second hypothesis, and one which seems tenable for the accumulation of the oil in this pool, is that the oil originated in the Glenn formation. It is known that the Glenn formation is productive of oil in southern Oklahoma, also that where it crops out asphalt seeps are frequently found. From the facts presented on the areal map (Fig. 23) it seems reasonable to suppose that the Glenn formation found on the south and west sides of the pool swings around to the north and is present either as such or its equivalents. These beds are probably dipping at an angle greater than 35° to the north. In Figure 24a, a north-south profile is drawn through the sections shown. The base of the Pontotoc is accurate south of section 11 while to the north of this section the base of the Pontotoc is generalized. There is a depression between sections 34, 35 and sections 14 and 15, T. 1 N., R. 3 W. In the intervening sections 20-28 the base of the red beds is found at a much greater depth than those sections immediately to the north and to the south. This depression would prevent any migration of oil from the south; and production from the Magnolia well in sec. 31, T. 1 N., R. 3 W., also proves that there is a second high, although probably very small, immediately to the southwest of Robberson. Wells drilled in sections 20-28 are all dry. From this evidence it seems probable that the oil may have migrated out of the Glenn formation and up the northern flank of the buried hills through the Pontotoc. This migration would account for the peculiar accumulation of oil and gas on the northern flanks of the buried hills.

The conditions which this hypothesis does not seem to satisfy are the same as those for the Permian excepting the fact that the position of the Glenn as shown would give an accumulation on the north flank if the Glenn was the source of the oil.

The last theory and the one which seems to be the most applicable is illustrated in Figure 24b. This figure is drawn the same as Figure 24a only more emphasis is laid upon the Ordovician as the source of the oil and gas. The oil is shown as having migrated along the fault planes through the Viola limestone from the Simpson formation, finding its way out on the north flank of Robberson, and then back up that slope thus giving the present accumulation.

The general tectonics of the nearby Arbuckle Mountains, the abnormal thickness of limestone recorded in several of the deep wells, together with the fact that the section below the Viola limestone corresponds with the Simpson section in the rest of the state, show that the Robberson uplift represents an asymmetrical fold with the steep dip on the north side, as the forces which produced the

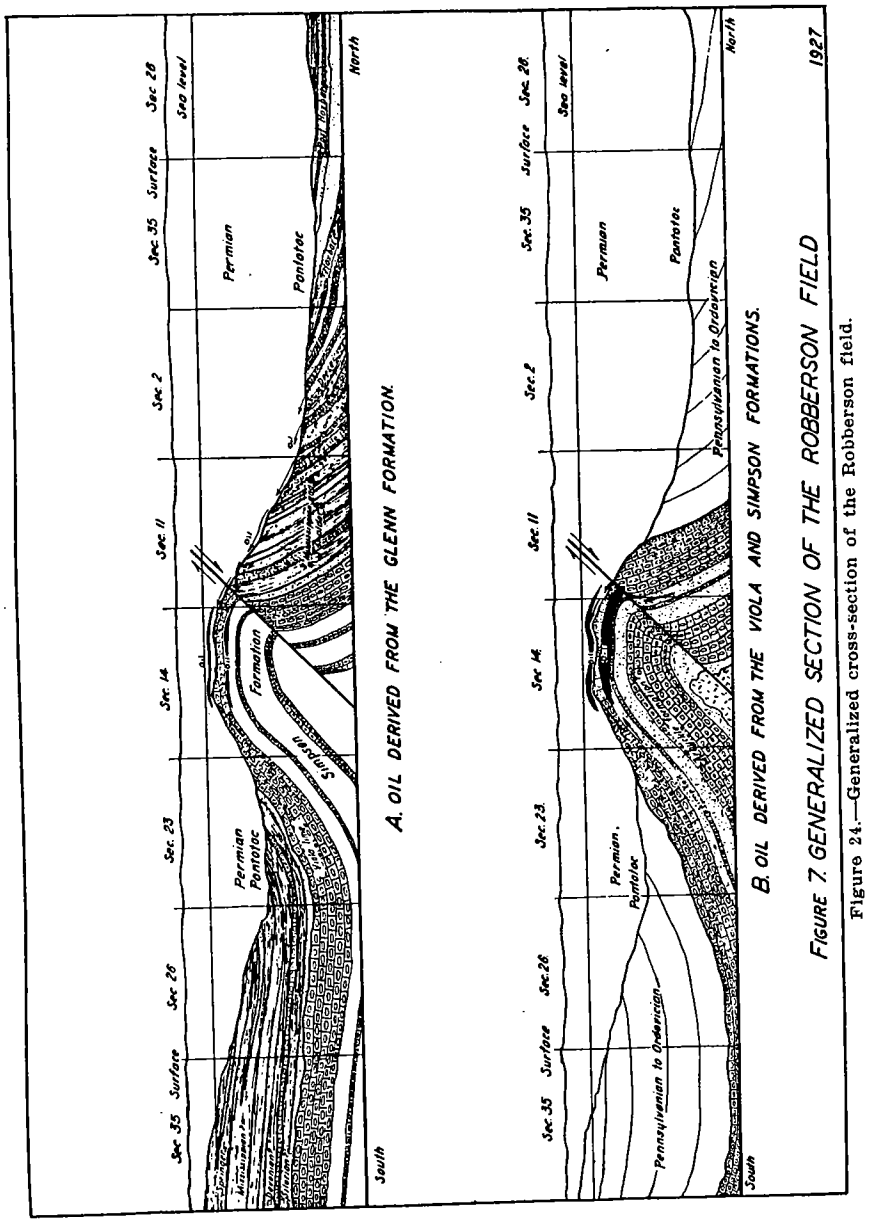



Figure 24.—Generalized cross-section of the Robberson field.



uplift were probably directed from the southwest. It will be noted that there are a number of faults and parallel folds to the south and southwest, while none of these occur in such magnitude on the north side of the Arbuckle Mountains. The Robberson fold has probably been faulted several times, though the vertical displacement is not great. The faults generally have a northwest-southeast strike with the downthrow on the north side. This fault zone has been generalized into one fault in the figure above mentioned. There can be little doubt that certain parts of the Simpson in the Arbuckle Mountains contain oil as there are many asphalt seeps along the outcrop of this formation. It is to be understood that the oil is not indigenous to the Simpson sands, but to the Ordovician limestones; and it is thought that an accumulation at Robberson occurred subsequent to the uplift. Erosion progressed until most of the Viola limestone was removed over the tops of the structure and near the close of this erosional period there probably was a large asphalt seep situated at Robberson. This seep was sealed in by the last advancing seas of the Pennsylvanian which deposited the Pontotoc, and possibly a part of the Mauldin sands. Permian deposition then commenced which laid down the rest of the Mauldin beds and the Garvin beds. Any later Permian beds which may have been deposited over this area have subsequently been removed. This asphalt seep at Robberson continued to disseminate gas and oil into these younger beds, resulting in a heavier oil in these younger beds because the more volatile constituents escaped as a gas.

In spite of this theory, the oil may have had a dual origin or it may have all been derived from the Glenn formation.

## PRODUCTION

### OIL

There are two classes of producing wells in the field. One is from the Permo-Pennsylvanian, which had an average initial production of 50 barrels per day (in some exceptional cases this initial production ran as high as 250 barrels). The other is from the Ordovician, which had a maximum initial production of 8,000 barrels per day.

The oil produced in both cases is a black mixed-base crude, varying in gravity from 25° to 33° Baumé, the average being 28°. The lightest oil is found in the Simpson sands below the Viola limestone. The gravity becomes progressively heavier the farther it has travelled into Permian sediments. Due to the lack of proper facilities for conserving the lighter constituents of the oil, most of it is sold as low gravity crude.

An average analysis of the oil shows the following fractions and temperature ranges of distillation:

Gasoline and Naptha below 302° F; 15.5 to 21.4 per cent.
Gasoline at 302° F; 11.1 to 15.8 per cent.
Kerosene at 302° F; 21 to 28 per cent.
Residuum at 572° F; 67.3 to 67.9 per cent.

The oil from the Permo-Pennsylvanian is notably free from water.

Many of the sands have been entirely penetrated and no water encountered. The oil from the producing horizon of the buried peaks shows water and emulsion which has caused a great loss of oil as it is extremely difficult to break, and since several of the wells have had as much as 25 per cent of this water and oil emulsion, the waste in getting it into pipeline condition has been quite large. The water may be separated by treating with chemicals, but the most efficient means is to treat this emulsion in centrifugal separators.

There has been a total of 342 wells drilled in the field up to the present time and of this number 221 produced oil and gas, and 52 were gas wells. The remaining 69 were dry or were abandoned.

### GAS

Gas was the first commercial product of the field, yet no effort has been made to develop the supply. The gas from the first few wells drilled was used for fuel in drilling later wells, and it was not until January, 1923, that an adequate pipeline was connected with the field. A great many of the gas wells in the field were the result of plugging back from a failure to find oil at lower depths.

The average initial gas production was from 15,000,000 cubic feet to 35,000,000 cubic feet per day. These wells were of fairly long life some of them were producing 8,000,000 cubic feet per day when two years old. The rock pressure varied from 275 to 600 pounds, the average being 350 pounds, and the gas was usually free from water and was low in gasoline content. Samples taken from various wells showed from 0.6 to 0.8 of a gallon of gasoline per 1,000 cubic feet of gas. This was too low to be of commercial value, and very little casing-head gas was made by the oil wells. No effort has been made to utilize this supply.

## DECLINE CURVES

The production curves of the wells in the Permian and Pontotoc as compared to those of the Ordovician differ radically in their form. For example, the wells producing from the Newberry sands show, in general, a rapid but very regular decline with very little flattening until the wells are more than a year old. These wells are generally much longer lived than those in the Ordovician, due to the coarseness and porosity of the sands and to the absence of water even after the available oil has been extracted.



The wells drilled into the older sediments have a very large initial production with a sharp, early decline followed by a flattening of the curve after seven months. This type of curve generally indicated water pressure. All of the large wells are on the apex of the buried peaks in sections 13 and 14. They are short-lived, flowing from two to three weeks and declining rapidly as the gas pressure decreased. For example, Humble's G. Powell No. 5 came in in May with an initial production of 8,000 barrels per day, and one month later it was pumping 50 barrels per day.

The decline curves showing the volume and rock pressure of a gas well when allowed to produce naturally give almost a straight line with some fluctuations. However, if a gas well is "pulled" the volume and pressure becomes abnormally low, but will re-establish itself after allowing the well to be shut in for several weeks.

In a curve showing the average daily production of oil per month, a number of high points can be shown which in every case are due to the bringing in of a gusher from the Ordovician, since these gushers had a high initial yield. Since June, 1923, there has been a steady decline in this curve. Its high point was 87 barrels per day per month, while at present it is little better than 12 barrels.

## METHODS OF DEVELOPMENT

### WELL SPACING

The early wells in the field were all drilled as line locations, 150 feet being the usual distance, but as the field progressed and many small tracts were developed, wells were spaced in an irregular manner according to the individual idea of the operator. The closest spacing is around gusher wells, where as many as four wells were drilled on 10 acres. However, in the Permo-Pennsylvanian coarse sand, the usual method was one well to 10 acres, and this spacing was found to be sufficiently close to drain the oil from the coarse sands. Wells on the buried hills were drilled much closer as it was found that the horizontal distance of 100 feet would mean the difference between a small well and a gusher.

### DRILLING SYSTEMS

Rotary tools were used exclusively to drill through the upper Permian beds. The common practice was to set a string of 8¼-inch casing on top of what was thought to be a producing horizon. The hole was then finished with either standard tools or a Star drilling rig, setting a liner from the bottom of the 8¼-inch casing to the top of the producing horizon.

All gas wells were drilled in with rotary tools. After cementing the 8¼-inch casing, the sand was penetrated and as the mud was thinned the wells usually "cleaned" themselves. Only one string of casing was necessary in drilling the average well. When deeper

tests were made, a string of 6⅝-inch casing was carried down the hole to shut off water horizons passed through.

### PIPELINE FACILITIES

Two pipelines run oil from the Robberson pool. The Magnolia Petroleum Company has a 6-inch line to Healdton with a capacity of 6,000 barrels per day. It began operation January 1, 1922, and has carried most of the production from the field. The Texas-Pacific Coal and Oil Company have a 4-inch line to their refinery at Wynnewood which has a capacity of 5,000 barrels. The independent operators were prorated on the Texas-Pacific Coal and Oil Company line. Aside from the stock tanks on the leases the only storage is two 55,000-barrel tanks used by the Texas-Pacific Coal and Oil Company in connection with their pipeline.

The Lone Star Gas Company is the only purchaser of natural gas. This company has a 12-inch delivery line connecting with a 16-inch trunk line at Dixie, Oklahoma. The pumping plant has six 160 hp. engines with a total daily capacity of 15,000,000 cubic feet. This plant started operation January 4th, 1923 and the amount of gas taken per day varied with the needs of the purchaser, the output decreasing in summer and increasing in winter. In 1923 the producer was paid 6c per 1,000 cubic feet and the amount taken was prorated among all the operators.

### CONCLUSION

As a producing field the Robberson pool is fast becoming history and in a few more years its production will be very small. Up to the present date the gross production of the field is 5,376,150 barrels, which is an average yield per acre of 1,680 barrels. Probably the final yield will not be much more than 2,000 barrels per acre when the field is abandoned. There can be no further hope of another producing horizon in the area by drilling deeper, as the Arbuckle limestone and the Reagan sandstone rest unconformably upon the granite porphyry. However, the Magnolia's Burr No. 1, sec. 31, T. 1 N., R. 3 W., may open up a new productive area in the upper Glenn formation immediately south of the Robberson field.

## BECKHAM COUNTY

By

Frank Gouin

### LOCATION

Beckham County is located in west-central Oklahoma, having for its western boundary a part of the eastern boundary of the Panhandle of Texas. The county includes T. 7 N., Rs. 25 and 26 W., Tps. 8 to 10 N., Rs. 20 to 26 W., inclusive, the south half of T. 11 N., Rs. 23 to 26 W. inclusive, T. 11 N. and the south half of T. 12 N., Rs. 21 and 22 W., and a tier of fractional sections between the west line of R. 26 W. and the western boundary line of the State. Altogether the area of the county, comprises about 960 square miles; Sayre, the county seat, with a population of about 2,800, is located in the central part, while Elk City, with a population of about 3,400 is located in the northeastern corner of the county. The Chicago, Rock Island and Pacific Railroad, main line from Memphis Tennessee to El Paso, Texas traverses the county from the northeast corner to the western line. The Wichita Falls and Northwestern Railroad passes through Elk City and thence south through the eastern part of the county on its way from Woodward south to Altus.

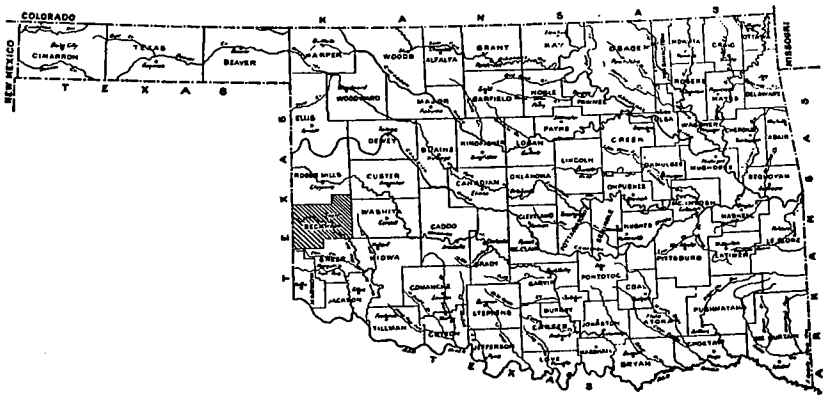



Figure 25.—Index map of Oklahoma showing location of Beckham County.

(This report originally issued as Bulletin 40-M, May, 1927).

## ACKNOWLEDGMENTS

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## TOPOGRAPHY

Beckham County has a topography varying from the rough gypsum hills of the southwestern part of the county where the relief amounts to several hundred feet, through the gently rolling sand dune country of the central portion, to the more hilly country in the northern part. The elevation ranges from about 2,100 feet above sea level in the western part of the county to about 1,600 feet above sea level in the southeastern corner where North Fork of Red River leaves the county. All of the drainage is into North Fork of Red River, which enters the county from the Texas Panhandle in the southwest corner, T. 10 N., R. 26 W., flowing east to the northwest corner, T. 9 N., R. 22 W., and thence southeast leaving the county on the south line of T. 8 N., R. 21 W. Aside from the usual trees along the streams the county is not wooded. In places there is a thick growth of such shrubs as scrub oaks, mesquite and chaparral.

## GEOLOGY

### SURFACE ROCKS

The surface rocks exposed in the county, excepting the Quaternary sands and alluvium, belong to the upper part of the Permian system. The formations of this age of rocks which are exposed are in ascending order as follows: Duncan sandstone, Chickasha formation, Blaine formation, Dog Creek shale, Whitehorse sandstone, Day Creek dolomite, Cloud Chief gypsum and the Quartermaster formation. Correlating with the Texas section, with which this area is very closely associated, these rocks are all a part of the Double Mountain formation. The Duncan sandstone is the equivalent of the San Angelo sandstone of Texas which is the basal member of the Double Mountain formation.[1]

1. Gould, Chas. N., Index to the stratigraphy of Oklahoma: Oklahoma Geol. Survey, Bull. 35, 1925.



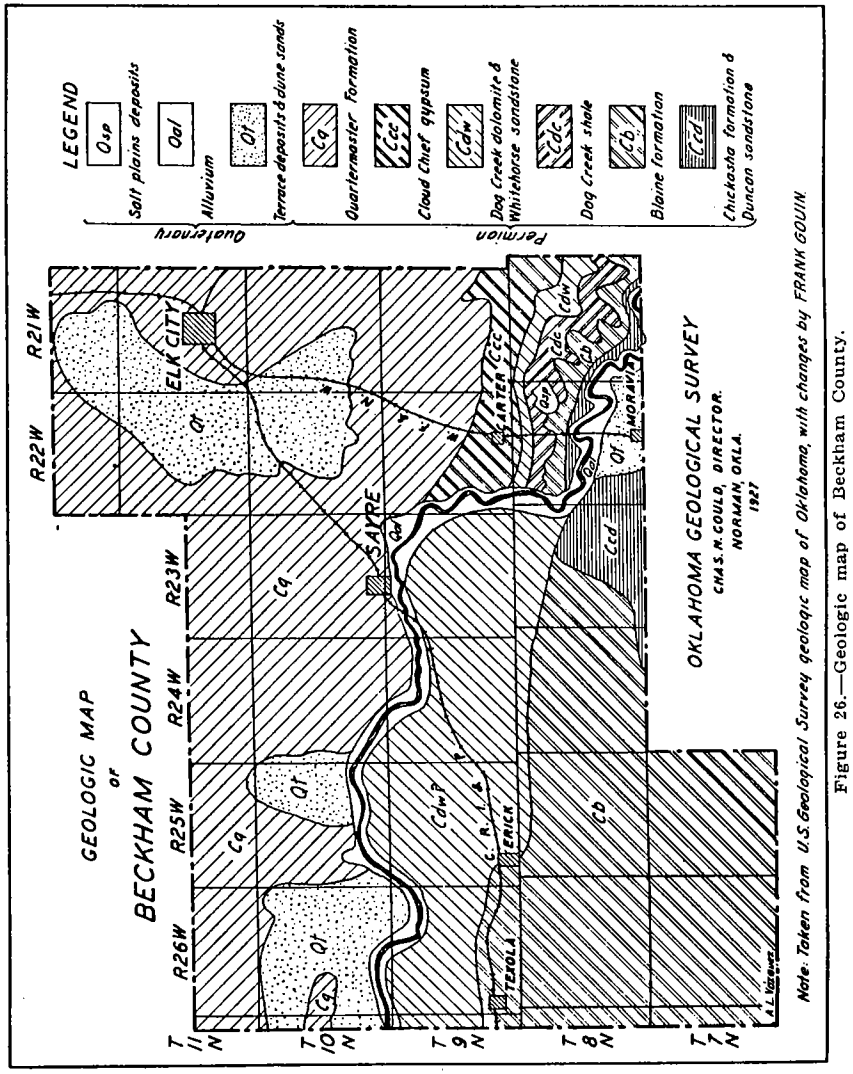


Figure 26.—Geologic map of Beckham County.

### DUNCAN SANDSTONE AND CHICKASHA FORMATIONS

These formations are exposed only in the extreme southeastern corner of the county in an escarpment of rocks along the north bank of North Fork of Red River in T. 8 N., Rs. 21 and 22 W., also in the southwestern part of the latter township and in the south end of T. 8 N., R. 23 W. The Duncan sandstone in this locality is a series of brown sandstones interbedded with brown shales having a total thickness of about 100 feet. The overlying Chickasha formation is here a series of reddish-brown, gypsiferous shales having a thickness of about 200 feet.

### BLAINE GYPSUM

Overlying the Chickasha formation is the Blaine gypsum. This gypsum covers the entire southwestern quarter of the county as well as being exposed in the escarpment on the north bank of North Fork mentioned in the paragraph above. A perusal of some of the old literature on this and other Permian formations of western and southwestern Oklahoma would have us believe that one cannot expect anything regular either as to the section or as to the structure of these rocks. The writer, with the assistance of several field parties, has worked on this formation from Hardeman County, Texas north through Jackson, Greer, and Beckham counties, Oklahoma and thence west into Wheeler and Collingsworth counties in the Texas Panhandle with the result that he finds it to be the most consistent of any Permian formation in this part of Oklahoma. A type section of the upper part of the formation, which will apply for all of this general area including the Oklahoma counties mentioned above, is as follows:

*Section of upper part of the Blaine gypsum, Beckham County*

| | Feet |
|---|---|
| Dolomite, honeycombed | 3 |
| Shale, red and blue | 20 |
| Gypsum, massive, white | 18 |
| Shale, red | 5 |
| Gypsum, massive, white | 15 |

The entire Blaine gypsum section averages 200 feet in thickness.

### DOG CREEK SHALE

Overlying the Blaine gypsum and exposed in this county only on the escarpment along the north bank of North Fork lies the Dog Creek shale. In this area it is made up of brick-red, gypsiferous shales approximately 90 feet in thickness.

### WHITEHORSE SANDSTONE

The Whitehorse sandstone in this locality has essentially the same characteristics as are so noticeable throughout its area of outcrop in this State. It is massive, friable, reddish to buff sandstone. Unless protected by overlying formations in an escarpment it has the appearance of recent dune deposits. In Beckham County it is exposed in the escarpment on the north bank of the North Fork. The writer also believes that there is some basis for correlating the sand hills which occupy a band about six miles in width from T. 29 N., R. 23 W. to T. 9 N., R. 26 W., inclusive with the Whitehorse sandstone. This belt of sandhills is parallel with the strike of the Blaine rocks to the south. If this belt is Whitehorse sandstone an explanation for this wide area of outcrop to the west of the east side of R. 23 W. as contrasted with the narrow band to the east of this line will be found under "Structure".



### DAY CREEK DOLOMITE AND CLOUD CHIEF GYPSUM

The Day Creek dolomite and the Cloud Chief gypsum are exposed in a belt averaging three miles in width in the extreme north side of T. 8 N., Rs. 21 and 22 W. and the south side of T. 9 N., Rs. 21 and 22 W., passing through the town of Carter. The Day Creek dolomite is a thin dolomite bed at the base of the 100 foot series of massive pinkish gypsum beds with interstratified reddish shales of the Cloud Chief gypsum.

### QUARTERMASTER FORMATION

The Quartermaster formation is exposed over most of the northern part of the county north of North Fork and north of the outcrop of the Cloud Chief gypsum in the northeastern part of the county with the exception of limited areas of Quarternary deposits. This formation is made up of brick-red, gypsiferous shales within which are lenticular beds of sandstone and gypsum, being altogether about 300 feet in thickness. It is this formation which has caused earlier writers on western Oklahoma to remark about the irregularities in bedding and in the dips of all formations in this broad area which are composed largely of gypsum. Everything which has been said about the irregularities of the gypsum formations of western Oklahoma is true of the Quartermaster formation but should be confined to that formation only.

## SUBSURFACE ROCKS

Due entirely to the search for oil and gas in the county it has been possible to determine the section of subsurface rocks in this general area. By reference to the cross-section "A-A" (Map No. XX), the section below the base of the Blaine gypsum can be noted.

The section is similar over this entire area from the Blaine gypsum to the dolomite at the base of the Big Lime. The only variation from one place to another is in the thickness of the Clear Fork formation which is the red shale section between the base of

the Blaine and the top of the Wichita-Albany or Big Lime. This interval is thinnest over the structural highs and thickest in the lows.

## PERMIAN

### CLEAR FORK FORMATION

Between the base of the Blaine gypsum and the top of the Wichita-Albany or Big Lime the entire section is predominately red shales. This interval varies from a thickness of 1,420 feet in the southern part of the county to over 2,170 feet in the northern end of the county. About 300 feet of the upper part of this section belongs to the Chickasha-Duncan formation of the Double Mountain. In addition to the salt horizon present at the base of the Blaine in the top of the Chickasha formation two salt horizons occur in the Clear Fork formation, one about 600 feet and the other about 900 feet below the base of the Blaine.

Several wells have logged either a show of gas or a show of oil in a horizon about 800 feet below the base of the Blaine. Lenticular sands are present at various horizons in this interval.

### WICHITA-ALBANY FORMATION

Lying immediately beneath the red shale section of Clear Fork rocks is a series of gray shales and anhydrite 700 feet thick. This section will probably average two-thirds gray shale and one-third anhydrite. The anhydrite interbedded in the gray shale in beds is usually only a few feet in thickness.

In this respect this group of rocks is the opposite of the same group in the interior of the Texas Panhandle where the proportion of anhydrite and gray shale is reversed, the anhydrite beds being extremely massive. This group of rocks is the Big Lime series of the Texas Panhandle.

## PENNSYLVANIAN

### CISCO-PONTOTOC GROUP

At the base of the Wichita-Albany occurs a group of rocks belonging to the upper part of the Pennsylvanian. While there is yet much room for study before all the problems concerning this group of rocks are cleared up yet the salient points are known at this writing. Above and immediately adjacent to the buried ridge of the Wichita Mountains the geologic section consists almost entirely of granite wash with some interbedded brown, blue and black shales. There is a transition in this zone both to the north and to the south—away from the ridge—in which the arkose section becomes one of limestones and dolomites. The transition is from the top of the section down, showing the gradual encroachment of the Cisco sea upon the granite ridge. In fact the top member of the lime phase—a bed of dolomite—extends to the south almost to the top



of the granite ridge. The thickness of this group of rocks is extremely variable, Just as it is in the area between the Wichita Mountains and the Arbuckle Mountains. It is thickest in the embayments and thinnest on top of the ridges. The thickness in the north end of the county is unknown for no well has been drilled through it. In the Pierce well in sec. 21 T. 8 N., R. 26 W., there was a thickness of 276 feet of Cisco between the Wichita-Albany and the basement rock. In the Skelly well in sec. 24, T. 8 N., R. 23 W., there was a thickness of 1,565 feet of Cisco, which was almost all arkose, between the Wichita-Albany and the basement rock.

While in the south end of the county the Cisco-Pontotoc is resting directly upon the basement rock, it is entirely possible and quite likely that in the north end of the county there are some older Pennsylvanian and possibly some of the lower Paleozoics present in the section. This is presumed because farther east in the vicinity of Gotebo in Kiowa County, on the north flanks of the Wichita Mountains, the Viola limestone, Simpson formation and Arbuckle limestone are exposed on the surface and have been penetrated in wells.

## STRUCTURE

### SURFACE STRUCTURE

The dip of the surface rocks in the county averages about fifty feet to the mile in a direction slightly east of north away from the axis of the Wichita Mountains. This dip is interrupted by the anticline in the southern part of T. 8 N., Rs. 23, 24, and 25 W. From T. 9 N. to the north end of the county the structure of the surface rocks is not known due to lack of satisfactory surface exposures upon which to obtain definite control. However, in the main the dip continues to the northward as shown by the contacts of the various surface formations. This north dip continues until the axis of the Anadarko Basin is reached.

### SUBSURFACE STRUCTURE

The regional dip of the underground rocks is similar to that of the surface rocks. However, there are structural features in the underground rocks that are not revealed in the surface rocks where surface control is lacking. The chief subsurface features are: the large fault just south of the Sayre field, the Sayre dome, and the domes to the west of the Sayre domes. (See Map No. XIX).

### BECKHAM COUNTY FAULT

The Beckham County fault is really a surface feature since were it not for the unconsolidated sand lying against the fault plane on the north or downthrow side it would be readily discernible at the surface. Since the writer and his assistants had worked the structure of the Blaine rocks in southwestern Oklahoma and part

of the Texas Panhandle in 1919 it was quite evident early in 1923 when the log of the Martin well in sec. 31 T. 9 N., R. 23 W. was studied, that the Blaine gypsum was encountered abnormally low. He immediately suspected the presence of a fault, with a downthrow to the north. Determining the trace of this fault was quite simple. In sec. 10, T. 8 N., R. 23 W. there is a large spring which has a volume probably exceeding ten thousand barrels of water a day. This spring gushed out at a point where the Blaine gypsum disappears below the surface. From this point northwest it was possible to get the trace of the fault to within a quarter of a mile by means of household wells of the farmers. It was found that water wells on the south or upthrow side of the fault were from 40 to 60 feet deep and that the water was highly impregnated with gypsum, while on the north or downthrow side of the fault wells were from 100 to 200 feet in depth and the water was very pure having no trace of gypsum whatever for it was coming from a loose, clean sand with a thickness of several hundred feet on the downthrow side of the fault. The fault was not traced farther to the northwest than just east of the center of T. 9 N., R. 25 W., but subsurface data which has been obtained later from wells drilled farther west in this county and in Wheeler County, Texas would make it seem probable that this fault continues into that county. This can easily be worked out by the method of using the household wells of the farmers living along the alignment of the projection of the fault.

Beckham County fault is a normal fault having a downthrow to the north of 300 to 500 feet. Its eastern terminus appears to be at the bend of the North Fork in sec. 12, T. 8 N., R. 23 W.

### THE SAYRE DOME

The top of the Sayre dome is located in sec. 22 T. 9 N., R. 23 W. This dome is the largest subsurface fold discovered to date in the county for it affects the structure of the rocks for several miles in all directions. It has a closure of about 100 feet. The north dip off this dome continues uninterrupted for many miles. It is upon this dome that the discovery well of the Sayre field is located.

### THE WINDLE DOME

The top of the Windle Dome is in the southwest corner of sec. 31, T. 9 N., R. 23 W. This dome is really a result of the Windle fault as the fault closes this dome to the south. This dome has a closure of something over 50 feet.

### THE NORTH FORK DOME

The North Fork dome is suggested by control from several wells drilled in this locality. The top of this dome probably lies at about the southwest corner of sec. 1, T. 9 N., R. 25 W. and is somewhat comparable in size to the Sayre dome but lack of subsurface



control prevents the exact determination of its elevation or of the location of the top.

## GEOLOGIC HISTORY

The earliest orogenetic movement in southern Oklahoma which directly affected the area in which Beckman County is a part of the Wichita Mountain uplift. While the age of this folding[2] has been suggested at least once in the literature, the first proof that this uplift was pre-Pennsylvanian in age was given by the writer.[3]

In that bulletin the writer cited instances where early Pennsylvanian rocks had been found to be resting unconformably upon Ordovician rocks and favored the age of this folding as being early in Mississippian. Since that writing—May, 1926—regional studies made by the writer along the line of *en echelon* folds known as the Red River uplift between the Burkburnett field and Grayson County, Texas have furnished additional evidence together with the probability that the age of this last named uplift is older even than that of the Wichita Mountains. It was the Wichita Mountain uplift which formed the granite ridge which extends from the present exposed Wichita Mountains across the Texas Panhandle into New Mexico, together with folds southeast of the present Wichita Mountains into northeast Texas. This sharp ridge remained above water probably until the close of Glenn time which is roughly equivalent to late Canyon time. Since the steep slopes of this ridge are to the north the main drainage lines were set up to the south.

### POST GLENN UPLIFT

The close of Glenn time was brought about by the uplift which produced the Arbuckle Mountains. Folding at this time also took place along the earlier folds such as the Wichita Mountains. This was followed by the period of erosion and deposition of Pontotoc (Cisco) time. That part of the Wichita Mountains between the present exposed mountains and New Mexico was above water until almost the close of Pontotoc time. Therefore, the arkosic materials from this sharp ridge were laid down as beach deposits on the flanks while at the same time, limestones and dolomites were being formed farther out both to the north and to the south in the area of deeper waters. Finally by the close of Pontotoc time that part of the present buried mountains in Oklahoma was completly submerged.

### WICHITA-ALBANY

The opening of Permian time was a continuaton of the sedimentation taking place during the latter part of the Pennsylvanian with no evidence of any regular unconformity. During this time

2. Schuchert, Chas., and Pirsson, L. V., Text-book of Geology, pt. 2, p. 343, 1924.
3. Gould, Frank. The geology of the oil and gas fields of Stephens County, Oklahoma: Oklahoma Geol. Survey, Bull. 40-E, 1926.

the Big Lime was deposited over western Oklahoma, the Panhandle of Texas, part of northeastern New Mexico and adjacent parts of Colorado and Kansas. During this time the deposition of anhydrite was widespread.

### CLEAR FORK

Sedimentation continued uninterrupted during Clear Fork time but the sediments deposited differ from that of Wichita-Albany time in that the former consists of red shales, sandstones, as stated under "Subsurface". The unconformity suggested by the writer[4] at the top of the Clear Fork seems more certain when studying western Oklahoma on account of the variation in the thickness of the Clear Fork as mentioned earlier in this bulletin.

### DOUBLE MOUNTAIN

That there was a period of folding after the deposition of the Blaine gypsum, possibly post-Permian, is evidenced not only by the folding on the Blaine throughout western Oklahoma but also by such marked structural features as the Beckham County fault. The writer does not take much stock in the often discussed subject of differential settling to explain the folding either in western Oklahoma or the Panhandle area of Texas where there is such a wealth of evidence to support the argument of true folding in all formations from the upper Permian to the basement rock.

## PRODUCTION

### THE SAYRE FIELD

The Sayre field is the only producing area in the county with the exception of a small area in which small gas wells are found at a depth of about 1,000 feet in the Clear Fork formation in the eastern part of T. 8 N., R. 22 W. The Sayre field is located in T. 9 N., R. 23 W. A discussion of the field has been well covered by Birk.[5]

The Twin Hills Oil Company completed the discovery well in the NE. cor. SW.¼, SE.¼ sec. 15 in July, 1922, This well had an initial production of 50.000,000 cubic feet of gas a day from the sand topped at 2,755 feet. Later this well started to make some oil. About 1918 a well had been started in the vicinity of this location but was abandoned at a few hundred feet due to financial difficulties of the owners. As Birk has stated, the completion of this gas well did not cause any undue excitement for at that time there were several large gas wells in the Panhandle of Texas with no market for the gas. It was not until the month of April, 1923 when Martin, et al completed an oil well with an initial production of 200 barrels of 35 gravity oil from a depth of 2,995 feet in the NE. cor. SE.¼ NW.¼ sec. 31, that there was any great interest

4. Goulin, Frank, op. cit.
5. Birk, R. A., The Sayre field, Beckham County, Oklahoma: Bull. Amer. Assoc. Pet. Geol., vol. 8, No. 3, 1924.



displayed in this county. The greater part of the development which has since been completed in that field was done in that same year. In July, the Carter Oil Company completed the north offset to the original discovery well in sec. 15 with an initial production exceeding 2,000 barrels a day at a depth of 2,763 feet. This well started to cut its oil almost from the beginning. Four wells, three of them drilled on five acre tracts, one-fourth mile north of this gusher were all dry, being too low on the fold. While there are now several gas wells on the Sayre dome the Carter well and the discovery well are the only wells producing oil. On the Windle Dome no gas wells have been completed. There were at one time seven oil wells in section 31 and 32 but five of them have been abandoned leaving two producers in section 31.

The pay is found in a dolomite horizon at the top of the Cisco. This whole horizon averages 60 feet in thickness with the oil pay at the base. In the case of gas wells the first gas pay is found at the top of this horizon. The producing horizon is identical in both domes. There is a varying percentage of quartz crystals found in the pay horizon. The quartz has evidently been deposited in porous parts of the dolomite by circulating waters. The differences in the initial production of the wells is no doubt due to the varying porosity of the dolomite from place to place. Indeed, some wells which were dry have been higher structurally than some of the producers. This has happened on the Windle dome only and may be due to some structural condition not known at this time. At the same time there is a definite water level for the field as a whole. The gas wells in this field have a pressure normal for the depth at which gas is found. In this respect this area differs from that of the Panhandle of Texas, the difference possibly being due to the greater contrast in the thickness of the reservoir rock. As will be seen by the accompanying production table the wells had a very rapid decline with a mediocre average production per well. The writer does not know of any well in the field which has been given a shot. In view of the increase of oil after the shooting of the Panhandle wells it would be interesting to learn if this would be of help in the Sayre field.

While the first wells in the field were drilled with cable tools entirely the later wells were drilled either to the top of the Big Lime with the rotary and then standardized or were drilled entirely with the rotary. The Big Lime is not difficult to drill with the rotary in the area but it is very unwise to drill to the pay with the rotary in a field with a producing horizon such as is found in this area.

*Total Lease Production by Months—Sayre District*

| Company | Rubana | Carter | Carter | Gypsy | Atlantic |
|---|---|---|---|---|---|
| Lease | W. O. Gray | W. O. Gray | Windle | Day | Windle |
| | | | 1923 | | |
| In storage when purchased | | | | | 10,878 |
| July | 2,517 | 4,116 | — | | 3,630 |
| August | 884 | 8,688 | 6,329 | | 4,094 |
| September | — | 3,121 | 17,294 | | 3,338 |
| October | — | 3,364 | 13,766 | | 3,007 |
| November | 437 | 5,209 | 10,743 | | 1,305 |
| December | — | 385 | 2,273 | | 1,925 |
| Total 1923 | 3,838 | 24,883 | 50,405 | | 28,177 |
| | | | 1924 | | |
| January | — | 2,573 | 7,037 | 752 | 1,092 |
| February | 376 | 2,016 | 4,760 | 687 | 893 |
| March | 295 | 1,922 | 4,340 | 785 | 890 |
| April | 162 | 1,710 | 4,200 | 765 | 875 |
| May | — | 1,612 | 4,340 | 774 | 1,771 |
| June | — | 1,860 | 3,900 | 386 | 414 |
| July | 140 | 1,085 | 3,720 | 412 | 347 |
| August | — | 1,085 | 2,790 | 290 | 888 |
| September | — | 1,050 | 1,950 | 240 | 785 |
| October | — | 1,953 | 2,077 | 248 | — |
| November | — | 1,650 | 1,950 | 210 | 273 |
| December | — | 1,488 | 1,860 | 180 | — |
| Total 1924 | 973 | 20,004 | 42,924 | 5,729 | 8,228 |
| | | | 1925 | | |
| January | | 1,240 | 1,705 | 155 | — |
| February | | 896 | 1,344 | 110 | — |
| March | | 3,100 | 1,364 | 124 | 437 |
| April | | 1,950 | 1,350 | 110 | — |
| May | | 2,325 | 1,240 | 113 | — |
| June | | 1,800 | 1,350 | abd | — |
| July | | 1,705 | 1,395 | — | 435 |
| August | | 15,500 | 1,395 | — | — |
| September | | 15,450 | 1,350 | — | — |
| October | | 9,003 | 1,240 | — | 129 |
| November | | 1,500 | 1,320 | — | — |
| December | | 1,860 | 1,354 | — | — |
| Total 1925 | | 56,329 | 16,407 | 612 | 1,001 |
| 1926 Production | | 14,628 | 9,125 | | |
| Totals | 4,811 (1 well) | 115,844 (1 well) | 118,861 (2 wells) | 6,341 (1 well) | 37,406 (1 well) |

Empire Gas and Fuel—Windle No. 1, sec. 31 produced 10,158 barrels in 2 years from 1 well.

Foster Investment Company, sec. 32 produced 8,345 barrels in 1½ years from 1 well.

TOTAL PRODUCTION SAYRE DISTRICT—301,766 BARRELS.

## FUTURE POSSIBILITIES

Bearing in mind the nature of the production in the Sayre district to date, in that the production figures show that every operator in the district has probably lost money, the writer will mention areas that have a possibility of producing. It is very unlikely that these will furnish any better results than have been achieved in the past. While there is apparently a very narrow rim of oil between the gas and the water on the Sayre dome the south flank of this dome offers chances for oil production. The top of the Windle dome has never been drilled. The same is true of the North Fork dome and a possible dome in the northwest part of T. 9N., R. 26 W.



Since there is very definite relation between the structure of the Blaine gypsum and the structure of the producing horizon procedure is to secure plenty of structural control on the Blaine by means of shallow tests—500 to 600 feet—before making any location for a deep test. For example on both the Sayre and Windle domes if the Blaine is encountered any deeper than 1,460 feet above sea level there is not much use of drilling any farther, while if it is encountered above 1,490 above sea level the well will probably produce gas rather than oil. The use of this information would have saved the drilling of several dry holes had the interested operators made use of it. Shallow wells can be drilled to the Blaine by means of a portable gasoline driven rotary at an extremely small cost. All of this is mentioned for the benefit of operators who, knowing the past history of the district, may still desire to prospect there. As a last resort for a location in the county there is still the dome in T. 8 N., R. 25 W., which has never been tested. In view of the dry holes drilled to the basement rock on similar domes to the south and west the chances on this dome do not appear encouraging. While pre-Cisco Pontotoc Paleozoic rocks are to be expected in the northern part of the county, all upper formations are dipping so steeply to the north, where the northernmost control is to be had, that there appears small chance of there being favorable structural conditions. In fact that part of the country does not appear at all promising.

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# CLEVELAND AND McCLAIN COUNTIES

By
G. E. Anderson

## INTRODUCTION

As the writer has prepared this preliminary report within a very limited time during which a full teaching schedule was carried, the discussion must necessarily be brief and many interesting problems have of necessity been left untouched. The work, therefore, is very incomplete. As no field work has been allowed for the purpose of this report hence nothing further is attempted than to assemble the existing knowledge of the geology of this area.

Within the last two or three years much attention has been given to red bed geology partly through the effort of Chas. N. Gould, Director of the Oklahoma Geological Survey and partly by the interest developed through oil discoveries in the Seminole area which has made large areas to the west covered by red beds potential oil territory. This recent study has resulted in the subdivision of the Enid Group, by Aurin, Officer and Gould,[1] and the correlation of one of its members, the Duncan sandstone from Texas through Oklahoma into Kansas. This work and the more detailed study of the members will result in definitely tracing their contacts. The eventual identification of these units in subsurface correlation is, in the writer's opinion, within our grasp. In the preparation of this report it is believed that the Hennessey-Garber contact at least, has been definitely established and accurately mapped through Cleveland County.

### ACKNOWLEDGMENTS

The writer has drawn upon any and all sources of information available. The work of Gould, Aurin, Green and Dott should be particularly mentioned. The members of the staff of the school of geology have one and all given unstinted help and suggestions and many field geologists have been of great help.

## CLEVELAND COUNTY

### LOCATION

Cleveland County is located in the central part of the State on the north side of the South Canadian River. It extends from T. 6 N., to T. 10 N., inclusive, and from R. 4 W., to R. 1 E., inclusive. It includes 12 whole townships and parts of 7 others. The total area is approximately 585 square miles

1. Aurin, F. L., Officer, H. G., and Gould, Chas. N., The subdivision of the Enid formation: Bull. Amer. Assoc. Pet. Geol., Vol. 10, No. 8, 1926.

(This report originally issued as Bulletin 40-N, July, 1927.)

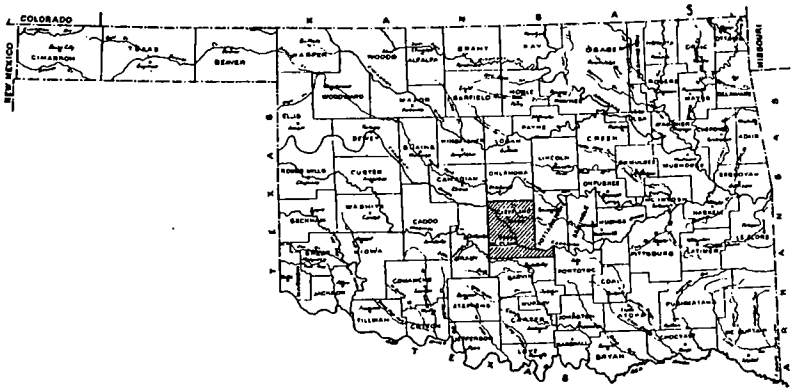

Fig. 27.—Index map of Oklahoma showing location of Cleveland and McClain counties.

### TOPOGRAPHY AND DRAINAGE

Cleveland County lies in the Sandstone Hills region with the exception of the western part, which is in the red beds plains. The western part of the county, in a strip from three to eight miles wide parallel to the Canadian River, is a rolling prairie, while all of the eastern portion is hilly and sandy, the streams having eroded narrow and deep valleys in many instances. The hills are in part due to erosional features in the shales and sandstones of the eastern part of the county, and in part to wind work, causing duning and ridging of the surface sands along the north bank of the Canadian River. The range in elevation is from 960 feet on Little River in sec. 1, T. 8 N., R. 1 E., to 1,320 feet on top of a hill 3½ miles northeast of Moore.

Little River and its tributaries drain the greater portion of the county especially the northeastern part. Canadian River drains the western and southern parts of the county. The tributaries of Little River head only about two miles from the north bank of the Canadian at Norman while Little River empties into the Canadian in T. 9 N., R. 6 E., some 60 miles to the east. This is in part due to dune sand accumulating on the north bank of the Canadian which has obstructed the Canadian tributaries on the north bank and the comparatively steeper gradient of the Little River tributaries and its headwaters on the north side of the dune sand accumulations. The Canadian River at this point is regarded as an overloaded stream though this condition is apparently recent since bed rock is reported to be at a depth of about 34 feet at the bridge south of Norman. The gradient of the river averages 9 feet per mile.



## GENERAL GEOLOGY

### STRATIGRAPHY

The rocks exposed at the surface within the county belong to the Enid[2] group of the Permian red beds. Unconsolidated gravels cap the hills, which probably represent outlying remnants of Tertiary gravels, and recent alluvium in the river flats and finally wind blown dune sands on the north bank of the Canadian River.

The upper portion of the Enid group has been recently subdivided by Gould[3] into the Chickasha formation and the Duncan sandstone in which the latter has been correlated with the Harper sandstone of Kansas and the San Angelo sandstone of Texas, and the entire Enid group was later subdivided and correlated by Aurin, Officer, and Gould[4] with the marine members of the lower Permian of northern Oklahoma and southern Kansas.

The latter discussion divides the Enid into six subdivisions as follows, reading from the oldest to the youngest: Stillwater, Wellington, Garber, Hennessey, Duncan, and Chickasha formations.

Within Cleveland County, as mapped by these writers,[5] should be exposed from east to west the upper portion of the Wellington, Garber, Hennessey, Duncan, and possibly the base of the Chickasha formations. All of these are running in approximately parallel belts from north to south through Cleveland and McClain counties and to the south of McClain into Garvin County. Dott[6] has recently subdivided the Enid in Garvin County into eight units below the Duncan based upon escarpment forming sandstones alternating with predominating units of shale.

In McClain, north of Garvin County, the upper five units of Dott grade laterally into predominating shales which render their mapping to the north very uncertain and probably impractical.

### WELLINGTON FORMATION

The Wellington formation of Kansas has recently been traced south from its marine equivalent in Kay County, Oklahoma[7] through the red beds of Logan, Oklahoma, Cleveland, McClain and Garvin counties. It is the oldest sedimentary surface formation and forms the surface outcrop in the northeast corner of Cleveland County. Its

2. Gould, Chas. N., Geology and water resources of Oklahoma: U. S. Geol. Survey, Water Supply Paper No. 148, 1905.
3. Gould, Chas. N., The correlation of the Permian of Kansas, Oklahoma, and northern Texas: Bull. Amer. Assoc. Pet. Geol., Vol. 10, No. 2 pp. 144-153, 1926.
4. Aurin, F. L., Officer, H. G., and Gould, Chas. N., The subdivision of the Enid formation: Bull. Amer. Assoc. Pet. Geol. Vol. 10, No. 8. pp. 786-799, 1926.
5. Op. cit. p. 788.
6. Dott, Robert H., The geology of Garvin County: Oklahoma Geol. Survey Bull. 40-K, 1927.
7. Aurin, F. L., Officer, H. G., and Gould, Chas. N., Loc. cit., p. 793.

contact with the underlying Stillwater formation is placed approximately three miles east of the Cleveland County boundary. It consists of red gray and black massive, fine grained sandstones with interstratified shales. In Stella Township it forms rather prominent standstone ridges covered with timber. Small open places in the timber are characteristic over the shale outcrops, suggestive of park landscape. The sandstones are cross-bedded. The dark or black color where present is probably due to manganese. Such a stratum is formed in a sandstone ridge near the top of the formation in the NW.¼ sec. 4, T. 8 N., R. 1 E., and in several other places in lesser amounts. Barite rosettes are found in place in the sandstone strata of the formation in several places from east of Stella to the county line. The formation grades laterally into more shale to the southeast in Pottawatomie County on the north side of the Canadian River. Its upper contact is indefinite and is here placed as follows: Entering the county on the north boundary in sec. 1, T. 10 N., R. 1 W., thence south along Hog Creek to the east boundary of sec. 30, T. 9 N., R. 1 E., thence southwest to the eastern boundary of Cleveland County in SE. cor. sec. 24, T. 8 N., R. 1 W., one and one-half miles east of Etowah. The formation has a west dip of about 50 feet per mile and an approximate thickness of 400 feet.

### GARBER FORMATION

The Garber formation rests on the underlying Wellington apparently conformable in Cleveland County.

It has been subdivided[8] into a lower shale, the Lucien shale, and an upper sandstone known as the Hayward sandstone member. The Lucien shale is considerably more sandy in Cleveland County than farther north which renders its boundaries indistinct and is here mapped with the upper sandstone as the Garber formation. It is characterized by sandy shales and interstratified, rather massive sandstone. In the lower fifty feet it is characterized by laminated sandstones and thin strata of pseudo-conglomerate associated with geoidal lime concretions. Above this is a zone of barite rosettes embedded in sandstone strata. In this locality these are mostly double barite rosettes though single and triple also occur. The Hayward sandstone member is characterized by massive bright red sandstone strata with minor amounts of interstratified shale. The upper contact of the Garber is readily traced by its jackoak covered surface in distinct contrast with the smoother prairie land on the Hennessey outcrop to the west. The upper contact is therefore easily traced by the west side of the timber which here makes a distinct cross timber belt similar to the jackoak belt on the Woodbine sandstone of Texas. The upper contact of the Garber strikes approximately southeast across the county entering at the north boundary of the west line of sec. 3, T. 10 N., R. 1 W., thence

8. Aurin, F. L., Officer, H. G., and Gould, Chas. N., Loc. cit.



east of Norman through NW.¼ sec. 36, T. 9 N., R. 2 W., through Maguire and Corbett and across the South Canadian River approximately one mile west of Pecan into McClain County. The sandstone is characterized by numerous barite rosettes found in place and as float upon the surface. These are more abundant near the top of the sandstone but are also distributed without any apparent regularity through the entire Garber formation. Pseudo-conglomerates similar to those found at the contact between the Garber and Wellington are also found in similarly thin sandstone strata about 100 feet below the top at a point about one and one-half miles northwest of Box in the SW.¼ sec. 23, T. 6 N., R. 1 E. These are similar to the pseudo-conglomerates described by Dott[9] but are found at two stratified horizons in the Garber formation. The Garber formation is the reservoir rock from which Norman obtains its water supply at depths from 240 to 618 feet. It has an approximate thickness in the county of 400 feet.

### HENNESSEY FORMATION

The Hennessey shale rests upon the Garber formation with apparently conformable contact in Cleveland County. It is characterized by predominating red shales, thin and frequently laminated. It weathers to a dark comparatively rich loam which forms a prairie belt over its entire outcrop. It is therefore easily recognized and can be readily mapped. Its lower 50 feet contains several thin, rather resistant sandstone strata which form characteristic flat topped hills along the east border of the prairie. Aside from the above described sandstone the Hennessey forms a continuous shale outcrop in Cleveland County from its east boundary in sec. 3, T. 10 N., R. 2 W., through the town of Moore to the east boundary of sec. 17, T. 10 N., R. 4 W., where it is overlain by the Duncan sandstone. It has a thickness of approximately 600 feet in the county.

The towns of Moore, Norman, Noble and Lexington are all situated on the Hennessey shale.

### DUNCAN SANDSTONE

The Duncan sandstone overlies the Hennessey shale and is exposed only in a strip one mile wide in the extreme western tier of sections in T. 10 N., R. 4 W. Its lower contact enters the county on the east line of section 6 and runs approximately due south and crosses the Canadian River into McClain County in sec. 20, T. 10 N., R. 4 W. The base of the Duncan sandstone which is the only part exposed in the county is characterized by massive red sandstone. In Canadian County to the west of Cleveland County boundary it forms rather subdued hills which topographically become more distinct escarpment-forming sand-

9. Dott, Robert H., The geology of Garvin County: Oklahoma Geol. Survey Bull. 40-K, 1927.

stones increasing in prominence to the south through McClain County and culminates in Flat Top Mountain of Garvin County where, according to Dott,[10] the entire Duncan sandstone is exposed in escarpments 150 feet high. Its thickness is approximately 150 feet, of which only the lower 50 feet are exposed.

### MESOZOIC

No Mesozoic is known or has been definitely recognized in Cleveland County.

### TERTIARY

Tertiary pebbles, water worn and rounded, are found in isolated places as float capping hills.

### RECENT

Recent alluvium has accumulated on the Canadian River flats and along the larger streams valleys forming narrow flood plains.

Wind blown sand has accumlated on the north side of the Canadian River due to the prevailing south winds and form in places rather conspicuous dunes 20 to 30 feet high. Some of the finer wind-carried materials are found incorporated with the soil several miles from the river. This material forms a light brown loess-like soil 3 feet thick in the southwestern part of the city of Norman.

## McCLAIN COUNTY

### STILLWATER FORMATION

The Stillwater formation is now regarded as the lowest subdivision of the Enid Group and is oldest sedimentary rock outcropping in this county. In eastern McClain County, Morgan[11] has mapped this as the Konawa formation. At least the upper part of the Konawa and the Asher will here be considered as time equivalents of the Stillwater formation as mapped farther north. Unit 1 of Dott[12] is included and forms the top of the Stillwater formation in McClain County. The strike of the Stillwater changes from northwest-southeast on the north side of the Canadian to southwest-northeast on the south side of the river in McClain County. Only the upper part of the formation is exposed in the county. This has a thickness, including 140 feet of Dott's Unit 1, of 390 feet.

### WELLINGTON FORMATION

The Wellington formation changes laterally from predominating sandstone in northeastern Cleveland County to shale in southwestern Pottawatomie and eastern McClain counties. It is the opinion of the

10. Dott, Robert H., Op. cit.
11. Morgan, Geo. D., Geology of the Stonewall Quadrangle: Bureau of Geology, Bull. 2, 1924.
12. Loc. cit.



writer that only the lower part of Dott's Unit 2 is in reality time equivalent of the Wellington. It has been rapidly reduced in thickness from north to south in McClain County has an approximate thickness of 100 feet. The surface outcrop in the county is characterized by gray shales weathering into light gray soil. Its upper contact grades without apparent change in sedimentation into the Garber.

### GARBER FORMATION

The Garber formation is characterized by massive red sandstone lenses in the upper portion grading into shale below. The sandstone of the Garber is covered with jackoak timber at the Canadian River by means of which it can be traced across the Canadian River at Pecan in Cleveland County, passing one and one-half miles west of Rosedale and south to the county line through the SW. cor. sec. 31, T. 5 N., R. 1 E. The top of the Garber should thus correspond to the top of Unit 3 as mapped by Dott in Garvin County. Its thickness is approximately 200 feet.

It will be noted that the Wellington and Garber both thin rapidly to the south from a total thickness of 800 feet in northern Cleveland County to about 300 feet in McClain County, a distance of about 35 miles. This may be due to an overlap in deposition to the south or to a somewhat different source for the sediments on the south side of the river where less sediments were available. The area of the river would thus be the area of less deposition being the area of confluence of two subareal fans the larger of which was to the north and consequently formed thicker sediments. This condition would in part account for the change in strike of the sediments forming a depression which also is probably structural in part.

### HENNESSEY FORMATION

West of the cross timber belt and east of the outcrops of the Duncan sandstone is a prairie belt all of which is here regarded a sthe outcrop of the Hennessey shale. It weathers to a rather dark soil in contrast to the usual red soils of the red beds. It is predominately shale in McClain County with a few sandstone lenses which rapidly grade laterally into shale, any of which cannot be definitely traced for more than a mile or two along the strike. The most notable of these is the sandstone bluff on the south side of Canadian River immediately north of Purcell. Another such sandstone lense forms a rather high bluff in sec. 21, T. 8 N., R. 2 W., on the north side of the Canadian and still another, though less prominent, two miles west of Purcell on the north line of sec. 16, T. 6 N., R. 2 W. All of these are apparently at different stratigraphic horizons within the shale and probably due to local variation in the conditions of sedimentation during the deposition of the shale. The Hennessey forms a broad belt many miles wide

and has a rather uniform thickness of approximately 650 feet. This is in marked contrast to the rapid convergence to the south of the Garber and Wellington.

### DUNCAN SANDSTONE

The Duncan sandstone forms the hilly area in the western part of the county. Unlike the sharp escarpment which characterizes the Duncan farther south it forms rather less prominent hills. Its base forms an irregular outcrop crossing the Canadian River in NW. ¼ sec. 29, T. 10 N., R. 4 W., thence in a generally southwesterly course to sec. 13, T. 8 N., R. 4 W., thence west to Blanchard, then southeast to SE. ¼ sec. 18, T. 6 N., R 2. W., about four miles west of Purcell; thence west through Criner and southwest from there crossing the west line of the county in sec. 18, T. 5 N., R. 4 W.

The Duncan is a massive red sandstone, rather crumbly, and less resistant to erosion in this county than farther south. It has an approximate thickness of 150 feet, and is the youngest Permian in the county.

### MESOZOIC

No Mesozoic is known in Cleveland or McClain counties although to the south in Garvin County Dott[13] reports unconsolidated sand underlain by cemented yellow sand which is in turn underlain by shales, all of which are regarded as of probable Trinity age. These are formed in the southern part of Garvin County and none are known farther north.

### CENOZOIC

Unconsolidated gravels and in places cemented, rounded, waterworn pebbles up to two inches in diameter are found, usually capping the hills in Cleveland and McClain Counties. Similar gravels have been reported over a large part of Oklahoma and which have long been regarded as of Tertiary age.

### GUERTIE SAND

The Guertie sand is found as a surface deposit in the extreme eastern part of McClain County as far west as Byars. It is composed of fine yellow unconsolidated sand and in isolated patches resting unconformably on the Stillwater formation. According to Taff[14] it was deposited by the Canadian River. It is probably of Pleistocene age.

### RIVER AND DUNE SAND

River sand is now accumulating along the Canadian River and its tributaries. Some of this is carried up by the wind along the north

13. Loc. cit.
14. Taff, J. A., U. S. Geol. Survey, 19th Ann. Rept. pt. 3, p. 439, 1899.



side of the river, forming dunes near the river, while the finer sand and dust is carried farther and mingles with the soil for several miles from the river. The southwestern part of Norman is covered with this material in patches of from two to three feet. Alluvium covers the flood plain of the river and its tributaries.

### SURFACE STRUCTURE

The surface strata in these two counties are composed of Permian red beds, being subdivisions of the Enid group. In northern Cleveland County they are all apparently conformably resting one upon the other. In eastern McClain County it is believed by the writer that the Wellington and the Garber overlap southward, rendering the former unconformable with the underlying Stillwater and similarly the Garber overlaps the Wellington so that only the upper portion of the Wellington and Garber outcrop at the surface in McClain County.

While the general regional dip is to the west, the strike of the strata in Cleveland County have an increasingly northwestern trend from the lower to the upper. Thus the strike of the base of the Stillwater formation in Pottawatomie County is slightly east of north while the strike of the top of the Hennessey is decidedly west of north. The strike of the formations thus arrange themselves spreading apart to the north with an approximate hub-like center on the Canadian River in eastern McClain County. Thus the strata on the north side of the river have a dip to the south of west.

On the south side of the river in McClain County and south into Garvin County the outcrop strikes southwest with a corresponding northwest dip. The change in direction of the strike of the strata is comparatively sharp especially is this the case with the Stillwater and the Wellington formation and becoming less pronounced in the Garber and Hennessey. This condition results in a major downfolding forming a syncline with an approximate west pitching axis passing south of Purcell. The axis has a comparatively steep pitch on the river west of Asher which flattens out to the west. The structural depression thus outlined is believed to merge into the Anadarko Basin to the west. The Anadarko Basin is thus split into a north extension as above outlined and a south branch which, as suggested by Dott,[15] is co-extensive with the Mill Creek syncline.

Local surface flexures of the strata have been reported[16] but owing to the cross-bedded nature of the formation, discontinuous outcrops, lensing, etc., their proper evaluation is rendered very difficult. Comparatively reliable horizon markers are to be found and with more de-

15. Loc. cit.
16. Shannon, C. W., and Trout, L. E., Petroleum and natural gas in Oklahoma: Oklahoma Geol. Survey, Bull. 19, 1915.

tailed study at least one of these, it is believed, may show sufficient flexure to reflect favorable subsurface structure.

## SUBSURFACE STRATIGRAPHY

In an area entirely covered by later geological formations as is the case in the area here under discussion, it is necessary to study adjacent areas where the underlying formations may approach the surface and thus be reached in drilling or better still where the underlying formations may actually outcrop on the surface. East of Cleveland County much information of the underlying formations has been uncovered in the intensive drilling campaign which has taken place in the Seminole area. Also to the southeast in the Arbuckle Mountains many of the earlier Paleozoic sedimentary formations outcrop, and from their character the geologist is able to reconstruct the physical condition of their deposition.

### EARLY PALEOZOIC

The Paleozoic sediments are found in many places of Oklahoma and adjacent states to rest on igneous rock usually termed granite and in a few mountainous areas as the Arbuckles such igneous rocks are actually exposed on the surface due to the erosion of the overlying sediments which once covered them. In the intervening lower areas of the igneous floor the sedimentary rocks are protected from erosion.

In mid-Cambrian or early-upper Cambrian the sea advanced over this area depositing sands along the shoreline, the Reagan sandstone and out beyond the sea, limestone. This is now known as the Arbuckle limestone. Its thickness in the Arbuckle Mountains has been stated at 6,000 feet of which the upper 2,000 feet has been shown to be of Ordovician age, probably equivalent to the Beekmantown. Its thickness in this area would probably only measure in hundreds of feet.

Following deposition of the Arbuckle limestone the area was uplifted during the St. Peter retreat of the sea. The upper surface of the Arbuckle limestone was then eroded. This was followed by the advance of the sea and depostion, during several minor oscillations, of shale, sandstone (Burgen), shale, Tyner sand, Wilcox and dolomite (post Wilcox) during the Simpson time in the area. A retreat of the sea resulted in the erosion of the upper surface of the dolomitic sandstone. The total thickness of these formations in this area is estimated at 800 feet. The sea again advanced over the irregular eroded surface of the sandy dolomite of late Simpson time and deposition of approximately 100 feet of limestone (Viola) took place in this area. In the deeper part of the submergence the Viola is much thicker (up to 800 feet). A shoaling of the sea caused the deposition of shale (Sylvan) approximately 100 feet in thickness. This was followed by submergence and deposition of the Hunton limestone. Only the lower 200 feet, more or less, remains as the upper part was eroded.



The seas again advanced over the eroded surface of the Hunton and the Woodford interstratified chert and dark shale was deposited, and finally predomiating dark organic shale (Chattanooga) was spread over a very extensive area in a compartively thin blanket. It rests on what apparently was a peneplaned surface of beveled earlier Paleozoic formations over an extensive area in northeastern Oklahoma. Probably continued submergence which covered nearly the entire State followed the Chattanooga deposition. This resulted in clear water and the deposition of the Boone limestone and chert. At this time dark organic sediments, the Caney shale, were carried into the sea from the southeast thinning rapidly seaward to the northwest. An emergence followed during which erosion cut deeply into the Boone and locally to the southeast removed it entirely. A reinvasion of the sea followed with the deposition of the Pitkin and Mayes limestone and Fayetteville shales. Following Mississippian time a complete emergence of this sea was attendant upon elevation in the Ouachita area and the beginning of the Jackfork deposition. Up to this time there appears to have been no local organic disturbances other than gentle oscillations of the sea level shown in the alternate deposition and erosion of successive sediments without strong angular unconformities. There is, however, a marked convergence of the sediments to the northeast so that while the Arbuckle limestone and the Chattanooga shale are separated by approximately 1,000 feet of sediments at Wewoka, the Chattanooga rests directly on the Arbuckle limestone at Collinsville, approximately 100 miles to the northeast.[17] This convergence is due in part to the erosional unconformities at the base of the Simpson, the Viola, and the pre-Chattanooga and in part due to the lesser amount of deposition in early Paleozoic over the northeastern area of the State.

### PENNSYLVANIAN

In early Pennsylvanian time the sea again invaded this area, depositing the Wapanucka limestone, while the Morrow shales were deposited to the northeast and the upper Caney in the Arbuckle Mountain area. This was followed by a retreat brought on by the uplift which formed the Hunton Arch and the Ozark Arch.[18]

This uplift confined the sea to the coal basin on the eastern side of the high area produced by the Hunton Arch and the Ozark Arch of Dott during the deposition of the Atoka, Hartshorne and McAlester. Following the McAlester time the sea overspread the Ozark Arch and progressively encroached upon the Hunton Arch but did not cover

17. White, Luther H., Subsurface distribution and correlation of the pre-Chattanooga ("Wilcox" sand) series of northeastern Oklahoma: Oklahoma Geol. Survey, Bull. 40-B, 1926.
18. Dott, Robert H., Pennsylvanian Paleogeography: Oklahoma Geol. Survey, Bull. 40-J, p. 12, 1927.

Cleveland and McClain counties until Calvin time or immediately following. The early Pennsylvanian formations from Atoka to Calvin time are accordingly not present in this area.[19] Preceding the buckling up of the Hunton Arch the Wapanucka shoreline extended westward probably to central Cleveland County. The Hartshorne to Calvin convergence is well shown in well logs from Seminole to Earlsboro. This represents the time of deposition of the Cherokee to the north which submerged the Ozark Arch in northeastern Oklahoma. The sediments intermingled with the more clastic sediments from the southeast and spread westward to Grant County over Cleveland and McClain, and progressively overlapped the west side of the Hunton Arch.

The arch was continuously submerged probably with minor oscillations from Ft. Scott to Seminole time during which the Ft. Scott, Oolagah and Lenapah limestone deposition probably reached this area.

This was probably initiated in Wewoka time. The Ouachita overthrust from the southeast, which elevated southeastern Oklahoma and resulted in the Choctaw fault and the folding of sediments on the east side of the Hunton-Ozark Arch area into a large geosyncline extending east into Arkansas. The continuous sedimentation was taking place west of the Hunton Arch giving little if any evidence of this disturbance other than shoaling of the water and the westward migration of the sea as shown in the more sandy character of the sediments. This condition continued during Kansas City time while the Francis formation of Morgan [20] was deposited on the northwestern side of the Ouachita uplift. Even during the Arbuckle uplift, which was initiated in the latter part of Kansas City time, no major disturbance of this area took place, though predominating sands and sandy shales were deposited from Francis to Ada time or Lansing to lower Wabaunsee time of the Kansas section.

During mid-Wabaunsee time an extensive area in southeastern Oklahoma, Arkansas and northwestern Lousiana was uplifted causing the rapid shift of the sea westward into northwestern Oklahoma. This caused rapid erosion of the uplifted area and the deposition, upon the northwest flank of the uplifted area, of large quantities of clastic sediments known generally as red beds.

During the early stage of the uplift, which was rather continuous in time, the Pennsylvanian red beds, the Stillwater, Wellington and Garber formations were deposited. In the sea to the west their marine equivalents interfingered with the red sediments during minor oscillations of the sea. During Stillwater and Wellington time a depression in the uplifted area was being filled in Pottawatomie County and westward in Cleveland County which caused these sediments to overlap the

19. See accompanying cross-section.
20. Op. cit.



higher area on the south in McClain and Garvin counties where consequently their equivalents are much thinner. This formed a rather featureless plain, a gradational partly marine, peneplain upon the surface of which was deposited the Hennessey shale. This was followed by slight uplift and the deposition of the Duncan sandstone upon the smoothed gradational surface of the Hennessey shale.

From this interpretation of red bed deposition it is evident that the later red beds progressively overlap marine sediments westward and that due to the uplift of Llanoria and the earlier red beds on the northwest flank of this uplift the upturned edges of the early red beds may have furnished the source for the later red sediments. The volume of total red beds materials may therefore be very considerably less than is indicated by their thickness. Furthermore, if the red beds deposition is the result of deposition in part at least by overloaded streams with constantly changing courses the red beds are essentially confluent delta deposits upon an aggradational plain with stream channelling and resulting slight unconformities common throughout the entire deposits. This condition renders the separation of the red beds by unconformities uncertain if not impossible.

## SUBSURFACE STRUCTURE

Drilling in the area has scarcely more than penetrated the red beds, which have a depth of approximately 1,950 feet in northeastern Cleveland County and over 3,000 feet in depth in southwestern McClain County. The westward dip of the red beds is approximately 50 feet to the mile. The Pennsylvanian sediments from Cherokee to Ada inclusive approximate 2,000 feet in thickness, and should include limestones equivalent to the Pawhuska, Oologah and Ft. Scott. The Wapanucka may have extended this far west.

The pre-Pennsylvanian and post-Arbuckle interval in this area is approximately 1,500 feet in thickness, and may include Pitkin, Boone, Caney-Chattanooga, Woodford, Hunton and Simpson formations. Unconformities exist between the Pitkin and Boone; probably smaller unconformities between Caney, Chattanooga and Woodford; on the top of the Hunton and probably within it; on top of the Simpson and at its base. Each unconformity might reasonably involve topographic "highs" or hills at the time, which were covered by subsequent sediments, thus producing the buried hill type of structure as have been discovered in Robberson, Garber, Tonkawa, and many other areas in Oklahoma. Aside from this type of structure no marked folding of the strata is thought likely in this area with the exception of the basin in the southeastern part of the area on the Canadian River, which is probably reflected at least into the Pennsylvanian. Compacting of sediments and minor folding and faulting may have produced suitable storage basins.

### DEVELOPMENT

No oil or gas have been discovered in this area so far, though immediately west of McClain in Grady County oil is found at approximate depths of 2,800 feet probably in the Stillwater formation. Also in the Chickasha area gas is found in a rather prominent fold in the Garber formation. It is interesting to note that this is located near the axis of the Anadarko Basin. On the east side of this area the recent discoveries at Seminole and farther west at Pearson in Pottawatomie County, has inaugurated a drilling campaign to the west which has reached eastern Cleveland County. The object of the drilling seems to be to reach these lower horizons without much attention to possible sands which are probably present in the Pennsylvanian. The estimated depth of the Hunton in eastern Cleveland County is probably not less than 4,600 feet; the Wilcox should be encountered at approximately 5,100 feet and the Burgen around 5,500 feet.

### LOCATION OF DRILLING WELLS

Six wells are now drilling in Cleveland County, located as follows:

The Wirt Franklin-Cromwell well drilling SW.¼ sec. 22, T. 10 N., R. 2 W. Wirt Franklin.

The Cosden Oil and Gas Company in SW.¼ sec. 20, T. 8 N., R. 1 E.

Galt Brown in NW.¼ sec. 7, T. 9 N., R. 1 W.

The Sooner State Oil Company, in SW.¼ sec. 15, T. 7 N., R. 1 W.

The Magnolia Petroleum Company, in SW.¼ sec. 11, T. 6 N., R. 1 W.

The Wiser Oil Co., in NW.¼ sec. 25, T. 6 N., R. 1 E.

All of these have penetrated the red beds but are not known to be definitely through the Pennsylvanian.

Several test wells have been drilled in McClain County. Hall and Briscoe of Chickasha drilled a well in sec. 3, T. 5 N., R. 4 W., to a total depth of 3,002 feet. It penetrated only about 500 feet of probable Pennsylvanian. A well was drilled in sec. 16, T. 8 N., R. 4 W., to a depth of 3,000 feet and in sec. 1, T. 5 N., R. 2 W., was drilled to a total depth of 3,325 feet, with red beds to approximately 3,000 feet. Earlier development therefore, has hardly more than penetrated the red beds with the underlying Pennsylvanian and earlier Paleozoics entirely unexplored.

# KINGFISHER AND CANADIAN COUNTIES

By

W. C. Kite

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### LOCATION

Kingfisher and Canadian counties lie just to the northwest of the center of the State. Kingfisher extends from T. 15 N. to T. 19 N., inclusive and from R. 5 W. to R. 9 W., inclusive. Its total area covers 25 townships and comprises 900 square miles. Canadian extends from T. 10 N. to T. 14 N., inclusive and from R. 5 W. to R. 10 W., inclusive. Its total area covers 24 entire townships and parts of four others, comprising approximately 927 square miles.

### ACKNOWLEDGMENTS

The writer wishes to express thanks and appreciation to Glenn C. Clark, Chas. N. Gould, R. L. Clifton, D. W. Ohern, the Bu-Vi-Bar Petroleum Corporation and the T. B. Slick Company, for aid and suggestions on this paper.

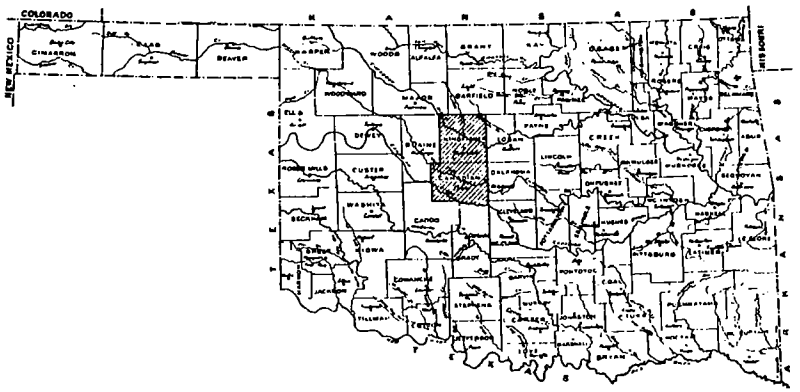


Figure 28. Index map of Oklahoma showing location of Kingfisher and Canadian Counties.

(This report originally issued as Bulletin 40-O, 1927.)

### TOPOGRAPHY AND DRAINAGE

The topography of most of the area is that of typical gently rolling western plains. The gypsum hills occupy the northwestern part of Canadian County and their topography is fairly rough, presenting many dissected escarpments peculiar to the gypsum hills region of western Oklahoma.

The Cimarron River crosses Kingfisher County in a northwest southeast direction and with its tributaries drains the entire county The lowest elevation in Kingfisher County, 960 feet, is in the bed of Cimarron River on the eastern border of the county and the highest elevation, 1,440 feet, is in the southwestern part of the county.

Most of Canadian County is drained by the North and South Canadian rivers with their tributaries. The northeastern part of the county is drained by the tributaries of Cimarron River.

## GEOLOGY

### SURFACE FORMATIONS

Surface formations in the counties are Permian, Tertiary (?), Quaternary (?) terrace deposits and dunes, and river alluvium. The valleys of the North and South Canadian and Cimarron rivers are chiefly alluvium. Bordering the alluvium deposits of the Cimarron River along its northern border is a wide band of Quaternary (?) terrace and dune sand deposits. Tertiary (?) sands and gravel cap some of the hills in western Canadian County.

The formations exposed in the eastern part of Kingfisher and northeastern Canadian counties belong to the lower Enid formation and are mostly soft red shales. The lower Enid exposed in the northeastern part of Kingfisher County correlates with Clark and Cooper's[1] Hennessey formation of Garfield County. The southwestern part of Kingfisher County and most of the eastern half of Canadian County is composed of the upper Enid formation, which is mostly red shales and lenticular sands. Farther south, the upper Enid is sub-divided into the Chickasha formation and the Duncan sandstone. The latter has been traced across Canadian and Kingfisher counties to connect with Clark and Cooper's Duncan formation of western Garfield County. The Chickasha and Duncan are not readily distinguished in the area here discussed.

The Blaine formation outcrops in a bed three to five miles wide and crosses the extreme southwestern corner of Kingfisher County and extends to the southeast across Canadian County, and consists of gypsum, red clay and shale. Its gypsum beds in northwestern Canadian

[1] Clark, G. C., and Cooper, C. L., Geology of Kay, Grant, Garfield and Noble counties: Oklahoma Geol. Survey, Bull. 40-H, 1927.



County are classified by Gould as Shimer, Medicine Lodge and Ferguson, members; the Ferguson, which is the lowest of the three, being the thickest and most conspicuous. These beds thin to the southeast with the escarpments fading into flat plains so that they often become difficult to trace.

Just above the Blaine is the Dog Creek formation, consisting of red clay and shales. It crosses the North Canadian River at Fort Reno. Its thickness is hard to estimate in this territory but is probably less than 300 feet.

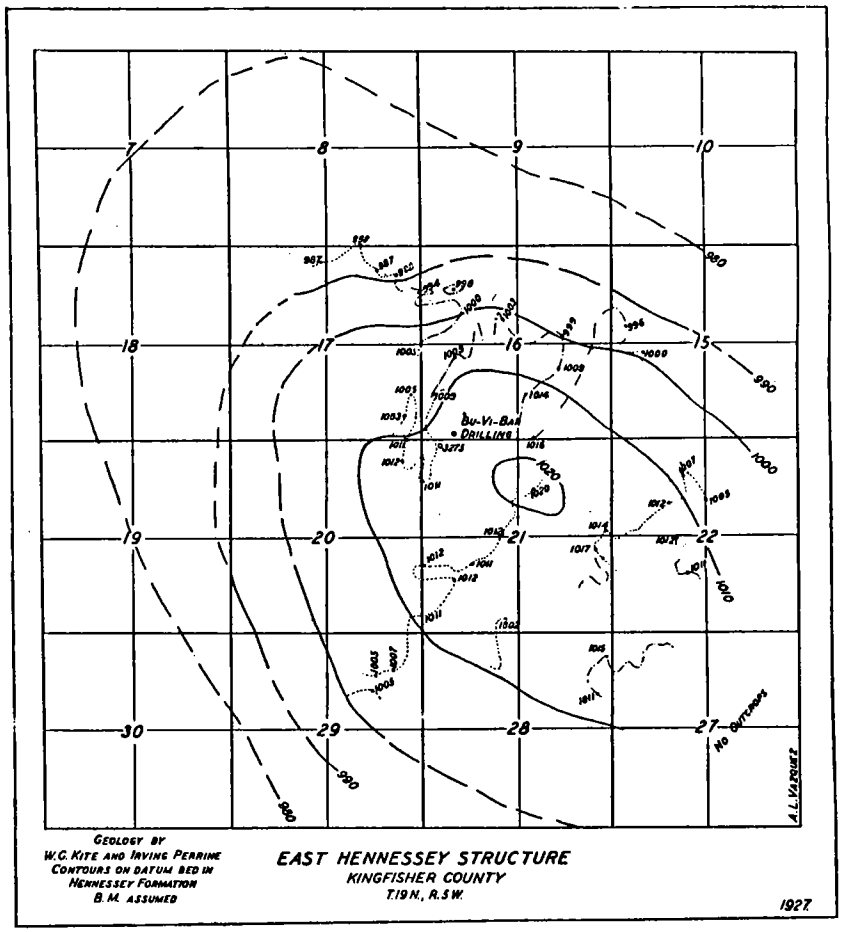


Figure 29. East Hennessey Structure.

The lower Whitehorse sandstone outcrops in about six townships in southwestern Canadian County. It is just above the Dog Creek shales and apparently lies unconformably on them. The Whitehorse is made up of fine red, frequently highly cross-bedded sandstones.

### SUBSURFACE FORMATIONS

Various geologists in interpreting subsurface stratigraphy from studying the log of the Bu-Vi-Bar well in sec. 16, T. 19 N., R. 5 W., northeastern Kingfisher County, place the base of the Garber formation at about 840 feet, the base of the Permian at 2,400 feet and estimate that the Layton sand will be found at around 4,950 feet, with the Wilcox probably below 6,000 feet.

### STRUCTURE

The general dip of the surface formations in Kingfisher and Canadian counties is about 15 to 20 feet per mile to the southwest and toward the axis of the Anadarko basin. There are possibly variations in this general dip but little evidence is found at the surface of anticlinal folding, due to the presence of much sand and shales in the Enid and Blaine formations. However, a few calcareous beds do occur in the lower Enid formation in the northeastern part of Kingfisher County, by means of which local structural conditions can be partly determined. A small plunging anticline occurs in secs. 16, 17, 20 and 21, T. 19 N., R. 5 W. The high point on this fold is in section 21, just to the southeast of the Bu-Vi-Bar well.

Meager well log information suggests thickening of the upper formations to the southwest so that the rate of the dip increases with depth. The base of the red beds probably dips more than twice as fast as the surface formations. The Pennsylvanian formations probably thin toward the northwest across the area as they do in the region to the east and north of the two counties.

In the Marland-Garber test in sec. 19, T. 23 N., R. 3 W., the interval from the top of the Layton to the top of the Wilcox is 1,050 feet, while the Roxana-Brunken well in sec. 29, T. 23 N., R. 4 W., this interval is 1,700 feet. With these changes in mind it is difficult to estimate what may occur below the Layton.

### OIL AND GAS DEVELOPMENT

In 1922 the Fensland Oil Company drilled a test in the NW. cor sec. 21, T. 19 N., R. 5 W., to a total depth of 3,275 feet and encountered only small showings of oil and gas. The Bu-Vi-Bar Petroleum Corporation is now drilling around 4,750 feet in section 16, just to the northeast of the old Fensland test. The following is a list of the wells drilled in the two counties, as reported to the Corporation Commission:



*Wells drilled in Kingfisher and Canadian Counties*

| Location | | Depth (feet) | Company |
|---|---|---|---|
| NW.¼ | sec. 21, T. 19 N., R. 5 W. | 3,275 | Fensland Oil Co. |
| SW.¼ SW.¼ NW.¼ | sec. 12 T. 18 N., R. 5 W. | 4,502 | Peerless Oil & Gas Co. |
| SW.¼ NE.¼ SW.¼ | sec. 31, T. 15 N., R. 7 W. | 3,012 | F. & N. Oil Co. |
| SE. cor. NW.¼ | sec. 7, T. 17 N., R. 8 W. | 3,471 | Plover Drilling Co. |
| Cen. NW.¼ SE.¼ | sec. 1, T. 18 N., R. 8 W. | 2,400 | |
| NW. cor. NE.¼ | sec. 13, T. 11 N., R. 10 W. | 2,850 | O. R. Howard |
| SE. cor. SE.¼ | sec. 25, T. 17 N., R. 5 W. | 2,317 | Carson-Malernee et al |
| NW.¼ | sec. 12, T. 11 N., R. 6 W. | 3,073 | Yukon Co-operative Co. |
| SE.¼ | sec. 6, T. 13 N., R. 5 W. | 2,270 | Deer Creek Oil & Gas Co. |
| NW. cor. NW.¼ | sec. 13, T. 14 N., R. 10 W. | 2,400 | Gladys Bell Oil & Gas Co. |
| NE. cor. | sec. 34, T. 13 N., R. 9 W. | 3,619 | T. E. Revels |

*Log of Hannum-Franks-Slick-Pazoureck No. 1.*

SW.¼ NE.¼ sec. 29 T. 13 N., R. 5 W., Canadian County, Oklahoma. Elevation 1,280 feet. Drilling commenced June 30, 1926. Contract depth 4,000 feet reached 11-17-26. Still drilling by T. B. Slick Nov. 20, 26.

| Formation | Top | Bottom |
|---|---|---|
| Surface soil | 0 | 50 |
| Sand | 20 | 100 |
| Red bed | 50 | 20 |
| Sand | 100 | 110 |
| Red bed | 110 | 175 |
| Sand | 175 | 200 |
| Red bed | 200 | 565 |
| Hard shale and shells | 565 | 700 |
| No record | 700 | 831 |
| Hard shale and shells | 831 | 941 |
| Broken lime | 941 | 951 |
| Hard shale | 951 | 1091 |
| Sandy shale | 1091 | 1151 |
| Broken lime shells and hard sandy shale | 1151 | 1191 |
| Broken lime | 1191 | 1200 |
| Hard shale | 1200 | 1246 |
| Red bed | 1246 | 1350 |
| Lime | 1350 | 1352 |
| Red bed | 1352 | 1400 |
| Hard shale | 1400 | 1450 |
| Red bed | 1450 | 1507 |
| Red bed and boulders | 1507 | 1617 |
| Blue shale and beds | 1617 | 1667 |
| Blue shale and boulders | 1667 | 1742 |
| Blue shale | 1742 | 1775 |
| Lime | 1775 | 1777 |
| Blue shale and boulders | 1777 | 1814 |
| Hard sand | 1814 | 1817 |
| Gumbo strkd. with brown shale | 1817 | 1835 |
| Gray gumbo sandy | 1835 | 1855 |
| Hard sand | 1855 | 1860 |
| Brown shale | 1860 | 1880 |
| Shale and shells | 1880 | 1890 |
| Sandy lime | 1890 | 1896 |
| Gumbo | 1896 | 1904 |
| Slate and lime, broken | 1904 | 1920 |
| Sticky shale | 1920 | 1930 |
| Lime | 1930 | 1932 |
| Slate and hard shale | 1932 | 1940 |
| White chalky lime | 1940 | 1945 |
| Shale | 1945 | 1960 |
| Lime and slate, broken | 1960 | 1985 |
| Lime | 1985 | 1995 |
| Brown shale | 1995 | 2001 |
| Lime, sandy | 2001 | 2003 |
| Broken lime | 2003 | 2013 |
| Sticky shale | 2013 | 2028 |
| Broken lime | 2028 | 2038 |
| Shale and lime | 2038 | 2045 |
| Lime | 2043 | 2045 |
| Hard shale and lime shell | 2045 | 2065 |
| Shale | 2065 | 2180 |
| Broken lime | 2180 | 2190 |
| Hard shale and slate | 2190 | 2220 |
| Hard shale | 2220 | 2237 |
| Lime | 2237 | 2238 |
| Shale | 2238 | 2245 |
| Lime | 2245 | 2246 |
| Shale and gumbo | 2246 | 2340 |
| Sand and slate | 2340 | 2347 |
| Tough shale | 2347 | 2357 |
| Sticky shale | 2357 | 2372 |
| Broken lime | 2372 | 2382 |
| Hard shale and shells | 2382 | 2407 |
| Shale | 2407 | 2422 |
| Tough shale | 2422 | 2434 |
| Sand, salt water | 2434 | 2435 |
| Hard sandy lime | 2435 | 2438 |
| Hard sand | 2438 | 2450 |
| Shale | 2450 | 2460 |
| Lime | 2460 | 2475 |
| Sticky shale | 2475 | 2510 |
| Broken lime | 2510 | 2515 |
| Sticky shale | 2515 | 2540 |
| Sticky shale, red | 2540 | 2575 |
| Lime shell | 2575 | 2577 |

| Formation | Top | Bottom |
|---|---|---|
| Tough shale | 2577 | 2600 |
| Hard shale | 2600 | 2609 |
| Sticky shale | 2609 | 2620 |
| Broken lime | 2620 | 2630 |
| Sandy lime | 2630 | 2644 |
| Sticky shale | 2644 | 2660 |
| Gumbo | 2660 | 2695 |
| Shale, blue and brown | 2695 | 2730 |
| Lime, gray | 2730 | 2732 |
| Shale | 2732 | 2755 |
| Soft brown sand | 2755 | 2762 |
| Sticky shale | 2762 | 2800 |
| Broken lime | 2800 | 2810 |
| Hard shale | 2810 | 2830 |
| Sticky shale | 2830 | 2833 |
| Sandy lime —Show some oil | 2833 | 2840 |
| Broken lime | 2840 | 2850 |
| Hard sandy lime | 2850 | 2857 |
| Sticky shale | 2857 | 2882 |
| Hard shale and shells | 2882 | 2902 |
| Sticky shale and shells | 2902 | 2922 |
| Lime | 2922 | 2942 |
| Hard lime | 2942 | 2952 |
| Shale and slate broken | 2952 | 2974 |
| Sticky shale | 2974 | 2994 |
| Shale | 2994 | 3030 |
| Tough shale | 3030 | 3038 |
| Sand, hard | 3038 | 3046 |
| Tough shale | 3046 | 3050 |
| Broken lime | 3050 | 3060 |
| Lime | 3060 | 3070 |
| Slate and lime, broken | 3070 | 3075 |
| Lime | 3075 | 3086 |
| Shale | 3086 | 3106 |
| Lime | 3106 | 3126 |
| Hard sand | 3126 | 3134 |
| Broken lime | 3134 | 3136 |
| Gumbo | 3136 | 3149 |
| Hard gray lime | 3149 | 3154 |
| Gumbo | 3154 | 3160 |
| Blue slate | 3160 | 3168 |
| Slate | 3168 | 3178 |
| Hard shale | 3178 | 3188 |
| Broken slate and shale | 3188 | 3196 |
| Lime | 3196 | 3198 |
| Lime, hard, gray Gumbo | 3198 | 3203 |
| Hard shale and lime | 3203 | 3210 |
| | 3210 | 3226 |
| Hard slate | 3226 | 3238 |
| Lime | 3238 | 3243 |
| Hard slate | 3243 | 3251 |
| Broken lime | 3251 | 3261 |
| Tough gumbo | 3261 | 3291 |
| Hard shale | 3291 | 3318 |
| Lime | 3318 | 3325 |
| Slate | 3325 | 3327 |
| Hard gray sand | 3327 | 3334 |
| Hard sandy lime | 3334 | 3344 |
| Hard sand | 3344 | 3355 |
| Slate and sand | 3355 | 3375 |
| Hard gray sand | 3375 | 3385 |
| Slate and sand | 3385 | 3415 |
| Hard sand | 3415 | 3417 |
| Tough shale | 3417 | 3430 |
| Shale and slate | 3430 | 3464 |
| Hard slate | 3464 | 3481 |
| Lime | 3481 | 3492 |
| Sand and hard shale, broken | 3492 | 3502 |
| Hard blue shale | 3502 | 3514 |
| Hard black slate | 3514 | 3525 |
| Lime | 3525 | 3549 |
| Sand water | 3549 | 3569 |
| Blue shale | 3569 | 3573 |
| Red Rock | 3573 | 3577 |
| Hard shale | 3577 | 3593 |
| Sandy shale | 3593 | 3610 |
| Sticky shale | 3610 | 3622 |
| Hard shale | 3622 | 3649 |
| Water sand and shale | 3649 | 3654 |
| Shale | 3654 | 3668 |
| Hard shale | 3668 | 3701 |
| Water sand and shale | 3701 | 3704 |
| Hard shale | 3704 | 3720 |
| Shale | 3720 | 3735 |
| Lime | 3735 | 3741 |
| **Standard Tools** | | |
| Black shale | 3746 | 3750 |
| Shale | 3750 | 3757 |
| White lime | 3757 | 3761 |
| Sand | 3761 | 3767 |
| Shale | 3767 | 3787 |
| Sand | 3787 | 3803 |
| Shale | 3803 | 3821 |
| Sand | 3821 | 3828 |
| Shale | 3828 | 3888 |
| Hard white lime | 3888 | 3935 |
| Shale | 3935 | 3942 |
| Lime | 3942 | 3952 |
| Water sand with water | 3952 | 3959 |
| Water sand | 3959 | 3967 |
| Sand | 3967 | 3970 |
| Sandy shale | 3970 | 3973 |
| Shale and sand | 3973 | 3978 |
| Sand water | 3978 | 3980 |
| Shale | 3980 | 3982 |
| Lime, black | 3982 | 3984 |
| Sand | 3984 | 3986 |
| Shale | 3986 | 3990 |
| Shale, blue | 3990 | 4000 |
| Blue shale | 4000 | 4010 |
| Sand | 4010 | 4013 |
| Sandy shale | 4013 | 4015 |
| Sand | 4015 | 4020 |
| Blue shale | 4020 | 4077 |
| Brown shale | 4077 | 4081 |
| Blue shale | 4081 | 4095 |
| Sandy lime | 4095 | 4105 |
| Blue shale | 4105 | 4170 |
| Sandy lime | 4170 | 4183 |
| Blue shale | 4183 | 4200 |
| Sandy shale | 4200 | 4210 |
| Sand | 4210 | 4215 |
| Lime | 4215 | 4220 |
| Sand | 4220 | 4225 |
| Blue shale | 4225 | 4245 |
| Sandy shale | 4245 | 4247 |
| Sand, water | 4247 | 4271 |
| Blue shale | 4271 | 4285 |
| Lime | 4285 | 4288 |
| Blue shale | 4288 | 4313 |
| Shale | 4313 | 4318 |
| Broken lime | 4318 | 4338 |
| Water sand | 4338 | 4372 |



| Formation | Top | Bottom |
|---|---|---|
| Shale, sand | 4372 | 4375 |
| Sand | 4375 | 4393 |
| Sand | 4393 | 4412 |
| Shale | 4412 | 4420 |
| Shale | 4420 | 4431 |
| Sandy lime | 4431 | 4439 |
| Sand | 4439 | 4445 |
| Shale | 4445 | 4452 |
| Lime | 4452 | 4454 |
| Correction | | |
| Total depth of hole | | 4468 |
| Black shale | 4468 | 4470 |
| Lime | 4470 | 4472 |
| B. shale | 4472 | 4476 |
| Red rock | 4476 | 4498 |
| Green sand | 4498 | 4505 |
| Gray sand | 4505 | 4515 |
| Dark shale | 4515 | 4533 |
| Water sand | 4533 | 4537 |

## *Log of Fensland Oil Co.'s Henry No. 1.*

NW.¼ NW.¼ NW.¼ sec. 21 T. 19 N., R. 5 W., Kingfisher County, Oklahoma. Drilling commenced Feb. 1, 1922. Completed July 15, 1922.

| Formation | Top | Bottom |
|---|---|---|
| Shale, red | 0 | 40 |
| Red shale | 40 | 130 |
| Red rock | 130 | 250 |
| Red shale | 250 | 270 |
| Wtr. sand | 270 | 295 |
| Shale, red | 295 | 310 |
| Red rock | 310 | 355 |
| Red shale | 355 | 430 |
| Wtr. sand | 430 | 455 |
| Red rock | 455 | 470 |
| Coarse gravel, wtr. | 470 | 480 |
| Red rock | 480 | 615 |
| Sand, wtr. | 615 | 620 |
| Pink rock | 620 | 630 |
| Red rock | 630 | 690 |
| Red shale | 690 | 790 |
| Sand, no wtr. | 790 | 830 |
| Blue shale | 830 | 840 |
| White slate | 840 | 1185 |
| White lime | 1185 | 1200 |
| White shale | 1200 | 1230 |
| Gray slate | 1230 | 1300 |
| Blue slate | 1300 | 1320 |
| White hd. lime | 1320 | 1330 |
| Broken lime shells | 1330 | 1345 |
| Blue slate | 1345 | 1365 |
| Broken shale | 1365 | 1375 |
| Broken lime | 1375 | 1460 |
| White shale | 1460 | 1475 |
| Broken lime | 1475 | 1535 |
| Gray slate | 1535 | 1610 |
| Red rock | 1610 | 1660 |
| White slate | 1660 | 1665 |
| Lime | 1665 | 1685 |
| Red rock | 1685 | 1765 |
| Sand, wtr. | 1765 | 1770 |
| Sand | 1770 | 1775 |
| Slate | 1775 | 1785 |
| White slate | 1785 | 1835 |
| Hd. white lime | 1835 | 1845 |
| White slate | 1845 | 1860 |
| Red rock | 1860 | 1910 |
| Sand, water, show gas | 1910 | 1915 |
| Gravel, wtr. red | 1915 | 1925 |
| Sand, wtr. | 1925 | 1935 |
| Blue slate | 1935 | 1965 |
| Gray lime | 1965 | 1985 |
| Brown shale | 1985 | 2010 |
| Red rock | 2010 | 2135 |
| Gray lime | 2135 | 2155 |
| White shale | 2155 | 2175 |
| Red rock | 2175 | 2200 |
| Sand, wtr. show gas | 2200 | 2225 |
| Red rock | 2225 | 2242 |
| Gray lime | 2242 | 2247 |
| White slate | 2247 | 2280 |
| Red rock | 2280 | 2350 |
| White slate | 2350 | 2360 |
| Red rock | 2360 | 2368 |
| Lime | 2368 | 2390 |
| Slate | 2390 | 2395 |
| Black sandy lime | 2395 | 2400 |
| White slate | 2400 | 2410 |
| Black sand | 2410 | 2415 |
| White slate | 2415 | 2420 |
| White lime | 2420 | 2440 |
| Black slate | 2440 | 2445 |
| White lime | 2445 | 2460 |
| Blue slate | 2460 | 2500 |
| White lime | 2500 | 2510 |
| Slate | 2510 | 2625 |
| Lime | 2625 | 2635 |
| Red rock | 2635 | 2695 |
| White slate | 2695 | 2700 |
| Gray lime | 2700 | 2705 |
| White slate | 2705 | 2720 |
| Brown slate | 2720 | 2730 |
| White slate | 2730 | 2820 |
| White lime | 2820 | 2825 |
| Red rock | 2825 | 2835 |
| Gravel, wtr, red | 2835 | 2840 |
| Sand, wtr. | 2840 | 2850 |
| White slate | 2850 | 2855 |
| Sandy lime, black | 2855 | 2860 |
| White slate | 2860 | 2870 |
| Gray lime | 2870 | 2875 |
| Blue slate | 2875 | 2885 |
| Red rock | 2885 | 2890 |
| Dry sand | 2890 | 2910 |
| Blue slate | 2910 | 2918 |
| Black slate, hd. | 2918 | 2938 |
| White sandy lime | 2938 | 2945 |
| Hd. rock | 2945 | 2950 |
| Broken gravel | 2950 | 2960 |
| Slate | 2960 | 2970 |
| Lime | 2970 | 2980 |
| Black slate | 2980 | 3000 |
| Broken lime | 3000 | 3020 |
| Red rock | 3020 | 3050 |
| Broken lime shell | 3050 | 3065 |
| White lime | 3065 | 3085 |
| Slate | 3085 | 3100 |
| Broken lime shells | 3100 | 3115 |
| Gray slate | 3115 | 3150 |
| Black slate | 3150 | 3170 |
| Red rock | 3170 | 3210 |
| Blue slate | 3210 | 3240 |
| Sandy lime | 3240 | 3245 |
| Shale | 3245 | 3250 |
| Sandy lime | 3250 | 3270 |

| Formation | Top | Bottom |
|---|---|---|
| Blue shale | 3270 | 3275 |
| T. D.** | | |
| Lime and slate | 3275 | 3280 |
| Lime | 3280 | 3300 |
| Broken lime | 3300 | 3305 |
| Hard shale | 3305 | 3320 |
| Sand and shale | 3320 | 3325 |
| Water sand | 3325 | 3335 |
| Hard shale | 3335 | 3345 |
| Slate | 3345 | 3355 |
| Sand | 3355 | 3365 |
| Blue shale | 3365 | 3375 |
| Lime | 3375 | 3385 |
| White sand | 3385 | 3390 |
| Sandy lime | 3390 | 3395 |
| Hard lime | 3395 | 3410 |
| Lime | 3410 | 3415 |
| Hard shale | 3415 | 3430 |
| Slate and lime shells | 3430 | 3450 |
| Broken lime and slate | 3450 | 3470 |
| Broken lime | 3470 | 3475 |
| Sand | 3475 | 3487 |
| Slate | 3487 | 3500 |
| Hard sand | 3500 | 3530 |
| Slate | 3530 | 3540 |
| Blue shale | 3540 | 3555 |
| Lime | 3555 | 3565 |
| Hard sandy lime | 3565 | 3575 |
| Lime, hard | 3575 | 3585 |
| Brown slate and lime shells | 3585 | 3595 |
| Broken lime | 3595 | 3600 |
| Shale and slate | 3600 | 3610 |
| Hard sandy lime | 3610 | 3620 |
| Lime and hard sand | 3620 | 3635 |
| Hard sand | 3635 | 3655 |
| Hard shale, sandy | 3655 | 3665 |
| Slate and shale | 3665 | 3685 |
| Hard shale | 3685 | 3700 |
| Shale | 3700 | 3710 |
| Hard sand | 3710 | 3720 |
| Sharp sand | 3720 | 3725 |
| Hard sand | 3725 | 3730 |
| Slate and shale | 3730 | 3740 |
| Slate | 3740 | 3760 |
| Red and brown shale with lime shells | 3760 | 3770 |
| Slate | 3770 | 3775 |
| Sand | 3775 | 3785 |
| Hard shale | 3785 | 3800 |
| Slate | 3800 | 3805 |
| Sandy lime | 3805 | 3810 |
| Black slate | 3810 | 3815 |
| Shale | 3815 | 3825 |
| Sand | 3825 | 3860 |
| Sandy lime | 3860 | 3870 |
| Sand | 3870 | 3880 |
| Hard shale | 3880 | 3885 |
| Shale | 3885 | 3890 |
| Lime | 3890 | 3905 |
| Hard shale and shells, sandy | 3905 | 3925 |
| Lime | 3925 | 3930 |
| Red shale | 3930 | 3935 |
| Shale and lime shells | 3935 | 3945 |
| Lime | 3945 | 3952 |
| Sand | 3952 | 3980 |
| Sandy lime | 3980 | 4005 |
| Broken lime | 4005 | 4015 |
| Broken sand and red shale | 4015 | 4025 |
| Slate and shale | 4025 | 4045 |
| Sand | 4045 | 4061 |
| Shale, blue | 4061 | 4065 |
| Red rock | 4065 | 4072 |
| Blue shale | 4072 | 4075 |
| Lime, blue | 4075 | 4077 |
| Blue shale | 4077 | 4085 |
| Red rock | 4085 | 4094 |
| Blue shale | 4094 | 4114 |
| White lime | 4114 | 4120 |
| Blue shale | 4120 | 4154 |
| Sandy shale | 4154 | 4160 |
| Blue shale | 4160 | 4170 |
| Sandy shale | 4170 | 4174 |
| Sand | 4174 | 4180 |
| Blue shale | 4180 | 4190 |
| Sandy shale | 4190 | 4218 |
| Black shale | 4218 | 4228 |
| White shale | 4228 | 4233 |
| Blue shale | 4233 | 4239 |
| Sand | 4239 | 4245 |
| White shale | 4245 | 4250 |
| Blue shale | 4250 | 4253 |
| White shale | 4253 | 4258 |
| Blue shale | 4258 | 4260 |
| White shale | 4260 | 4265 |
| Blue shale | 4265 | 4269 |
| White shale | 4269 | 4271 |
| Shale | 4271 | 4276 |
| White shale | 4276 | 4278 |
| Blue shale | 4278 | 4282 |
| Blue lime | 4282 | 4284 |
| Blue shale | 4284 | 4304 |
| Blue shale | 4304 | 4339 |
| Sandy shale | 4339 | 4368 |
| Sandy lime | 4368 | 4370 |
| Lime | 4370 | 4374 |
| Blue shale | 4374 | 4380 |
| Water sand | 4380 | 4405 |
| Lime | 4405 | 4410 |
| Blue shale | 4410 | 4430 |
| Broken sand | 4430 | 4437 |
| Blue shale | 4437 | 4444 |
| White water sand | 4444 | 4473 |
| Hard sand | 4473 | 4479 |
| Sand | 4479 | 4484 |
| Blue shale | 4484 | 4501 |
| Sand, hard | 4501 | 4505 |
| Blue shale | 4505 | 4511 |
| Lime | 4511 | 4516 |
| Blue shale | 4516 | 4530 |
| Sand | 4530 | 4542 |
| White water sand | 4542 | 4556 |
| Sand | 4556 | 4565 |
| Blue shale | 4565 | 4572 |
| Blue slate | 4572 | 4595 |
| Blue shale | 4595 | 4609 |
| Blue shale | 4609 | 4691 |
| Lime | 4691 | 4696 |
| Blue shale | 4696 | 4702 |
| Lime | 4702 | 4703 |

Depth Feb. 25, 1927.

**The first 3275 feet shown above is the Fensland log, which was drilled with standard tools. The balance of the log from 3275 feet to 4703 feet is log of the Bu-Vi-Bar Petroleum Corporation's drilling Well No. 1 School Land, in the SW.¼ SW.¼ sec. 16, T. 19 N., R. 5 W., Kingfisher County, Oklahoma.



## CONCLUSIONS

So few wells have been drilled to the deeper formations in this area that it is impossible at this time to determine the presence of any pronounced subsurface folding. With the normal dip of the formations to the southwest, the Wilcox sand would occur too deep for drilling under present methods. However, with the trend of folding in Kay, Noble and Garfield counties being generally northeast-southwest and with the arching of the deeper formations being very much more pronounced than the surface folding, as in the case of the Garber field where the Wilcox sand is arched more than 1,700 feet, it is possible that some extension of that line of folding will be found in the region here discussed and that folding in the Wilcox sand may be high enough to bring it within reach of the drill.

The few well logs obtainable in northeastern Canadian county seem to have less red beds than do some of the wells farther north, which suggests that the line of folding here mentioned may come into the territory from the northeast near the northeastern corner of Kingfisher County. However, the logs in that vicinity show considerable thickness of shale which may be red, but logged by drillers merely as "shale".

Any well-defined surface fold is a good possibility for oil production in the shallow formations of the lower Permian and Pennsylvanian. Producing horizons underlie the area and it is very likely that sufficient folding to trap oil is present. Therefore, it is reasonable to expect oil to be produced in these counties.

# COMANCHE COUNTY

By
Frank Gouin

## INTRODUCTION

In previous reports the writer has stressed the importance of keeping samples of formations encountered when drilling wells and most especially all wildcat wells. A set of samples from a rotary drilled well, if continuous, can be interpreted as successfully as a set from a well drilled with standard tools. A knowledge of paleontology is not essential for a study of the pre-Carboniferous rocks in southwestern Oklahoma. Many conclusions now inferred from the logs of wells drilled in the past would be definite had cuttings been preserved. For those not having facilities for the examination of cuttings, the Department of Geology of the State University is well equipped to perform such work. Also several of the larger oil companies maintain well equipped laboratories for the special study of well cuttings.

The writer hopes that a reading of this report will demonstrate that the information based on well samples is of value and that the lack of such samples is regretable. As stated in previous reports if this results in a little more attention being paid to this phase of the oil business he will feel that his feeble efforts have been rewarded.

### Location

Comanche County is located in southwestern Oklahoma. It includes all or parts of the townships included in the area from T. 2 S., to T. 4 N., inclusive and from R. 9 W., to R. 15 W., inclusive. Its area

Figure 30. Index map of Oklahoma showing location of Comanche County.

(Originally published as Bulletin 40-DD, June, 1928.)

is about 1,083 square miles. It is bounded on the north by Caddo and Kiowa counties, on the east by Grady and Stephens counties, on the south by Cotton and Tillman counties, and on the west by Tillman and Kiowa counties. Lawton, the county seat, with a population of about 9,000, is located just southeast of the center of the county. The old historic army post, Fort Sill, is located some six miles north of Lawton. The post and military reservation is now an army School of Fire for Field Artillery officers training. Both the Chicago, Rock Island, and Pacific, and the St. Louis and San Francisco railroads traverse the county.

#### Acknowledgments

The writer wishes to acknowledge the following individuals who have assisted greatly in making this report possible: To Sidney Powers and Dollie Radler of the Amerada Petroleum Corporation for furnishing the base maps; to F. A. Bush of the Sinclair Oil and Gas Company; Frank Clarke, and L. K. Foley of the Mid-Kansas Oil & Gas Company for information on well samples; to T. B. Gilbert, superintendent of the Duncan district of the Magnolia Petroleum Company for production statistics used, and to the numerous geologists and operators from whom the writer has secured miscellaneous information and ideas. Finally to Chas. N. Gould and his staff in the office of the Oklahoma Geological Survey for their valuable assistance and suggestions.

#### Literature

The earliest detailed report on the geology of Comanche County is that of J. A. Taff, assisted by E. O. Ulrich and Chas. N. Gould, in Professional Paper 31 of the United States Geological Survey, published in 1904. This work has lately been republished by the Oklahoma Geological Survey as Bulletin 12, entitled, "Preliminary Report on the Geology of the Arbuckle and Wichita Mountains in Indian Territory and Oklahoma". The field work for this report was done in 1900 and 1901. The facts as set forth in this paper not only form the foundation stone of the geology of Oklahoma, as stated in the foreword to the reprint by the Oklahoma Geological Survey, but the work was so thoroughly handled that to this day there has never been any question as to its accuracy even to the smallest detail. For this reason, much material for this report is copied from Taff's work verbatim.

The only other report that goes into detail on the geology of the county is that by C. H. Wegemann entitled "The Lawton Oil and Gas Field, Oklahoma," published as a part of bulletin 621 by the U. S. Geological Survey in 1915. That part of Bulletin 19, Part 2 of the Oklahoma Geological Survey, "Oil and Gas in Oklahoma," covering this county is largely a reprint of Wegemann's report. There are numerous references in the literature to the geology of the county,



an excellent bibliography which can be found in Oklahoma Geological Survey, Bulletin 12, January, 1928.

#### Topography

Comanche County has both the mountain and red beds plains topography. The Witchita Mountains extend from Fort Sill northwest through the county, occupying the northwest quarter of the county. The rolling country of the red beds plains occupies the remainder of the county. The elevations of the tops of the most prominent peaks is over 2,000 feet, while that of the plains averages from 900 to 1,000 feet. All of the drainage is to the south into Red River, West Cache Creek draining the western part, Cache Creek the central part, and Beaver Creek the eastern part.

## GEOLOGY

### Stratigraphy

#### Surface Rocks

The surface rocks exposed in the county belong to the pre-Cambrian, Cambrian, Cambro-Ordovician, and Permian (Map No. XXIII). The following descriptions of the pre-Permian surface rocks are quoted from Taff's[1] report.

#### IGNEOUS ROCKS

> In the general survey of the Wichita Mountains only sufficient time was available to study the salient features of the igneous rocks. The kinds of igneous rocks which occur abundantly or in large masses were distinguished, classified in respect to age as far as conditions would permit, and mapped. Local variations of the larger masses and various phases of the dike rocks were noted and specimens collected, but a study of their relations in detail was not attempted. The rocks collected were submitted to Mr. Ernest Howe, of the Geological Survey, for study, and the petrographic descriptions are from his report.
>
> The igneous rocks of the Wichita Mountains are separated into four general classes, distinguished by their large mass or abundant occurrence, and also by their age relations. These, in order of apparent age, are, gabbro and related anorthosite, granite and related aplites, granite-porphory and associated aporhyolite, and diabase dike rocks.
>
> * * * *
>
> The prevailing physical aspect of the gabbro is that of a dark-gray to black, rather coarsely crystalline, rock. The gabbro proper consists of labradorite, augite, and magnetite with a little

1. Taff, J. A., Preliminary Report on the Geology of the Arbuckle and Wichita Mountains in Indian Territory and Oklahoma, U. S. Geol. Survey, Prof. Paper 31, 1904; also, Oklahoma Geol. Survey, Bull. 12, 1928.

biotite and accessory titanite. It is a typical gabbro, fairly fresh, or with augite altered to uralitic hornblende.

The rocks which on close study have proved to be anorthosite were collected as phases of the gabbro, and occurred near the contact with the granite or near dikes of granite or aplite. Between the anorthosite and the gabbro a continuous gradation can be made out, even in hand specimens. The specimens of anorthosite collected show a reddish, greenish, or bluish-gray rock, with lath-shaped crystals of labradorite.

* * * *

### GRANITE AND ASSOCIATED APLITE

Granite is the principal mountain-making rock in the Wichita region. Its area is greater than that of all the other igneous rocks combined, and is about equal to that of the others and the older Paleozoic sediments. It makes all of the high land of the Wichita, Quana, Devils Canyon, and Headquarters mountains, and a large part of the Raggedy group.

The relations of the granite to the gabbro indicate that the granite is younger and that it intrudes the gabbro. Both occur in large masses, as shown, and the gabbro is cut by a great number of granite or aplite dikes, which in many cases can be traced from the granite mass.

In physical aspect this granite varies from dark red to light pink and from moderately coarse to finely granular. A representative of a large part of the granite mass is found in Mount Scott, which consists of a rather deep-pink, even-textured, and moderately fine-grained (granite).

* * * *

The granite in its various phases is rich in orthoclase and quartz, with relatively subordinate amounts of the dark silicates, hornblende, augite, or biotite. The majority of the specimens studied are from dikes cutting the gabbro or very near the contact of the granite with the gabbro. A specimen from the top of Mount Scott may be taken as typical of the granite as a whole. It is a medium coarse-textured rock, to which the feldspar gives a dominant red color, which is varied by small spots of a dark-greenish mineral and grains of quartz. The microscope shows that orthoclase and quartz in nearly equal amounts and together make up by far the greater part of the rock. A little hornblende also occurs, and accessory magnetite, apatite, and zircon. Although not evident in hand specimens, the rock is seen to have a crude porphyritic structure when examined under the microscope. The feldspar occurs in large phenocrysts, surrounded by quartz and feldspar in micropegmatitic intergrowths. The dark, turbid character of the feldspar is to be attributed to finely divided hematite which fills the crystals as a dust.

### GRANITE-PORPHYRY

A class of rocks apparently closely related to the granite composes practically all of the Carlton Mountains, the igneous mass lying between the limestone hills in the vicinity of Blue Canyon, north of Mount Scott, and some hills near the northwest end of the limestone areas east of Rainy Mountain Mission. They vary from brick red to shades of light pink. The porphyritic



character is variable, and specimens may be selected which have a near resemblance to certain parts of the granite, but on the whole the masses designated granite-porphypry are different from those described as granite.

Megascopically the rock appears to be a rather coarse-grained and largely feldspathic porphyry. With the exception of the feldspar phenocrysts, there seem to be usually no real crystal grains, the remainder of the rock consisting of a dense felsitic groundmass. Rarely a specimen is found which shows occasional small quartz grains. A microscopic examination shows, with the exception of a very little altered hornblende, the rock is composed almost entirely of spherulitic aggregates of feldspar and micropegmatite, often grouped about small crystals of feldspar. A little quartz also occurs, in grains.

In some instances the feldspars have a faint zonal structure, but these and a small proportion of the others, presumably plagioclase, are undeterminable on account of their decomposition. The greater part of the feldspar is orthoclase. The above description applies to the rock of Carlton Mountain, on Medicine Creek, near the western side of sec. 28, T. 3 N., R. 12 W.

* * * *

### DIABASE

The gabbro, granite, and granite-porphyry, the only igneous rocks in the Wichita region which are known to occur in large masses are cut by great numbers of diabase dikes. These dikes range in thickness from several feet to thin stringers. They cross the contact between the granite and the gabbro and intersect the granite dikes at the gabbro.

The diabase dikes extend in various directions, but sufficient time was not given to their study to determine whether they conform to any system of arrangement. Dikes of the same texture and color penetrate one another at various angles, but whether they are of one or more generations was not ascertained.

The diabase ranges from a moderately fine-grained dark-gray to fine-textured bluish-black rock. As a rule, the larger the dikes the coarser the texture. A thick and apparently neck-like dike in the granite-porphyry of Blue Creek Canyon has a texture approaching that of the average gabbro.

Petrographically these dike rocks have the typical structure and mineral composition of diabase. One specimen, from a dike 18 inches wide cutting both gabbro and granite, contains, in addition to labradorite, augite, and magnetite, a considerable amount of a brownish-yellow mineral which is evidently an alteration product, but which possesses the optical characters of serpentine, and was probably derived from olivine, as outlines of olivine crystals are still to be made out. The ophitic structure of the rock is emphasized by this mineral, for it partly surrounds the laths of labradorite after the manner of the augite.

A number of diabase dikes were noted intruding the granite-porphyry of the Blue Creek Canyon area near the Cambrian contact, and pebbles, both of granite-porphyry and of diabase, make conglomerate beds in the Reagan formation, which is in the oldest sedimentary deposit of the region, being middle Cambrian in age. Thus all the evidence of the age of the igneous rocks so far

obtainable indicates that they are older than middle Cambrian, and, since granites form only at considerable depths or under great pressure, the inference is that they are much older than middle Cambrian.

* * *

## SEDIMENTARY ROCKS

In the Wichita region and the Arbuckle Mountain region the formations below the "Red Beds" agree in all essentials, both in lithologic characters and in age, in so far as they are exposed, and are of essentially the same thickness. Therefore, the classification and the formation names employed for the Arbuckle region are used also for the Wichita Mountains.

### CAMBRIAN ROCKS

**Reagan Sandstone.**—The Reagan sandstone is the lowest Cambrian formation in the Wichita region, and it rests on the eroded uneven surface of the granite-porphyry, from which most of its materials have been derived. The formation is known to outcrop in this region in but four areas. The largest of these lies on the northeastern side of the large mass of porphyry east of Blue Creek Canyon and is beneath the thick section of the Cambro-Ordovician limestone, which follows in regular stratigraphic succession. The other three areas are near the northwestern end of the group of limestone hills, 8 to 12 miles northwest of and in the strike of the large area near Blue Creek Canyon. The same granite-porphyry either is exposed near by or is in contact beneath the Reagan sandstone and the Cambro-Ordovician limestone. Between the smaller outcrops of the Reagan sandstone, as well as in many other places where the succeeding limestone indicates that it should occur, the Reagan sandstone is concealed by the wide-spread "Red Beds" deposits. In all the occurrences cited the Reagan sandstone dips in a northeasterly direction and is so aligned in strike as to show, without doubt, that it is continuous beneath the "Red Beds."

In a part of the larger area east of Blue Creek Canyon the Reagan sandstone is repeated in parallel belts by faulting. The fault approaches the stratified rocks in the porphyry from beneath the "Red Beds" bearing nearly due northwest. The downthrow is toward the southwest, giving sufficient displacement to bring the whole section of the Reagan sandstone against the belt of porphyry which occurs between the duplicate outcrops of the sandstone. The displacement due to faulting decreases toward the northwest and comes to an end near the northwest corner of sec. 1, T. 4 N., R. 13 W. The normal dip of the rocks is toward the northeast, varying from a few degrees to about 25°. Next to the fault on the southwest or downthrown side there is a reverse dip, due to the upward flexing of the strata in the faulting, which is sufficient to produce a narrow synclinal fold a mile or more in length, ending in a spoon-like form, with porphyry upon each side and beneath. The Reagan sandstone is softer than either the porphyry beneath it or the succeeding Arbuckle limestone. In consequence it forms the base and northeast side of valleys, and forms bluffs and steep slopes in which the rocks are admirably exposed.

* * * *



The Reagan sandstone is approximately 300 feet thick and is composed of hard and soft sandstone, grit, conglomerate, shales, and siliceous shell limestones. The section of the formation is essentially the same as in the western end of the Arbuckle Mountains. In each case porphyry is beneath it, and the limestone which overlies the Reagan is of the same nature and contains the same fossil fauna. In both localities the Reagan formation is made up of conglomerate composed of porphyry pebbles and included basic rocks, gritty light-brown to gray and greenish sandstones, greenish clay shales, and siliceous limestones, interstratified. The limy layers contain many species of Cambrian fossils, which were carefully collected, but which have not yet been thoroughly studied. The conglomerate occurs invariably near the base as local beds or lentils, while the calcareous sandstone and limestone beds are without exception in the upper part of the formation.

* * * *

### CAMBRO-ORDOVICIAN ROCKS

**Arbuckle limestone.**—Above the Reagan formation in conformable succession is a great limestone section essentially the same as the Arbuckle formation in the Arbuckle Mountains, where the lower part, practically the lower third, was found to be Cambrian, and the upper two-thirds Ordovician in age. Near the transition zone, between the rocks of the two periods, very few fossils have been found, so that precise distinctions as to age can not be made at the present time. The same conditions of deposition seem to have occurred in the Wichita region as in the Arbuckles, and the rocks must be classified in the same manner. There seems to be no reason to doubt that the formation is continuous from one region to the other beneath "Red Beds" deposits.

With the exception of three small areas near Rainy Mountain Mission (not located in Comanche County), all the limestones found in the area mapped belong to the Arbuckle formation. There are certain thin limy strata in the "Red Beds" which do not resemble the older limestones and have not been mapped. The Arbuckle limestone is composed of practically continuous succession of limestone beds, usually less than 5 feet in thickness and aggregating 4,000 to 6,000 feet. The individual beds vary from dense, fine-grained white limestone to cream-colored dolomitic limestones interstratified with slightly argillaceous and siliceous lime beds, which are usually not so hard. Occasionally cherty limestones, and more rarely thin beds of chert, occur. As a result of the variable hardness of the beds, the more resistant ones have a relief which rarely exceeds 5 or 6 feet. A complete section of the formation is not exposed in the region. The thickest exposure found is northeast of Blue Creek Canyon, where the rocks outcrop in regular succession from the base upward for nearly three miles. The dip is approximately 20° NE., and approximately 4,000 feet of this limestone are exposed. It is estimated that the same thickness is exposed in the long arm of limestone hills outcropping northwestward from Blue Creek Canyon. Neither the top nor the base of the limestone, has been found in the hills west of Blue Creek Canyon. The lowest limestones exposed beneath the "Red Beds" at the southwestern side, however, are near the base and those of the northeastern side are toward the top.

The elongated limestone hills at the northeastern part of T. 5 N., R. 15 W., and in the southwestern portion of T. 6 N., R. 15 W., belong most likely below the middle of the section, as determined by the abundant fossil remains and by the position in the strike of the central part of the section exposed in the large limestone mass toward the southeast. Likewise the limestones occurring at the quarries southeast of Fort Sill, south of Signal Mountain, and farther west at the eastern end of the Quana Mountains, belong below the middle of the Arbuckle formation. The limestone in the hills south of Signal Mountain and farther west yields an abundant fauna of upper Cambrian and lower Ordovician age, closely related to that of the quarries at Fort Sill and of the limestone hills 3 to 6 miles southeast of Rainy Mountain Mission. The Arbuckle limestone north and east of the porphyry in T. 6 N., R. 14 W., is in the lower and middle part of the formation and belongs to the Cambrian and lower Ordovician parts of the section.

### PERMIAN ROCKS

The Permian beds in the county belong to the Hennessey, Garber, Wellington, and Enid of the Oklahoma section or to the Wichita-Albany, Clear Fork, and Double Mountain of the Texas section[3]. A fairly close correlation is that the Hennessey and Garber formations are the equivalent of the Wichita-Albany, the Wellington the equivalent of the Clear Fork, while the Double Mountain is thought to be the equivalent of the Enid[4].

*Wichita-Albany Formation.* Only the upper part of the Wichita-Albany formation is exposed in the county, that area being in the southeastern part. This is the formation shown as the "red sandstone" traversing Stephens County on the areal map of the State[5]. This formation is made up of red clay shales, sandstones, and red mudstone conglomerates and is usually wooded with blackjack oak. This is a tentative correlation by the writer. However, this group of rocks could be basal Clear Fork.

*Clear Fork Formation.* The Clear Fork formation is exposed over all the remainder of the county not covered by the Wichita Mountains and that part of the northeastern part of the county covered by rocks of the Enid or Double Mountain formation. This is the formation shown as "calcareous shale" across Stephens County on the areal map of Oklahoma. The formation consists of red and gray clay shales, and lenticular red and gray sandstones. It is quite conglomeratic between and around the granite peaks of the Wichita Mountains. The Wichita-Albany—Clear Fork contact extends southwest from this county through Tillman County, crossing Red River in T. 5 S., R. 15 W., southwest of the town of Grandfield. The outcrop of this formation is rarely wooded.

3. Gould, Chas. N., The correlation of the Permian of Kansas, Oklahoma, and northern Texas: Bull. Amer. Assoc. Pet. Geol., vol. 10, no. 2, 1926. Index to stratigraphy of Oklahoma: Oklahoma Geol. Survey, Bull. 35, 1925.
4. Aurin, F. L., Officer, H. G., and Gould, Chas. N., The subdivisions of the Enid formation: Bull. Amer. Assoc. Pet. Geol., vol. 10, p. 786, 1926.
5. Miser, Hugh D., Geologic map of Oklahoma: (Scale, 1:500,000) U. S. Geol. Survey, Geologic Atlas of the United States, State of Oklahoma, 1926.



*Enid (Double Mountain) Formation.* Members of the Enid formation are exposed across the northeast corner of the county, all having a northwest-southeast line of outcrop. Named in ascending order, they are; Duncan sandstone, Chickasha formation, Blaine formation, Whitehorse sandstone, and Cloud Chief gypsum. A description of these formations is so well given in other publications that this will not be discussed here. However, it might be of interest to state here that aside from the great lithological difference in these formations they are alternately favorable or unfavorable to the growth of blackjack oak so that they can be traced by means of vegetation alone. Blackjack does not grow on the Duncan sandstone except where the Chickasha formation has eroded down over it in stream re-entrants. However, blackjack grows luxuriantly on the Chickasha formation, is not present on the Blaine, but again appears on the Whitehorse. From Comanche County to the east end of the Anadarko basin the Dog Creek shale is non-existent, the Whitehorse sandstone resting directly upon the topmost gypsum member of the Blaine. This has been verified by core drilling to the east in Stephens County.

### SUBSURFACE ROCKS

The only clue to the nature of the subsurface rocks in the county is from the information obtained from wells drilled in and close to its limits. Many of these wells were drilled before it was the custom to save samples so it is necessary to interpret the logs of these wells by keeping in mind the anticlinal structure of the Wichita Mountain folding with the subsequent truncation that has taken place.

### ORDOVICIAN

*Simpson formation and Viola limestone.* Since the Viola limestone and Simpson formation are exposed near Rainy Mountain Mission just north of the northwest corner of the county, and since the Simpson has been encountered in wells just to the north of this Viola outcrop it is assumed that both the Simpson formation and Viola limestone are present in the northeast corner of the county. The writer has no knowledge of any well having encountered these formations in this county as they are absent over most of this area; while, if they are present in the northeast corner of the county, they are at depths greater than wells have been drilled in that area.

There are probably no post-Ordovician—pre-Pennsylvanian rocks present in the county for this area is thought to be south of the deposition of such sediments.

### PENNSYLVANIAN

*Pre-Pontotoc.* That section of rocks which is the equivalent of the Glenn formation is represented in the county only in the north-

east corner, the east edge, and the southeast corner. Its maximum thickness is unknown for it has not been drilled through in places where it should be the thickest. It overlaps the older formations around the east edge of the Wichita Mountain uplift. In places where it is present it is a formation made up of blue shales, thin limestones, and a few thin sandstones. On the south side of the uplift the section between the base of the Pontotoc and the top of the Arbuckle is probably represented by the lower part of the Pennsylvanian section. On the north side of the uplift the upper part of this section immediately below the Pontotoc may be represented by pre-Pontotoc rocks slightly younger in age.

*Pontotoc.* The Pontotoc formation is present in the eastern part of the county where it encircles the Wichita Mountain uplift, thickening outward from the uplift. As in northern Stephens County[6] its chief characteristic is the large percentage of brown shale in the section, in direct contrast to the brick red shales of the overlying Permian and to the blue shales of the underlying lower Pennsylvanian. Due to the proximity to the source of the material there is a large quantity of coarse, arkosic sands and gravels. In fact much of the brown shale is quite gravelly. From a formation less than a hundred feet in thickness where it abuts the pre-Pennsylvanian rocks in the western part of T. 3 N., R. 11 W., it attains a thickness of about 2,400 feet in sec. 10, T. 3 N., R. 10 W., or in less than ten miles; and a thickness exceeding 3,200 feet in sec. 26, T. 2 N., R. 9 W. In the northeastern corner of Comanche County this formation probably attains a thickness as great, if not greater, than any other place. To the northeast, on the opposite side of the Anadarko basin, a well in sec. 28, T. 11 N., R. 5 W., had 2,250 feet of Pontotoc beneath 1,950 feet of Permian, the combined thickness of the two formations being almost as great as the combined thickness of the two formations in the well mentioned above as having the greatest amount of Pontotoc. The Pontotoc is correlative with upper Cisco of the Texas section and the upper part of the Missouri group of the northern Oklahoma and southern Kansas section.

### PERMIAN

*Wichita-Albany.* The entire Wichita-Albany group including that part exposed on the surface in the southeast corner of the county probably nowhere exceeds 1,000 feet in thickness. In many places, where resting on the lower Paleozoics, it has a thickness of less than half of that amount. The unexposed portion has characteristics in common with those given earlier in this paper in the description of the surface rocks.

6. Gouln, Frank, Geology of Stephens County, Oklahoma: Oklahoma Geol. Survey, Bull. 40-E, 1926.



**Structure**

## STRUCTURE OF THE WICHITA MOUNTAINS

After an interval of over 25 years the words of Taff[7] leave nothing more to be said about the structure of the Wichita Mountains so the writer is quoting them here.

> The Wichita Mountain range, except the group of outlying ridges on the northeastern side and some low detached hills on the southern side, near the eastern end, is composed entirely of igneous rocks. These igneous rocks are separated into more than 250 detached areas, and form mountains and hills which range from closely connected groups of 150 square miles in area to isolated, sharp knobs which rise above the plains like islands. The numerous small igneous mountains and hills in the western half of the range are especially broken and disconnected. All these groups and mountains are surrounded by the nearly horizontal "Red Beds" deposits which extend on all sides of the range for long distances. They conceal the rocks of the Wichita Mountains to such a degree that no adequate conception can be had of the extent of the Wichita uplift. The archipelago-like arrangement of the granite mountains and peaks in the plain leaves one to assume that only a small part of the igneous core of the Wichita uplift is now exposed.

### EVIDENCE OF DISTURBANCE IN THE IGNEOUS ROCKS

> These igneous masses of the Wichita Mountains possess certain general, yet pronounced structural features. The granite has been intruded through the gabbro, in part at least, and spread out in a broad way upon it. Where the erosion of Permian and more recent times has uncovered the gabbro in what is now the generally level plain, the gabbro areas are found to be oriented in a direction approximately N. 60° to 70° W., as would be the case if the gabbro had been arched in the axial part of an uplift. The larger areas of granite, especially in the Wichita and Quana mountain groups, and also a great number of the smaller ones, are found to be oriented in the same general northwest-southeast direction.
>
> In the strike of the principal ridges and lines of peaks and hills there are marked zones of fracture or of major jointing. These lines of jointing are especially pronounced in the western part of the Wichita group, south of Mount Baker. The same structures were also noted near the eastern end of this group, east of Mount Cummins, and in the porphyry of Carlton Mountains. In the western part of the range the major joints are generally nearly vertical, while in the eastern part they are inclined toward the south at an angle of 30° to 40°. This inclined jointing is so marked in the eastern end of the Carlton Mountains, and in the granite east of Mount Cummins, that at a distance it resembles pronounced stratification. Such structures, causing variable weaknesses in the igneous rocks, were emphasized to a marked degree by agents of degradation before the present drainage system was established. Especially pronounced instances are found in the large resurrected Permian valley leading southeastward from Military Pass between the Wichita and

7. Taff, J. A., op. cit, pp. 85-88.

Quana mountain groups. Other instances of less pronounced character occur in the southern part of the Wichitas south of Mount Baker, where the ridges and valleys are oriented in the general strike of the range. These major structural lines would naturally be concealed to a greater extent in the large area of isolated mountains and hills making the western half of the range. Many of these mountains, however, and even some of the smaller ones, show pronounced major joints in zones of crushed rocks bearing in northwesterly directions. Such occur in Elk Mountain and are especially marked in Twin Mountains. Aside from the major jointing, it will be observed by reference to the map that with a few exceptions these igneous mountains and even small hills have their long axes arranged in directions generally northeast and southwest. This is doubtless due to the survival of the more resistant zones of the igneous mass parallel with the lines of weakness. Conspicuous jointing occurs in other directions than northwest and southeast, the most pronounced being north and south, across the trend of range.

## FOLDING AND FAULTING OF THE STRATIFIED ROCKS

In the stratified rocks on the northeastern side and near the eastern end of the range the structures are more pronounced and easily interpreted. These rocks occur in a small part of the Wichita Range, and, as explained above, are probably but a small part of the uplift. The Ordovician limestone, which forms part of the thick Arbuckle formation, occurs upon the northern and southern sides of the Wichita Mountains near the eastern end, showing that this part of the range is anticlinal. On the southern side of the range, south and southwest of Signal Mountain, the remnants of the Arbuckle limestone occur in low hills dipping south and southwest. One-half mile southeast of Fort Sill the same limestones dip toward the southeast. Beginning north of Fort Sill and extending northwestward to Rainy Mountain Mission the whole Cambrian section and a large part of the Ordovician are exposed in a group of straggling, low mountains and hills. Local foldings occur in these limestone hills and there are repetitions in the section due to faulting, but throughout the exposed section of 4,000 to 6,000 feet the general directions of the dip is toward the northeast. This shows, without doubt, that these separated limestone hills are parts of the northern limb of a great anticlinal fold which encompassed at least the eastern part of the Wichita Range. The diverging strikes of the rocks on each side of the eastern end of the range indicate that the uplift became broader and probably more elevated toward the northwest.

The Reagan sandstone, the lowest Cambrian formation in the region, lies upon the porphyry east of Blue Creek Canyon and dips northeast. In the strike of these rocks toward the northwest the same formation occurs in three small areas near the northwestern end of the group of hills, dipping in the same northeastern direction. Below it is the same kind of porphyry as at Blue Creek Canyon, and above it the limestone occurs, dipping in order toward the northeast. Between these small areas, and separating them from the larger limestone mass east of Blue Creek Canyon, the "Red Beds" conceal all the older strata. The regularity of the dip and strike of the Reagan sandstone and succeeding limestones indicates, without much doubt, that they occur and continue without break beneath the "Red Beds" deposits.



**Blue Creek faults.**—In the vicinity of Blue Creek Canyon, about 7 miles north of Mount Scott, there are two lines of pronounced faulting One of these faults follows the canyon and bears nearly N. 20° W., while the other is a mile east of the canyon and strikes N. 40° W. In each case the throw is downward and toward the southwest, and the displacement of the canyon fault is greater than the other. As a result of the displacements due to these faults the prophyry mass has been elevated with respect to the stratified rocks on the northeastern and southwestern sides. The Blue Creek fault extends toward the northwest and separates the limestone and porphyry areas upon the northeast from limestones of the same character and age upon the southwest. Excepting along Blue Creek Canyon the extensive deposits of "Red Beds" conceal the fault contact. The limestones southwest of the prophyry belong to the same formations as those upon the northeast, and in each area the dips are in the same general northeastward direction, exposing the limestone section to a thickness of 4,000 to 5,000 feet.

The lowest rocks exposed on the southwestern side of this group of limestone hills are below the middle of the Arbuckle formation and belong to the upper part of the Cambrian or the lower part of the Ordovician, the Reagan sandstones being here concealed by the "Red Beds," so that there is no positive connection, except as indicated by the structure, between the igneous mass of the Wichitas and the limestones. The structure section accompanying the map of the Wichita Mountains shows the succession of stratified rocks and their relations to the igneous masses.

A glance at Map No. XXIV will show how thoroughly Taff's work was done, for subsequent drilling has borne out his conclusions to a remarkable degree especially his estimate of the size of the uplift.

## STRUCTURE OF THE PENNSYLVANIAN

The structure of the pre-Pontotoc Pennsylvanian is probably quite similar to that of the lower Paleozoics. This is inferred from conditions to the south and east of the county, which should be similar. On the other hand the structure of the Pontotoc formation is known to be quite similar to that of the Permian, except that the Pontotoc folds are more pronounced.

It might be well to call attention here to the fact that the area of the Anadarko basin as shown on the areal map of Oklahoma does not coincide with the true subsurface Anadarko basin in so far as its eastern portion is concerned. The true Anadarko basin in the Pennsylvanian rocks has an axis which roughly includes western McClain northern Grady, southern Canadian, northern Caddo, and southern Blaine counties, and thence northwest through Custer County.

## STRUCTURE OF THE PERMIAN

The surface Permian rocks dip at low angles with the major component toward the north. Below the Duncan sandstone the dip is in-

terrupted in many places by low folds. Over that part of the county covered by the Enid or Double Mountain rocks the dip increases from 50 to 80 feet to the mile in a northeasterly direction without interruption to the Cyril syncline. Strange to say it has not been possible to get any unanimity of opinion as to the direction of dip of the Wichita-Albany and Clear Fork rocks in southern Oklahoma until the last few years. This has been due to two reasons: first, the assumption that all rocks should dip away from the mountain uplifts for a great many miles regardless of the age of the uplift; and second, the fact that the dips are extremely low and are interrupted everywhere by folds. Much of the field work in the past has been done in patches in connection with surface structural mapping. Extensive mapping of units within these formations has revealed the true conditions. In these days of intense competition in the oil business we are prone to go over things too hurriedly. It is refreshing, to say the least, to go back to Taff when he states *"In and near* the Wichita Mountains the 'Red Beds' have local variable but low dips away from the mountains, which were the old Permian land areas. These local structures are considered to be due to deposition of the sediments upon the sloping near-shore sea bottom rather than to post-Permian orogenic movements." (The italics are the writer's).

### Geologic History

The age of the original folding of the Wichita uplift is not definite at this time. We can only state here that it occurred between Ordovician and early Pennsylvanian times. Some argue that it was certainly not later than Ordovician time for there is apparent structural conformity in the Cambrian and Ordovician rocks exposed on the northeast flanks of the Wichita Mountains, yet there have been found no rocks of an age younger than the Arbuckle and older than the Pennsylvanian to date south of this uplift. Pennsylvanian rocks are resting directly upon the Arbuckle limestone in and around the Walters field in T. 1 S., R. 10 W., the Empire field in T. 1 S., R. 8 W., and the Comanche pool in T. 2 S., R. 7 W. Indeed, it is entirely possible that from the Wichita-Criner Hills uplift southwest into Texas there was no deposition of post-Arbuckle—pre-Pennsylvanian sediments. The majority of writers to date favor an early Pennsylvanian age for the original folding[8]. The writer has favored an early

8. Howell, J. V., Some structural factors in the accumulation of oil in southwestern Oklahoma: Econ. Geology, vol. 17, no. 1, pp. 15-33, 1922.
Powers, Sidney, Reflected buried hills and their importance in petroleum geology: Econ. Geology, vol. 17, no. 4, pp. 233-259, 1922.
Powers, Sidney, Crinerville oil field, Carter County, Oklahoma: Bull. Amer. Assoc. Pet. Geol. vol. 11, p. 1072, 1927.
Powers, Sidney, The Seminole uplift, Oklahoma: Bull. Amer. Assoc. Pet. Geol., vol. 11, p. 1105, 1927.
Powers, Sidney, Age of folding of the Wichita, Arbuckle, Ouachita mountains of Oklahoma and Llano Burnet and Marathon uplifts of Texas: Bull., Geol. Soc. of America, vol. 38, 1927.



Mississippian age in previous publications but is inclined now to place it earlier[9]. However, all such views are merely theories at this time.

The next regional uplift occurred in late Pennsylvanian time being part of the general uplift which raised the main Arbuckle Mountains[10]. During most of the intervening period a very small part of the county was low enough for the deposition of sediments which attained such a great thickness in the Ardmore basin. Subsequent to this folding occurred the deposition of the Pontotoc, a formation deposited as the result of rapid erosion. Again only the eastern part of the county was low enough to receive any of these materials. The opening of Permian time was not marked by any movement, the only difference being in the source of the materials deposited. The Permian sea finally covered the southern part of the county and between the scattered peaks of the Wichita Mountains leaving the present exposed mountains as islands. There have been several periods of very gentle uplift since Wichita-Albany time but only enough to fold the more unconsolidated younger beds into gentle flexures. If any of these later uplifts could be called the more intense perhaps the post-Cretaceous can be classed as such but it had little or no effect upon the rocks in this county.

### OIL AND GAS DEVELOPMENT

According to Wegemann[11] the first oil found in Comanche County was in a well dug for water in 1901 to a depth of 60 or 70 feet near what is now the Midland Hotel in Lawton. The water was so tainted with oil that the well was finally abandoned. In 1904 a well dug to a depth of about 90 feet in the southern part of the city produced 3 or 4 barrels of oil a day for several years. The product was sold locally. During the same year the first well was completed in the Lawton field in sec. 6, T. 1 N., R. 10 W. This well had an initial production of about one-half million cubic feet of gas with a pressure of 125 pounds from a sand found at 400 feet in depth. Later in the year a small amount of heavy oil was found in another well drilled in section 1, T. 1 N., R. 11 W. No more wells were drilled until 1906 when several small oil and gas wells were completed in the sands found at 300 to 400 feet. Since that time a small amount of drilling has been done at irregular intervals in the same area resulting in the completion of small wells at depths of 300 to 800 feet.

9. Gouln, Frank, op. cit.
Gouln, Frank, Geology of Beckham County, Oklahoma: Oklahoma Geol. Survey, Bull. 40-M. 1927.
Schuchert, Chas., and Pirsson, L. V., Text-book of geology, Pt. 2, p. 343. 1924.
Plummer, F. B., and Moore, R. C., Stratigraphy of the Pennsylvanian formations of north-central Texas: Univ. of Texas Bull. No. 2132, 1921.
10. Powers, Sidney, op. cit.
11. Wegemann, C. H., and Howell, R. W., The Lawton oil and gas field, Oklahoma: U. S. Geol. Survey, Bull. 621, 1915.

*Tabulation of Deep Tests in and Adjoining Comanche County.*

| LOCATION | COMPANY | Total Depth | Top Arbuckle | REMARKS |
|---|---|---|---|---|
| 32-1S-10W | Garvin Drg. | 4,335 | 3,976 | Determined from samples. |
| 9-1S-12W | Humble | 2,560 | 1,341 | Artesian sulphur water—fresh. |
| 30-1S-13W | Mid-Kansas | 1,920 | 1,373 | Into granite at 1,860—samples. |
| 15-1S-15W | Cosden | 1,960 | 603? | Possibly igneous at bottom. |
| 5-2S-12W | Magnolia | 2,475 | 2,150 | Fresh artesian water in Arbuckle limestone. |
| 23-2S-12W | Mt. State | 3,066 | 3,027? | Base Pontotoc about 1,860—No samples. |
| 5-1N-9W | Sykes, et al | 2,501 | 1,555 | From samples. Top of Arbuckle uncertain. |
| 10-1N-9W | Graham | 2,765 | ? | Had sulphur water. |
| 20-1N-9W | Ramsey | 2,572 | 2,880 | Top of Arbuckle uncertain. |
| 26-1N-9W | Magnolia | 3,250 | 1,700? | No samples—based on log and nearby control. |
| 11-1N-10W | Porter | 2,170 | 1,614? | No samples. |
| 20-1N-10W | Magnolia | 2,500 | 1,757? | Artesian water. Top of Arbuckle—uncertain. |
| 27-1N-10W | Consolidated | 2,112 | 2,180? | No samples. |
| 35-1N-10W | Page, et al | 2,501 | 831 | No samples. |
| 3-1N-11W | Homa-Okla. | 1,340 | 640 | Samples. |
| 32-1N-14W | Booth, et al | 2,000 | None | Base Pontotoc about 4,555. No Arbuckle—sample. |
| 26-2N-9W | Magnolia | 4,555 | 985 | Into granite at 2,050—samples reported. |
| 29-2N-10W | Franklin | 2,570 | 890 | Samples—reported by others. |
| 33-2N-10W | J. C. Keys | 1,249 | 650 | Reported by Wegemann. |
| 21-2N-11W | Comanche Oil | 2,348 | 4,160? | Samples of Arbuckle but exact top uncertain. |
| 10-3N-10W | Magnolia | 4,310 | None? | Samples suggest granite from about 1,920. |
| 33-3N-10W | Mid-Kansas | 2,003 | 850 | Samples reported by others. |
| 34-4N-11W | Emerald Oil | 1,152 | | |

Note: Rocks older than the Arbuckle limestone and younger than the Pennsylvanian have not been identified in the above wells. Several scattered wells between the exposed portion of the Wichita Mountain uplift and the wells listed above have encountered the Arbuckle limestone at depths consistent with the contours on the regional map.



The first oil production of consequence was discovered in the summer of 1920 by the Gladys-Belle Oil Company in sec. 32, T. 2 N., R. 9 W. This well had an initial production of about 100 barrels of 40 gravity oil at a depth of 1,530 feet. The decline in this well and in the three offsets that were drilled was so rapid that further drilling was discouraged, but not before several scattered wells had been drilled in the general area without results. Nothing further in the way of deeper development took place in the county until Harry Hanbury completed a well in sec. 30, T. 2 N., R. 9 W. in August, 1925 which had an initial production of about 400 barrels of 42 gravity oil from a depth of 2,010 feet. The development caused by this producer was northwest of the discovery well. A month or so later a well was completed with an initial production of 20 barrels of 34 gravity oil from a depth of 1,120 feet in sec. 3, T. 3 N., R. 10 W. by the White Eagle Oil Company and the Becker-Reed Oil Company. Aside from later discoveries around the wells previously mentioned there are no other areas producing in the county.

## THE LAWTON OIL AND GAS FIELD

This field has been very well written up by Wegemann[12]. Drilling since the time of his report has been mainly within the limits of the area which was producing at that time. This pool centers around the southwest corner of T. 2 N., R. 10 W., and includes portions of the three adjoining townships. As mapped by Wegemann the producing area appears to be on a terrace of the Clear Fork group.

Production is from sands in the Wichita-Albany group, this group resting directly upon the Arbuckle limestone in this field. A well drilled in the NW.¼ sec. 29, T. 2 N., R. 10 W., to a total depth of 2,570 feet found Arbuckle limestone from a depth of 985 to 2,050 feet and is reported to have had granite from 2,050 feet to 2,570 feet. Another well drilled in the NW.¼ section 33 had Arbuckle limestone from 890 feet to its total depth of 1,249 feet. Incidentally both of these wells were drilled on the dome of the northeast of the terrace as mapped by Wegemann so that it is quite possible that the Arbuckle was found somewhat higher in these two wells than it would be in the area immediately adjacent.

## THE LAWTON-HANBURY POOL

This pool was mentioned by the writer in his report on Stephens County[13]. As previously stated the discovery well was located in sec. 30, T. 2 N., R. 9 W., but since that time production has extended into section 19 of the same township and in secs. 24 and 36, T. 2 N., R. 10 W.

12. Wegemann, C. H., and Howell, R. W., op. cit.
13. Gouin, Frank, op. cit.

The surface rocks in this area belong to the Clear Fork group. There is a section of 1,200 to 1,400 feet of Permian rocks below which is found the Pontotoc group in which the producing sands of this field occur. The Pontotoc rests unconformably upon the Arbuckle limestone probably throughout the extent of the field. The underlying Arbuckle evidently has considerable relief and its topography is quite irregular. A well, in section 24 drilled to a depth of 1,723 feet, encountered what was thought to be Arbuckle at about 1,546 feet. This could have been a coarse conglomerate made up of boulders from the Arbuckle as has been found in some wells drilled on the flanks of the Wichita uplift, but since the coarse material has been found to rest directly upon the Arbuckle, this point is of minor importance only.

The structure of the surface rocks is that of a flat-lying dome with the apex about west of the center of section 19. Production is so scattered that control is not sufficient to map the structure of the producing sands with any degree of satisfaction. It is the belief of many that accumulation is controlled altogether by the pinching out of the sands against the Arbuckle topography. While this may be true in section 24 it is not the case in section 30 where there is enough control to map a structural condition of the sand that governs the accumulation.

Sands in this field are found between 1,800 and 2,100 feet with initial production as high as 400 barrels per day. All the oil is over 40 gravity. The decline, however, has been extremely rapid in most cases. The producing sands in the majority of the wells are very coarse. In two wells where the sands were of finer texture the decline has been much slower.

There are large gaps between production in this field but one can almost figure beforehand, that, if successful in getting a producing well by drilling in these gaps, it is doubtful if the well would pay for itself. Then the chances are more than even that a dry hole will result. An example of this can be seen on the map. The well in the northeast corner of section 36 flowed through ten inch casing from a sand at 1,800 feet. Both the east and northeast offsets to this well were dry. Practically the same thing happened in the NW.¼ of section 19 and the NE.¼ of section 24 only that two more dry holes were drilled than in the first example.

### ELGIN AREA

The well in sec. 3, T. 3 N., R. 10 W., mentioned under "History of Development", after producing a small quantity of oil for a short time at a depth of 1,120 feet was later deepened to a sand found from 1,430 to 1,448 feet, in which it had an initial production of about 20 barrels of oil and a little gas. The sand was an arkose but much finer than the gravels of the Lawton-Hanbury field. Subsequent drilling

*Production Data, Hanbury-Lawton Pool, Eastern Comanche County, Oklahoma.*

Average Daily Production per month (in bbls.)

| COMPANY | FARM | | LOCATION | 1925 Sept. | Oct. | Nov. | Dec. | 1926 Jan. | Feb. | Mch. | Apr. | May | June | July | Aug | Sept. | Oct. | Nov. | Dec. | 1927 Jan. | Feb. | Mch. | Apr. | May | June | July | Aug | Sept. | Oct. | Nov. | Dec. | 1928 Jan. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Magnolia | W. T. Price | 1 | 30-2N.-9W. | 35 | 25 | 20 | 20 | 17 | 15 | 15 | | 15 | 12 | 10 | 10 | 8 | 7 | 7 | 7 | 7 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 5 |
| Magnolia | W. T. Price | 2 | 30-2N.-9W. | | 50 | 50 | 20 | 20 | 15 | 10 | | 10 | 8 | 8 | 8 | 7 | 5 | 5 | 4 | 4 | 4 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 |
| Magnolia | W. T. Price | 4 | 30-2N.-9W. | | | | | 45 | 12 | | | 10 | 10 | 8 | 8 | 7 | 6 | 6 | 6 | 6 | 5 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 3 |
| Magnolia | W. T. Price | 5 | 30-2N.-9W. | | | | | 15 | 10 | 7 | | 5 | 5 | 4 | 4 | 3 | 4 | 4 | 3 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Magnolia | G. E. Hardy | 1 | 30-2N.-9W. | | | | | | 30 | 30 | | 10 | 7 | 5 | 5 | 4 | 4 | 3 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 2 | 2 | 2 | 1½ | 2 | 1½ | |
| Magnolia | School Land | | 36-2N.-10W | | | | | | | 21 | | 14 | 14 | 12 | 10 | 9 | 9 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 5 |

NOTE: Price No. 1 above completed in August, 1925, had an initial production of 400 bbls. the first 24 hours. Compare its average in September.

around the 40 acre tract upon which the well was located resulted in failures. The horizon is probably the upper part of the Pontotoc.

### SCATTERED SHOWINGS

There has hardly been a well drilled in the county to any considerable depth that has not encountered showings of oil or gas, or both. These showings occur in both the shallow sands of the Permian and in the deeper sands of the Pontotoc. In wells drilled with cable tools these showings have amounted to as much as five barrels of oil a day or up to one million cubic feet of gas. The showings encountered by the rotary drilled wells of course have not been measurable. It is also remarkable that many of the sands carrying these showings have been free from water.

### OIL SEEPS

Wegemann[14] mentions the presence of oil seeps and occurrences of asphalt in localities scattered all over that part of the county covered by sedimentary rocks. Some of those he noted are as follows:

T. 1 S., R. 10 W. A light yellow asphaltic sandstone outcrops in the NE.¼ of section 27. This section is now part of the Walters oil and gas field of Cotton County.

T. 2 N., R. 11 W. In section 21 there is a seep of asphalt in broken sand in the SW.¼ NE.¼ of the section. In the NE.¼ of section 24 there is an asphaltic sandstone. There is also an oil seep in the northeast corner of this section.

T. 2 N., R. 12 W. There is an occurrence of asphaltic sandstone in the southeast corner of section 17. In the SW.¼ NW.¼ section 21 and in the NW.¼ NE.¼ of section 34 there are occurrences of asphalt bearing sandstone.

T. 2 N., R. 13 W. Asphalt noted in a sandstone bed that outcrops along a creek in the SE.¼ of section 36.

T. 3 N., R. 11 W. In the SE.¼ of section 9 in three small southward-opening draws that drain the S.½ of section 10 seepages of asphalt or asphaltic oil occur at about the same elevation, as if derived from one bed.

T. 3 N., R. 12 W. In the NE.¼ of section 29 there is an oil seep from an arkosic conglomerate which is close to the igneous mass of the mountains.

T. 4 N., R. 11 W. In the NW.¼ SW.¼ of section 26 there is an outcrop of asphaltic sandstone. Another occurs in SE.¼ NE.¼ of section 32. A water well dug to a depth of 72 feet in the SE.¼ SW.¼ of section 30 is reported to have struck a sand carrying dark oil that yielded four or five barrels per day.

Wegemann also reports many showings in wells drilled for water.

14. Wegemann, C. H., and Howell, R. W., op. cit.



### FUTURE POSSIBILITIES

There are possibilities for finding small wells in the shallow Permian sands in all of the county where the Permian outcrops. Judging from the structure of the Lawton field it would probably be necessary to have some sort of structural conditions favorable for accumulation. The area of the county in which the Pontotoc beds are present is quite limited, while the area covered by beds older than the Pontotoc in which producing sands are found in other counties of the state is even more limited. In this connection it will be remembered that the northeastern corner of the county is very low structurally. There is thus left a strip roughly paralleling the outcrop of the Duncan sandstone having the escarpment of that sandstone as its eastern limit with a width of about six miles at the north edge of the county and enlarging to a width of not over eight miles at the east edge of the county. The length of this strip would be about 20 miles. West of this strip there is no Pennsylvanian while east of it the Pennsylvanian is low structurally. Future production within the confines of this strip is dependent upon conditions favorable for accumulation.

While the present production and the future possibilities of Comanche County are anything but favorable when compared to other oil producing counties of the state, yet the writer feels that there is an immense amount of reserve oil that can be obtained by artificial means other than in present day drilling when the day comes that this oil will be needed. It is a known fact that a sand can be saturated with oil and yet will not produce in commercial quantities if the dissolved gas that was once in solution in the oil in that sand has been dissipated. This is true of many sands in Comanche County, so if the day comes that there is a shortage of oil obtained from production methods now used, this county can be depended upon for a reserve supply.

# LOGAN COUNTY

By

Hubert E. Bale

## GENERAL STATEMENT

It is the purpose of this paper to present to the reader very briefly some conditions found in Logan County, Okahoma, and to discuss that county's possibilities for oil and gas production in the future. Logan County has a place among the oil producing counties of the State but to date only a small part of the county has proved productive. It is dangerous to predict what the final result will be, due to poor surface beds and to complicated surface conditions.

It is hoped that this paper may help the reader to form an opinion and encourage closer study of conditions and methods used in this county, for, at present, Logan County contains Oklahoma's deepest oil field and daily presents new problems of drilling and production.

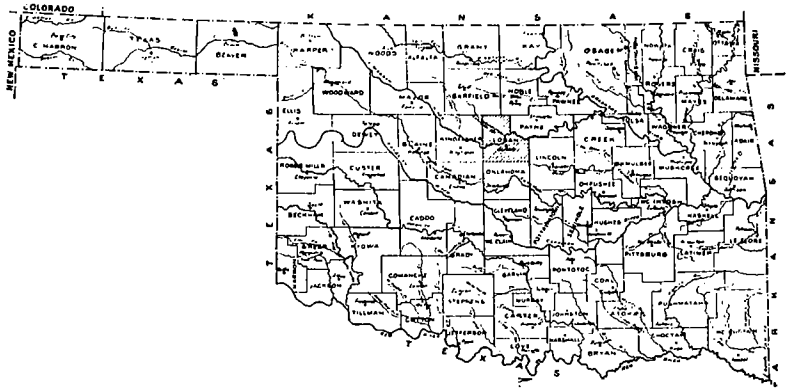


Fig. 31. Index map of Oklahoma showing location of Logan County.

## LOCATION

Logan County is located in the north-central part of Oklahoma. It has for its southern boundary the south line of T. 15 N., and extends north to the Cimarron River in Rs. 1 E., and 1 W., and to the south line of T. 20 N., in Rs. 2, 3, and 4 W., embracing about 755 square miles.

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## ACKNOWLEDGMENTS

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Thanks are also due Clifford W. Byron, David Donoghue, and Dr. A. J. Williams for valuable suggestions and criticisms. Published maps and bulletins of the United States Geological Survey and the Oklahoma Geological Survey were used freely.

## TOPOGRAPHY AND DRAINAGE

The southern and eastern portions of Logan County are regions of sandstone hills which are chiefly features of stream erosion and the northern and western portions are more typically red bed plains.

The Cimarron River and its tributaries drain almost the entire county except the southeastern corner where drainage is to the North Canadian River.

The relief of the county is about 340 feet, the lowest known point being on the Cimarron River just north of the village of Goodnight in sec. 13, T. 17 N., R. 1 E., and the highest known point is about 3 miles northwest of Crescent in T. 17 N., R. 4 W., where the elevation is 1,160 to 1,180 feet above sea level. Topographic maps of central and northern Logan County have never been made, hence the relief of the entire county cannot be accurately given.

## GENERAL GEOLOGY

### Stratigraphy

### SURFACE FORMATIONS

The rocks exposed in the county belong to the Enid group of Permian red beds. (See Map No. XXV.) Along the streams there is much alluvial and wind blown material.

The Enid group has recently been subdivided by Aurin, Officer and Gould[1] into six parts here named in ascending order; the Stillwater formation, the Wellington formation, the Garber sandstone, the Hennessey shale, the Duncan sandstone, and the Chickasha formation.

The four older members outcrop in Logan County forming relatively narrow strips across the county north and south. So far as is known no unconformities occur between the beds exposed in Logan County, except of course, at the base of the recent deposits.

#### STILLWATER FORMATION

The Stillwater formation outcrops only in the extreme eastern portion of the county, being here almost entirely covered by the recent

1. Aurin, F. L., Officer, H. G., and Gould, Chas. N., The subdivision of the Enid formation: Bull. Am. Assoc. Pet. Geol., Vol. X, No. 8, 1926.



sand deposits along the Cimarron River. The Stillwater formation in this region is made up of red shale and reddish gray sandstone.

#### WELLINGTON FORMATION

The Wellington formation, exposed in the eastern one-third of the county, is made up of alternating beds of red shales and sandstones with a combined thickness of about 500 feet. The Wellington formation is correlated with the Wellington shale of Kansas, but its physical characteristics are very different. In Kansas the formation is made up of gray-blue shales and gray "mudstones."

#### GARBER SANDSTONE

The Garber sandstone forms by far the greater part of the exposed rocks in Logan County. The Garber sandstone has been divided by Aurin, Officer and Gould[2] into two members, the Lucien shale and the Hayward sandstone.

*Lucien shale member.* The Lucien shale member is made up chiefly of red shales with several more or less lenticular sands and one rather prominent red sandstone at the base which is also the base of the Garber sandstone. The Lucien shale member is about 250 feet thick.

*Hayward Sandstone.* The Hayward sandstone consists chiefly of red massive sandstone, complexly cross-bedded, and interstratified with shales and sandy shales. Over a wide area the Hayward member is more or less lenticular and loses its massive character northward. The thickness of the Hayward sandstone is about 350 feet.

#### HENNESSEY SHALE

The Hennessey shale is generally easily distinguished from the Garber sandstone below and the Duncan sandstone above because of its typically clay-shale character. These shales are rather blocky and commonly have concoidal fracture. Throughout the Hennessey are numerous bands of white or light green color varying in thickness from a few inches to 4 or 5 feet. There are also many very round, almost white, spots which do not vary from the adjacent material in other properties. The cause of these white spots is, so far as the writer knows, very questionable. They do not seem to occur at any regular interval vertically or horizontally, nor to be of any uniform size, varying from one-half inch or less in diameter to two inches or more. Ross Gahring in "A Study of the Red Bed Concretions" says, in substance, "At the time of the deposition of the shale, small pieces of pyrite and organic material were included which later reduced the iron present and changed its red color to a whitish green. The highly spherical shape of the spots perhaps is due to chemical change radiating from the center in a homogeneous medium."

The Hennessey shale has been divided by Aurin, Officer, and

2. Aurin, F. L., Officer, H. G., and Gould, Chas. N., The subdivision of the Enid formation: Bull. Am. Assoc. Pet. Geol., Vol. X, No. 8, 1926.

Gould[3] into the Fairmont shale and the Bison banded member. Only the Fairmont member is exposed in Logan County.

*Fairmont Shale Member.* The Fairmont shale member is generally composed of deep-red clay shales which break with rather characteristic concoidal fracture and appear quite blocky. There seem to be alternating beds of hard and soft material, and throughout both beds are scattered thin bands of almost white material, generally only a few inches in thickness, thus differing from the thicker white bands in the Bison banded member above. The Fairmont shale member is about 250 feet thick.

### RECENT

Along the streams, chiefly along the Cimarron River, occur rather large deposits of recent alluvial soil and wind blown sand. The wind blown sand has accumulated in dunes 10 to 40 feet high on the north side of the Cimarron River due to prevailing south winds.

## SUBSURFACE STRATIGRAPHY

The lack of deep wells except in the northern part of the county makes a study of the subsurface stratigraphy of necessity very general.

Beds above the Mississippian diverge southward and to a lesser degree also westward. In general the formations become more shaly and interstratified making very precise subsurface mapping quite difficult. Many of the key horizons of areas north and east of Logan County lose their identity and occur in the county as interbedded series rather than clear-cut beds. Another great difficulty is encountered in the large number of unconformities present which makes early predictions on drilling wells quite hazardous.

### ENID GROUP

Above the Neva-Foraker series the beds are here grouped in one series and called the Enid Group. This series is made up of sands, limestones, and shales, and in the upper part is characteristically crimson red in color.

The base of this crimson red color may be used for tentative correlation. It is found at around 1,000 feet in northwest Logan County.

### NEVA-FORAKER LIME SERIES

The Neva-Foraker lime series, with an average thickness of about 150 feet, forms the first good key bed in this region. It is found in Logan County at around 2,000 feet.

### GARBER-ELGIN SAND SERIES

Between the Neva-Foraker limestones and the Oread limestone occur about 1,000 to 1,200 feet of interbedded sands, shales, and limes.

This series is not important from the standpoint of oil and gas production nor does it contain a reliable key bed for mapping.

3. Aurin, F. L., Officer, H. G., and Gould, Chas. N., op. cit.



### OREAD LIMESTONE

The Oread limestone is 80 to 100 feet thick. It is a grayish-white crystalline lime and forms a very good key bed for subsurface mapping.

### ENDICOTT-TONKAWA SAND SERIES

In this report all those beds between the Oread limestone and the Layton sand series are grouped, and called the Endicott-Tonkawa series. The thickness of this series is about 900 feet. It is made up of shales, limes, and sands, similar perhaps to the Layton series in their lenticular character. Several wells in Logan County have found oil and gas production from this series but offset or near-offset wells may not find production at the same stratigraphic level.

Some of the sands in this series are quite salty, so salty that if well cuttings are allowed to dry out large crystals of salt will form in the sands. These very salty sands may not carry any water and are very misleading to the geologist who is examining rotary cuttings, for he may pronounce it a salt water sand when really it is only a salt sand and may be perfectly dry.

The sands in this series are often rather thin, separated by beds of shale. Some of the sands may carry oil and gas and others water. Several cases are known where two thin oil-bearing sands are separated by only a few feet with a water sand in the thin shale interval. The writer has seen cores of sands that show this very plainly.

The character of this series makes production from the Endicott-Tonkawa horizon quite difficult but some oil and some gas is produced. The largest gas well being about 40 million feet in the Sinclair No. 1. Webber in sec. 18, T. 19 N., R. 4 W., and the largest oil well, about 450 barrels, in Sinclair No. 1. Knecht, sec. 28, T. 18 N., R. 4 W. The gas is usually a wet gas and the oil of good gravity—40° to 44° Baume.

### LAYTON SAND SERIES

The Layton sand series is 60 to 200 feet in thickness and is characteristically a series of lenticular sands and shales. This lenticular character of the sands is often responsible for good shows of oil and gas but these shows do not seem to bear any definite relation to subsurface structure, hence are misleading.

### OSWEGO—BIG LIME SERIES

The Oswego-Big lime series averages about 200 feet in thickness. It is one of the important key beds for subsurface mapping and often a part of the series is sandy and has good shows of oil and gas.

### CHEROKEE SHALE

Above the "Mississippi" lime and unconformable to it is the Cherokee shale with an average thickness of about 150 feet. It is characteristically a dark shale and locally has a sand near the middle which is no doubt a near equivalent of the Bartlesville sand known to the east of this area. This sand has not proved an important producing horizon in Logan County but usually shows some oil and gas.

### MISSISSIPPI LIMESTONE

The "Mississippi" limestone is conformable in this area to the Chattanooga shale below. Its thickness varies from 30 to 350 feet dependent upon its position on the underlying structure. The "Mississippi" lime is brown to black in color and often cherty at the top. This horizon, commonly known as chat, produces oil and gas to the north in Garfield and Kay counties.

### CHATTANOOGA SHALE

The Chattanooga shale lies unconformably on the Hunton limestone. In some places the Hunton limestone is absent and the Chattanooga rests upon the Sylvan shale. The Chattanooga shale is rather uniform in thickness and its color is always black. The average thickness is about 75 feet.

### HUNTON LIMESTONE

The Hunton limestone is present in the greater part of Logan County as a white lime of varying thicknesses from 0 to 150 feet. It may or may not be conformable to the Sylvan shale below. The Hunton limestone usually carries shows of oil and gas but so far has not proved an important oil producing horizon in Logan County.

### SYLVAN SHALE

The Sylvan shale, blue-green in color, rests on the Viola limestone and is probably conformable to it. The Sylvan shale is about 100 feet thick.

### VIOLA LIMESTONE

The Viola limestone is present in Logan County as a hard white lime with an average thickness of about 50 feet. It rests unconformably on the Simpson formation below, and may be eroded away on the higher structures. Opinions differ—some geologists think it entirely absent in Roxana Petroleum Corporation No. 1 Cully in sec. 30, T. 19 N., R. 4 W.

### SIMPSON FORMATION

The Simpson formation, made up of limes, shales, dolomites, and sands, is found in Logan County at 5,600 to 6,400 feet. The Wilcox sand, a member of the Simpson formation, is productive where found on favorable structure. So far, Logan County's chief hope to become one of the important oil producing counties of the State lies in the Wilcox sand production in the Lovell-Crescent area.

## STRUCTURE

### SURFACE STRUCTURE

In general, the structural geology of the surface formations in Logan County is monoclinal with a dip of about 40 feet per mile to the northwest.

The geologist meets with extreme difficulty in trying to do surface mapping in the county due to the thickness and the cross-bedded character of the exposed beds. No known unconformities occur between the surface outcrops except at the base of the recent sand and alluvial deposits. So far as the writer knows there are no closed surface structures in the county, but several terraces and noses are known.



### SUBSURFACE STRUCTURE

The subsurface structure of beds above the Hunton limestone is probably in general very similar to the surface structure with perhaps local exceptions which will come to light with more drilling. The writer believes that subsurface beds may show closed structures in some cases where surface beds only show noses and terraces. Below the Hunton lime the beds probably dip south and southwest.

Recent deep drilling in Logan and adjacent counties gives a strong suggestion that the "granite ridge" known in southeastern Kansas and northeastern Oklahoma, or perhaps a similar "high" may show up in Logan County giving it a series of very pronounced "highs" which can be expected to yield some important oil fields.

## DEVELOPMENT

To date more than 60 wells have been drilled or are drilling in Logan County and all except five have reported one or more shows of oil and gas. The first commercial well to be completed in the county was No. 1, Gragg, in NW.¼ NW.¼ SE.¼ sec. 16, T. 18 N., R. 4 W., by T. T. Eason and Wood, Gilbert, and Wood. This well was completed in May, 1927 for about 20 million cubic feet of wet gas. It is producing from the Endicott-Tonkawa series at 3,985-3,994 feet.

### LOVELL-CRESCENT FIELD

The first well to be completed in the Lovell field was No. 1, Cully, SW.¼ NE.¼ SE.¼ sec. 30, T. 19 N., R. 4 W., by the Roxana Petroleum Corporation. This well is producing from the Wilcox sand from 5,901 to 5,989 feet. It came in for about 2,900 barrels of high gravity oil.

The Lovell field structure was located by the Roxana Petroleum Corporation with diamond core drills. The structure mentioned above, sec. 16, T. 18 N., R. 4 W., was located by the Marland Refining Company, also with the core drill. Much core drilling has been done and is being done in Logan County and perhaps in time other favorable structures may be found.

### DRILLING

The cost of drilling deep wells in Logan County at present is $9.00 to $10.00 per foot for actual drilling and with additional costs for casing, fuel, water, etc. A Wilcox sand test would cost more than $100,000.00. Time required for completing one of these deep wells is 5 to 6 months where the rotary method is used most of the way. If the rotary method is used only to the top of the Endicott-Tonkawa series perhaps a little more time would be required to reach the Wilcox sand.

Both methods of drilling have been tried in Logan County and where the rotary method has been used part of the way casing has been set at various points. In some cases a second smaller string of rotary casing has been employed and the rotary method of drilling used to near completion. In all cases the standard tool method has been used for "drilling in."

The writer believes that where the Wilcox sand is the objective that the rotary method is most satisfactory to about 4,700 feet from

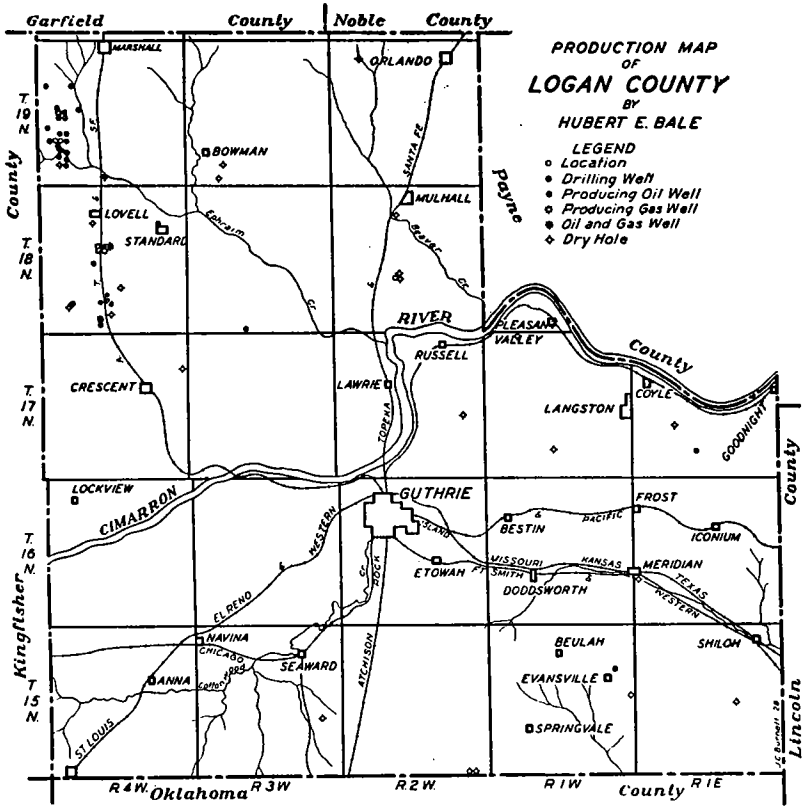



Figure 32.

which depth standard tools would be employed to completion. Time has not proved that present rotary methods are very satisfactory to greater depths than that mentioned above.

The Endicott-Tonkawa series may be tested with standard tools after changing from the rotary method at about 3,900 feet in the northwestern part of the county and even from that depth the standard tool method can be satisfactorily used in drilling to the Wilcox sand.



*Completed Wells, Logan County, Oklahoma*

| COMPANY | FARM | LOCATION | TOTAL DEPTH | ELEVATION | DATE | SHOWS OF OIL & GAS | PRODUCTION | METHOD OF DRILLING | REMARKS |
|---|---|---|---|---|---|---|---|---|---|
| Magnolia Petr. Co. | Prichard | NW NW NW 23-15-1E | 4145 | 1034 | 1925 | None | None | Standard | |
| Empire Gas & Fuel Co. | Vicks | SE SE SE 13-15-1W | 3483 | 1053 | 1917–21 | Gas 1295 Oil 1658-66 | None | Standard | |
| American Drilling Co. | Johnson | SW SW SW 36-15-2W | | | 1920–23 | Gas 1530-65 | None | Standard | |
| Gibraltar Oil & Refining Co. | Johnson | SE SE SW 36-15-2W | 1693 | | | Gas 1623-28 | None | Rotary | |
| Ramsey-Bailey | McMillen | NW NW SW 24-15-3W | 4507 | 1105 | 1926 | None | None | Rotary 3500 Stand. 4507 | |
| ? | ? | NW NW NW 30-16-1E | 2727 | | | Gas 2060-80 Gas 2145-55 Gas 2328-50 | None | Standard | |
| Bailey-Kilgore, et al | Baker | NE NE NW 5-17-1W | 5712 | 945 | 1926 | Oil 4560-70 Oil 5540-60 | None | Rotary 3503 Stand. 5712 | |
| T. B. Slick | Fisher | NW SE SE 20-17-1E | 5335 | 999 | 1927 | | None | Rotary 4157 Stand. 5335 | |
| Roxana Petr. Corp. | Carter | SE SE SE 28-17-1W | 2872 | 976 | 1916–18 | Gas 2090-98 | None | Standard | |
| Roxana Petr. Corp. | Cole | SW SW NW 24-17-2W | 3893 | 1036 | 1920–22 | None | None | Standard | |
| Champlin & Bass | Steimbaugh | SE SE NE 12-17-4W | 3006 | 1080 | 1920–22 | None | None | Standard | |

*Completed Wells, Logan County, Oklahoma, Cont'd.*

| COMPANY | FARM | LOCATION | TOTAL DEPTH | ELEVATION | DATE | SHOWS OF OIL & GAS | PRODUCTION | METHOD OF DRILLING | REMARKS |
|---|---|---|---|---|---|---|---|---|---|
| Ponca Oil & Gas Co. | Wyant | NW NW NE 9-18-2W | 2550 | 935 | 1920–22 | Oil & Gas 1217-19 Gas 1395 | None | Standard | |
| Big Star Oil Co. | Donohue | NW SE SE SE 21-18-2W | 1750 | 998 | 1914–19 | Gas 1350-61 Oil 1600-05 Oil 1640-55 | None | Standard | |
| J. J. Donohue | Donohue | NW NW SE 21-18-2W | 3501 | 1078 | 1925–26 | Oil 1570-75 Oil 1665-75 Oil 1840-50 Gas 2080-85 Gas 2470-2500 Gas 3030-35 Gas 3099-3115 Gas 3440-90 | None | Standard | |
| Bailey-Kilgore, et al | Lovell | SW SW NW 9-18-4W | 4719 | 1011 | 1926–27 | Gas 3135-38 Oil 3997-4006 Oil 4630-50 | None | Rotary 3821 Standard 4719 | |
| Harris & Haun | Hull | NE NE SE 11-18-4W | 6620 | 1004 | 1927–28 | Gas 1734 Oil 3800 Oil 4752-4870 | 80 Barrels 4752-4870 | Rotary 4384 Std. 6620 | Production from Layton sand Series. |
| Marland Refining Co. | Lovell | SW SW NE 16-18-4W | 4005 | 1008 | 1928 | Oil 3969-4005 | 365 Bbls. | Rotary 3969 Std. 4005 | Production from Endicott-Tonkawa sand series |
| W. R. Ramsey | Lovell | SW SE NE 16-18-4W | 4085 | 1013 | 1927–28 | Oil & Gas 3988-4000 | 14 Million Gas, 100 Bbls. Oil | Rotary 3981 Standard 4085 | Production from Endicott-Tonkawa sand series. |
| Roxana Petr. Corp. | McDaniel | NE NE SW 16-18-4W | 4026 | 1016 | 1928 | Oil 3999-4026 | 89 Bbls. | Rotary 3993 Standard 4026 | Production from Endicott-Tonkawa sand series. |
| Mid Continent Petr. | Poston | SE SE NW 16-18-4W | 4032 | 1007 | 1928 | Gas 4010-32 | 9 Million | Rotary 3 6 Standard 4032 | Production from Endicott-Tonkawa sand series. |



*Completed Wells, Logan County, Oklahoma, Cont'd.*

| COMPANY | FARM | LOCATION | TOTAL DEPTH | ELEVATION | DATE | SHOWS OF OIL & GAS | PRODUCTION | METHOD OF DRILLING | REMARKS |
|---|---|---|---|---|---|---|---|---|---|
| T. T. Eason Wood-Gilbert-Wood | Gragg | NW NW SE 16-18-4W | 3994 | 1014 | 1927 | Gas 3060-65 Gas and Oil 3119-28 Gas 3994 | 20 Million Wet Gas | Rotary 3941 Standard 3994 | Production from Endicott-Tonkawa sand series. |
| Texas Pacific Coal & Oil Co. | Rahe | NW NE NW 27-18-4W | 6285 | 1038 | 1927–28 | Oil 4240-46 | None | Rotary 4120 Standard 6285 | |
| Texas Pacific Coal & Oil Co. | Moore | SW NE SE 28-18-4W | 4090 | 1069 | 1925–27 | Gas 3877-89 Oil 4061-65 Oil 4088-90 | 10 Million Gas 3877-89 70 Bbls. Oil 4061-90 | Rotary 3579 Standard 4090 | Production from Endicott-Tonkawa sand series. |
| Sinclair Oil & Gas Co. | Knecht | SW SW NE 28-18-4W | 6325 P. B. 4200 | 1058 | 1927 | Oil 4040-4118; Gas 5407-5570 | 500 Bbls. | Rotary 4776 Standard 6325 | Production from Endicott-Tonkawa sand series after plugging back. |
| Blackwell Oil & Gas Co. | Sade | NE NE SW 28-18-4W | 4944 P. B. 4250 | 1061 | 1927 | Oil & Gas 3851-62. Oil 4201-50 | 100 Bbls. | Rotary 3801 Standard 4944 | Production from Endicott-Tonkawa sand series after plugging back. |
| Healdton Oil & Gas Co., Wood-Gilbert-Wood | Gragg | SW SW SW 29-18-4W | 3988 | 1039 | 1927 | | | Rotary 3988 | Lost hole—Drilling twin well. |
| Prairie Oil & Gas Co. Twin State Oil Co. | Moore | SE NE NE 33-18-4W | 6218 | 1075 | 1927 | Oil 5535 Oil 6037 | None | Rotary 4210 Standard 6218 | |
| W. R. Ramsey | Smith | NE NE SW 33-18-4W | 4747 P. B. 4126 | 1110 | 1927–28 | Oil 4118-26 | 50 Bbls. | Rotary 4107 Standard 4747 | Production from Endicott-Tonkawa sand series. |
| Texas Pacific Coal & Oil Co. | Speaks | SE SE NW 33-18-4W | 4150 | 1114 | 1927 | Oil & Gas 4121-23 Oil & Gas 4133-43 | 10 Million Gas 25 Barrels Oil | Rotary 4150 | Production from Endicott-Tonkawa sand series. |
| Berry Petr. Co. | Myier | SE NW SW 5-19-2W | 3408 | | 1925 | Gas 2833-43 | None | Standard | |

*Completed Wells, Logan County, Oklahoma, Cont'd.*

| COMPANY | FARM | LOCATION | TOTAL DEPTH | ELEVATION | DATE | SHOWS OF OIL & GAS | PRODUCTION | METHOD OF DRILLING | REMARKS |
|---|---|---|---|---|---|---|---|---|---|
| Buford & Brimm | Newman | NW NW NE 32-19-3W | 3007 | 1043 | 1925 | Gas 1270-76 Gas 1295-1300 Oil 1780-1807 Oil 2340-45 Oil 2450-55 | None | Standard | |
| Carter Oil Co. | Rodgers | SW NE SW 32-19-3W | 6205 | 1025 | 1926-27 | Oil 5310-22 | None | Standard | |
| Roxana Petr. Corp. | Freelove | SW SW SW 17-19-4W | 6103 | 1035 | 1927–28 | Oil 6082-6103 | 2550 Bbls. | Rotary 5817 Standard 6103 | Production from Wilcox sand. |
| Sinclair Oil & Gas Co. | Webber | SE SE SE 18-19-4W | 4809 | 1035 | 1927–28 | Gas 3984-96 | 50 Million | Rotary 4809 | Production from Endicott-Tonkawa sand series about 4000 feet. |
| Roxana Petr. Corp. | Ross | NW NW NW 29-19-4W | 6050 | 985 | 1927–28 | Oil 4650-97 Oil 5838-6054 | 724 Bbls. | Rotary 5818 Standard 6050 | Production from Simpson formation (Wilcox sand productive.) |
| Roxana Petr. Corp. | Stevens | SW SW SW 29-19-4W | 6113 P. B. 6090 | 990 | 1927–28 | Oil 6025-91 | 100 Bbls. | Rotary 5802 Standard 6113 | Production from Simpson formation (Water in Wilcox Sand.) |
| Roxana Petr. Corp. | Cully | SW NE SE 30-19-4W | 5989 | 994 | 1927 | Gas 3601-25 Oil 3954-65 Gas 4695-4723 Oil 5310-22 Oil 5825-5989 | 2900 Bbls. | Rotary 4355 Standard 5989 | Production from Simpson-Wilcox Formation (Wilcox sand Productive.) |
| Roxana Petr. Corp. | Sebranek | SE SE NE 30-19-4W | 5221 | 965 | 1927-28 | Oil 3921-27 | None | Rotary 5221 | Lost hole—drilling twin well. |



*Completed Wells, Logan County, Oklahoma, Cont'd.*

| COMPANY | FARM | LOCATION | TOTAL DEPTH | ELEVATION | DATE | SHOWS OF OIL & GAS | PRODUCTION | METHOD OF DRILLING | REMARKS |
|---|---|---|---|---|---|---|---|---|---|
| Wentz Oil Corp. | Williams | NE NE NE 31-19-4W | 6280 | 995 | 1927–28 | ? | None | Rotary 4396 Standard 6280 | H. F. W. Wilcox sand. |
| Roxana Petr. Corp. | Williams | NW NW NW 32-19-4W | 6178 | 1001 | 1927–28 | Oil 6000-6178 | 305 Bbls. | Rotary 5917 Standard 6178 | Simpson-Wilcox Productive. |
| Bryan-Emery | Scott | C NW SE 33-19-4W | 4504 | 995 | 1927–28 | Oil about 4000 | | Rotary | Lost hole. |

*Drilling Wells, Logan County, Oklahoma*

| COMPANY | FARM | LOCATION | PRESENT DEPTH | METHOD OF DRILLING | REMARKS |
|---|---|---|---|---|---|
| Bu-Vi-Bar Co. | Fitzpatrick | C SW 12-15-1W | 5620 | Rotary 3492 Standard 5620 | |
| T. B. Slick | Woods | SW SW SE 28-17-1E | 5730 | Standard | Show oil 4535-50<br>Show oil 4660-70<br>Show gas 4830-50 |
| Tippett & Bond | Donohue | SW NW SE 21-18-2W | Location | | |
| Roland Oil Co. | Quier | SE SE SW 33-18-3W | 3912 | Rotary | Gas 3604-07 |
| Galt-Brown Co.-Wirt Franklin Co. | Knecht | NW NW NW 21-18-4W | 5085 | Rotary | 4 Million Gas 4029-33 |
| Blackwell Oil & Gas Co. | Moore | NW NW SE 28-18-4W | 4005 | Rotary 4005, R. U. S. T. | |
| Healdton Oil & Gas Co. | Gragg | SW SW SW 29-18-4W | 4120 | Rotary | Twin well. |
| Olean Petr. Co. | Shephard | SE SE SW 7-19-4W | 4125 | Rotary | Shut down. |
| Champlin Refining Co. | Clark | SE SE SW8-19-4W | 5837 | Rotary—Standard and back to Rotary. | |
| Sinclair Oil & Gas Co., Margay Oil Co. | Murphy | SW SW SE 17-19-4W | 3480 | Rotary | |
| Sinclair Oil & Gas Co. | Webber | SE SE SE 18-19-4W | 4680 | Rotary | Twin to gas well. |
| Barnsdall Refining Co. | DeJarnett | NE NE SW 19-19-4W | 4450 | Rotary | |
| Roxana Petr. Corp. | Ross | SE SE SE 19-19-4W | 5456 | Rotary | |
| Roxana Petr. Corp. | Rouse | NE NE NE 19-19-4W | 4730 | Rotary | |
| Twin State Oil Co., J. E. Crosbie | Shaffer | NW NW NW 20-19-4W | 5058 | Rotary—Standard and back to Rotary. | |
| Roxana Petr. Corp. | Rouse | SW SW SW 20-19-4W | 5841 | Rotary 5841 R. U. S. T. | |
| Roxana Petr. Corp. | Stevens | NW NW SW 29-19-4W | 4640 | Rotary | |
| Roxana Petr. Corp. | Sebranek | SE SE NE 30-19-4W | 4230 | Rotary | Twin well. |
| Roxana Petr. Corp. | Sebranek | NE NE NE 30-19-4W | 4735 | Rotary 4710, Standard 4735 | |
| Roxana Petr. Corp. | Sebranek | NE NE NE 30-19-4W | Location | Rotary | |
| Roxana Petr. Corp. | Sebranek | NW NW NE 30-19-4W | 3935 | Rotary | Shut down. |

# CARTER COUNTY

By
C. W. Tomlinson

## ACKNOWLEDGMENTS

Mr. C. L. Cooper and Dr. Charles N. Gould of the Oklahoma Geological Survey have furnished valuable assistance and advice in the preparation of this paper. The geologists of the county, and the producers and purchasers of oil and gas have collaborated willingly in completing the maps and production records. The production statistics compiled by the Krohn Oil Review of Ardmore have been very useful. Free use has been made of all previous publications relative to the geology of this part of Oklahoma. Particular thanks are due the following men for reports on the major fields of the county: Mr. A. M. Meyer, Sholom Alechem; Mr. Geo. E. Burton, Hewitt; Mr. John R. Bunn, Fox; and Messrs. Sam H. Woods and J. P. McKee, Graham.

## PHYSIOGRAPHY

The highest point in Carter County lies in sec. 36, T. 1 S., R. 2 W., in the western end of the Arbuckle Mountains, and has an elevation of about 1,330 feet. The elevation of the lowest point, on the Washita River at the east line of the county, is approximately 630 feet above sea level, giving the county a total relief of 700 feet. The topography varies from rugged hill country to rolling uplands, with small stretches of flat bottom lands along the major streams. The northern part of the county drains into Washita River, mostly through Caddo Creek. The southern portion drains into Red River, principally through Walnut Bayou and Big Hickory Creek.

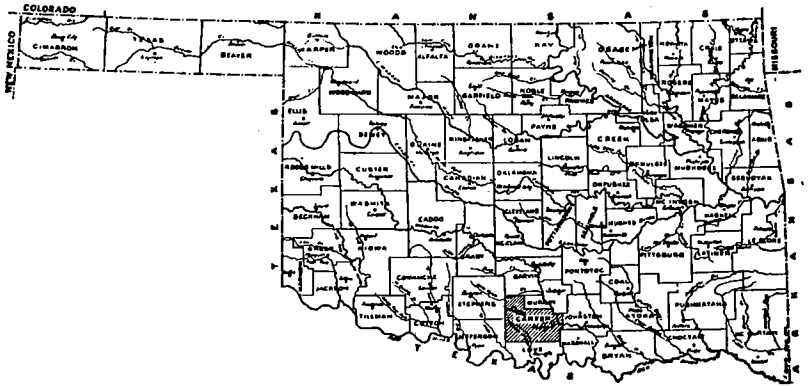



Figure 33. Index map of Oklahoma showing location of Carter County.

(This report originally issued as Bulletin 40-Z, September, 1928.)

The sandier portions of the county were originally, and still are for the most part, covered with low oak forest. These include the greater part of the areas occupied by the Trinity sand, the red beds above the Pontotoc series, the Deese formation, and the sandy members of the other Pennsylvanian formations. Clayey and limy soils provide smaller areas of open grassland, particularly on the lower red beds (Pontotoc series), the Caney shale, the Sycamore, Viola, and Arbuckle limestones, and the shale and limestone members of the Pennsylvanian formations above the Caney. In the area of Pennsylvanian rocks, ridges covered with blackjack timber commonly alternate with strips of prairie in the narrow intervening valleys, creating stripes of vegetation running parallel to the strike of the underlying rocks and therefore stretching as a rule from northwest to southeast across country.

Relatively simple dendritic drainage forms occupy the areas of gently-dipping rocks, including the Cretaceous system and the late Pennsylvanian red beds. The older rocks have been so steeply folded that minor drainage lines have adjusted themselves to structure in many places in the eastern part of the county, creating typical trellised drainage. However, the major streams in the areas of marine Pennsylvanian and older rocks appear to have been superimposed upon the Pennsylvanian mountain structures, and have been strong enough to maintain their former courses across the resistant ridges which now occur in this area. Examples are the course of Washita River through its gorge at the south edge of the Arbuckle Mountains on the north line of the county, and the course of Hickory Creek through the Criner Hills in secs. 26 and 35, T. 5 S., R. 1 E., near the south line of the county. The Washita River above the gorge in Murray County, however, is mainly in a synclinal position, and follows the course of least resistance through the Arbuckle Mountains.

It is probable that the courses of these major streams were acquired when this county was entirely covered by a mantle of Cretaceous or possibly Tertiary sediments lying unconformably above the folded Paleozoic rocks. The surface of the county in late Tertiary or Quaternary time was probably a plain sloping gently southeastward, part of the Great Plains which then stretched more smoothly and more nearly continuously than now from the Rocky Mountains to the Gulf of Mexico. It is not likely that within the limits of Carter County there were any monadnocks rising above the general level of this gently-sloping surface.

The present erosion surface on the Hoxbar and older formations in Carter County probably differs only slightly from the erosion surface which was created here immediately following the later Pennsylvanian mountain building in this region. That surface was buried beneath the red beds, and in part at least has only been re-exposed in relatively recent times. A part of it was probably exposed to erosion just prior to Trinity time, but this Jurassic erosion cannot have cut very deeply below the old late-Pennsylvanian peneplain.



## STRATIGRAPHY

### PRE-CAMBRIAN ROCKS

No pre-Cambrian rocks outcrop or have been reached by the drill in Carter County. Two miles north of the County line in Murray County, however, is a mass of the pre-Cambrian Colbert porphyry, rising in the East Timbered Hills to the highest point in the Arbuckle Mountains, above 1,400 feet in altitude. This "consists largely of pink feldspar phenocrysts in a reddish to gray groundmass, cut by numerous diabase dikes."[1]

Five and one-half miles east of the northeast corner of Carter County is the western edge of a much larger area of pre-Cambrian rock, the Tishomingo granite. This is uniformly coarse-grained, more typically plutonic than the Colbert porphyry with its dense groundmass, and probably formed at greater depth than the latter. It is described by Gould as "largely a coarse-grained, pinkish granite associated with quartz-monzonite, aplite, and granite porphyry, cut with dikes of various basic materials."[2]

The exposed area of the Tishomingo granite is some 30 miles long by 10 miles wide, and its extent beneath the Cretaceous sediments of the Gulf Coastal Plain may be much greater. These dimensions suggest that it is of batholithic origin. No remnant is now exposed of the original overlying rocks into which this igneous mass was intruded, as the roof was wholly eroded away in this area prior to the deposition of the Reagan sandstone in upper Cambrian time.

The lack of metamorphism in the Tishomingo granite and the Colbert porphyry suggests that they are not older than Algonkian. They may be as recent as Keweenawan or even Cambrian.

Ten to 15 miles southwest of the southwest corner of Carter County, certain wells[3] in the vicinity of the Oscar and Nocona oil pools have penetrated granite at depths less than 2,000 feet.

This appears to form part of a group of buried mountain ranges extending southeastward from the Wichita Mountains as far as Denton and Grayson counties, Texas. They probably form part of the same mountain system with the Criner Hills and the buried hills beneath the Healdton, Hewitt, and Brock (Crinerville) oil pools in Carter County. This system was formed early in the Pennsylvanian period.

In spite of these occurrences of granitic rocks at or near the surface both north and south of Carter County, it is believed that the surface of the granite is at least 5 miles deep in the Ardmore syncline

1. Gould, Charles N., Index to the Stratigraphy of Oklahoma. Oklahoma Geol. Survey, Bull. 35, p. 11, 1925.
2. Loc. cit.
3. E. g., Humble Oil & Ref. Co.'s well No. 1 Alexander, NW.¼ NE.¼ NE.¼ sec. 19, T. 7 S., R. 5 W., which logged pink granite from 1,924 feet to total depth of 1,980 feet.

and three miles deep even beneath the anticlinal oil fields in northern Carter County—the Graham, Fox, and Sholom Alechem pools. No production of oil or gas is to be expected from these granitic rocks.

### REAGAN SANDSTONE

This formation, of upper Cambrian age, does not outcrop in Carter County, and has not been reached in any well; but the Reagan overlies the Colbert porphyry two miles north of the north line of the county, and forms the base of the sedimentary sequence overlying the Tishomingo granite east of Carter County, so that it probably underlies the entire county. It averages about 300 feet thick in the Tishomingo district, and grades from very coarse arkosic sandstone at the base to relatively fine-grained shaly calcareous sandstone near the top.[4] The Reagan sandstone would make an excellent reservoir rock for the accumulation of petroleum, but no bituminous shale or other promising source rocks from which oil might be derived occur in normal contact with it, and it is older than any sand at present yielding commercial petroleum anywhere in the world. No production is therefore to be expected from this sandstone.

### ARBUCKLE LIMESTONE

This great Cambro-Ordovician mass of limestone and dolomite has a measured thickness exceeding 7,800 feet[6] along U. S. Highway No. 77 near the north line of the county, although only the upper part of it is exposed south of the line. It occupies most of the upland area in each of the major anticlines of the Arbuckle Mountains. The upper part appears also in the Criner Hills.

The Arbuckle limestone has been identified tentatively in logs of wells in the Healdton oil field, and may occur beneath the Brock field also. A sandy phase near the top of the formation is tentatively correlated with the Turkey Mountain oil sand of northern Oklahoma, but no production of oil or gas has been obtained from the Arbuckle limestone in southern Oklahoma.

### SIMPSON FORMATION

The Ordovician is made up of "sandstones and thin limestones with interbedded greenish clay shales and marls", which average about 1,500 feet in total thickness.[6] This formation occupies a valley belt encircling the main plateau formed by the Arbuckle limestone in the Arbuckle Mountains. It occurs also in the Criner Hills, and has been found in wells in the Brock and Healdton fields, and possibly at Hewitt also.

A little high grade oil has been produced in the Healdton field from sandy limestones assigned to this formation. The Simpson contains

4. Cf. J. A. Taff, Tishomingo Folio. U. S. Geological Survey, Geol. Atlas of the U. S., Folio No. 98, 1903.
5. Decker, Charles E., and Merritt, Clifford A., Physical Characteristics of the Arbuckle Limestone: Oklahoma Geol. Survey, Circular No. 15, pp. 15 and 37, 1928.
6. Gould, Chas. N., op. cit., p. 14.



thick porous sandstones, tentatively correlated with the Wilcox and Burgen sands, and these sands probably underlie most of the county; but they have not yet been found in any well. It is reasonable to expect that valuable production will be obtained in Carter County from these sands. They probably occur at least two miles deep, however, in the oil fields of the northern part of the county.

### VIOLA LIMESTONE

This Ordovician limestone has a thickness of 500 to 750 or more feet[7] in the Arbuckle Mountains and the Criner Hills. Gould describes it as "thin to heavy-bedded massive, homogeneous limestone," which "is typically exposed as a series of bare, rounded limestone knobs, lying outside of the eroded Simpson Valley."[7] It has been reported in wells in the Brock (?), Hewitt, and Healdton oil fields, but has yielded no oil in this county. A few wells in the Hewitt and Brock fields have yielded large but short-lived production from what appears to be the surface of unconformity between Ordovician and Pennsylvanian rocks —possibly from a basal conglomerate of the soil and subsoil material formed on the Ordovician rocks in Pennsylvanian time.

### SYLVAN SHALE

"A greenish shale, weathering typically into long, narrow valleys, usually wooded; thickness averaging 150 feet."[8] This shale occurs in the Arbuckle Mountains and Criner Hills, but is rarely exposed. It has been tentatively identified in one well in the Hewitt field, but yields no oil or gas.

### HUNTON FORMATION

The Hunton formation is sub-divided paleontologically into four thin formations, to-wit: (in order from the lowest upward): Chimney-hill limestone and Henryhouse shale (Silurian), Haragan shale and Bois d'Arc limestone (Devonian); with a total thickness of 150 to 300 feet.[9] The limestones outcrop usually in low, bare stony ridges, and the shales in grassy valleys. Both shales include very limy members, and a dense limestone or marl in the Haragan contains some of the most generously fossiliferous strata in the county. At least the lower three of these "Hunton" formations outcrop in the southern edge of the Arbuckle Mountains and at Rock Crossing in the Criner Hills, and the uppermost Hunton limestone at these localities is commonly identified with the Bois d'Arc.

This formation yields oil in important quantities in Seminole and adioining counties of Oklahoma, but not, as yet, in Carter County. It has not been positively identified in any wells in the county.

7. Op. cit., p. 15.
8. Op. cit., p. 16.
9. Op. cit., p. 17.

### WOODFORD CHERT

Thin-bedded black or banded chert and siliceous black shale, with a considerable thickness of highly bituminous black shale, of a type elsewhere regarded as a possible future direct source of oil obtainable from it by distillation. The maximum thickness is about 425 feet.[10] It is probably an important original source of oil now found in sandstone or limestone members of other formations. The age is Mississippian or upper Devonian and it outcrops in the south edge of the Arbuckle Mountains, and at the southeast and northeast edges of the Criner Hills. It has been found in one well in the Hewitt field.

### SYCAMORE LIMESTONE

"Rather hard blue limestone, weathering yellow."[11] It forms the southernmost ridge of the Arbuckle Mountains where its thickness ranges up to 400 feet or more,[12] and outcrops also in the Criner Hills. It is the "Mississippi Lime" of southern Oklahoma, and is not certainly identified in any wells in Carter County.

### CANEY SHALE

As the term is here employed, the Caney shale includes approximately 2,000 feet of black bituminous shales immediately overlying the Sycamore limestone. The top of the formation is drawn at the base of the Rod Club sandstone member of the Springer formation. This usage corresponds as nearly as can be determined to that of Taff, who first employed the name Caney in this district,[12] although Miser's recent geologic map of Oklahoma[13] included the entire Springer formation as part of the Caney.[14]

As above restricted, the Caney consists exclusively of black bituminous fissile shales, varied only by ferruginous, calcareous, and phosphatic concretions. Fossils have never been found in it except in the basal 200 to 500 feet of the formation, where they are fairly numerous and are generally regarded as indicating late Mississippian age. The Caney occupies a fertile lowland belt of cultivated fields and grassy pastures at the south foot of the Arbuckle Mountains, and a similar strip 8 miles long by ½ mile wide in the axis of the Caddo anticline in Tps. 3 and 4 S., R. 1 E. It is believed to have been found in one or two wells in the Hewitt field, and in wells on the Preston and Mannsville-Madill anticlines in Marshall County. A well[15] drilled on the Caddo anticline in 1927,

10. Cooper C. L., personal communication.
11. Gould, op. cit., pp. 22-23.
12. Taff, J. A., Tishomingo Folio. U. S. Geological Survey, Geol. Atlas of the U. S., Folio 98, 1903.
13. Miser, H. D., Geologic map of Oklahoma: U. S. Geol. Survey and Oklahoma Geol. Survey, 1927.
14. For further discussion of the Caney correlation as affecting Carter County see: C. W. Tomlinson, The Pennsylvanian System in the Ardmore Basin, Oklahoma Geol. Survey, Bull. 46, 1928.
15. L. E. Trout's well No. 1 Noble, center SE.¼ NW.¼ sec. 22, T. 3 S., R. 1 E.



starting several hundred feet below the top of the Caney shale, penetrated 3,500 feet into that formation without reaching even the distinctive basal portion of it. Due to the very steep dips on this anticline, which is practically a hairpin fold, it is probable that this well actually cut less than 1,000 feet of beds in drilling 3,500 feet.

Like the Woodford, the Caney shale is probably an important orginal source for oil, though wholly lacking in reservoir rocks.

### SPRINGER FORMATION[16]

This formation, 3,000 feet or more in thickness, consists in the main of barren black shales like the restricted Caney shale below it, with hard ferruginous and calcareous concretions. However, the Springer contains several persistent sandstone members which afford important prospects for future oil production in Carter County.

At the base of the Springer formation is the Rod Club member, a sandy zone 250-400 feet thick containing several sandstones ranging up to 25 feet in maximum individual thickness. About 1,000 feet above the Rod Club is the white, massive Overbrook sandstone, ranging from 45 to 100 feet thick which is thoroughly saturated with asphalt along several miles of its outcrop in T. 3 S., R. 1 W., where it possesses its maximum thickness and was formerly quarried for asphalt. Three hundred to 500 feet higher in the section is the Lake Ardmore member, a persistent sandstone 15 to 20 feet thick and very similar to the Overbrook. From 100 to 300 feet above the Lake Ardmore sandstone is the Primrose member, a zone of shaly to thin-bedded semi-crystalline calcareous sandstone 150 to 250 feet thick, locally carrying one to two feet of impure unfossiliferous limestone.

Except for the shales above the Primrose member and a single locality in the Overbrook (?) sandstone, the Springer formation has so far proved almost wholly barren of fossils. Its age is probably earliest Pennsylvanian.

The Caney shale and the Springer formation together contain over 4,000 feet of bituminous shales. These formations may have been the chief source for the oil which has accumulated in younger Pennsylvanian beds in this region. Unlike the Caney and Woodford formations, the Springer contains excellent reservoir rocks. Although its sandstone members probably are not now yielding oil in Carter County they are believed to underlie the Graham, Fox, and Sholom Alechem fields at depths of a mile or more, and may be expected to yield oil at lesser depths in the Overbrook anticline. The Springer formation is not present in the Brock, Hewitt, or Healdton fields, where it is cut out by unconformity.

16. For more detailed description of this and other Pennsylvanian formations see: Tomlinson, op. cit. (cf. footnote 14).

### DORNICK HILLS FORMATION[16]

Immediately above the Springer occurs the Dornick Hills formation, consisting of bluish and tan shales interrupted by limestones and sandstones, with conspicuous limestone conglomerates south of Ardmore. The pebbles of the conglomerates consist chiefly of pre-Pennsylvanian limestones and chert such as now outcrop in the Criner Hills. At the base of the formation is the Jolliff member, a tan fossiliferous limestone from 4 to 15 feet thick, locally associated with a little conglomerate. The next resistant member, the Otterville limestone, is a ledge of ferruginous, oolitic, and locally conglomeratic limestone about 25 feet thick.

The most resistant part of this formation is a massive limestone conglomerate with associated limestones and sandstones, known as the Bostwick member. It disappears northward from Ardmore. Above the Bostwick member occur three or more very fossiliferous limestones including the coarsely crystalline and oolitic Lester limestone. At the top of the formation is the Pumpkin Creek limestone, which has a maximum exposed thickness of 70 feet, including 20 feet of shaly beds.

The Dornick Hills formation shows a greater change of thickness than any of the other Pennsylvanian formations in this area. It is about 4,000 feet thick near the north edge of Love County, thinning to 2,500 feet near Ardmore and to less than 1,500 feet near the village of Glenn, where the conglomerates are absent. The Dornick Hills formation is believed to be at least partially equivalent to the Bend group of Texas.

The productive oil sands in the Graham, Fox, and Sholom Alechem fields belong, in part at least, to the Dornick Hills formation, and this may possibly be true of Hewitt also. The formation does not occur, however, in the Healdton or Brock fields, where it is cut out by unconformity.

### DEESE FORMATION[16]

The Deese formation is about 7,000 feet thick in Love County, diminishing to about 5,000 feet northwest of Ardmore. It is characterized by a succession of sandstone beds and chert conglomerates, separated by blue and tan shales with a few limestone members which diminish or disappear to the southeast. The Deese is believed to be at least partially equivalent to the Strawn group of Texas, and to the Wewoka and subjacent formations of northeastern Oklahoma, down at least to the Boggy and possibly to the Atoka.

About 800 feet above the Pumpkin Creek limestone occurs the Devil's Kitchen member, some 500 feet thick, comprising two massive buff sandstones each from 60 to 200 feet thick, separated by a shale interval with 10 feet or more of fossiliferous impure limestone and calcareous shale. The upper sandstone contains chert grains, and develops southeast from Ardmore into a coarse conglomerate of angular to subangular chert pebbles.



Above the Devil's Kitchen member is a series of blue and tan shales with numerous sandstone ledges, two or three of which carry abundant chert pebbles in some localities. The Arnold member north of Ardmore, near the middle of the formation, includes also a fossiliferous limestone up to 50 feet thick. Much thinner limestone beds occur at several other horizons in the Deese formation north of Ardmore, but have not been noted to the south.

Sandstone members of the Deese are extensively saturated with asphalt, and have been quarried for their asphalt content, on both flanks of the Overbrook anticline and on the southwest flank of the Caddo anticline. The Deese formation occurs at least on the flanks of all the major oil fields in Carter County, and may be producing in the southern group. The producing section in the Sholom Alechem field may include the base of the Deese. (See following descriptions of separate fields.)

### HOXBAR FORMATION

The Hoxbar formation in the type area southeast of Ardmore includes about 4,000 feet of strata. It disappears unconformably beneath the red beds near Ardmore, and beneath the Trinity in Love County. It is believed to be at least partially equivalent to the Canyon group of north-central Texas.

As with the rest of the Pennsylvanian section, the Hoxbar consists dominantly of shale, with interbedded resistant members of limestone and sandstone. The base of the formation has been drawn at the base of the Confederate limestone member, the lowest persistent limestone of this upper Pennsylvanian sequence. This member reaches a maximum thickness of about 60 feet at its westernmost outcrop, northwest of Ardmore. Elsewhere it contains conglomerate streaks, with chert and limestone pebbles which are found also in a ledge some 200 feet higher in the section.

Some 400 feet above the Confederate member is the Union Dairy limestone member, locally carrying abundant *Fusulinae* and other fossils. Eight hundred feet above the base of the Hoxbar occurs the Westheimer member, including a 10 foot pinto limestone conglomerate of variegated pebbles of chert, shale, and limestone in a limestone matrix, together with a calcareous sandstone or sandy limestone.

About 600 feet above the Westeimer member occurs the Crinerville limestone member, 10 feet or more in thickness. The lower layers locally are crammed full of *Fusulinae*. The Anadarche conglomerate lies about 1,800 feet above the base of the formation. It carries pebbles

of chert and of early Pennsylvanian as well as pre-Pennsylvanian limestones. Some 200 feet higher is the Anadarche limestone, a very dense, hard, bluish-gray limestone up to 20 feet thick.

Some 600 feet above the Anadarche member is the Daube member, including a limestone similar to the Anadarche limestone, associated in one locality with a limestone conglomerate.

Just below the Daube limestone occurs the only bed of coal known in the Ardmore basin. This coal reaches a maximum reported thickness of four feet, and is known for at least 4 miles along the strike in T. 5 S., R. 2 E.

Above the Daube limestone the upper 1,200 feet of the Hoxbar formation consist of tan to brown shales with several sandy limestones or calcareous sandstones, including the Zuckerman sandy limestone member.

The Hoxbar formation is not certainly known to be producing oil in Carter County, but it is probable that at least the higher oil sands in the Brock field belong to this formation, and the position of the pay sands at Healdton and Hewitt within the Pennsylvanian system is in doubt. Thick sections of brown shale reported beneath typical red beds in certain synclinal areas, especially in Tps. 3 and 4 S., R. 1 W., may be upper Hoxbar.

### PONTOTOC SERIES

The Hoxbar and all older formations throughout Carter County, after the close of Hoxbar sedimentation, were folded into a series of mountain ranges, which were eroded to a peneplain during the ensuing portion of the Pennsylvanian period. Over this peneplain and across the truncated edges of the now steeply-dipping older formations, there spread in late Pennsylvanian or earliest Permian time a new series of sediments radically unconformable with the older beds. The first of these, as shown by Birk,[18] belongs to the Pontotoc series, which lies in different parts of the county upon each of the older formations from the Hoxbar to the Arbuckle limestone.

The maximum known thickness of the Pontotoc at its outcrops in Carter County is about 400 feet. A greater thickness, probably due to the addition of lower arkosic beds, is suspected in some of the synclinal troughs a short distance west or southwest of the outcrop.

The most easily traceable member of this series is the Hart limestone, an unfossiliferous gray limestone "formed with reworked material from the Ordovician limestones in the Arbuckle Mountains,"[19]

18. Birk, Ralph A., The extension of a portion of the Pontotoc Series around the western end of the Arbuckle Mountains: Bull. Amer. Ass'n. Pet. Geol. vol. 9, pp. 983-989, 1925.
19. Birk, Ralph A., op. cit., p. 986.



which has a maximum thickness of 200 feet in T. 1 S., R. 2 W. Locally, farther south, it plays out entirely or is represented only by associated red shales containing small, roughly spherical limestone concretions. These occur also as constituents of beds of arkosic limestone conglomerate which underlie the more typical Hart limestone in places, but are much more widespread than the limestone itself south of the Arbuckle Mountains.

The Hart limestone member locally constitutes nearly all that is recognizable of the Pontotoc series. In most places, however, it is underlain by from 50 to 200 feet of deep red shales and coarse arkose with beds of sandstone. Asphalt occurs in these beds in secs. 10 and 11, T. 2 S., R. 2 W. Birk[20] also maps a little Stratford shale (part of the Pontotoc) overlying the Hart limestone in T. 1 S., R. 2 W.

"The oil in the Homer shallow field is found in sand breaks in the Hart limestone member at an average depth of 200 feet."[21] The oil and part of the gas of the Wheeler pool, the oil at Blue Ribbon, the shallowest oil in the Wildcat Jim field, and the gas (and oil shows) found in the Graham field at about 900-1,000 feet, also come from the basal part of the red beds, probably from the Pontotoc series. The unconformable overlap of the Pontotoc on older Pennsylvanian rocks also sufficed to trap the asphalt of the little Sopasco pool, and may similarly be responsible to a large extent for the Roundup, Cox, and Wildcat Jim pools, where anticlinal closure in the productive strata has not been proved. The oil produced in all these pools is of heavier gravity than the average in any of the major pools of the county.

### CISCO (?) RED BEDS

Above the Pontotoc series there outcrop in Carter County at least 1,000 feet of typical "red beds", so-called from the dark red shales and reddish-buff cross-bedded sandstones which make up much of the sequence. Much of the sandstone is buff, brown, gray, or white rather than red, however; and there are bluish, tan, green, and white shales as well as red. Perhaps the most common type of sandstone is semi-crystalline and almost white when fresh, but mottled with dark-brown specks and blotches (probably of ferruginous stain) in the weathered portions.

Sands in this sequence yielded the shallower gas in the Wheeler pool, and the first oil produced in the Graham field, from depths less than 300 feet. They yield showings in most of the other fields of Carter County. Asphalt saturations and seepages at outcrops of these sands in the Wheeler and Graham fields were directly responsible for the discovery of those pools, although such seeps and saturations occur also in adjoining areas where prospects of commercial oil production are very poor.

20. Op. cit., Fig. 1, p. 985.
21. Birk, R. A., op. cit., p. 989.

One of the highest members of the red beds of Carter County is a white, massive cross-bedded sandstone which forms a scarp fronting northeast along the southwest side of the Healdton field, and underlies gentle dip slopes extending from the scarp to the southwest corner of the county, interrupted by valleys and ravines which have cut to lower strata. This Cornish sandstone member immediately underlies the city of Ringling and the village of Cornish, just over the line in Jefferson County.

Outcrops of this and closely associated sandstone beds are traceable through ten or twelve townships in the eastern part of Jefferson County, where in general they underlie a much-dissected plateau surface, finally disappearing westward and northwestward beneath higher strata. The same beds appear to underlie the dissected plateau between Nocona and Belcherville, Texas, just across Red River, and to be equivalent to beds in the middle or upper portions of the Cisco group farther southwest. However, this correlation is not in accord with paleontologic determinations of the Permian-Pennsylvanian contact, which has commonly been placed at the top of the Cisco in Texas, but at the top of the Pontotoc or even lower in Oklahoma.

The Cisco red beds below the Cornish sandstone member generally possess ruggedly dissected topography, clad with oak woods. The higher beds include more shales, giving rise to broad upland prairies.

### TRINITY SAND

The Trinity sand, of early Comanchean age, spreads across most of the southern edge of Carter County, unconformably overlapping all older formations. It is about 400 feet thick and consists chiefly of poorly consolidated soft massive buff to pale reddish sandstone, with buff to greenish sandy clays and an occasional thin streak of maroon clay shale. Through most of its area the basal 10 feet or more of the formation consists of a hard coarse sandstone or conglomerate, varying from white to dark brown and commonly so well cemented as to be truly quartzitic. Grains and pebbles of clear quartz are most abundant, set in a chalk-white matrix. Chert pebbles and grains are present in variable proportions, and there are pebbles of older quartzites. Feldspar and limestone are rare or absent.

Near Washita River at the east side of the county, where the present Trinity outcrops closest to the limestone plateau of the Arbuckle Mountains, an entirely different facies appears at the base of the formation. It is a massive chalky limestone 40 feet or more in maximum thickness, with streaks and vugs of calcite spar, and locally containing abundant pebbles of the subjacent formations.

Petrified wood is fairly common in the Trinity. Fragments of this, with boulders of the basal Trinity quartzite or conglomerate and pebbles derived from the latter, are scattered over the uplands for



several miles north of the present limits of the formation. There are also isolated patches of residual sand which probably represent former Trinity outliers. A remarkable bit of additional evidence of greater extent of the Trinity in former times was found in a well in the Cox pool[22], where Comanchean fossil shells were obtained at a depth of 90 feet. The surface formation at this point is recent alluvium, surrounded by post-Pontotoc red beds. The Comanchean sediments here must occupy a valley in the pre-Trinity erosion surface.

No conglomerate has been noted in the Trinity of Carter County except at or very near the base of the formation. Where well exposed, most of the Trinity sediments are readily distinguishable from the Carboniferous red beds. To the latter are unhestitatingly assigned the typical red beds near Orr in the northwest corner of Love County, underlying the unique basal Trinity quartzitic conglomerate.[23]

Parts of the Trinity formation are well saturated with asphalt over considerable areas in T. 6 S., Rs. 2 and 3 E., in Love County. It has yielded small production of oil in the Madill pool and gas in the Enos pool, both in Marshall County. However, no indications of asphalt or of oil or gas have been noted in this formation in Carter County.

### GOODLAND LIMESTONE

"A pure, semicrystalline, massive white limestone approximately 25 feet in thickness".[24] It occurs in Carter County only as the caprock of the Provence Buttes, occupying a total area of 100 acres or so in secs. 3, 4, and 10, T. 5 S., R. 3 E.

### HIGH-LEVEL GRAVELS

Unconsolidated gravels cap several upland areas in the north half of T. 3 S., Rs. 1 E. and 1 W., with smaller patches on hilltops elsewhere in the county. They consist chiefly of limestone and chert pebbles apparently derived from the Arbuckle Mountains, although quartzite pebbles of unknown origin dominate in similarly situated gravels in Jefferson County. These gravels are probably fluviatile, and constitute remnants of a sheet of gravel which appears to have spread over much or all of the county in late Pliocene or Pleistocene time, prior to the excavation of modern stream valleys below that level.

Bench gravels, also consisting largely of pebbles derived from the Arbuckle Mountains, occur in the same townships at one or more terrace levels lower than the gravels just discussed, but higher than the

22. Humble Oil & Refg. Co.'s No. 1 Hefner, Center SW.¼ NE.¼ NE.¼ of sec. 16, T. 2 S., R. 2 W. Verbal communication from Geo. E. Burton.
23. But cf. C. W. Shannon as quoted by Fred M. Bullard, in his Geology of Love County, Oklahoma: Oklahoma Geol. Survey, Bull. 33, pp. 15-16, 1925.
24. Bullard Fred M., Geology of Love County, Oklahoma: Oklahoma Geol. Survey, Bull. 33, p. 22, 1925.

modern flood-plains of adjacent streams. Red alluvium, derived from the red beds north and northwest of the Arbuckle Mountains and transported through the mountains by the Washita River, occurs on similar but larger terraces along that stream.

### RECENT ALLUVIUM

All the streams in the county engage in alternate cutting and filling as rainfall varies. In the main, erosion has the upper hand. Recent alluvial deposits vary from coarse, poorly-rounded, ill-assorted gravels, to fine loess-like silt. The most remarkable Recent deposits in the county, from an economic standpoint, are the small accumulations of tarry asphalt. The largest of these, in the Wheeler field near the SE. corner of sec. 21, T. 3 S., R. 2 W., covers an acre or more and is several feet thick.

The only fossils so far reported from the Quaternary deposits of Carter County is a mastodon tooth found in sec. 4, T. 4 S., R. 1 E. It was exposed in a cut bank of alluvium by the under-cutting of a small stream.

## THE PENNSYLVANIAN-PERMIAN CONTACT

The contact between the Pennsylvanian and Permian systems in northern Oklahoma is drawn on the geologic map of Oklahoma at the base of the Cottonwood limestone. Beede[25] preferred to draw it from 40 to 150 feet lower, somewhere between the Neva limestone and the base of the Elmdale shale. Farther south, in the Stonewall quadrangle, Morgan[26] placed the Permian-Pennsylvanian contact at the base of his Hart limestone, the lowest member of his Stratford formation of the Pontotoc series. Miser's map shows clearly that this horizon is lower than either the Cottonwood or the Neva and lower than the Cushing limestone. It probably corresponds roughly to the top of the Buck Creek formation of northern Oklahoma, some 350 feet below the Cottonwood. The Hart limestone, as shown by Birk[27], is the lowest member of the Pontotoc series which now extends continuously around the west end of the Arbuckle Mountains, overlapping all older formations to the Cambrian. The base of the Permian, as chosen by Morgan in central Oklahoma, therefore coincides with the horizon of tremendous angular unconformity produced by late Pennsylvanian mountain building and erosion in southern Oklahoma. For the western Arbuckle region and the Ardmore district this is a very satisfactory division between stratigraphic units which are structurally and historically distinct. Unfortunately it is lower than the horizon paleontologically

25. Beede, J. W., The Neva limestone in northern Oklahoma: Oklahoma Geol. Survey, Bull. 21, pp. 21-23, 1914.
26. Morgan, Geo. D., Geology of the Stonewall quadrangle: Bureau of Geology, Bull. 2, 1925.
27. Birk, R. A., The extension of a portion of the Pontotoc series around the western end of the Arbuckle Mountains: Bull. Am. Assoc. Pet. Geol., Vol. 9, No. 6, pp. 983-989, 1925.



selected for the Permian-Pennsylvanian contact in the marine sections farther north and farther south.

Part or all of the Cisco group of Texas, there regarded as Pennsylvanian in age, is represented in southern Oklahoma in the lower 1,500 feet of the red beds overlying the great post-Hoxbar angular unconformity.[28] The Wichita-Clearfork of Miser's map also includes an equivalent of at least the upper half of the Cisco group.

## DEVELOPMENT

### Importance of age of folding

The date of folding of a given mountainous anticline in this region is of vital importance to the oil producer who is testing its commercial possibilities. In the folds formed in early Pennsylvanian time, the drill passes through a relatively thin section of upper Pennsylvanian beds into exceedingly steeply folded pre-Pennsylvanian strata lying unconformably beneath them. In these older rocks no commercial production of importance has yet been obtained in Oklahoma south of the Arbuckle and Wichita Mountains, although the possibilities have by no means been exhaused. In the late Pennsylvanian folds of northern Carter County, on the other hand, there is every reason to expect a complete section of the Pennsylvanian system lying conformably above the older rocks. In none of these fields has the drill yet penetrated entirely through the Pennsylvanian, although a depth of 5,120 feet has been reached, stopping in the uppermost part of the Springer formation.

## FOX FIELD

By

John R. Bunn

### EARLY DRILLING IN THE FOX FIELD

The Fox field embodies the producing oil and gas wells in the S.½ secs. 19, 20, 21, and 22, in the W.½ sec. 26, and in secs. 27, 28, 29, 32, 33, 34, and 35, T. 2 S., R. 3 W., Carter County, Oklahoma.

In 1912 the Gypsy Oil Company, finding indications of a favorable oil and gas structure in the red beds at Fox, secured leases in sections 16, 21, 22, 27, 28, and 34. This company drilled a test well to 1,585 feet near the SW. cor, sec. 22, but it proved to be a dry hole.

In 1915, however, the Gypsy brought in a gas well in the west half of the Fox field. This well, Gypsy No. 1 Johnson in the SW.¼ sec. 28, T. 2 S., R. 3 W., was completed at 2,018 feet on December 25,

28. Tomlinson, C. W., Op. cit.

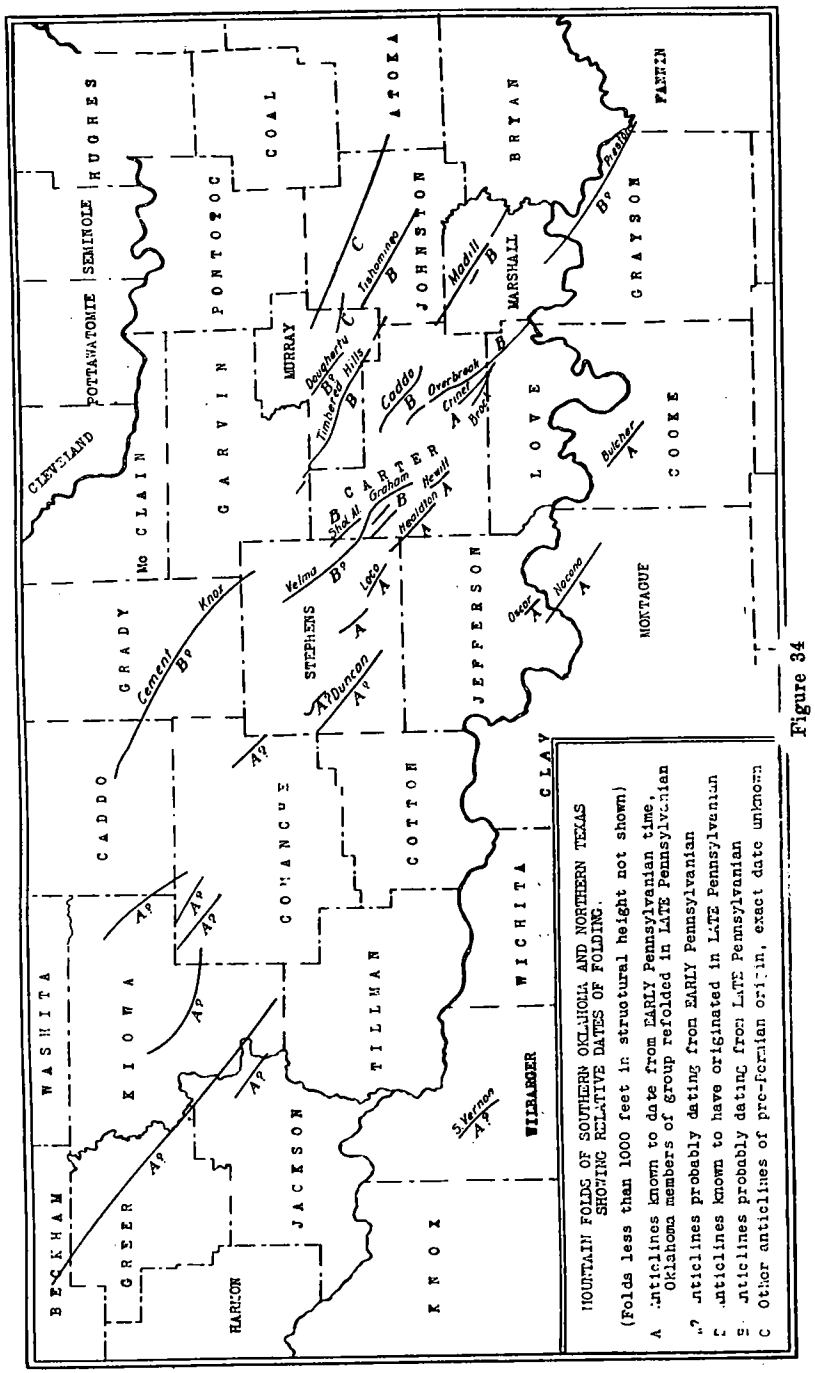



Figure 34



1915, with initial open flow of 22 million feet per day. The rock pressure was not determined.

The first oil well in the Fox field was in the west half of the field and was known as Gypsy No. 1 Mattie Morris in the NW. cor NE.¼ SE.¼ NE.¼ sec. 29, T. 2 S., R. 3 W., completed at 2,033 feet on April 2, 1917, with an initial production of 604 barrels during the first 24 hours.

The first oil well drilled in the east part of the field was the Empire No. 1 Ella Williams, on restricted Indian land, on a working agreement with S. M. Davis and C. R. Smith, who held the lease. This well was completed in February, 1919.

The Humble Oil and Refining Company, Wirt Franklin, Fox Petroleum Company, and the Magnolia Petroleum Company soon after completed producing wells on leases held by them to the north and east of the Empire well.

In 1918, prior to the completion of the Empire No. 1 Ella Williams, the Humble had completed a shallow gas well in the NW.¼ section 35.

### STRATIGRAPHY

Red beds to a depth of 1,050 to 1,200 feet form the uppermost series of rocks penetrated in the Fox field. These beds consist of red, brown, and gray shales and sandstones with an occasional thin nodular limestone stringer.

Unconformably underlying the red beds is a series of steeply dipping Pennsylvanian rocks consisting of blue shales, sandstones, and thin limestones, thought to belong to the Deese and Cup Coral members of the Glenn formation. No strata older than Pennsylvanian have as yet been penetrated in the Fox field.

### STRUCTURE

The structure of this field may be described as consisting of two major anticlinal folds, roughly parallel and connected by a dome-like saddle, all having a definite northwest-southeast trend.

Production in the northwest area of the Fox oil and gas field is on a narrow, elongated, and steep anticline. The dip and shape of this anticline is quite comparable to the Graham anticline.

Production in sections 22, 26, 27, 34 and 35 is found on a fold that is lower structurally, much flatter, and of larger extent. On this fold are several minor domes and terrace structures.

The productive area of the larger and flatter fold is limited to the northwest by two dry holes; the Magnolia Petroleum Company, No. 1

Morris, sec. 21, T. 2 S., R. 3 W., with a total depth of 3,320; and Wirt Franklin, No. 1 Bently, sec. 28, T. 2 S., R. 3 W., with a total depth of 2,702 feet. These wells appear to be low structurally.

The adjustment of oil and gas to structure is very exact. In all instances gas is found in the higher structural points with the oil farther down the flanks and in the low areas between the minor folds.

### PRODUCING HORIZONS IN THE FOX FIELD

*Shallow Gas Sand.* At the intersection of secs. 26, 27, 34, and 35 T. 2 S., R. 3 W., a shallow gas sand, found at a depth of 900-950 feet, yielded considerable gas and was used in early development of this part of the field. The C. R. Smith No. 1-A Fee, in section 26, had initial gas volume of 18 million cubic feet at 270 pounds rock pressure. This well was completed September 10, 1918. The most recent completion in this sand, the Rockland No. 8 Brooks, completed March 19, 1923, had initial gas volume of 2 million cubic feet at 80 pounds rock pressure, showing the depleted condition of the gas sand at that time. There has been a total of six wells drilled for gas production from this sand, of which five obtained production, while a sixth, at a depth of 1,000 feet, found nothing but a trace of gas and oil, with some water.

*Stray Upper Gas Sand.* Magnolia No. 1 Heffner-Mills, sec. 27, T. 2 S., R. 3 W., found a productive upper gas sand from 1,615 to 1,665 feet. The production from this sand was five million cubic feet at 500 pounds rock pressure. This sand is stratigraphically 420 feet higher than the productive zone termed the first sand horizon. Wells drilled with rotary tools have not tested this sand, so that its productive extent is unknown. Wells drilled with cable tools at other parts of the field found a prolific water sand at this horizon.

The existence of several distinct folds and the variation in depth and nature of producing sands, caused considerable confusion in the early correlation of sands in this field. The producing horizons at Fox have never been named, but for the sake of clarity and convenience, they will be termed the first and second producing horizons, and the third, fourth, fifth, and sixth sands.

*First Sand Horizon.* Gas wells of large initial volume have been obtained in this sand horizon, Gypsy No. 2, Mattie Morris, sec. 28, T. 2 S., R. 3 W., had an initial gas volume of 60 million cubic feet per day from this sand. So far this has been the largest gas well ever completed in the Fox-Graham area. A number of other gas wells have been completed in this sand with initial volumes ranging from 40 to 50 million cubic feet per day.

Many oil wells have also been completed in this sand. The largest of these wells was Gypsy No. 1 Mattie Morris, sec. 29, T. 2 S. R. 3 W., which flowed 604 barrels during the first 24 hours.



Many wells which originally produced dry gas from this sand are now producing oil with very little gas.

This sand horizon in most instances consists of a zone from 80 to 120 feet thick. In some wells it is logged as a solid oil or gas sand, but in most instances it is logged as two or more sands, with intervening beds of lime, sandy lime, and sandy shale. From 100 to 150 feet above the top of the upper member of this horizon is the base of the last water sand of the field. No intermediate water sands have been encountered.

Production from this sand horizon has been more extensively developed in secs. 28, 29, 33, 34, and 35, T. 2 S., R. 3 W. In sections 26 and 27 this sand horizon has generally been cased off and production obtained from lower sands, but when production has been secured from it, the wells have been small.

*Second Sand Horizon.* The second sand horizon is quite similar to the first, but in most instances thicker bodies of unbroken sand are present. This horizon generally ranges from 60 to 130 feet in thickness. In some wells as much as 100 feet of solid oil sand is present. In general there are several productive sands in this horizon, separated by thin shale and lime beds. An interval of shale and sandy shale from 70 to 150 feet thick separates the first and second sand horizons.

This productive zone is the most extensively developed oil producing horizon in the Fox field. In the S.½ sec. 27, T. 2 S., R. 3 W., the thickest bodies of unbroken sand have been found. Wells when first completed have initial production ranging from 250 to 350 barrels for the first 24 hours.

The second sand horizon is a gas producer of great importance. In section 27, C. R. Smith No. 1 Fee with an initial production of 44 million cubic feet at 813 pounds rock pressure, and C. R. Smith No. 2 Fee, with initial production of 60 million cubic feet at 750 pounds rock pressure, show the importance of this horizon. Other wells, having initial production ranging from 25 to 50 million cubic feet per day, have been completed in this sand in section 27.

In secs. 32 and 33, T. 2 S., R. 3 W., some big gas wells were found in this same horizon. The Gypsy No. 2 Moncrief in section 32, blew in for 45 million cubic feet for the first 24 hours, at 608 pounds rock pressure, and the Gypsy No. 2 Lindersmith in section 33, had an initial yield of 50 million cubic feet for the first twenty-four hours.

Edge wells producing from the first sand horizons have found water in the second sand horizon in some instances. Love and Thurmond No. 1 Fee, sec. 27, T. 2 S., R. 3 W., a well located structurally low, was originally drilled into the second sand, but finding water was

plugged back and is now producing from the first sand. Since most of the adjoining wells produce from the second sand horizon and only a few from the first, it is possible that edge water encroachment has been more rapid in the second sand horizon than in the first.

*The Third Sand.* A sand of irregular extent and thickness has been found by certain wells in different parts of the Fox field. This sand is found at depths of 400 to 500 feet below the first sand horizon, and is not present in several wells drilled stratigraphically lower than this horizon. It is possible that this sand is a lower member of the second sand horizon and not a distinct and different sand. There have been six gas wells with initial volumes ranging from 5 million to 25 million cubic feet per day completed in this sand. Gypsy No. 2 Pruitt, section 29, with an initial volume of 25 million cubic feet at 540 pounds rock pressure, has been the gas well of maximum initial production.

The Gypsy No. 1 Fitzgerald, is the only well to this sand that produced oil when first completed. It flowed 175 barrels during the first 24 hours. Several of the wells originally producing gas now produce oil.

*The Fourth Sand.* Magnolia No. 9 Heffner-Mills, section 27, and Gypsy No. 5 W. B. Johnson, section 28, penetrated a gas sand occurring from 550 to 590 feet below the top of the first sand horizon. These wells had an initial volume of 10 and 25 million cubic feet per 24 hours, with rock pressure of 1,100 and 900 pounds respectively. It is thought that Carter No. 2 Tucker, with a total depth of 2,725 feet is producing from this sand. A poor and indefinite log makes correlations uncertain.

Humble No. 3 Lester, section 35, reached the fourth sand at 2,695 feet, this sand occurring 400 feet lower structurally than the same sand in Gypsy No. 5 W. B. Johnson, section 28, two miles distant. The interval between the top of the first sand horizon and this sand was approximately the same in both wells. The fourth sand in the Humble No. 3 Lester, was penetrated but a few feet, and according to the log carried water. The fact that the upper sands in this well produced gas in commercial quantities makes the presence of water in the fourth sand hard to explain.

*The Fifth Sand.* A few wells in the Fox field have penetrated a deep sand lying approximately 970 feet below the top of the first producing sand horizon. Gas production was obtained in this sand by the Gypsy No. 2 Fitzgerald in section 28 at a depth of 3,012 to 3,053 feet. The initial gas flow of this well was 15,493,000 cubic feet with rock pressure of 910 pounds.

The Humble No. 2 Ruth Williams in the SW.¼ NE.¼ SW.¼ section 27 found the fifth sand at a depth of 2,970 feet, but was drilled to a deeper sand.



Franklin No. 5 Williams, in the NE.¼ NE.¼ SW.¼ sec. 27 penetrated the top of the fifth sand at a depth of 2,950 feet. This well was likewise carried to a deeper sand. Both the Franklin No. 5 Williams and the Humble deep well, however, set pipe above the fifth sand and obtained production from this and lower sands.

C. R. Smith in his No. 5 Fee, section 26, penetrated the fifth sand at a depth of 3,245 feet. This well was located low on structure and is apparently an edge well. It was completed as a small well producing a low gravity oil. The low gravity of the oil is due to the low structural position of this well.

The fifth sand correlates with the Johnson sand of the Graham field which is the chief producing sand of that area.

*The Sixth Sand.* A sand encountered approximately 365 feet below the top of the fifth sand in Franklin No. 5 Williams at a depth of 3,315 feet, and likewise penetrated by the Humble No. 2 Ruth Williams in section 27 at a depth of 3,320 feet, has been termed the sixth producing sand horizon of the Fox field. This sand probably correlates with the Graham sand of the Graham field. The lower sand and lime bodies recorded in the Franklin No. 5 Williams belong to the lower Graham sand series.

*Log of Wirt Franklin, No. 3, Love & Thurmond.*

NE.¼ SW.¼ SE.¼ sec. 27, T. 2 S., R. 3 W. Completed February 19, 1921.

| Formation | Top | Bottom | Formation | Top | Bottom |
|---|---|---|---|---|---|
| red bed | 0 | 25 | hard sand | 500 | 502 |
| hard sand | 25 | 50 | sandy shale | 502 | 519 |
| gas sand | 50 | 56 | sand-bldrs. | 519 | 522 |
| hard sand rock | 56 | 60 | shale-bldrs. | 522 | 550 |
| hard sand | 60 | 66 | sandy shale | 550 | 580 |
| shale | 66 | 106 | hard sand | 580 | 590 |
| sand rock | 106 | 125 | gumbo | 590 | 614 |
| sand | 125 | 140 | hard rock | 614 | 623 |
| red bed | 140 | 170 | gumbo | 623 | 631 |
| sand rock | 170 | 174 | hard sand | 631 | 634 |
| red bed | 174 | 194 | gumbo | 634 | 655 |
| hard rock | 194 | 204 | blue shale | 655 | 667 |
| oil sand | 204 | 212 | sand rock | 667 | 673 |
| gumbo | 212 | 222 | oil sand | 673 | 675 |
| sand rock | 222 | 232 | sand rock | 675 | 700 |
| gumbo | 232 | 252 | sandy shale | 700 | 720 |
| sand rock | 252 | 312 | oil sand | 720 | 722 |
| sand rock-pyrites | 312 | 322 | sand rock | 722 | 735 |
| sand rock | 322 | 331 | red bed | 735 | 758 |
| sandy shale | 331 | 341 | gumbo | 758 | 763 |
| gumbo | 341 | 351 | sand | 763 | 772 |
| hard sand | 351 | 365 | lime rock | 772 | 779 |
| sandy shale | 365 | 400 | sand rock | 779 | 789 |
| sand-bldrs. | 400 | 465 | shale | 789 | 799 |
| sandy shale | 465 | 500 | gyp | 799 | 807 |
| | | | lime shell | 807 | 819 |

(Continued on page 260)

| Formation | Top | Bottom |
|---|---|---|
| hard sand rock | 819 | 837 |
| sandy shale | 837 | 915 |
| hard sand | 915 | 947 |
| gumbo | 947 | 954 |
| shale | 954 | 974 |
| gumbo | 974 | 984 |
| blue shale | 984 | 1076 |
| shell | 1076 | 1081 |
| hard sand | 1081 | 1093 |
| sand rock | 1093 | 1102 |
| sandy shale | 1102 | 1138 |
| sand | 1138 | 1142 |
| shale | 1142 | 1167 |
| sand | 1167 | 1177 |
| sandy shell | 1177 | 1197 |
| shale | 1197 | 1207 |
| shell | 1207 | 1217 |
| shale | 1217 | 1225 |
| sand | 1225 | 1231 |
| sandy shale | 1231 | 1298 |
| hard sand | 1298 | 1304 |
| sandy shale | 1304 | 1312 |
| sand rock | 1312 | 1315 |
| gumbo | 1315 | 1323 |
| sandy shale | 1323 | 1361 |
| hard sand | 1361 | 1417 |
| lime rock | 1417 | 1419 |
| oil sand | 1419 | 1421 |
| sand rock | 1421 | 1437 |
| sandy shale | 1437 | 1467 |
| sand rock | 1467 | 1526 |
| gumbo | 1526 | 1530 |
| sand rock | 1530 | 1559 |
| gyp | 1559 | 1569 |
| sand rock | 1569 | 1584 |
| lime shell | 1584 | 1589 |
| sand rock | 1589 | 1627 |
| sandy lime | 1627 | 1629 |
| sand | 1629 | 1639 |
| lime | 1639 | 1645 |
| sand rock | 1645 | 1647 |
| sandy lime | 1647 | 1663 |
| shell | 1663 | 1675 |
| sand rock | 1675 | 1685 |
| asphalt | 1685 | 1689 |
| sand rock | 1689 | 1705 |
| sandy shale | 1705 | 1720 |
| gyp | 1720 | 1723 |
| sand rock | 1723 | 1752 |
| sandy shale | 1752 | 1767 |
| sand rock | 1767 | 1769 |
| gyp | 1769 | 1771 |
| sandy shale | 1771 | 1788 |
| lime | 1788 | 1798 |
| rock | 1798 | 1803 |
| sandy lime | 1803 | 1817 |
| sand rock | 1817 | 1835 |
| sandy shale | 1835 | 1845 |
| gumbo | 1845 | 1851 |
| sandy shale | 1851 | 1867 |
| oil sand | 1867 | 1869 |
| sandy shale | 1869 | 1918 |
| hard sand | 1918 | 1936 |
| sand rock | 1936 | 1943 |
| lime rock | 1943 | 1945 |
| sandy lime | 1945 | 1961 |
| sand | 1961 | 1975 |
| sandy lime | 1975 | 1989 |
| sandy lime rock | 1989 | 2015 |
| sand-shale | 2015 | 2055 |
| hard sand | 2055 | 2105 |
| hard sand rock | 2105 | 2120 |
| hard sand show oil | 2120 | 2140 |
| shale | 2140 | 2218 |
| sand | 2218 | 2229 |
| oil sand | 2229 | 2269 |
| broken sand | 2269 | 2273 |
| blue shale | 2273 | 2275 |
| gyp rock | 2275 | 2277 |
| oil-gas sand | 2277 | 2296 |
| hard gas sand | 2296 | 2303 |
| oil-gas sand | 2303 | 2351 |

## SUMMARY AND CONCLUSIONS

1. Red beds to a depth of 1,050 to 1,200 feet overlie the Fox field.

2. Steeply dipping Pennsylvanian rocks of middle Glenn age lie unconformably below the red beds.

3. The Fox field consists of several pronounced anticlinal folds with definite structural trends.

4. Oil and gas are bing produced from six distinct horizons, of which the first and second sand horizons are the most extensively developed. The third, fourth, fifth, and sixth sands have been penetrated by comparatively few wells. These sands have furnished commercial production when penetrated on favorable locations and are a potential reserve of great importance to producers in this field.



# THE GRAHAM FIELD

By

Sam H. Woods and J. P. McKee

## LOCATION

The Graham field is located in secs. 5, 6, and 8, T. 3 S., R. 2 W., and secs. 30, 31, and 32, T. 2 S., R. 2 W., and secs. 15, 22, 23, 24, 25, 26, and 36, T. 2 S., R. 3 W.

## HISTORY OF DEVELOPMENT

The first well drilled by the Kirk Oil Company in April, 1917, is located in the NW.¼ NE.¼ sec. 31, T. 2 S., R. 2 W. It had three to four barrels of heavy black oil at 270 feet. Four more similar shallow wells were drilled in the vicinity. The original well was then deepened to 1,490 feet, making an estimated production of 14 million cubic feet of gas per day with 650 pounds rock pressure.

The discovery oil well, located in the SW.¼ SW.¼ NE.¼ sec. 31, T. 2 S., R. 2 W., was drilled jointly by Roy M. Johnson, the Healdton Petroleum Company, and C. R. Smith. This well had 15 million cubic feet of gas at 1,478 feet. It was later deepened to 2,539 feet, producing 90 barrels of oil per day from sand at 2,466 to 2,539 feet. From June, 1922, development was rather active until the pool had been defined in all directions.

## STRATIGRAPHY

*Permian.* The surface rocks over the Graham field are of Permain or late Pennsylvanian age. The section is approximately 1,000 feet thick, and consists of red shales and sandstones with some gray shales.

The base of the series is exposed about eight miles northeast of Graham at the western edge of the Arbuckle Mountains, where it overlaps successively the Pennsylvanian, Mississippian, Devonian, Silurian, and Ordovician. These beds repose at an angle of about 45 degrees, dipping southwest from the axis of the Arbuckle uplift.

The Permian beds rest unconformably upon the Pennsylvanian rocks in the Graham field, where the dips in the Pennsylvanian rocks range from 10 to 40 degrees.

In the Graham pool a limestone member has been found in many wells near the base of the red beds that has been regarded as basal Permian and the equivalent of Morgan's Hart[29] limestone member of the Stratford formation.

29. Morgan, Geo. D., Geology of the Stonewall Quadrangle: Bureau of Geology, Bull. 2, Norman, Oklahoma, pp. 137-140, 1924.
Birk, R. A., Tracing a part of the Pontotoc series around the western end of the Arbuckle Mountains: Bull. Am. Assoc. Pet. Geol., Vol. 9, No. 6, pp. 983-984, 1925.

*Pennsylvanian.* The following is a portion of Tomlinson's[30] description of the Pennsylvanian rocks associated with oil and gas production in the Graham field.

> The sequence of strata in the Pennsylvanian producing zones in the Graham field resembles quite closely a sequence to be found in the outcrops of the "Cup Coral member" of the Glenn formation between Graham and Ardmore. No limestone member more than two or three feet in thickness is exposed in the outcrops of Carboniferous strata between Ardmore and Graham, between the Otterville limestone, immediately underlying the "Cup Coral member," and the Sycamore limestone (Mississippian) below * * *.
>
> A 30 foot bed of true limestone has been found in two Graham wells below all present producing horizons. This may be regarded as sufficient proof that the producing zones are not older than the "Cup Coral member." It is suggested the deep limestones in these two wells may be Otterville * * *.
>
> A number of cores taken from the Johnson sand in the Graham field contain fossils. From these more than a dozen species have been identified * * *. A comparison of a list of these species with the faunal list published by Girty and Roundy[31] shows that nearly all the species obtained from the Johnson sand are found in the outcrops of the "Cup Coral member" of the Glenn formation.

### STRUCTURE

The subsurface structure of the Graham field can be readily worked, as the top of the Johnson sand serves as an excellent datum horizon. The structure on this horizon shows a pronounced elongated anticlinal fold, the major axis extending northwest-southeast, to the east line of sec. 22, T. 2 S., R. 3 W., where the direction of the axis swings almost due west to the end of the field in that direction. Dips to the east, northeast, and north are much steeper than elsewhere around the field, standing as much as 40 degrees in places.

### PRODUCING SANDS

Following is a description of the producing horizons of the Graham field taken largely from the report by George and Bunn.[32]

### SHALLOW OIL SANDS

Showings of heavy oil or gas have been found in many of the shallow Permian sands penetrated in the Graham field. These sands range in depth from 150 to 1,100 feet. They are of an irregular and lenticular nature, medium fine-grained and loosely cemented. In the N.½ sec. 31, T. 2 S., R. 2 W., several shallow wells produced from four to six barrels of 19 gravity oil. In the E.½ sec. 6, T. 3 S., R. 2 W., several wells produced small amounts of gas at depths varying from 435 to 650 feet. In the early development of the field fuel oil and gas from these wells were used in drilling.

30. Tomlinson, C. W., Contribution to the petroleum engineering in the Fox and Graham oil and gas fields: Bull. U. S. Bureau of Mines, pp. 4-5, 1924.
31. Girty, Geo. H. and Roundy, P. V., Notes on the Glenn formation of Oklahoma: Bull. Am. Assoc. Pet. Geol., vol. VII, pp. 332-388, 1923.
32. George, H. C., and Bunn, John R., Petroleum engineering in the Fox and Graham oil and gas fields: Bull. U. S. Bureau of Mines, pp. 12-16, 1924.



*Producing Horizons, Graham Field*

| AGE | HORIZON | RELATION OF PRODUCTION TO STRUCTURE | LITHOLOGIC CHARACTER | THICKNESS OF SAND & ZONE (Feet) | DEPTH (Feet) | AV. INIT. PROD. OIL (Bbls.) | AV. INIT. PROD. GAS (M.cu.ft.) | GRAVITY |
|---|---|---|---|---|---|---|---|---|
| PERMIAN | SHALLOW OIL AND GAS SANDS | Southeast edge of Graham anticline | Medium fine-grained, loosely cemented sands | Av. 20 sand<br>Av. 25 sand<br>Av. 15 sand | 250<br>435<br>650 | 3 | Gas<br>Gas | 19.0 |
| | PATSY GAS SAND | SW. flank of southern producing zone | | Av. 10 sand | 900-985 | | 8 Dry | |
| PENNSYLVANIAN | KIRK GAS HORIZON | Highest structural points | Sandy limes and limes | Zone 30-50 | 1,450-1,800 | | 15 Wet | |
| | JOHNSON SAND HORIZON | Oil on flanks<br>Gas on higher structual points | Fine-grained soft, porous sands | Zone 150-300<br>Sands av. 55 | 1,830-2,180 | 200 | 24 Wet | 31 |
| | GRAHAM SAND HORIZON | Best prod. on top of structure and SW. flank | | Zone 200<br>Sands av. 35 | 2,050-2,630 | 350 | 15 Wet | 33.0 |
| | UN-NAMED | Southeast of top of structure | Hard, close fine-grained sands | Sands av. 19 | 3,220 | 15 | | 38.8 |
| | SMITH SAND | Southeast of top of structure | | Av. 15 sand | 3,375 | 60 | | 39.9 |

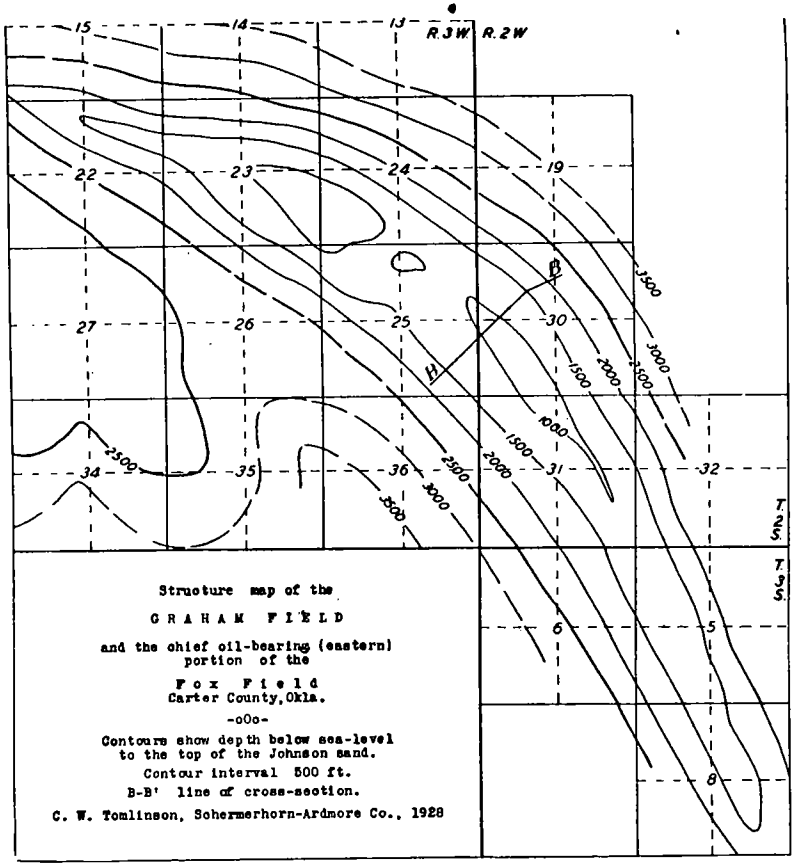



Figure 35

*Log of Schermerhorn-Ardmore Co., No. 1, G. E. Holman.*
SW.¼ NW.¼ SE.¼ sec. 25, T. 2 S., R. 3 W. Completed November 30, 1923

| Formation | Top | Bottom |
|---|---|---|
| sand & rock | 0 | 31 |
| hard sandy lime-shells | 31 | 47 |
| hard lime | 47 | 51 |
| blue shale | 51 | 75 |
| red bed | 75 | 112 |
| OIL sand | 112 | 122 |
| sand & shale | 122 | 185 |
| OIL sand | 185 | 213 |
| lime rock | 213 | 216 |
| hard sand & shale | 216 | 246 |
| water sand | 246 | 263 |
| pack sand | 263 | 335 |
| sand & clay | 335 | 346 |
| sand & boulders | 346 | 405 |
| lime rock | 405 | 408 |
| sharp sand | 408 | 523 |
| shale | 523 | 644 |
| hard sand | 644 | 756 |
| sticky shale | 756 | 778 |
| hard sand | 778 | 815 |
| hard rock | 815 | 817 |
| hard sand | 817 | 866 |
| lime rock | 866 | 894 |

(Continued on page 265)



| Formation | Top | Bottom |
|---|---|---|
| hard shale & sand | 894 | 923 |
| lime rock | 923 | 936 |
| gumbo | 936 | 946 |
| hard sand-sand rock | 946 | 995 |
| sand rock & lime | 995 | 1017 |
| shale | 1017 | 1029 |
| broken lime | 1029 | 1041 |
| hard sand | 1041 | 1063 |
| rock | 1063 | 1065 |
| hard rock | 1065 | 1073 |
| hard lime rock | 1073 | 1078 |
| hard lime pts of iron | 1078 | 1085 |
| lime rock | 1085 | 1089 |
| broken lime | 1089 | 1094 |
| lime rock | 1094 | 1102 |
| hard sand | 1102 | 1104 |
| sandy lime | 1104 | 1129 |
| sandy lime & lime | 1129 | 1155 |
| broken lime | 1155 | 1185 |
| hard broken lime | 1185 | 1197 |
| hard shale | 1197 | 1200 |
| GAS sand | 1200 | 1203 |
| broken lime | 1203 | 1222 |
| gumbo | 1222 | 1246 |
| GAS sand | 1246 | 1257 |
| hard lime | 1257 | 1264 |
| hard sand | 1264 | 1285 |
| broken lime | 1285 | 1297 |
| gumbo-hard sand | 1297 | 1328 |
| GAS sand | 1328 | 1337 |
| shale | 1337 | 1359 |
| hard sand | 1359 | 1390 |
| shale | 1390 | 1392 |
| sticky shale | 1392 | 1426 |
| tough gumbo | 1426 | 1456 |
| boulders | 1456 | 1458 |
| sandy shale | 1458 | 1491 |
| shell & GAS sand | 1491 | 1495 |
| shale | 1495 | 1553 |
| GAS sand | 1553 | 1554 |
| shale | 1554 | 1581 |
| —KIRK SAND ZONE— GAS sand | 1581 | 1582 |
| lime rock | 1582 | 1585 |
| hard lime | 1585 | 1592 |
| GAS sand core 1598' | 1592 | 1602 |
| shell | 1602 | 1605 |
| GAS sand, salt wtr. S. L. M. | 1605 | 1616 |
| hard sand | 1616 | 1618 |
| Broken lime | 1618 | 1620 |
| hard lime rock | 1620 | 1621 |
| lime | 1621 | 1621½ |
| sandy shale | 1621½ | 1660 |
| sticky shale | 1660 | 1716 |
| sand, show GAS | 1716 | 1717 |
| blue shale | 1717 | 1745 |
| blue shale | 1745 | 1755 |
| gumbo | 1755 | 1765 |
| shale carrying Gas | 1765 | 1795 |
| sandy shale | 1795 | 1817 |
| hard shale | 1817 | 1832 |
| gumbo | 1832 | 1874 |
| sticky shale | 1874 | 1900 |
| sand rock | 1900 | 1902 |
| shale | 1902 | 1914 |
| JOHNSON SAND ZONE— lime | 1914 | 1919 |
| OIL sand | 1919 | 1923 |
| gumbo | 1923 | 1926 |
| brown shale | 1926 | 1933 |
| GAS sand | 1933 | 1948 |
| sand, solid | 1948 | 1953 |
| GAS & OIL sand | 1953 | 1965 |
| broken mixed shale & gas sand. S. L. M. | 1965 | 1969 |
| mixed shale | 1969 | 2000 |
| shell | 2000 | 2001 |
| sand-core at 2011' | 2001 | 2011 |
| clay & brown shale | 2011 | 2016 |
| hard sand, show GAS | 2016 | 2022 |
| GAS sand-lime | 2022 | 2027 |
| shell | 2027 | 2028 |
| hard shale & shells | 2028 | 2035 |
| GAS sand, showing some oil | 2035 | 2039 |
| mixed shale | 2039 | 2054 |
| hard shell | 2054 | 2055 |
| sticky shale | 2055 | 2059 |
| sand, showing good | 2059 | 2074 |
| mixed shale, showing some OIL sand | 2074 | 2087 |
| blue shale | 2087 | 2095 |
| mixed shale | 2095 | 2125 |
| DEEPENING RECORD | | |
| shale | 2125 | 2132 |
| shell | 2132 | 2133 |
| gumbo | 2133 | 2143 |
| shale | 2143 | 2173 |
| black shale | 2173 | 2187 |
| broken sand | 2187 | 2192 |
| sandy shale | 2192 | 2198 |
| shale | 2198 | 2213 |

| | Formation | Top | Bottom |
|---|---|---|---|
| ATLANTIC SAND ZONE | broken sand | 2213 | 2215 |
| | sandy shale | 2215 | 2216 |
| | hard sandy lime | 2216 | 2220 |
| | lime shell | 2220 | 2222 |
| | sandy shale | 2222 | 2235 |
| | sand, showing OIL & GAS | 2235 | 2241 |
| | sand, OIL | 2241 | 2253 |
| | lime shell | 2253 | 2256 |
| | shale | 2256 | 2262 |
| | lime shell | 2262 | 2264 |
| | shale | 2264 | 2280 |
| | gumbo | 2280 | 2284 |
| | sticky shale | 2284 | 2300 |
| | brown shale | 2300 | 2315 |
| | sandy shale | 2315 | 2319 |
| | brown shale | 2319 | 2327 |
| | hard sandy lime | 2327 | 2331 |
| | lime shell | 2331 | 2334 |

| | Formation | Top | Bottom |
|---|---|---|---|
| Rickets Sand Zone | brown sand | 2334 | 2337 |
| | sand | 2337 | 2339 |
| | sandy shale | 2339 | 2345 |
| | sandy shale-br. sand | 2345 | 2353 |
| | sand—OIL showings | 2353 | 2360 |
| | sandy shale | 2360 | 2368 |
| | sticky shale | 2368 | 2378 |
| | sand | 2378 | 2381 |
| | sticky brown shale | 2381 | 2386 |
| | sticky shale | 2386 | 2395 |
| | brown shale | 2395 | 2405 |
| | gumbo | 2405 | 2414 |
| | shale | 2414 | 2436 |
| | OIL sand (Graham Sand) | 2436 | 2447 |
| | sticky shale | 2447 | 2452 |
| | shell | 2452 | 2453 |
| | sticky shale | 2453 | 2460 |
| | gumbo | 2460 | 2463 |
| | shell | 2463 | 2465 |
| | gumbo | 2465 | 2475 |
| | shale | 2475 | 2490 |
| | TOTAL DEPTH—S. L. M. | | |

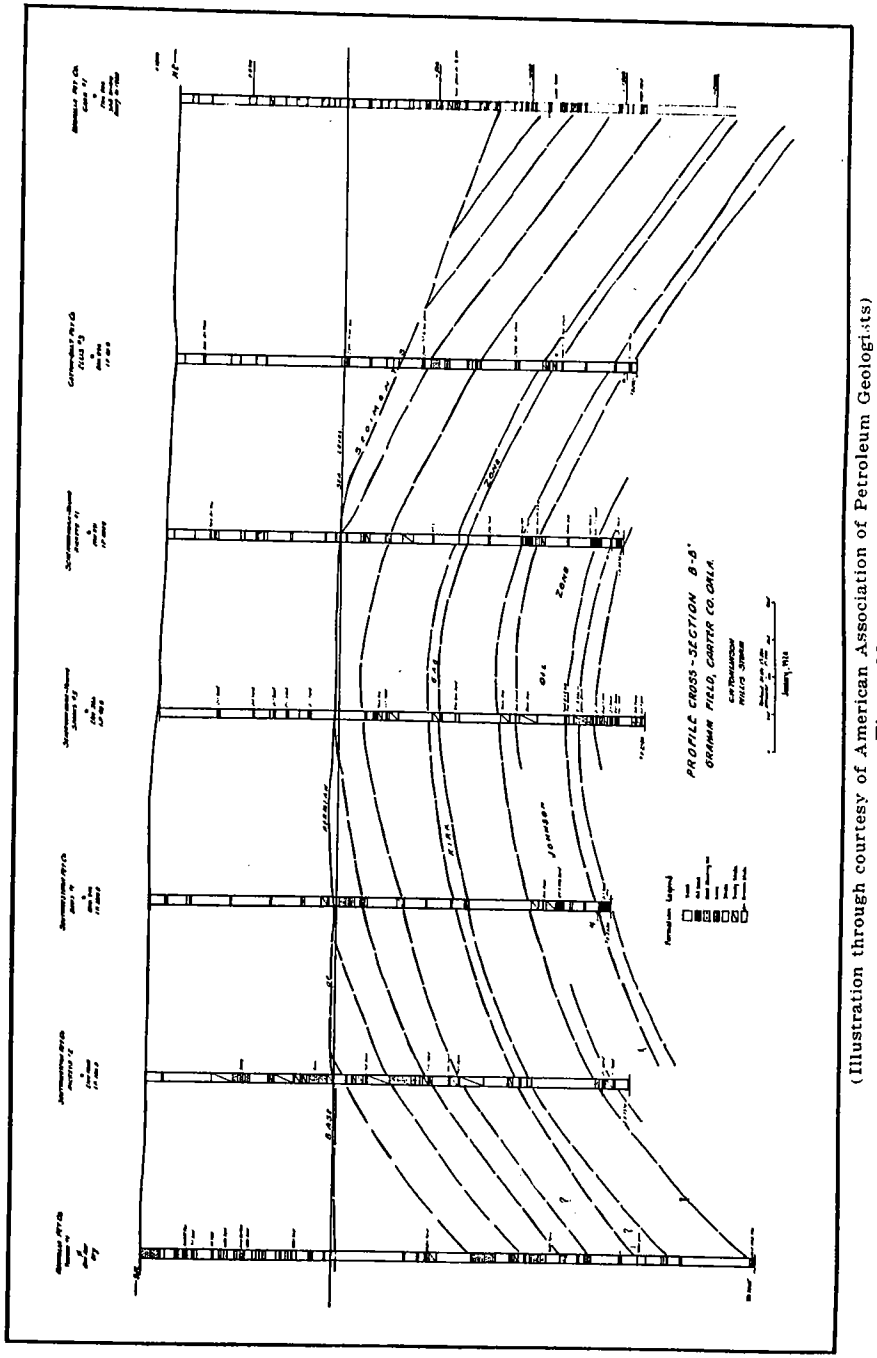
### PATSY GAS SANDS

A sand found by the Patsy Oil and Gas Company and the Kirk Oil Company at a depth of 985 feet near the cen. sec. 6, T. 3 S., R. 2 W., produced 17 million cubic feet of gas in the initial well. This sand was productive in several other wells in the E.½ sec. 6, T. 3 S., R. 2 W. The initial production of wells from this sand was 8 million cubic feet of dry gas. This sand is medium fine-grained and loosely cemented.

### THE KIRK GAS HORIZON

A gas and water horizon from 30 to 150 feet in thickness and occurring along the axis of the structure, produced gas in a few wells. This horizon was found at depths ranging from 1,450 to 1,800 feet. Rotary cores have shown this horizon to be very calcareous in nature and associated with sandy limes and limes. Production of gas from this horizon is limited to the highest structural points. This zone was found to carry water on the flanks and was usually cased off. George and Bunn found that no wells produced oil from this horizon although rotary cores had shown the presence of saturated oil sands. Later H. E. Ley[33] contended that some wells had been plugged back to this horizon and were producing oil.

33. Ley, H. E., Note on Kirk gas and water horizon: Bull. Am. Assoc. Pet. Geol. vol. 9, no. 6, p. 1024, 1925.



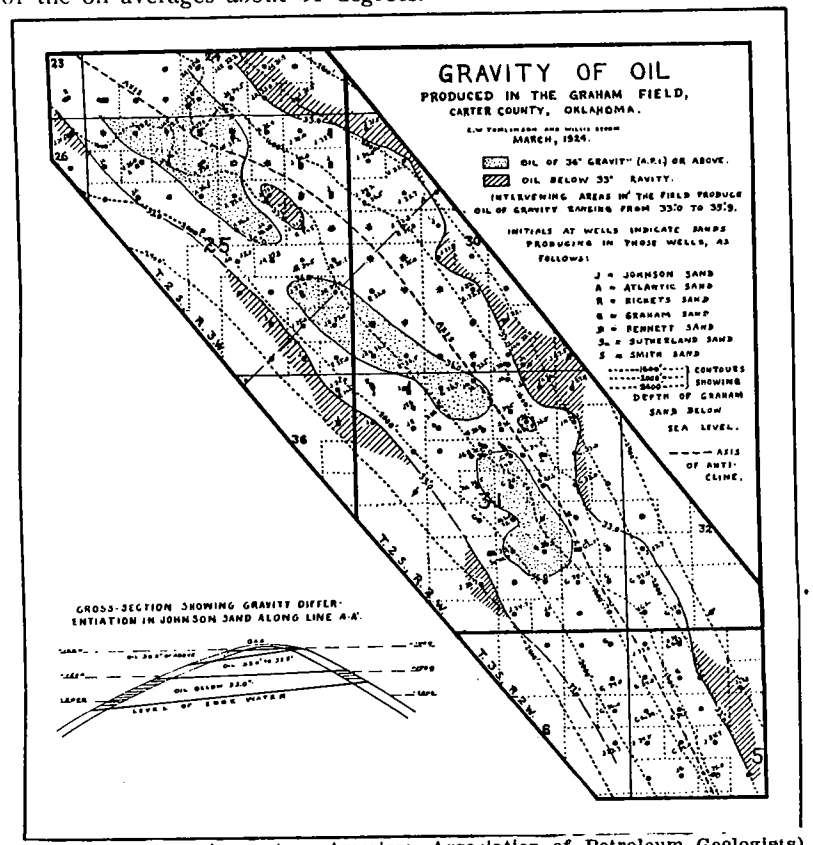

(Illustration through courtesy of American Association of Petroleum Geologists)
Figure 36

### JOHNSON SAND HORIZON

The top of this horizon is found at depths ranging from 1,830 to 2,180 feet along the axis of the Graham anticline. This zone lies from 250 to 475 feet below the base of the Kirk gas sands and is separated from it by a shale interval. This interval is easily recognized in well logs and has been used in subsurface correlations.

This zone ranges in thickness from 150 to 300 feet. The upper Johnson sands are usually thinner than the lower Johnson sands, and are fine-grained, soft, and porous. The interval between these two sands is greatest in the southeast end of the field, decreasing to the northwest. The edge water level in this horizon is higher on the northeast flank than on the southwest flank of the fold.

The initial production of wells from this horizon averaged 200 barrels of oil and 24 million cubic feet of gas per well. The gravity of the oil averages about 31 degrees.




(Illustration through courtesy American Association of Petroleum Geologists)
Figure 37



### GRAHAM SAND HORIZON

In the southeast part of the field the Graham sand horizon lies about 450 feet below the base of the lower Johnson sand horizon. The interval thins to the northwest until in sec. 24, T. 2 S., R. 3 W., it is less than 200 feet. The interval is largely shale with a few thin beds of limes, sands, and sandy shales.

The Graham horizon averages about 200 feet in thickness, and the Graham sands average from 30 to 40 feet in thickness and are less lenticular than those of the Johnson horizon. These sands are fine-grained, soft, and porous.

Initial production of wells in the Graham horizon averages 350 barrels, 15 million cubic feet of wet gas. The gravity of the oil averages 32 degrees.

### DEEPER SANDS

Production of 15 barrels of 38.8 gravity oil from an unnamed and relatively unimportant sand has been obtained in one well in sec. 31, T. 2 S., R. 2 W. This sand was topped at 3,217 feet. This sand was found in other nearby deep wells but failed to produce.

A lower sand, topped at about 3,375 feet, produced small amounts of oil in a few wells in sec. 31, T. 2 S., R. 2 W. The initial production of these wells averaged about 60 barrels of 39 gravity oil.

Deeper drilling in the Graham field has not met with any success. In the northwest portion of the field these deeper sands failed to produce.

The Graham field has produced at this writing (July, 1928) nearly 16 million barrels of oil from 320 wells.

## THE HEALDTON POOL

### EARLY HISTORY

About the year 1888 a visiting prospector drilled a well some 400 feet deep on a sloping prairie in what later turned out to be the S.½ sec. 5, T. 4 S., R. 3 W. He struck a sand which filled the hole with tarry fluid and slopped over, letting heavy black asphaltic oil creep down the slope, where it lay for years afterward. It was not a commercial venture at that early date, and the discoverer moved on to other fields.

In 1912 two young business men of Ardmore, Roy M. Johnson and Edward Galt, interested Wirt Franklin and others in the possibilities of this area, and got together a block of leases. The following year they succeeded in persuading J. M. Critchlow of Titusville, Pa., to drill a test well on land belonging to Mr. Franklin in sec. 8, T. 4 S., R. 3 W. In August, 1913, it was completed as a 25 barrel well at a depth of 920 feet. A second well was then drilled one-half mile

farther northwest, and this one yielded 300 barrels per day. This well started the earnest development of the field.

By November, 1914, there were some 275 producing wells in the field. Low prices of crude oil slowed up development during 1915, but in 1916 the main part of the field was fully developed, and in 1917 the southeast extension was defined.

### PRODUCTION

The Healdton oil pool is by far the largest in Carter County, both in area and in yield. Between two and three times as extensive as any other pool (see statistical table), and covering nearly 40 per cent of the total productive area of the county, it has produced to date 50 per cent more oil than all the other pools in the county. Hewitt alone has exceeded Healdton in per acre yield.

No other pool in Oklahoma south of Cushing and Glenn pool approaches Healdton in continuous productive area, or has equaled its total production to date. None of the pools in the Seminole group has yet passed Healdton in total production, in spite of their much larger flush yield. Healdton is phenomenal among Oklahoma pools in its exceedingly slow rate of decline. Although it reached its peak 12 years ago, its present daily production is one-fourth as great as in the peak month. Certain leases in the field which reached peak production in 1916 have not yet (1928) fallen to one-half of their 1916 average yield.

Although Healdton production has been aided to some extent in the past two or three years by drilling additional wells inside the proven area, these wells have tapped no new sands. Vacuum has not been used to any considerable extent as an aid to production, nor has flooding or repressuring been tried. It seems safe to predict that ten years from now Healdton will be producing more oil than any pool in the present Seminole group, and that its productive life will continue through additional decades.

Although Healdton's average yield per acre to date is only a little over 20,000 barrels, certain tracts (parts of leases) in the northwestern part of the pool have yielded over 100,000 barrels per acre, and are still adding 5,000 barrels per acre to those figures each year. Several different companies and landowners own rich spots of this kind. Obviously, the greater part of the field has averaged considerably less than 20,000 barrels per acre to date. One or two edge properties in the southeastern part of the field have been abandoned, and scattered wells throughout the field have met the same fate; but the total number of producing wells has been kept nearly constant by new drilling in the richer areas.

### PRODUCING SANDS

The great bulk of Healdton's production comes from a group of Pennsylvanian sands known as the Healdton sand zone, from 800 to



1,200 feet deep. The gravity of this oil ranges from 25° to 37° A. P. I., with most of it between 31° and 35°. Gas and a little oil have been obtained from shallower Pennsylvanian sands scattered through a belt of blue shale between 400 and 800 feet deep. The only persistent member of this series, which is of little commercial consequence, occurs 150 to 200 feet above the top of the main Healdton zone. In the southeastern part of the field little production is obtained above 1,200 feet, but moderately prolific Pennsylvanian sands, carrying oil of similar gravity, are found at various depths down to 2,050 feet. Half a dozen deep wells in the south-central portion of sec. 4, T. 4 S., R. 3 W., have obtained small production of very light (40° to 45°) oil from Ordovician sandy limestones at depths ranging from 2,100 to 4,200 feet. Only three of these are now producing and their total yield is only about 50 barrels per day. One of these wells, now abandoned (Bullhead Oil Co.'s No. 1 Daney), was the first Ordovician producer in Oklahoma,[34] antedating the first Wilcox sand development. It was drilled in 1917.

The extraordinary although variable thickness of oil sands in the main Healdton sand zone in the northwest one-half or two-thirds of the Healdton field is largely responsible for the remarkably long life and slow decline of oil production there. Solid sands from 40 to 150 feet thick are the rule rather than the exception if the well records are trustworthy; some wells have logged between 200 and 300 feet of sand in this zone. Such thicknesses of solid or nearly solid sand of good porosity are known only in the outcrops of the Deese formation in the Pennsylvanian sediments of Carter County. The outcropping Deese sandstones, as a rule, vary much less rapidly along the strike than do the Healdton oil sands; but the variability of the latter may be due to their proximity to the rugged buried hills of Ordovician rocks which rise in places above the level of the pay sands.

The suggestion that these sands may belong in the Deese formation is admittedly based on very inconclusive evidence. Available paleontologic evidence marks them as Pennsylvanian, but is not adequate to determine their exact position in that system.[35]

The surface rocks in the Healdton field are late Pennsylvanian (Cisco ?) or early Permian red beds, 200 to 500 feet thick over most of the field but increasing to 800 feet at some places along its borders. The highest member exposed in the field is the Cornish sandstone, which caps a butte in sec. 6, T. 4 S., R. 3 W., and a scarp at the northwest corner of that section.

34. Powers, Sidney, The Healdton oil field, Oklahoma: Econ. Geol., vol. 12, p. 600, 1917.

35. Powers, Sidney, loc. cit.
Gardner, James H., The oil pools of southern Oklahoma and northern Texas: Econ. Geol., vol. 10, pp. 425-426, 1915.
Powers, Sidney, Age of the oil in southern Oklahoma fields: Trans. Amer. Inst. Min. Met. Eng., vol. 59, pp. 571-577, 1918.
Bartram, John G., and Roark, Louis, The Healdton field, Oklahoma Bull. Am. Assoc. Pet. Geol., vol. 5, pp. 470-471, 1921.

*Log of J. B. Schermerhorn, Inc., No. 29 Schermehorn.*
SE.¼ SW.¼ NW.¼ sec. 5, T. 4 S., R. 3 W. Completed April 27, 1927.

| Formation | Top | Bottom |
|---|---|---|
| yellow clay | 0 | 15 |
| blue clay | 15 | 27 |
| red bed | 27 | 48 |
| pin shale | 48 | 58 |
| red bed | 58 | 120 |
| lime shell | 120 | 122 |
| blue shale | 122 | 140 |
| water sand | 140 | 168 |
| blue shale | 168 | 195 |
| red bed | 195 | 232 |
| lime | 232 | 236 |
| sand | 236 | 257 |
| red bed | 257 | 313 |
| lime | 313 | 315 |
| sand | 315 | 321 |
| lime shells | 321 | 341 |
| red bed | 341 | 386 |
| Oil sand show of oil | 386 | 392 |
| blue shale | 392 | 417 |
| lime | 417 | 428 |
| pink shale | 428 | 442 |
| blue shale | 442 | 459 |
| lime | 459 | 465 |
| blue shale | 465 | 615 |
| Oil sand, show of oil | 615 | 628 |
| blue shale | 628 | 948 |
| HEALDTON SAND ZONE: soft Oil sand | 948 | 1012 |
| HEALDTON SAND ZONE: blue shale | 1012 | 1031 |
| HEALDTON SAND ZONE: lime shell | 1031 | 1037 |
| HEALDTON SAND ZONE: Oil sand (Pay sd.) | 1037 | 1046 |
| HEALDTON SAND ZONE: lime | 1046 | 1053 |
| HEALDTON SAND ZONE: Oil sand (Pay sd.) | 1053 | 1064 |
| HEALDTON SAND ZONE: lime | 1064 | 1066 |
| HEALDTON SAND ZONE: Oil sand (Pay sd.) | 1066 | 1072 |
| HEALDTON SAND ZONE: lime | 1072 | 1074 |
| HEALDTON SAND ZONE: Oil sand (Pay sd.) | 1074 | 1077 |
| HEALDTON SAND ZONE: hard lime (SLM) | 1077 | 1088 |

(Shot formation 1031-1080 with 50 qts. 4-27-27.)

### STRUCTURE

The Healdton field is strictly anticlinal. According to the structural map by Bartram and Roark, reproduced herewith (see Fig. 6), the top of the Healdton sand zone is about 275 feet above sea level at the highest point on the fold. Production extends down the flank until that horizon reaches sea level, and in places about 300 feet below. The broader parts of the arch are fairly flat, with dips of one degree or less, but a maximum dip (for the producing Pennsylvanian sands) of about 15 degrees is attained on the flanks of the anticline.

Over the flat part of the arch the surface red beds parallel the underlying productive Pennsylvanian section fairly closely, so that the unconformity between the two is inconspicuous. To the west and south, and in part to the east, the flanks of the fold are also well shown in the red beds, but with dips averaging only about one degree, as against 5 to 15 degrees in the Healdton sand zone. The surface of unconformity at the base of the red beds appears to slope away from the field at an intermediate rate, so that the red beds thicken by the addition of lower members which failed to cover the Healdton anticline.

The unconformity between the marine Pennsylvanian section, including the productive sand series, and the underlying Ordovician is



much more pronounced within the area of the field than is the upper unconformity just described. The surface of the Ordovician appears to be hilly, with a local relief of several hundred feet. At one point in the SE.¼ sec. 5, T. 4 S., R. 3 W., it projects up through the Healdton sand zone into the base of the overlying blue shales, within 800 feet of the surface of the ground, causing a dry hole (Sinclair Oil & Gas Co.'s No. 7 Million & Thomas) to appear in the midst of the field. Nearby wells drilled to 1,100 or 1,200 feet do not reach the Ordovician. In secs. 15 and 16, T. 4 S., R. 3 W., its depth ranges from 1,200 to 1,500 feet or more, and it is below 2,000 feet in the southeastern part of the field, where a much thicker Pennsylvanian section appears. Powers[36] recognizes three moderately productive Pennsylvanian oil sands (the Jackson, Simpson, and Pugh sands) below the Healdton sand zone in the southeastern half of the field, which apparently terminate against the Ordovician buried limestone hills after the manner of the lower oil sands in the Brock field.

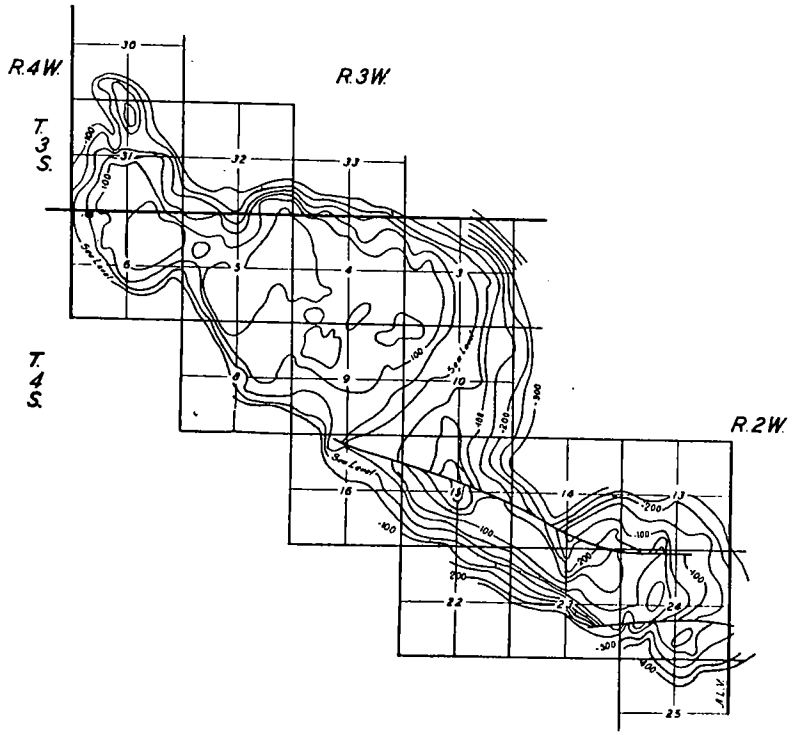



Figure 38. Structure map of Healdton field. Contours on Healdton sand zone. (After Bartram and Roark).

36. Op. cit.

Bartram and Roark[37] say that the Ordovician formations penetrated in the Healdton field are believed to include the Viola limestone, Simpson formation, and Arbuckle limestone. They state that the first two have been identified by fossils, and that the Simpson formation includes the Orodvician productive horizon in two wells (in sec. 4, T. 4 S., R. 3 W.). Complete information from the Ordovician wells is not available, but it is supposed that the Simpson formation underlies the Pennsylvanian rocks across the central and southeastern parts of sec. 4, T. 4 S., R. 3 W., with the Arbuckle appearing to the south and southwest and the Viola to the north.

The straightness of the southwest edge of the Healdton field, and the steep Pennsylvanian dips along that edge, suggest the possibility of a fault bordering the buried Ordovician hills on that side, comparable to the Criner fault along the corresponding side of the Criner Hills, but this is wholly conjectural. The situation in the Brock field and the Criner Hills, folds of similar age and orogenic history to those at Hewitt and Healdton, suggests that dips in the Ordovician rocks at Healdton are probably much steeper than in the overlying Pennsylvanian. This makes it rather difficult to locate a particular horizon in the Ordovician except by accident. If the Wilcox and other sand members of the Simpson formation are present beneath the Healdton field, and with any such thickness as they possess in their nearest outcrops in the Arbuckle Mountains, they may yet yield splendid production in this pool. Their presence is open to question, but the prospect warrants further exploration.

## HEWITT[38]

**By**

**Geo. E. Burton**

### LOCATION

The Hewitt oil field is located in secs. 9, 10, 15, 16, 21, 22, 23, 27, and 28, T. 4 S., R. 2 W., Carter County, Oklahoma, fifteen miles west and two miles north of Ardmore. It is only four miles east of the east end of the great Healdton oil pool. There is a small pool lying to the southeast of the Hewitt field which is sometimes regarded as an extension. In this paper, however, only the Hewitt field proper will be discussed.

### HISTORY

The Hewitt field was discovered June 5, 1919, when the Texas Company No. 1, A. E. Denny, NE.¼ NW.¼ NW.¼ NW.¼ sec. 27, T. 4 S., R. 2 W., found big pay sand at a depth of 2,100-3,134 feet which

37. Op. cit.
38. Geo. E. Burton, Humble Oil and Refining Company, Box 58, Ardmore, Okla.

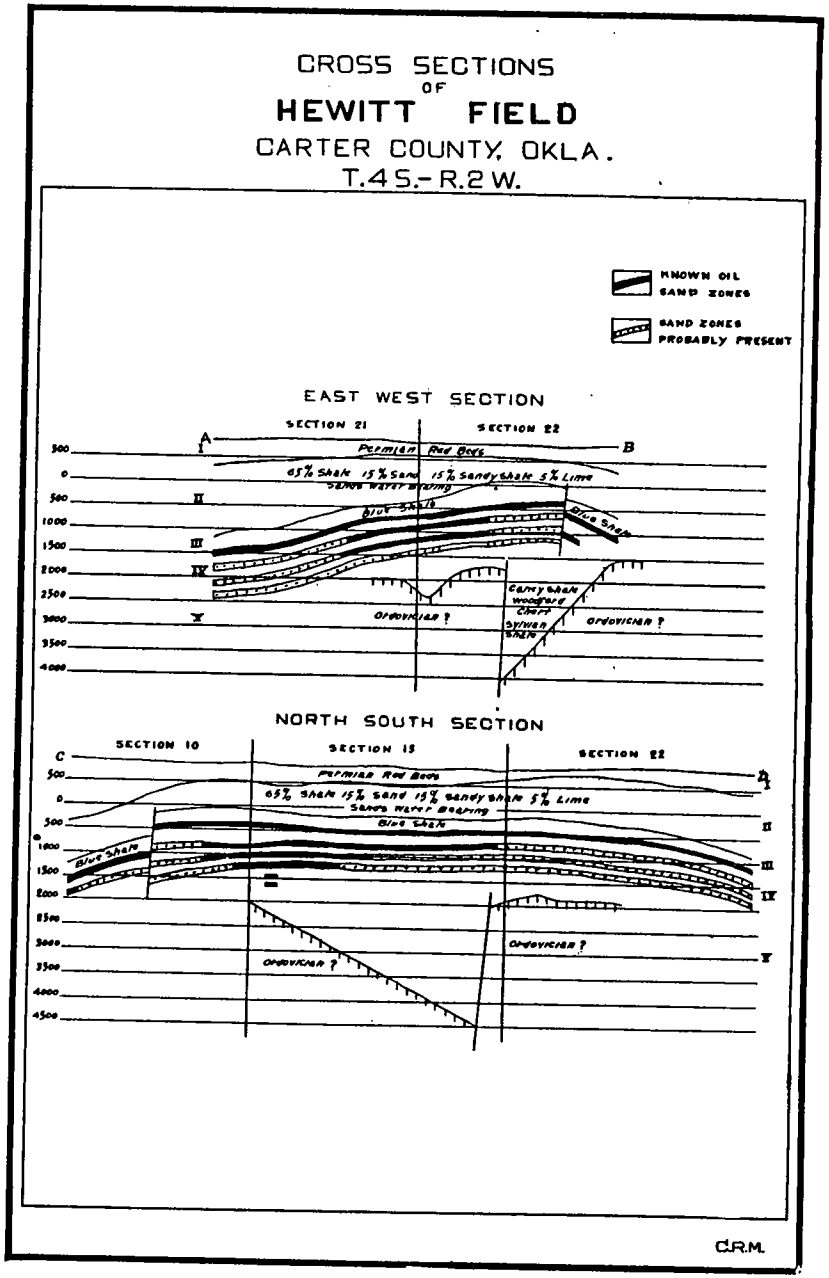



Figure 39

flowed an initial production of 410 barrels of oil. This location was made on a surface anticline, but after the field was developed, it was found that the discovery well was very near the south edge of the field. The production from the Hewitt field reached its maximum during the month of September, 1921, when the average daily production over the entire month was 43,902 barrels of oil.

In June, 1922, Baker and Strawn in their Dillard No. 8-B, 1,610 feet east and 290 feet south of NW. cor. sec. 22, T. 4 S., R. 2 W., discovered deep production in lime from 2,863-2,878 which made 450 barrels initial production. This production was reported as coming from the Viola lime at the time of completion. About 24 wells were drilled in the vicinity of the Baker Strawn discovery in search of the deep production. The Carter Oil Company No. 33 Noble, SW.¼ NE.¼ NE.¼ sec. 21, T. 4 S., R. 2 W., was the most sensational find, making 14,000 barrels initial production at 2,941-2,942 feet. On account of the quick decline of this lime production and the intensely folded and faulted condition of the pre-Pennsylvanian rocks the search for this production was soon abandoned. It has been only a small factor in the production of the field.

### GEOLOGY

The rocks at the surface in the Hewitt field are Permian red beds. Drilling in the field has revealed five zones (Figure 39) as follows:

*Zone* 1, Permian red beds, 1,300 feet thick around the edge of the field, thinning to 200 feet over the center of the field;

*Zone* 2, made up of about 65 per cent shale, 15 per cent sand, 15 per cent sandy shale, and 5 per cent lime, most of the sands water bearing;

*Zone* 3, a rather regular blue shale zone maintaining a thickness of about 300 feet over the entire field;

*Zone* 4, 1,400 feet of sand and shale, the main oil bearing zone in the field, with six more or less well developed, fairly continuous, sands and numerous sand lenses; and

*Zone* 5, an irregular zone made up of limestones, shales, and some sandstones, with as much as 1,400 feet of limestone in some of the wells.

Zone 1 is Permian red beds. Zones 2, 3, and 4 are Pennsylvanian. Zone 5 is pre-Pennsylvanian and in this zone investigators have reported Caney shale, Woodford chert, Viola lime, and probably Simpson formation. There is an unconformity between the Permian red beds and



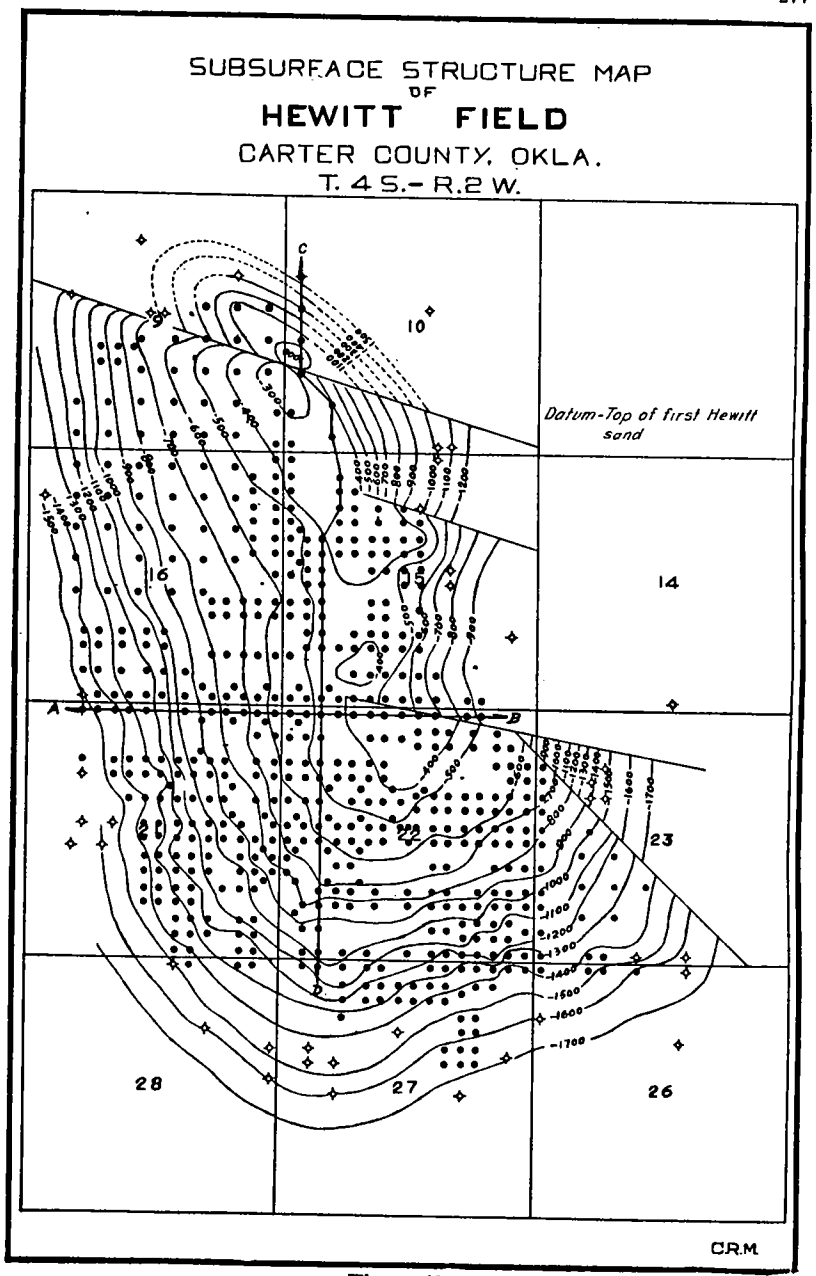



Figure 40

Pennsylvanian (between zones 1 and 2) and another unconformity between Pennsylvanian and pre-Pennsylvanian (between zones 4 and 5).

### STRUCTURE

There seems to be surface structure at Hewitt, although the high point on the surface high is somewhat south of the subsurface high. At the time the discovery of oil was made there was considerable open acreage in this area and this surface structure was, of course, the only geological aid to buying. The result was that what afterwards proved to be a great deal of the best acreage commanded small prices or was unsold while some of the acreage that brought high prices was later proved barren of oil. The subsurface fold[39] mapped (Fig. 40) on the top of the first Hewitt sand is a north-south trending, somewhat faulted, anticlinal fold, the highest point on which is just north of the SE. cor. sec. 9, T. 4 S., R. 2 W.

Structural conditions in the rocks below the Pennsylvanian are quite complex. Fig. 41 shows a possible interpretation of these conditions. North of the fault cutting the north part of section 22 and the SW. cor. section 16, it is probable that the contours represent the dip and strike of what is usually regarded as Viola lime. The contours south of this fault probably represent the topography of the buried Viola ridge.

Two sections are shown (Fig. 39) one north-south and the other east-west across the field. These sections show the unconformity between the red beds and the Pennsylvanian and also the unconformity between Pennsylvanian and pre-Pennsylvanian.

### ECONOMIC IMPORTANCE

At the end of 1927 Hewitt had 806 producing wells, giving a total production of 60,349,876 barrels. There are 3,050 producing acres in the Hewitt field, the per acre yield to the end of 1927 would then be 19,786 barrels. The decline curve for Hewitt shows that at the end of 1941 the average production per well per day will be 2.8 barrels. Up to the end of 1941 it is figured that with present methods of production, an additional 22,920,000 barrels will be produced. This will be an additional per acre yield of 7,515, making a total ultimate per acre yield of 27,301 barrels per acre. It is possible that by 1941 oil may be priced so that the wells will continue to be produced even when the average per well per day becomes much less than 2.8 barrels. The Hewitt field has made good money for its producers because its flush production came when the general production of oil was low, with consequent handsome prices.

39. Map made by W. E. Hubbard, Humble Oil & Refining Company.

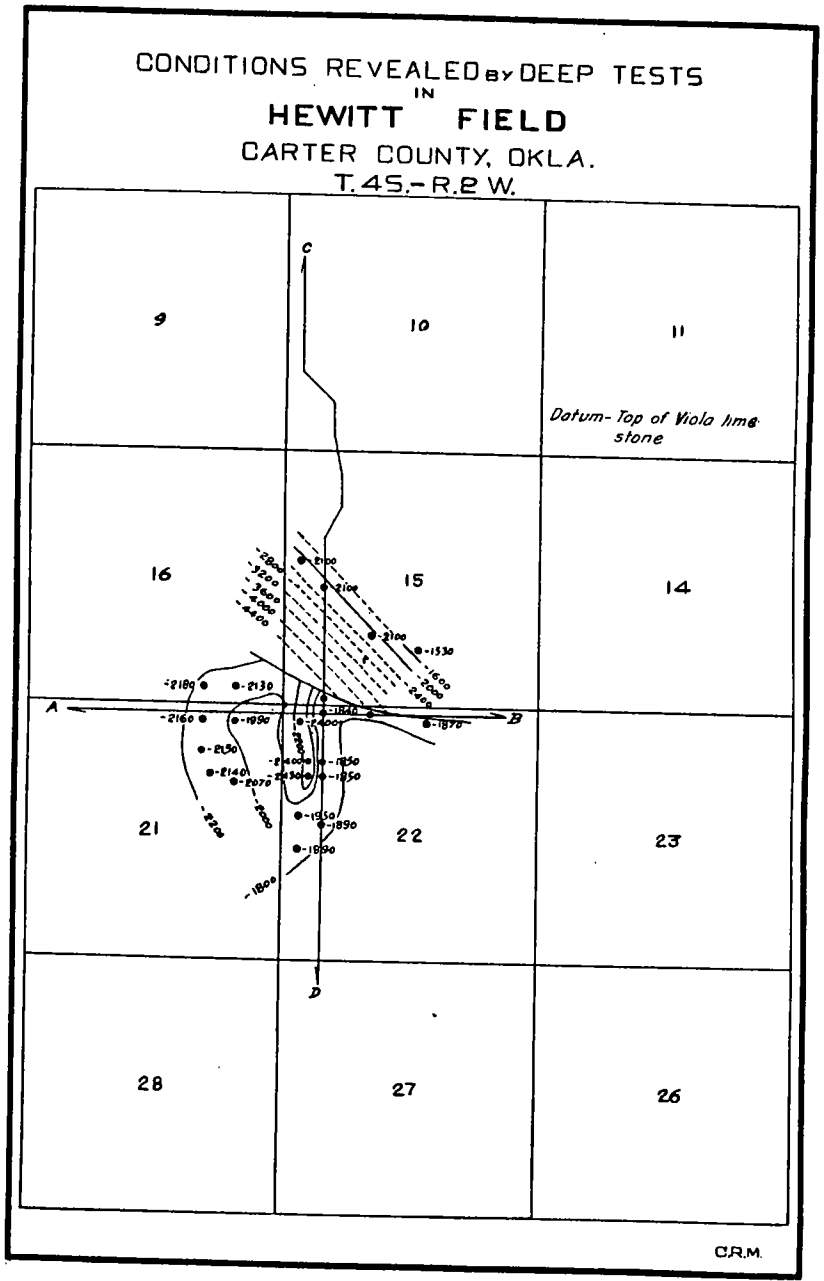



Figure 41

*Log of the Texas Co., No. 7, V. E. Dillard.*
SE.¼ NE.¼ NW.¼ NE.¼ sec. 27, T. 4 S., R. 2 W. Completed October 6, 1920.

| Formation | Top | Bottom |
|---|---|---|
| surface soil | 0 | 8 |
| mud | 8 | 45 |
| sand | 45 | 70 |
| red bed | 70 | 80 |
| sand | 80 | 130 |
| red bed | 130 | 160 |
| shale | 160 | 170 |
| red bed | 170 | 190 |
| sand | 190 | 205 |
| red bed | 205 | 230 |
| shale | 230 | 240 |
| sand | 240 | 265 |
| red bed | 265 | 275 |
| shale | 275 | 300 |
| sand | 300 | 380 |
| shale | 380 | 405 |
| sand | 405 | 415 |
| shale | 415 | 465 |
| sand | 465 | 550 |
| shale | 550 | 555 |
| lime | 555 | 560 |
| blue shale | 560 | 600 |
| sand | 600 | 615 |
| shale | 615 | 640 |
| sand | 640 | 670 |
| lime | 670 | 675 |
| shale | 675 | 825 |
| lime | 825 | 840 |
| shale | 840 | 1000 |
| sand | 1000 | 1010 |
| shale | 1010 | 1150 |
| sand | 1150 | 1160 |
| shale | 1160 | 1250 |
| lime | 1250 | 1260 |
| shale | 1260 | 1360 |
| lime | 1360 | 1370 |
| shale | 1370 | 1475 |
| sand | 1475 | 1500 |
| shale | 1500 | 1645 |
| sand | 1645 | 1700 |
| shale | 1700 | 1820 |
| sand | 1820 | 1845 |
| shale | 1845 | 1923 |
| lime | 1923 | 1930 |
| shale | 1930 | 2000 |
| sand | 2000 | 2020 |
| shale | 2020 | 2266 |
| lime | 2266 | 2271 |
| sandy shale | 2271 | 2298 |
| oil sand (Hewitt sand) | 2298 | 2351 |

## SHOLOM ALECHEM[40]

By

**A. M. Meyer**

### ACKNOWLEDGMENTS

The writer wishes to thank E. D. Luman for permission to use material in the files of the Atlantic Oil Producing Co., Robert Roth and Bruce Harlton for their contributions, and C. W. Tomlinson for criticising manuscript.

### LOCATION

The Sholom Alechem field at this time extends northwest from the cen. sec. 11, T. 2 S., R. 3 W., to the cen. sec. 12, T. 1 S., R. 4 W. It is one and one-fourth miles across at its widest part but averages about three-fourths mile.

### HISTORY

The discovery well of the Sholom Alechem field was the Humble Oil and Refining Company No. 1 Jennings in the SW.¼ SW.¼ SE.¼ sec. 28, T. 1 S., R. 3 W., completed in December, 1923. It was drilled

40. A. M. Meyer, Atlantic Oil Producing Co., Ardmore, Okla.



to a total depth of 4,065 feet and had an initial production of 90 barrels on the pump after plugging back to 3,382 feet. It was one of the few standard tool wells drilled in the field.

The second well to be completed was the Magnolia Petroleum Company No. 1 Hardin in the SE. ¼ SE.¼ NE.¼ sec. 19, T. 1 S., R. 3 W., which was completed in April, 1924 with an initial production of about 100 barrels. From these two wells the field has spread to its present state of development.

### STRATIGRAPHY

Lenticular is the one term descriptive of all the sediments penetrated by the drill. Red beds and sandstones, with some conglomerates which outcrop over the field, extend to a depth of 1,400 to 2,000 feet below the surface.

Beds probably belonging to the Pontotoc of upper Pennsylvanian age are found below the red beds. They consist of blue, brown, and gray shales with some red shale interbedded with coarse and fine sandstones, conglomerate, and some limestones. As a rule the clastic sediments become coarser toward the unconformable contact of the Pontotoc with the Glenn of middle Pennsylvanian age. The thickness of this coarse material at the base of the Pontotoc varies from 150 to 800 feet and seems to be thicker along the structure than it is in wells drilled low or off the structure. Beds belonging to Glenn of middle Pennsylvanian age are in contact with the Pontotoc.

In the northwest part of the field along the highest parts of the structure a dense to crystalline white limestone of Glenn age is found in contact with the Pontotoc. It is from 200 to 400 feet thick with a few of the logs showing an even greater thickness. Locally it carries shows of oil and gas. This lime is best developed in sec. 19, T. 1 S., R. 3 W., and northwestward. Southeast of sec. 19, T. 1 S., R. 3 W., it breaks up into a number of thinner limestones and in a number of logs of wells drilled in the southern part of T. 1 S., R. 3 W., it cannot be recognized with any degree of satisfaction. This lime horizon forms the best general marker in the field.

A cross-section (Map. No. XXVIII) from the northwest part of the field to the southeast part which illustrates the change in this lime, was made using the logs of wells characteristic of the part of the field in which they were drilled. One well, Wirt Franklin and Atlantic No. 1 Brittain, is producing from the Pontotoc. With but few other exceptions the production is coming from below the lime horizon.

The producing sands can in general be divided into three sand zones. The individual sandstone beds in all the horizons are very lenticular.

The first sand zone is from 20 to 150 feet below the base of the big lime section, which is from 0 to 150 feet thick. The best production from this zone is found in that part of the field north and west of sec. 19, T. 1 S., R. 3 W. It also produced in some of the wells in secs. 32 and 33, T. 1 S., R. 3 W., and in T. 2 S., R. 3 W. It is not represented in a number of the wells drilled in the field.

The second sand zone is about 300 feet below the top of the first. It is from a few feet to 200 feet thick and is missing in some of the wells.

The third sand zone which is the most persistent is from 250 to 350 feet below the top of the second.

Some of the wells in the field have found production from sands that do not fit into any of the above zones. The wells that have been drilled below the third sand zone in the northwest part of the field found a thin series of limes at approximately 600 feet below the top of the third sand horizon and then went into black shale. In the southeast part of the field, at the horizon of this black shale, a series of thin sands and sandy shales are found from which some production has been obtained. (See log of Schermerhorn-Ardmore Co. No. 2 Lyles in the cross-section). Robert Roth[41] of the Atlantic Oil Producing Co. who has examined cuttings from a number of wells drilled in the field has contributed the following on the stratigraphy:

> Starting from the surface down we have various thicknesses of the so-called Permian red beds, usually about 1,500 feet. Below this we find the first zone which can in any way be called a true zone. It is about 400 feet thick and consists of very arkosic sand, separated by thin beds of various colored red and gray shales and dolomites. At the base of this zone there is a gradational but rather sharp demarcation from the next zone. This zone is usually very conglomeratic and chert pebbles predominate, though arkose is still present to a considerable extent. This second zone is also about 400 feet thick, and lies above a point where fossils are first found which lived in the depositing sea. These two zones are very clastic; they were deposited with great rapidity; some of the arkoses may almost be called a granite wash; they show practically no weathering; their deposition appears to be purely mechanical; and probably were derived from the Arbuckle and Wichita Mountains. In this interesting zone of coarse sedimentation one may read the rapid erosion of nearby land masses as the cherty limestones were removed and the pre-Cambrian granites were brought to the surface and their erosion contributed the final arkoses. The advancing sea (?) which deposited these zones seems to have covered an erosional peneplain as far as the upper Pennsylvanian is concerned. The Pennsylvanian rocks composing the sediments involved in this peneplanation were highly folded and probably faulted to considerable extent. To prove this the first fossiliferous

41. Roth, Robert, Personal communication. (As the systematic microscopic study of well cuttings is in its infancy in southern Oklahoma, the contributions by Roth and Harlton should be considered as progress reports and subject to change as more information becomes available on this and adjoining areas.)



> formations penetrated by the drill differ widely in different sections. The wells drilling in on the sides of the peneplaned folds encounter younger beds and a much increased thickening of the shales, sands, and chert beds above the thick limestone horizon found in the field. No attempt has definitely been made to tie this limestone with any outcrop in the Glenn formation as exposed, principally because a good faunal section of the Glenn has not yet been obtained. Some light on the age of this massive limestone may be given by comparison of the fauna contained in it and the shales above and below with the Pennsylvanian found north of the Arbuckle Mountains. The wells which are off the Sholom Alechem structure show considerable shales above the limestone. The fauna found in the upper part of these shales suggests a fairly close correlation with the Belle City and Francis. The shales immediately above the limestone and the limestone itself have many forms which are also contained in the Holdenville. The shales below this limestone are in many cases non-fossiliferous and in many cases those fossils which are found in the cuttings probably came from above. However, it seems that these lower shales which contain the main producing horizon are probably of Wetumka and Wewoka age, though in some cases it seems that part of these lower shales contain a fauna which is very similar to some that I have found in the Stuart and Sonora groups. In all events they certainly are not any older if as old.

There is some controversy over the part of the Glenn in which the Pennsylvanian section in the Sholom Alechem field should be placed. At this time the writer tentatively correlates the section from the top of the lime to approximately 600 feet below the third sand zone, with the Deese. The top of the black shale horizon in the northwest part of the field and the top of the sand and sandy shale series in the southeast part of the field would then be the contact of the Deese and Dornick Hills.

Bruce Harlton of the Amerada Petroleum Corporation has kindly contributed the following on the paleontology of the Sholom Alechem field:

> The surface formation of the Sholem Alechem field is in the Wichita series of Permian age and varies in thickness from 1,580-1,650 feet. Near the top of this formation there occurs a fossiliferous limestone zone which carries abundant fossils:
>
> Bairdia sp.
> Jonesina arcuata (Bean) | Rhombopora lepidodendroidae Meek and other bryozoas
>
> Underlying the Wichita formation there occurs the Pontotoc series of upper Pennsylvanian age, which is composed of conglomeratic material containing mainly quartzite, feldspar, and chert. Its thickness varies from 100-300 feet. The beginning of the Pontotoc is marked by a great hiatus as the Hoxbar formation is entirely missing on top of the structure. The Pontotoc series is underlain by the upper Glenn or Deese formation of middle Pennsylvanian age. The top of this formation may be encountered anywhere from 1,700-1,900 feet.
>
> The Deese formation consists in its upper portion mainly of limestone. The first 100 feet is a rapidly changing unit, sometimes it consists of sandy limestone and again it may be sandstones, shales, and thin limestones.

Below this 100-foot unit there occurs a solid limestone body anywhere from 200-400 feet in thickness. The lower portion sometimes is interbedded with thin shale layers. This entire body is very fossiliferous and contains very diagnostic fossils:

Bradyina holdenvillensis Harlton
Tolypammina grahamensis Harlton
Orobias texana (Harlton)
Crisrostomun jeffersonensis Harlton
Globivalvulina gaptankensis Harlton
Cornuspira harltoni (Cushman and Waters)
Textularia grahamensis Cushman and Waters
Stachia pupoides (Brady)
Climacammina antiqua Brady
Textularia maxima var. depressa Schwellwien, etc., etc.
Endothyra bowmani Phillips
E. involuta Galloway and Harlton
Ammobaculites rectum (Brady)
Tetrataxis decurrens (Brady)
Ammphissites dattoensis Harlton
A. centrinota Ulrich
Hollina granifera Ulrich
Kirkbya permiana n. var.
Bairdia subelongata Jones and Kirkby

The upper Deese limestone is underlain by shales, sandstones, and thin limestones.

In the lower formations of the Sholom Alechem field there occur three zones in which oil is found. The upper two zones are determined, based upon paleontological evidence, as belonging to the Deese formation. The third zone suggests lower Glenn in age.

*Log of Amerada Pet. Corp., Hanson No. 2.*

Sec. 12, T. 1 S., R. 4 W.

| | Depth | Formation |
|---|---|---|
| WICHITA | 998 | Buff fine text. ss. |
| | 1121-40 | Buff fine text. ss. |
| | 1140-90 | Do. with ls. and shale partings |
| | 1190-1439 | Buff fine text. ss. with occasional bed of shale |
| | 1439-47 | Buff sandy limestone |
| | 1447-54 | Buff fine text. ss. |
| | 1522-74 | Buff fine text. ss. |
| PONTOTOC | 1595-1658 | Cgl. ss. with coarse quartzite and feldspar |
| | 1658-63 | Cgl. made up of coarse quartzite and chert |
| | 1663-1888 | Cgl. made up of chert, feldspar and coarse quartzite, etc. |
| UPPER GLENN | 1888-1917 | Buff sandy ls.<br>Fusulina secalica Say<br>Rhombopora lepidodendroidae Meek<br>Orobias bassleri Galloway and Harlton<br>Amphissites dattonensis Harlton |
| | 1917-47 | Buff calc. ss. with chert partings<br>Fusulina secalica Say<br>Rhombopora lepidodendroidae Meek |
| | 1947-60 | Buff sandy ls.<br>Fusulina secalica Say<br>Rhombopora lepidodendroidae Meek<br>Abundant Crinoids<br>Tolypammina grahamensis Harlton<br>Fusulina bocki Moller<br>Orobias texana Harlton |

(Continued on page 285)



| | Depth | Formation |
|---|---|---|
| UPPER GLENN | 1960-2256 | Buff fine grained ls.<br>Fusulina secalica Say<br>Rhombopora lepidoednroidae<br>Tolypammina grahamensis Harlton<br>Bradyina holdenvillensis Harlton<br>Amphissites dattonensis Harlton<br>Bairdia subelongata Kirby<br>Ammobaculites rectum (Brady)<br>Climacammina antiqua Brady<br>Cornuspira harltoni Cushman and Waters<br>Cornuspira involuta Galloway and Harlton<br>Textularia grahamensis Cushman and Waters |
| | 2256-2306 | Buff sandy ls.<br>Rhombopora lepidoednroidae Meek<br>Tolypammina grahamensis Harlton |
| | 2306-35 | Buff ls. with shale<br>Rhombopora lepidodendroidae Meek<br>Fusulina secalica Say<br>Tolypammina grahamensis Harlton |
| | 2350-52 | Greenish fine grained shale |
| | 2352-62 | Buff sandy ls. |
| | 2362-2414 | Buff fine grained ls.<br>Rhombopora lepideodrnoidae Meek<br>Fusulina secalica Say |
| | 2414-49 | Buff fine grained sandy ls. |
| | 2449-69 | Buff calc. ss. |
| | 2469-2525 | Green shale with ls. and ss. Partings<br>Rhombopora lepidodendroidae Meek |
| | 2525-29 | Buff ls. with shale |
| | 2529-49 | Green shale with cgl. partings<br>Fusulina cylindrica Fischer<br>Crinoids |
| | 2549-76 | Green shale with ls. and ss. partings<br>Fusulina secalica Say<br>Tolypammina grahemensis Harlton |
| | 2576-2609 | Green shale with ls.<br>Calcitornella tuberculata Galloway and Harlton |
| | 2642 | Buff ss. (saturated with oil) |
| | 2649-94 | Grey green shale with ss. partings<br>Rhombopora lepidodendroidae Meek |
| | 2700-40 | Buff ls. with ss.<br>Tolypammina grahamensis Harlton<br>Crinoids<br>Fusulina secalica Say<br>Rhombopora lepidodendroidae Meek<br>Shell fragments |
| | 2760-2850 | Green fine grained shale<br>Crinoids, shell fragments<br>Tolypammina grahamensis Harlton<br>Ammodiscus incertus d'Orbigny<br>Bairdia subelongata Jones and Kirkby |
| | 2875-80 | Buff fine text. ss. |
| | 2880-2910 | Buff cherty ls. with ss.<br>Rhombopora lepidodendroidae Meek<br>Fusulina cylindrica Fischer<br>Crinoids |
| | 2910-20 | Buff. ss. with ls. and shale partings<br>Rhombopora lepidodendroidae Meek<br>Healdia boggyensis Harlton |
| | 2920-36 | Buff ls. with ss. and shale<br>Tolypammina grahamensis Harlton<br>Crinoids |
| | 2936-39 | Buff ss. with shale and ls. |
| | 2939-41 | Green and red shale with ls. and ss. partings.<br>Crinoids<br>Tolypammina grahemsis Harlton |

(Continued on page 286)

| | Depth | Formation |
|---|---|---|
| UPPER GLENN | 2941-43 | Buff fine text. ss. (saturated with oil) |
| | 2943-64 | Buff cherty ls. with shale and ss. |
| | 2964-73 | Buff ss. with shale |
| | | Cribrostomum jeffersonensis Harlton |
| | | Tuberitine bulbacea Galloway and Harlton |
| | | Healdia sp. (broken) |
| | 3000-05 | Buff very fine text. ss. |
| | 3029-3072 | Buff ss. with ls. and shale |
| | | Rhombopora lepidodendroidae Meek |
| | | Crinoids |
| | | Tolypammina grahamensis Harlton |
| | | Climacammina gracilis Moller |
| | | Ammodiscus sp. |
| | [Still drilling in upper Glenn (Deese) near base.] | |

*Log of Amerada Pet. Corp., Hanson No. 1.*

Sec. 12, T. 1 S., R. 4 W.

| | Depth | Formation |
|---|---|---|
| WICHITA | 20-69 | Grey impure limestone |
| | | Bairdia n. sp. |
| | | Jonesina arcuata (Bean) |
| | | Rhombopora lepidodendroidae Meek |
| | | Fenestella sp. |
| | 1314½-15½ | Buff fine grained pyrit. shale |
| | 1329-63 | Buff fine text. ss.. |
| | 1363-68 | Buff argill. ss. |
| | 1368-76½ | Buff ss. with shale |
| | 1376½-84 | Buff pure ang. ss. |
| | 1384-1401 | Buff pyrit. shaly ss. |
| | 1401-08 | Red shale with ls. and ss. |
| | 1408-10 | Green glauconitic shale |
| | 1410-12 | Green shale with ss. |
| | 1412-21 | Grey argill. ss. |
| | 1421-23 | Buff pure ang. ss. |
| | 1423-23.9 | Do. with gray shale |
| | 1425-65 | Buff fine text. ss. |
| | 1465-85 | Buff ss. with shale |
| | 1485-92 | Do. with shale and ls. |
| | 1500-1624½ | Buff pyrit. ss. (This sandstone gradually grades into the Pontotoc series). |
| PONTOTOC | 1624½-27 | Do. with coarse quartz pebbles |
| | 1627-34 | Buff fine text. ss. |
| | 1634-50 | Do. with quartz pebbles, chert, and shale |
| | 1650-1709 | Conglomerate |
| UPPER GLENN | 1709-21 | Green argill. ss. |
| | | Amphissites centromata U. & B. |
| | | A. dattonensis Harlton |
| | | Rhombopora lepidodendroidae Meek |
| | | Orobias texana Harlton |
| | | O. bassleri Galloway and Harlton |
| | 1721-47 | Grey argill. ss. with chert |
| | | Staffella texana Harlton |
| | | Tolypammina grahamensis Harlton |
| | | Crinoids |

(Continued on page 287)



| | Depth | Formation |
|---|---|---|
| UPPER GLENN | 1747½-52 | Grey fine grained shale with ls. and chert |
| | 1752-58 | Buff fine grained ls. |
| | | Fusulina secalica Say |
| | | F. bocki Moller |
| | 1748-93 | Buff. ss. with shale and ls. and chert, some green shale partings |
| | 1793-2010 | Buff to grey fine grained ls. |
| | | Bradyina holdenvillensis Harlton |
| | | Globivalvulina gaptankensis Harlton |
| | | Cornuspira harltoni Cushman and Waters |
| | | Climacammina antiqua Brady |
| | | Endothyra involuta Galloway and Harlton |
| | | Fusulina cylindrica Fischer |
| | | Tuberitina bulbacea Galloway and Harlton |
| | | Hollina granifera Ulrich |
| | | Amphissites dattonensis Harlton |
| | | Bairdia subelongata Jones and Kirkby |
| | | Fusulina secalica Say |
| | 2010-41 | Do. with interbedded shale |
| | | Fusulina secalica Say |
| | | Rhombopora lepidodendroidae Meek |
| | 2041-47 | Buff crinoidal ls. |
| | | Fusulina secalica Say |
| | | Fusulina cylindrica Fischer |
| | 2047-69 | Buff crinoidal ls. with few shale cavings |
| | | Fenestella sp. |
| | | Fusulina bocki Moller |
| | | Bradyina holdenvillensis Harlton |
| | | Rhombopora lepidodendroidae Meek |
| | 2069-87 | Buff crinoidal ls. with abundant concretions |
| | 2087-90 | Buff fine text. ss. |
| | 2090-93 | Buff siliceous crinoidal ls. |
| | 2097-98 | Buff fine text. ss. |
| | 2098-2560 | Missing |
| | 2560 | Buff ss. with few shale partings |
| | | Very abundant Ammodiscus and Crinoids |
| | | Calcitornella tuberculata Galloway and Harlton |
| | 2677-85 | Buff fine text. ss. |
| | 2853-59 | Do. with shale partings |
| | | Healdia boggyensis ? Harlton |
| | 2931 | Brown ss. (saturated with oil) |
| | 2941 | Grey argillaceous ls. |

## STRUCTURE

The structure contoured on the Glenn is an anticlinal fold with a maximum closure of more than 1,200 feet, with a northwest-southeast trend typical of the southern Oklahoma fields. The anticline is modified by nosings on the flanks and by rapid changes in the amount of dip.

In the northwest part of the field there is a dip along the southwest flank which amounts to as much as 520 feet between locations. At the base of this steep dip some of the best wells in the field have been brought in. The contours of the structure map (Map No. XXIX) are drawn on a datum approximately 535 feet below the top of the first sand zone.

### PRODUCTION

The highest single initial production in the field was 2,973 barrels. The average initial production has been about 280 barrels. Decline curves on a number of the wells in the field show an expected ultimate yield of 6,000 barrels per acre for some of the smaller wells to 18,000 barrels for some of its better wells. The average decline is very slow.

### *Log of Schermerhorn-Ardmore Co. No. 1 Lyles.*

NW.¼ SE.¼ NW.¼ sec. 11, T. 2 S., R. W. Completed June 26, 1926.

| Formation | Top | Bottom |
|---|---|---|
| hard sand | 0 | 27 |
| red bed | 27 | 90 |
| bro. sand & lime rock | 90 | 185 |
| strks of sand & red bed | 185 | 245 |
| red bed | 245 | 375 |
| strks. of sand red bed | 375 | 470 |
| hard sand, sand rock, streak red bed | 470 | 530 |
| red bed | 530 | 720 |
| red bed & sand rock | 720 | 780 |
| hard sand | 780 | 800 |
| red bed | 800 | 890 |
| sand hard | 890 | 910 |
| red bed | 910 | 960 |
| hard sand | 960 | 970 |
| sticky red bed | 970 | 1070 |
| red bed | 1070 | 1120 |
| hard sand | 1120 | 1135 |
| red bed | 1135 | 1202 |
| lime shell | 1202 | 1205 |
| broken lime | 1205 | 1209 |
| stky. shale & lime shs. | 1209 | 1298 |
| red bed strks. of shale | 1298 | 1350 |
| hard sand | 1350 | 1375 |
| blue shale | 1375 | 1428 |
| sticky shale | 1428 | 1470 |
| hard sand | 1470 | 1490 |
| lime | 1490 | 1495 |
| lime | 1495 | 1497 |
| sticky shale | 1497 | 1530 |
| lime shells | 1530 | 1532 |
| stick shale | 1532 | 1570 |
| shale & shells | 1570 | 1590 |
| lime | 1590 | 1615 |
| sticky shale lime shells | 1615 | 1652 |
| broken lime | 1652 | 1672 |
| shale & hard sand | 1672 | 1703 |
| hard lime & sand | 1703 | 1705 |
| lime & strks. of sand | 1705 | 1730 |
| sticky shale & lime | 1730 | 1752 |
| broken lime | 1752 | 1800 |
| stky. shale & lime shs. | 1800 | 1830 |
| broken lime | 1830 | 1868 |
| broken lime & shale | 1868 | 1900 |
| sticky shale & shells | 1900 | 1913 |
| broken lime | 1913 | 1962 |
| blue shale | 1962 | 2000 |
| sticky shale | 2000 | 2117 |
| grey sand | 2117 | 2121 |
| sticky shale | 2121 | 2170 |
| hard sand | 2170 | 2173 |
| hard shale | 2173 | 2187 |
| hard shale | 2187 | 2190 |
| broken lime | 2190 | 2200 |
| sticky shale | 2200 | 2240 |
| hard shale | 2240 | 2244 |
| shale & shells | 2244 | 2253 |
| FIRST SAND ZONE — sand lime oil sand (Sand 1 (No Pay)) | 2253 | 2258 |
| broken lime hard (Sand 1 (No Pay)) | 2258 | 2270 |
| hard shale (Sand 1 (No Pay)) | 2270 | 2281 |
| sandy lime (Sand 1 (No Pay)) | 2281 | 2289 |
| sticky shale | 2289 | 2293 |
| hard sand | 2293 | 2305 |
| lime | 2305 | 2311 |
| hard shale | 2311 | 2320 |
| sticky shale | 2320 | 2347 |
| broken lime | 2347 | 2350 |

(Continued on page 289)



| Formation | Top | Bottom |
|---|---|---|
| hard sandy shale | 2350 | 2364 |
| hard shale | 2364 | 2370 |
| sticky shale | 2370 | 2400 |
| sandy shale | 2400 | 2415 |
| sticky shale | 2415 | 2439 |
| tuff gumbo | 2439 | 2445 |
| gumbo | 2445 | 2450 |
| sticky shale | 2450 | 2480 |
| sandy shale | 2480 | 2500 |
| hard shale | 2500 | 2508 |
| blue shale | 2508 | 2570 |
| sticky shale | 2570 | 2606 |
| SECOND SAND ZONE — lime sandy (Sand 3 (No. Pay)) | 2606 | 2609 |
| hard sandy lime (Sand 3 (No. Pay)) | 2609 | 2615 |
| light brown sand (Sand 3 (No. Pay)) | 2615 | 2619 |
| sandy shale (Sand 3 (No. Pay)) | 2619 | 2625 |
| sandy lime (Sand 3 (No. Pay)) | 2625 | 2630 |
| hard sand (Sand 3 (No. Pay)) | 2630 | 2635 |
| sand & shale | 2635 | 2640 |
| blue shale | 2640 | 2657 |
| sandy shale | 2657 | 2663 |
| gumbo | 2663 | 2670 |
| brown & blue shale | 2670 | 2690 |
| sticky shale | 2690 | 2700 |
| sandy shale | 2700 | 2710 |
| hard sandy lime | 2710 | 2712 |
| sandy lime | 2712 | 2714 |
| brown sand | 2714 | 2717 |
| gray sand | 2717 | 2726 |
| sticky shale | 2726 | 2731 |
| sandy lime | 2731 | 2746 |
| sticky shale | 2746 | 2765 |
| sandy lime (Sand 6 (No Pay)) | 2765 | 2770 |
| pink shale (Sand 6 (No Pay)) | 2270 | 2773 |
| broken oil sand (Sand 6 (No Pay)) | 2773 | 2777 |
| hard sandy lime (Sand 6 (No Pay)) | 2777 | 2779 |
| sandy lime show gas (Sand 6 (No Pay)) | 2779 | 2781 |
| sandy shale | 2781 | 2788 |
| blue shale | 2788 | 2795 |
| sandy shale | 2795 | 2810 |
| sticky shale sdy shale | 2810 | 2822 |
| lime shells | 2822 | 2833 |
| sandy shale | 2833 | 2838 |
| blue shale | 2838 | 2906 |
| sandy shale | 2906 | 2914 |
| THIRD SAND ZONE — sandy shale oil sand (Sand 8 (Main Pay, SE.¼)) | 2914 | 2916 |
| broken oil sand (Sand 8 (Main Pay, SE.¼)) | 2916 | 2926 |
| hard sh. & shells (Sand 8 (Main Pay, SE.¼)) | 2926 | 2932 |
| broken oil sand (Sand 8 (Main Pay, SE.¼)) | 2932 | 2937 |
| brown shale (Sand 8 (Main Pay, SE.¼)) | 2937 | 2945 |
| lime shells (Sand 8 (Main Pay, SE.¼)) | 2945 | 2946 |
| brn. and blue shale (Sand 8 (Main Pay, SE.¼)) | 2946 | 2951 |
| bkn. oil sand (Sand 8 (Main Pay, SE.¼)) | 2951 | 2960 |
| soft oil sand (Sand 8 (Main Pay, SE.¼)) | 2960 | 2965 |
| hard lime (Sand 8 (Main Pay, SE.¼)) | 2965 | 2966 |
| lime (Sand 8 (Main Pay, SE.¼)) | 2966 | 2969 |
| hard shale (Sand 8 (Main Pay, SE.¼)) | 2969 | 2974 |
| lime (Sand 8 (Main Pay, SE.¼)) | 2974 | 2976 |
| oil sand (Sand 8 (Main Pay, SE.¼)) | 2976 | 2997 |
| blue shale | 2997 | 3005 |
| gumbo & gravel | 3005 | 3014 |
| gumbo & gravel | 3014 | 3019 |
| blue shale | 3019 | 3030 |
| hard shale | 3030 | 3032 |
| sticky shale | 3032 | 3062 |
| broken oil sand | 3062 | 3066 |
| blue shale | 3066 | 3070 |
| broken lime | 3070 | 3075 |
| lime | 3075 | 3077 |
| broken oil sand (Sand 9) | 3077 | 3079 |
| broken oil sand (Sand 9) | 3079 | 3081 |
| sticky shale (Sand 9) | 3081 | 3101 |
| sandy shale (Sand 9) | 3101 | 3111 |
| broken sand (Sand 9) | 3111 | 3117 |
| blue shale | 3117 | 3124 |
| sandy shale | 3124 | 3132 |
| hard shale | 3132 | 3165 |
| broken oil oil sand (Sand 10) | 3165 | 3168 |
| blue shale (Sand 10) | 3168 | 3175 |
| sticky shale (Sand 10) | 3175 | 3183 |
| oil sand (Sand 10) | 3183 | 3185 |
| broken oil sand (Sand 10) | 3185 | 3189 |
| blue shale | 3189 | 3215 |
| hard shale | 3215 | 3225 |
| blue brown shale | 3225 | 3245 |

(Continued on page 290)

| Formation | Top | Bottom |
|---|---|---|
| blue & brown shale | 3245 | 3260 |
| sandy shale | 3260 | 3275 |
| hard shale | 3275 | 3292 |
| sticky shale | 3292 | 3300 |
| hard shale | 3300 | 3311 |
| sticky shale | 3311 | 3319 |
| hard shale | 3319 | 3345 |
| blue shale | 3345 | 3358 |
| broken lime | 3358 | 3360 |
| hard shale | 3360 | 3374 |
| blue shale | 3374 | 3393 |
| hard shale | 3393 | 3400 |
| blue brown shale | 3400 | 3405 |
| hard shale | 3405 | 3413 |
| blue shale | 3413 | 3427 |
| sticky shale bldrs. | 3427 | 3445 |
| blue shale & shells | 3445 | 3466 |
| blue & sticky shale | 3466 | 3491 |
| sticky shale | 3491 | 3493 |
| broken lime | 3493 | 3496 |
| blue shale | 3496 | 3505 |
| FOURTH SAND ZONE — Sand 14: broken oil sand | 3505 | 3512 |
| oil sand | 3512 | 3514 |
| shell, lime | 3514 | 3515 |
| lime | 3515 | 3517 |
| hard shale | 3517 | 3529 |
| hard lime | 3529 | 3530 |
| lime | 3530 | 3533 |
| broken oil sand | 3533 | 3538 |
| lime shells | 3538 | 3539 |
| hard shale & lime | 3539 | 3548 |
| blue shale | 3548 | 3562 |
| lime | 3562 | 3563 |
| strks. bro. oil sand | 3563 | 3564 |
| blue shale & shells | 3564 | 3574 |
| blue shale streaks of oil sand | 3574 | 3582 |
| lime | 3582 | 3584 |
| sticky shale | 3584 | 3588 |
| blue shale | 3588 | 3592 |
| hard shale | 3592 | 3618 |
| lime | 3618 | 3620 |
| blue shale | 3620 | 3620 |
| broken oil sand | 3626 | 3628 |
| blue shale streaks of oil and gas sand | 3628 | 3632 |
| FOURTH SAND ZONE — blue shale | 3632 | 3648 |
| Sand 16: Oil sand & str. bl. sh. | 3648 | 3656 |
| broken oil sand | 3666 | 3672 |
| sticky shale | 3672 | 3677 |
| blue shale | 3677 | 3683 |
| sandy shale & bro. oil s. | 3683 | 3692 |
| sandy shale & broken oil sand | 3692 | 3699 |
| blue & brown shale | 3699 | 3711 |
| hard shale | 3711 | 3714 |
| blue shale | 3714 | 3720 |
| hard shale | 3720 | 3724 |
| blue shale with streaks of oil sand | 3724 | 3739 |
| sandy shale streaks of oil sand | 3739 | 3748 |
| sticky shale oil sand | 3748 | 3752 |
| blue shale & broken oil sand | 3752 | 3765 |
| hard shale | 3765 | 3770 |
| TOTAL DEPTH | | 3770 |

### Minor Pools

#### BAYOU

The Bayou pool is often called the Hewitt southeast extension, although a gap of condemned territory over half a mile in width intervenes between the two. Its production is usually included with that of Hewitt in news reports. The Bayou area produces from part of the same series of Pennsylvanian sands as the Hewitt pool, but finds them at greater depth and much less prolific in yield. Its per acre yield (nearly 11,000 bbls.) is somewhat greater than that of the other fields



of the county excepting Healdton and Hewitt, but this may be credited to the fact of closer drilling in the Bayou than at Graham or Sholom Alechem, for example.

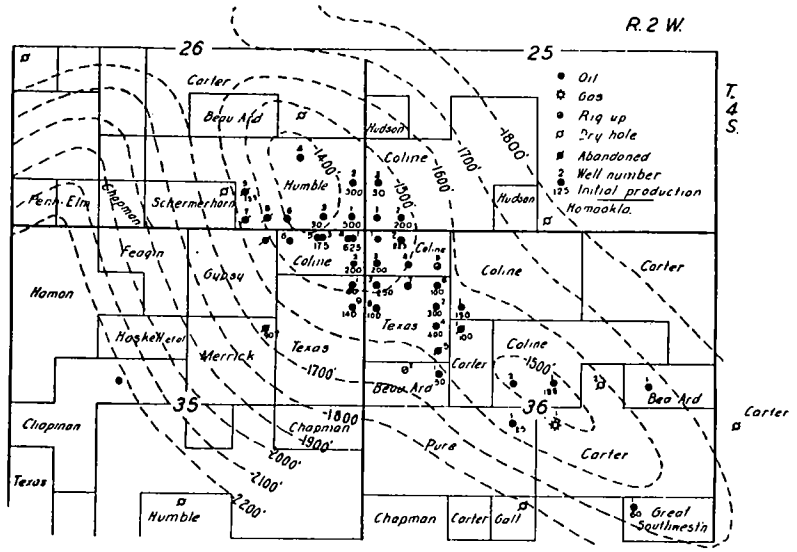



Figure 42. Structure map of Bayou pool.

This little pool owes its existence to a minor closure along the Hewitt anticlinal axis southeast of the main pool and at a lower structural level. From 200 to 700 feet of red beds cover the surface. The anticlinal crest indicated in the surface beds is one-fourth mile or more to the southwest of that in the Pennsylvanian producing section. There are two chief sands, at average depths of 2,300 and 2,850 feet, respectively. The upper one carries gas on the crest of the fold. One isolated well one-half mile southwest of this pool produces from sands found at 3,600 to 3,900 feet. No rocks older than Pennsylvanian have been reached. Dips in the producing sands average 8 or 10 degrees, but attain a maximum of 23 degrees.

The discovery well, No. 1 Harts, was drilled by the Coline Oil Co., in 1921, in the SW. cor. sec. 25, T. 4 S., R. 2 W. Practically no drilling has been done in this pool since 1923.

*Log of Humble Oil & Refg. Co., No. 1, Gill.*

SE.¼ SE.¼ SE.¼ SE.¼ sec. 26, T. 4 S., R. 2 W. Completed May 12, 1921.

| Formation | Top | Bottom |
|---|---|---|
| Sand | 0 | 210 |
| hard sandy shale | 210 | 576 |
| hard sand rock | 576 | 629 |
| sandy shale | 629 | 679 |
| lime | 679 | 680 |
| sand | 680 | 721 |
| blue shale | 721 | 813 |
| gumbo | 813 | 829 |
| lime rock | 829 | 831 |
| gumbo | 831 | 894 |
| shale & gumbo | 894 | 945 |
| rock | 945 | 964 |
| gumbo & shale | 964 | 1070 |
| rock | 1070 | 1077 |
| gumbo | 1077 | 1098 |
| blue shale | 1098 | 1173 |
| lime | 1173 | 1202 |
| sand | 1202 | 1206 |
| gumbo | 1206 | 1217 |
| hard sandy shale | 1217 | 1335 |
| gumbo | 1335 | 1466 |
| sand | 1466 | 1470 |
| gumbo | 1470 | 1497 |
| hard shale | 1497 | 1521 |
| sand rock | 1521 | 1529 |
| rock | 1529 | 1530 |
| lime | 1530 | 1548 |
| blue shale | 1548 | 1590 |
| gumbo | 1590 | 1610 |
| blue shale | 1610 | 1650 |
| gumbo | 1650 | 1703 |
| rock | 1703 | 1705 |
| hard sand | 1705 | 1775 |
| gumbo | 1775 | 1794 |
| rock | 1794 | 1814 |
| blue shale | 1814 | 1916 |
| gumbo | 1916 | 1926 |
| blue sandy shale | 1926 | 1998 |
| gumbo | 1998 | 2012 |
| blue sandy shale | 2012 | 2086 |
| gumbo bldrs. & shale | 2086 | 2173 |
| hard sand | 2173 | 2213 |
| hard shale | 2213 | 2216 |
| blue shale | 2216 | 2264 |
| trace oil sand | 2264 | 2267 |
| blue shale | 2267 | 2278 |
| oil sand T. D. | 2278 | 2811 |

### WILDCAT JIM

This pool takes its name from the efforts at discovery made by the Wildcat Jim Oil Co., in 1915-17 in the SW.¼ sec. 18, T. 2 S., R. 2 W., where two small wells (later abandoned) of heavy black oil were completed in a sand near the base of the red beds, about 1,660 feet deep. The Coline Oil Co., in 1916 obtained a 70 barrel well (No. 1 Pierce) of 22 gravity oil in a Pennsylvanian sand at 2,600 feet one-half mile farther north, in section 7. These early wells offered so little promise that only about one additional well a year was drilled until 1925, when some better results and good market prospects caused a pipeline outlet to be provided, and a spurt of drilling followed. In 1926 several excellent wells were completed in the SE.¼ sec. 7, T. 2 S., R. 2 W., but only three or four wells have been drilled since that year.

The field is not yet sufficiently well defined to make possible an adequate description of its structure. Anticlinal closure is doubtful. Its present limits are determined in part by the fact that the edge wells are too small to encourage further drilling, although dry holes limit the pool in some directions. Dips in the chief producing sands average 10 degrees or less. Production comes from much the same section of the Pennsylvanian system as in the Sholom Alechem field, plus the



sand at the base of the red beds, which is probably in the Pontotoc series and yields heavier oil than the deeper sands. The field does not promise to average more than 3,000 barrels of oil per acre, though some tracts will do considerably better than that.

*Log of Roxana Petro. Corp., No. 3, E. Kauffman.*

NE.¼ SE.¼ SE.¼ sec. 7, T. 2 S., R. 2 W. Completed April 8, 1926.

| Formation | Top | Bottom |
|---|---|---|
| surface | 0 | 5 |
| red bed | 5 | 45 |
| sand | 45 | 255 |
| red bed, gray & sand | 255 | 265 |
| hard sand | 265 | 270 |
| sandy lime | 270 | 273 |
| broken sandy lime | 273 | 279 |
| sand | 279 | 346 |
| lime shells | 346 | 349 |
| sand | 349 | 396 |
| red bed & sand | 396 | 445 |
| sandy lime | 445 | 450 |
| red bed & sand | 450 | 510 |
| lime shells | 510 | 511 |
| sandy shale | 511 | 558 |
| sand | 558 | 583 |
| sandy lime | 583 | 589 |
| sand | 589 | 594 |
| sandy lime | 594 | 595 |
| sandy shale | 595 | 605 |
| sand | 605 | 628 |
| sand & hard shells | 628 | 650 |
| broken sandy lime | 650 | 690 |
| blue shale | 690 | 720 |
| sandy shale | 720 | 745 |
| hard sand | 745 | 758 |
| shale & gyp. | 758 | 770 |
| red bed & sand | 770 | 887 |
| lime | 887 | 893 |
| shale | 893 | 930 |
| hard sand | 930 | 947 |
| shale | 947 | 992 |
| red bed, bldrs & s. | 992 | 1013 |
| shale | 1013 | 1043 |
| broken lime | 1043 | 1050 |
| shale | 1050 | 1075 |
| broken lime | 1075 | 1083 |
| gumbo | 1083 | 1100 |
| red bed | 1100 | 1175 |
| broken lime | 1175 | 1181 |
| shale | 1181 | 1243 |
| hard sand | 1243 | 1248 |
| shale | 1248 | 1260 |
| red b. boulders & s. | 1260 | 1270 |
| broken lime & sand | 1270 | 1290 |
| broken lime | 1290 | 1296 |
| red bed | 1296 | 1322 |
| lime | 1322 | 1334 |
| r. b. grav. & ls. shells | 1334 | 1356 |
| broken lime | 1356 | 1368 |
| lime | 1368 | 1380 |
| red bed | 1380 | 1384 |
| shale & brkn oil s. | 1747 | 1759 |
| shale | 1759 | 1880 |
| lime shells | 1880 | 1881 |
| shale | 1881 | 1883 |
| gumbo & boulders | 1883 | 1898 |
| sticky shale | 1898 | 1965 |
| lime shells | 1965 | 1966 |
| shale | 1966 | 2008 |
| gas sand | 2008 | 2010 |
| broken sand & shale | 2010 | 2020 |
| lime shells | 2020 | 2025 |
| shale | 2025 | 2030 |
| sandy shale | 2030 | 2065 |
| shale | 2065 | 2100 |
| red mud | 2100 | 2120 |
| shale | 2120 | 2165 |
| sandy shale | 2165 | 2170 |
| shale | 2170 | 2315 |
| lime | 2315 | 2320 |
| broken sand | 2320 | 2335 |
| sandy shale & ls. sh. | 2335 | 2345 |
| hard sand | 2345 | 2355 |
| shale | 2355 | 2460 |
| oil sand | 2460 | 2495 |
| total depth | 2495 | |
| broken lime | 1384 | 1399 |
| shale | 1399 | 1443 |
| sandy shale | 1443 | 1453 |
| broken lime | 1453 | 1464 |
| shale | 1464 | 1476 |
| broken lime | 1476 | 1482 |

(Continued on page 294)

| Formation | Top | Bottom | Formation | Top | Bottom |
|---|---|---|---|---|---|
| sticky shale | 1482 | 1496 | lime | 1625 | 1626 |
| shale & lime shells | 1496 | 1525 | shale | 1626 | 1642 |
| broken lime | 1525 | 1541 | lime | 1642 | 1653 |
| shale | 1541 | 1586 | shale | 1653 | 1655 |
| gumbo | 1586 | 1594 | lime | 1655 | 1669 |
| lime | 1594 | 1600 | shale & brkn oil s. | 1669 | 1672 |
| shale | 1600 | 1621 | shale | 1672 | 1746 |
| broken lime | 1621 | 1625 | lime shells | 1746 | 1747 |

### WHEELER

H. B. Goodrich, a pioneer among petroleum geologists in Oklahoma, is credited with the discovery of this first oil pool to be opened south of the Arbuckle Mountains in the State. His attention was attracted to the area by an accumulation of asphalt which had seeped from an

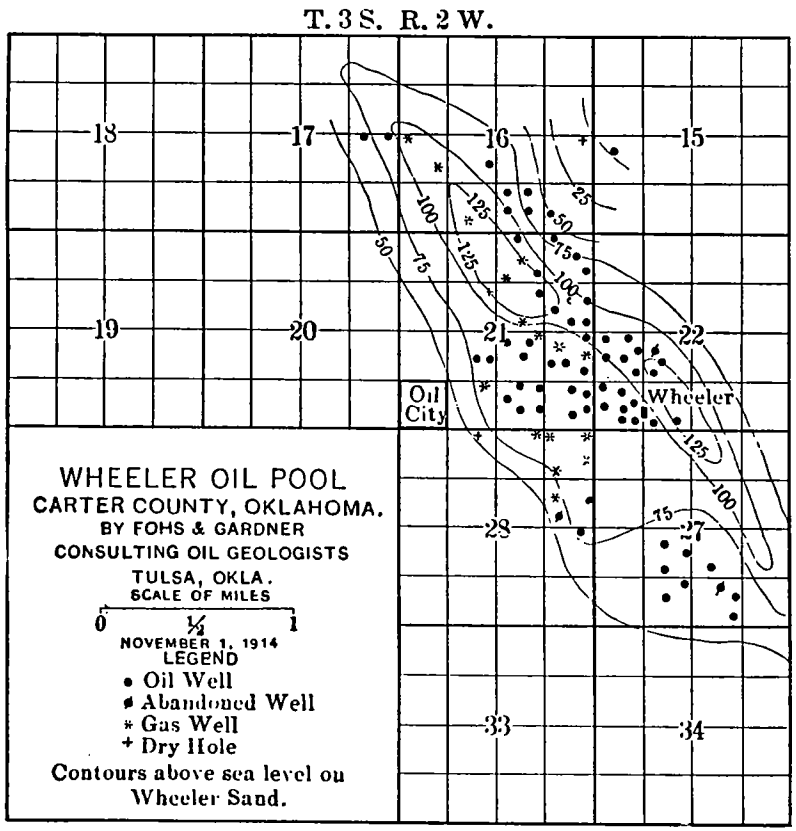



Figure 43. Reproduced from Economic Geology, vol. 10, fig. 5, 1915.



outcropping sand in the post-Pontotoc (Cisco ?) red beds near the SE. cor. sec. 21, T. 3 S., R. 2 W. This evidence was reinforced by the presence of an anticline in the surface rocks (see map, Fig. 43, reproduced from Fohs and Gardner.[42])

All of southern Indian Territory, and the red beds region in particular, had been regarded with so much disfavor by the oil industry up to that time that extra courage was demanded for this venture. The discovery well was drilled by the Coline Oil Co. in 1904. According to Gardner[43] and Fohs[44], the surface rocks show about 125 feet of reverse dip toward the Arbuckle Mountains. Two gas sands were found, at about 230 and about 600 feet, respectively, and an oil sand in the base of the red beds at about 1,000 feet. The latter is described as varying from fine sand to coarse gravel. The oil is heavy (17 to 23 degrees) and black. Two or three deep wells in section 21 penetrated the marine Pennsylvanian (one of them to 3,900 feet) without success.

A pipeline was built to provide Ardmore with its first supply of gas, but there has never been a regular pipeline outlet for the oil. Most of the field is operated by the Coline Oil Co. Two or three minor operators sell their production for fuel oil, delivering it by tank-wagon to various parts of the county. The area of the field probably could be extended somewhat if production of this type should become profitable.

### TATUMS

In January, 1927, the Magnolia Petroleum Company surprised the oil fraternity of southern Oklahoma by completing as producing oil wells, within a week of each other, two rank wildcat tests only six miles apart. One was No. 1 Burr, in sec. 31, T. 1 N., R. 3 W., in the southwest corner of Garvin County near the village of Tussy, and the other was No. 1 Pollock in sec. 14, T. 1 S., R. 3 W., discovery well of the Tatums pool. Neither well was large enough to insure profitable returns on additional drilling, which has therefore proceeded no faster than offset requirements compelled. However, the Tatums pool soon yielded some better producers, and has now (June, 1928) built up a production exceeding 1,500 barrels per day. Enough drilling has been done to prove the presence of an anticline. The productive sands apparently correlate satisfactorily with a portion of the oil-bearing sequence in the neighboring Sholom Alechem field, and are probably in the Dornick Hills formation. Red beds are 1,000 to 1,500 feet deep. Drilling is relatively easy, and rotary tools land casing on the 2,200 foot sand in 20 days or less, and complete 2,600 foot wells in less than 30 days.

42. Gardner, James H., The oil pools of southern Oklahoma and northern Texas: Econ. Geol., vol. 10, Fig. 59, 1915.
43. Gardner, James H., Op. cit., pp. 429-430.
44. Fohs, F. Julius, quoted by Gardner, loc. cit.

### COX

Discovery of this pool must be credited to the sales ability of Edwin B. Cox of Ardmore, chief landowner in the pool, and to the persistent wildcatting policy of the Magnolia Petroleum Company in southern Oklahoma. Oil is found in Pennsylvanian sands from 1,000 to 1,400 feet deep, just under the red beds. The field is not defined at either end by dry holes, but by wells too small to be profitable on the present market. Definite anticlinal closure cannot yet be proved to exist here, and the pool may owe its accumulation to a small terrace or nose, aided by the unconformity at the base of the red beds, truncating the productive sands below.

*Log of Magnolia Petro. Co., No. 2, May Cox.*

NE.¼ NE.¼ SE.¼ sec. 16, T. 2 S., R. 2 W. Completed June 19, 1926.

| Formation | Top | Bottom | Formation | Top | Bottom |
|---|---|---|---|---|---|
| sand lime | 0 | 6 | shale | 570 | 600 |
| sand rock | 6 | 15 | red mud | 600 | 610 |
| red rock | 15 | 98 | sandy shale | 610 | 635 |
| water sand | 98 | 103 | blue mud | 635 | 652 |
| red rock | 103 | 108 | lime | 652 | 672 |
| blue mud | 108 | 120 | sand | 672 | 680 |
| red rock | 120 | 145 | blue mud | 680 | 700 |
| water sand | 145 | 160 | sand | 700 | 710 |
| red rock | 160 | 170 | blue mud | 710 | 745 |
| red gumbo | 170 | 180 | sandy shale | 745 | 760 |
| red mud | 180 | 195 | red gumbo | 760 | 770 |
| red rock | 195 | 223 | blue mud | 770 | 820 |
| red mud | 223 | 284 | red mud | 820 | 835 |
| sand | 284 | 292 | blue shale | 835 | 892 |
| blue mud | 292 | 300 | red mud | 892 | 960 |
| red gumbo | 300 | 305 | hard lime shell | 960 | 967 |
| blue mud | 305 | 350 | red mud | 967 | 1012 |
| water sand | 350 | 392 | broken sand | 1012 | 1038 |
| blue mud | 392 | 415 | show of oil | | |
| sand | 415 | 440 | blue slate | 1038 | 1060 |
| blue mud | 440 | 460 | sandy shale | 1060 | 1070 |
| red mud | 460 | 465 | blue slate | 1070 | 1192 |
| blue mud | 465 | 490 | lime shell | 1192 | 1195 |
| sandy shale | 490 | 508 | blue slate | 1195 | 1208 |
| sand | 508 | 518 | broken sand | 1208 | 1211 |
| lime shell | 518 | 523 | broken oil sand | 1211 | 1268 |
| red mud | 523 | 550 | shale | 1268 | 1270 |
| water sand | 550 | 563 | pay sand | | |
| lime | 563 | 570 | Total depth | 1270 | |

### ROUNDUP

This little pool was opened in 1926 by F. W. Merrick of Ardmore. Except for very steep dips in the Pennsylvanian pay sands it is very similar in character to the Cox pool a mile farther northwest, and the two areas may really be parts of the same pool. The Roundup pool is partially defined to the southeast and west. Extension in any direction must await better market conditions, although there is a pipeline outlet.



### BLUE RIBBON

Shortly after the opening of the Wheeler pool (in 1904), a well drilled by the American Industrial Development Co., in sec. 19, T. 4 S., R. 1 W., near Blue Ribbon School, some 7 miles southeast of Wheeler, encountered favorable showings at shallow depth. In 1925 McCrory Brothers of Ardmore completed two wells near this old test, obtaining initial production of 10 to 15 barrels per day from a sand in the red beds at a depth of 700 feet. The Oklahoma Pipe Line Co. gave them a connection. One or more adjacent failures have since been drilled, but the two producers are still making oil—somewhat less than 10 barrels a day.

### SOPASCO

This little enterprise, abandoned for the present at least, comprised three small asphalt wells which were drilled through the gently-dipping Pontotoc series and obtained their production from nearly vertical older Pennsylvanian sands below, at depths from 165 to 480 feet. The output was used for a short time in the manufacture of paint by the Southwestern Paint and Asphalt Co., of Ardmore, which drilled the wells.

### HOMER

Some 70 shallow wells have been drilled in the Homer area, of which all but 15 have had showings or small production of oil or gas, at depths ranging from 40 to 350 feet. There are said to be about 15 wells now in shape to produce, with a combined capacity of 30 or 40 barrels per day. The property of J. P. Hivick is being produced, although there is no regular market for the oil. It is a heavy green crude, reported to be unusually high in lubricants. No pipeline outlet has ever been provided for this pool, but at times in the 12 years since its discovery some of the oil has been hauled to Davis by tank trucks and shipped thence by rail.

The oil is found in the Pontotoc series, in and just below the Hart limestone member, which outcrops close to the field and has its maximum thickness in this vicinity. There is no anticlinal closure, but the pool occurs on the flank of a broad nose plunging gently away from the west end of the Arbuckle Mountains.

## BROCK (CRINERVILLE)

By

Sidney Powers[45]

### LOCATION

Crinerville oil field, named from a school house is 2 miles southeast of Brock and 7 miles southwest of Ardmore. The field extends southeast from the C. S. L. SW.¼ sec. 17, through the E.½ sec. 20 and the E.½ sec. 28, the cen. sec. 32, T. 5 S., R. 1 E. By July, 1927, 5½ years after the discovery, 139 oil wells (7 now abandoned), 3 gas wells (2 now abandoned), and 46 dry holes had been drilled. The depth of production ranged from 845 to 2,200 feet. The initial production averaged about 50 barrels, and the settled production, 15 barrels.

This field is located 15 miles southeast of the southeastern end of Healdton and 10 miles southeast of the southeastern extension of Hewitt. It lies in a belt parallel to the Criner Hills and at a distance ranging from one-quarter to three-quarters of a mile from their southwestern flank. It is 15 miles south of the Arbuckle Mountains.

### GEOLOGY

*Geologic History.* Within the Arbuckle Mountains there are exposed pre-Cambrian granites and the well-known section of Paleozoic sedimentary rocks extending upward through the Caney shales of Mississippian age and through part of the Glenn and other formations of Pennsylvanian age. The most important group of rocks is that of the Ordovician limestones. Structural conformity marks the entire pre-Pennsylvanian section when considered as a whole, but there is an unconformity above the Hunton group (Devonian at the top) which marks undulating folding of the entire region. This folding is known best on the north flank of the Arbuckle Mountains, at Seminole and other oil fields.

Fragments of the formations in the Arbuckle Mountains, from the Arbuckle at the base through to the Sycamore limestone at the top, are exposed in the Criner Hills, the older rocks generally speaking, being on the southwest side. Faulting has masked the relationship of different formations, but structural conformity is supposed to exist to the top of the Woodford.

On the west side of the Criner Hills, the wells at Crinerville start in the Hoxbar formation and find Ordovician limestones below, with an intervening wedge of the Deese formation which thickens southwestward from the axis of the anticline. Cuttings from wells show

45. Consulting geologist, Amerada Petroleum Corporation, Box 2022, Tulsa, Oklahoma. Original article revised and condensed by C. W. Tomlinson from the Bull. Am. Assoc. Pet. Geol. vol. 11, pp. 1067-1085, 1927. Illustrations used through courtesy of the Am. Assoc. Pet. Geol.



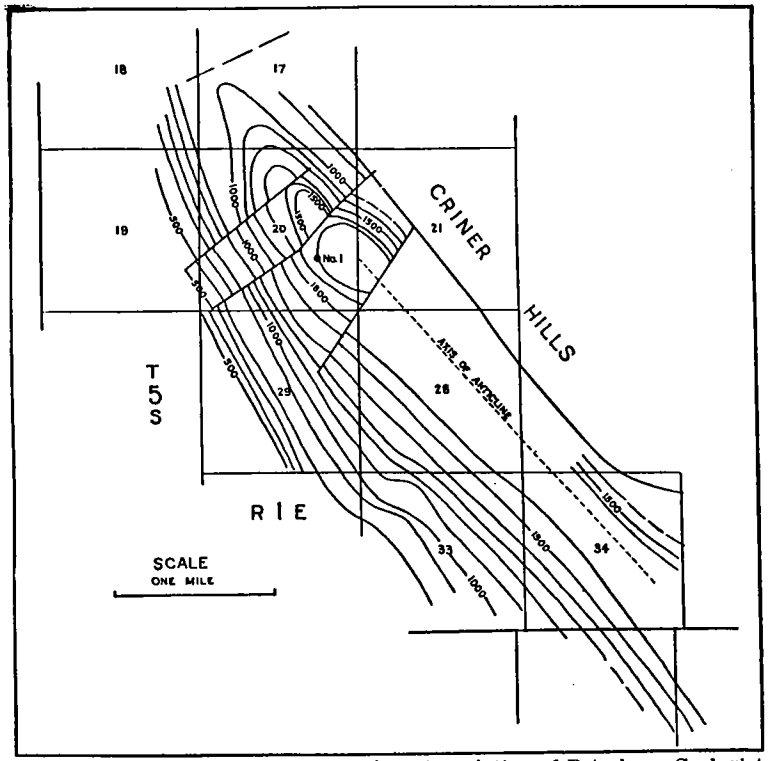
that the buried Ordovician rocks are Arbuckle on the east, but both the Simpson formation and Viola limestone may occur under the field. This unconformity proves that the folding and faulting of the ancestral Criner Hills took place after the deposition of the Springer formation and before the deposition of the Deese formation. The writer believes that the uplift is a part of the ancestral Wichita Mountains, and that these mountains were once continuous as far southeast as Gainesville, Texas, but that granite was exposed in a few places in the portion now concealed by Permian and late Pennsylvanian rocks.

Coarse conglomerates in and directly beneath the Otterville limestone and in higher members of the Dornick Hills formation on the east side of the Criner Hills, fix the time of the uplift of the ancestral Criner Hills and Wichita Mountains. The pebbles are largely of Ordovician limestone; there are none of granite because whatever granites were exposed in the Wichitas were too far distant. It is evident that these conglomerates came from the nearby ancestral Criner Hills and the area to the west—the Wichita Mountains. Finally this region was leveled and submerged by the upper Deese. Conglomerates have not been found at the unconformity under Crinerville on the west side of the Hills.

Both the northern Arbuckles and the Wichitas were folded early in the Pennsylvanian. Refolding and faulting occurred several times during the Pennsylvanian and at the close of this period. The ancestral Criner Hills were faulted again late in the Pennsylvanian. These faults on the west and north sides of the present hills were normal with a downthrow of at least 1,000 feet on the west and north. After this faulting, compression, which squeezed the plastic Pennsylvanian shales against the resistant block of limestone and made the anticlinal fold seen at the surface at Crinerville. This folding probably occurred at the time the Ardmore basin was compressed into long anticlines and synclines.

Sedimentation recommenced before the Permian. The Pontotoc arkoses and conglomerates were deposited late in the Pennsylvanian on the flanks of the Arbuckles and on the northeastern flank of the Wichitas, the ancestral Healdton, Hewitt, and Criner Hills. Still later Pennsylvanian or early Permian red beds overlie the Pontotoc. Another uplift folded the red beds into gentle flexures, and some of the anticlines of this generation overlie the older ones. The folds in the red beds cannot be mapped with satisfaction because of cross-bedding and scarcity of exposures. These sandstones and shales covered an area of considerable relief in which the hills were anticlines. It seems remarkable that these hills are not reflected more distinctly because there are only about 300 feet of red beds under Healdton, and 2,400 feet under an area 3 miles north of this field.

Trinity sand, of Lower Cretaceous age, was deposited throughout most of southern Oklahoma, and probably on the Criner Hills. The character of folding of the Cretaceous is indicated in the Preston anticline of Marshall County, yet the Cretaceous beds do not reflect folding in the older rocks in Cooke County, Texas.




(Illustration through courtesy of American Association of Petroleum Geologists)

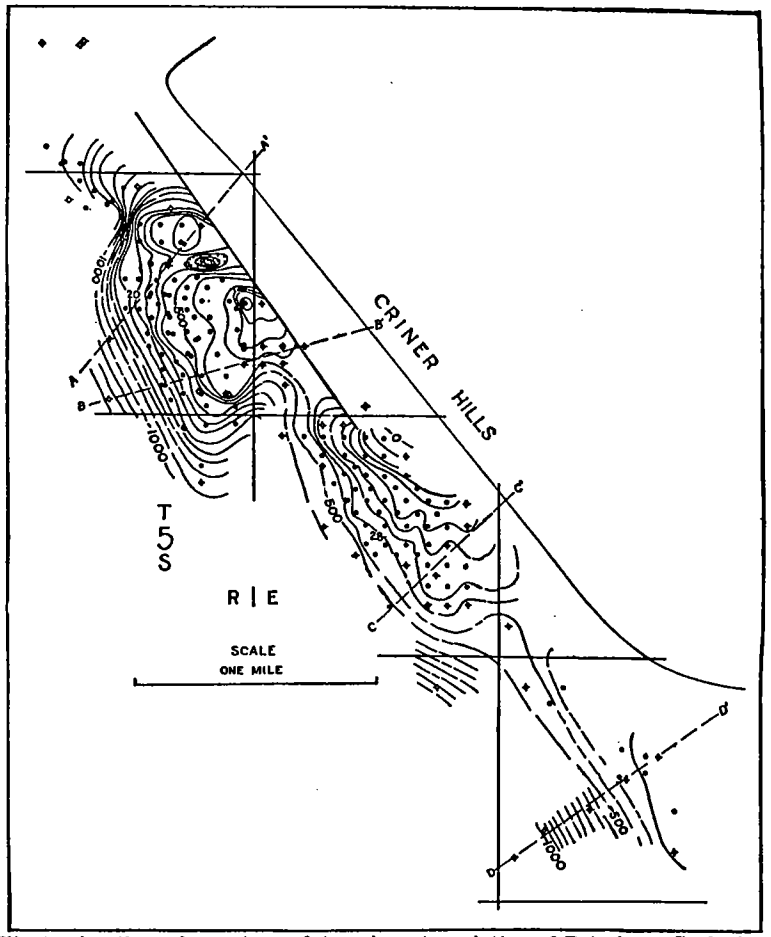
Figure 44. Structure contours, above sea level, of the surface geology, Brock (Crinerville) anticline. Contour interval, 100 feet. Datum, sea level. Location of the discovery well is shown.

Later uplift has elevated the peneplain of the Arbuckles and the antecedent Washita River. Still later uplift has elevated the lower peneplain of the softer rocks. It is difficult to connect the anticlinal hills of Healdton, Hewitt, Velma, and other fields with differential uplift in post-Cretaceous time because most of the anticlines in the Mid-Continent region have been hills at several times since the Ordovician.



## STRUCTURE

*Surface Structure.* The axis of the Crinerville fold extends northwest and southeast, but it might be termed a "geological accident" because of its superposition on truncated Ordovician limestones and its faulted relationship to the present Criner Hills with downthrown beds dipping steeply toward a normal fault, and also because the fold dies out at a shallow depth.




(Illustration through courtesy of American Association of Petroleum Geologists)

Figure 45. Structure contours of the Brock (Crinerville) oil field, below sea level, on the "second" oil sand. Contour interval, 50 feet. Location shown of sections D-D of figure 47. The anticline at the surface cannot be recognized at this horizon, depth 900-1,800 feet.

The surface structure contour map of the anticline (fig. 44) is based on planetable mapping of limestone outcrops. In order to confirm the presence of a northeast dip where there are no exposures, several excavations were made in the Pennsylvanian shales at the faulted contact with the Criner Hills, and two lines of shallow holes were drilled across the axis of the anticline. Instead of drag dips, steep northeast dips were found in the shales at the fault plane.

The anticline is a symmetrical fold which starts in sec. 2, T. 6 S., R. 1 E., as a nose cut off on the south by a fault against the Criner Hills. The axis runs parallel to the fault at the west side of the Criner Hills as far as the center of the west line of sec. 17, T. 5 S., R. 1 E., where it is cut off by a fault. North of this point the limestones bend broadly around the Criner Hills and do not seem to be affected by the Crinerville fold. The length of the fold is 4 miles.

Closure was not found along the anticlinal axis, though there is almost a closure in the southeast corner of section 20. In section 34 the axis plunges more steeply northwest and older beds occur at the surface.

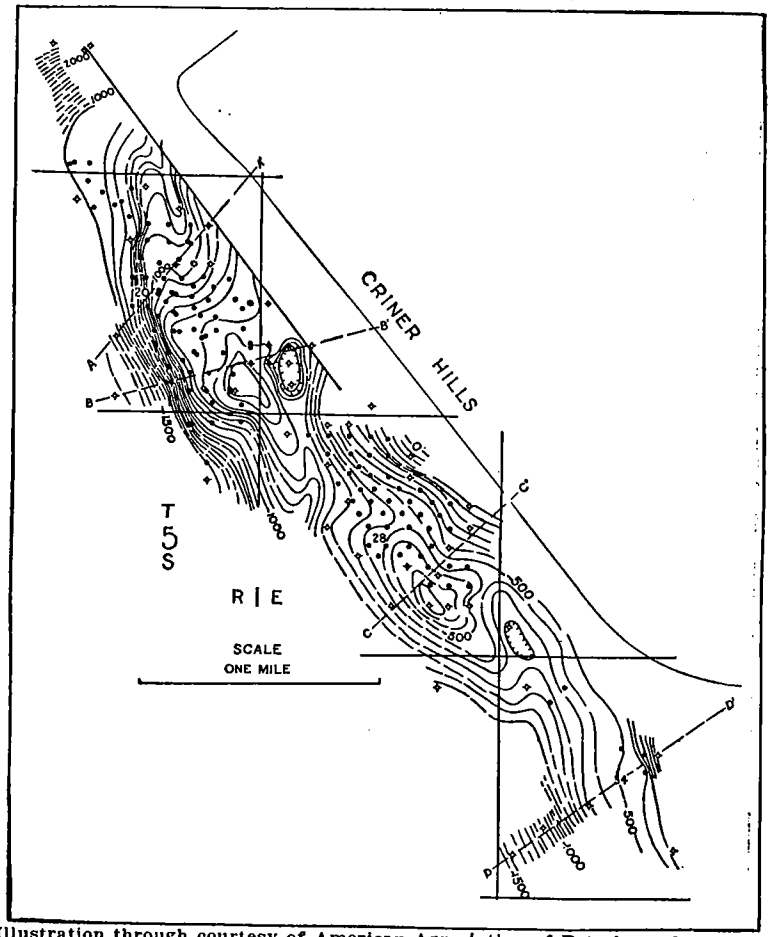
Faulting is very common at the surface, but minor faults die out at a shallow depth.

*Subsurface Structure.* The structure on the second oil sand is shown in figure 45. There is a general southwesterly dip, with high areas in sections 20, 28, 34, and separated by synclines. The cross-faults at the surface (fig. 44) are not clearly shown at this horizon, but those with the largest throw may extend to this depth. Another fault is shown in sections 21 and 17 parallel to the Criner Hills because the Ordovician was found in the easternmost well 400 feet higher than in the offset on the west in section 21. The correlations are too unsatisfactory to prove that this fault cuts the Pennsylvanian.

The eroded and folded surface of the Ordovician (fig. 46) resembles the structure of the second sand, but the west slope is much steeper and there is a more pronounced flattening in the E.½ of section 20. The Pennsylvanian sands overlap this surface, and each has a separate short line against it. The highest, or first, sand has its shore line on the eastern edge of the field in sections 28 and 34. Low hills and valleys, with a local relief of 50 feet or less, have been found on the surface of the limestone, and some of the hills project above the pay sand in the SE. cor. section 20, the SE.¼ section 28, and cen. section 34 (fig. 45). The larger valleys underlie those shown on the second sand map. This relief is in places so local that both in section 28 and in section 20 a five-spot well in the center of a rectangle of producers 400 feet and 460 feet apart was a dry hole because the lime projected above the level of the sand.

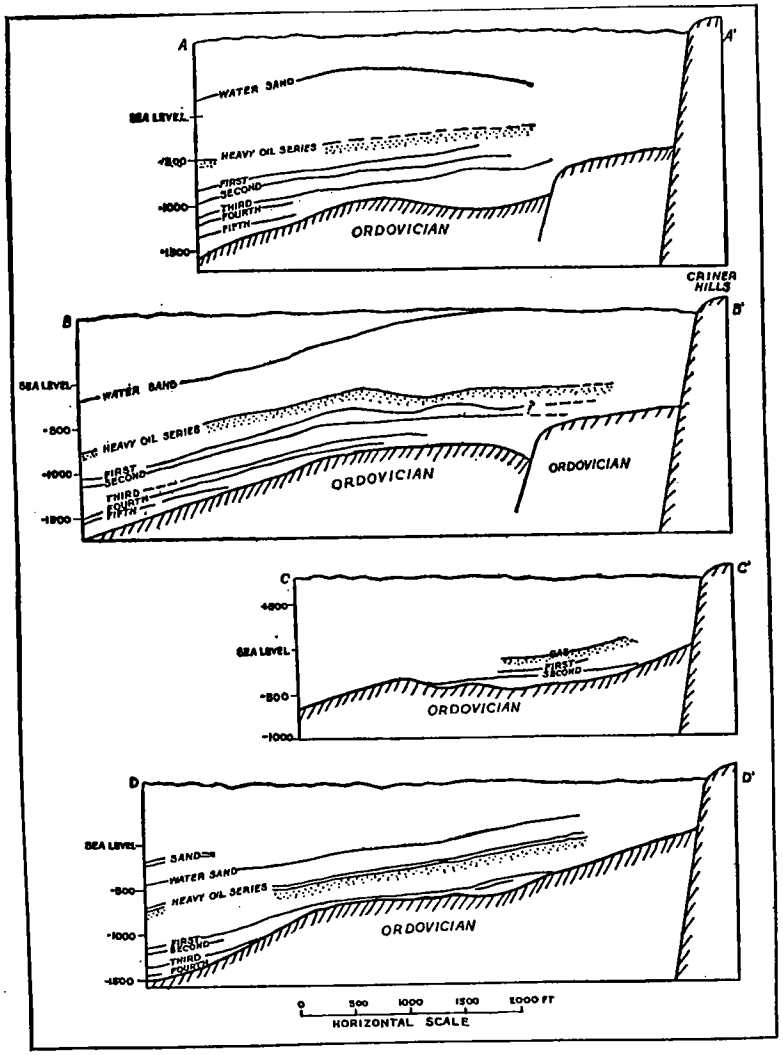


The distribution and structure of the oil sands which rest against and on the Ordovician unconformity are determined by the configuration of this surface in upper Deese time. Explanation of the irregularities in the surface of the Ordovician is found in the lithology of the older rocks. The folding which made the anticline in the upper beds tilted all the rocks toward the southwest at an angle of about 10°.




(Illustration through courtesy of American Association of Petroleum Geologists)

**Figure 46. Structure contours of the Brock (Crinerville) oil field on the eroded surface of the Ordovician, below sea-level, at a depth underground of 1,200-2,500 feet in the producing area. There is no hill on this eroded surface underlying the anticline at the surface. Oil was produced from the Ordovician in four wells surrounding the NE. cor SE.¼ SE.¼ section 20. Contour interval 50 feet.**




(Illustration through courtesy of American Association of Petroleum Geologists)

Figure 47. Cross-sections of the Brock (Crinerville) oil field showing that the anticline disappears in the Pennsylvanian strata and that the eroded surface of the Ordovician is irregular. The subsidiary fault block west of the main Criner Hills fault was a topographic ridge during the deposition of the Pennsylvanian. Location of the sections shown on figures 44 and 45. Length of section A-A', one mile, and depth, 2,500 feet. Vertical scale in feet.



## FAULTING

The gently curved fault line which separates the Pennsylvanian and Ordovician at the surface slopes away from the Hills at an angle of about 70°. The sinuous plane in many places follows the strike of the steeply tilted limestones, and this fact makes the contact appear as though the Pennsylvanian shales had slid away from steep-sided limestone hills. Drilling has, however, proved a major fault with a drop of about 1,000 feet. The fault seems to turn at right angles in sec. 17 and to continue northeast; farther east it makes two more similar turns to encompass the north end of the hills, or else there are two sets of faults.[46] It is possible that at these corners short faults extend between the Pennsylvanian outcrops, and therefore cannot be found.

South of the oil field the major fault turns and extends north and south and cuts off the anticline in secs. 1 and 2, T. 6 S., R. 1 E. Still farther south the Pennsylvanian beds dip away from the fault at an angle of 15° and there is no anticline.

On the map of surface structure contours (fig. 44) several cross-faults may be seen, each with a downthrow on the northwest. The maximum vertical displacement along the major faults is 250 feet. Innumerable small faults occur which cannot be shown except on a large-scale map, and many other faults probably exist in the area of no exposures. The major faults have their greatest displacement at the crest of the anticline, and most of the faults practically die out at a depth of about 900 feet. In these particulars they resemble the faults at Salt Creek, Wyoming.

Both the anticlinal and the minor faults disappear within 900 to 1,000 feet of the surface by flowage of the shale. It is clear that the anticline is not due to settling or compacting of the shales—one of the theories advanced to account for the anticlinal folds in northern Oklahoma. It was made by the same tangential compression which squeezed the Pennsylvanian sediments of the Ardmore basin into tightly folded long anticlines and synclines. Intensity of folding seems to increase upward, but this appearance may be due to buckling against the major fault plane. There are no drag dips in the Pennsylvanian at this fault, but instead there are steep dips toward the plane. The minor cross-faults may have been caused by this buckling.

## RESERVOIR ROCKS

The reservoir rocks, with the exception of the Ordovician limestone in four wells which produced from this horizon, are thin fine-grained sands which feather out or merge into brown shale where they intersect the unconformable surface of the older limestone. The

46. C. W. Tomlinson believes that these contacts on the northern edge of the Criner Hills are unconformities instead of faults; (Letter of October 19, 1926).

productivity of wells has not been as great as in similar fields of southern Oklahoma, comparing sands of equal thickness. This may be due to shale content. There are no "shells" or cap rocks over the sands, and the change from shale to sand in cable-tool wells is frequently noticed only from cuttings. During Pennsylvanian sedimentation no sandstone was exposed in the Criner Hills, and the nearest source for quartz grains must have been miles away; hence the oil sands probably represent material derived from the washing of sandy muds at or near sea-level in a shallow sea free from well-defined beaches and bars and entirely free from pebbles derived from the underlying limestone.

Volume of gas and water pressure are both low. The gas wells have yielded less than 5,000,000 cubic feet a day. Water has not been troublesome except in one well drilled into the Ordovician, from which a pocket of sulphur gas caused an artesian flow of sulphur water for several days.

Pennsylvanian shales are evidently the source rocks, and in this field, where the sands are more or less lenticular, it seems logical to assume the generation of oil locally.

Development of the field has brought many surprises. It was first thought that the oil sands were anticlinal, and that production would be both east and west of the axis of the surface anticline; but the structure proved to be three terraces on a monocline, and the wells on the reverse dips in sections 20 and 21 found brown shale instead of sand. It was also thought that accumulation would be on the more gentle dips, but the reverse is true. Wells making 200 barrels offset small wells making 25 barrels, and the explanation appears to be sand condition rather than structure. Salt-water wells and some which missed the oil sands have been drilled along the supposed trace of subsurface cross-faults which are beneath the major surface faults. The small wells in section 34, where the structure resembles that in section 28, are explained by a thin and shaly sand. In brief, accumulation depends on the lensing-out of the sands and on the lithology of the sand bodies. Accumulation under similar structural conditions may be expected beneath *any* homocline where sands in a thick shale section are cut off by progressive overlap on an older eroded surface; especially with the aid of anticlinal nosing to localize the accumulation.

### DEVELOPMENT

The Crinerville anticline seems to have been known since about 1916, but neglected as a possible oil prospect. It was discovered by Amerada Petroleum Corporation about June 1, 1920, and the leasehold was secured in 1920 and 1921, giving a solid block except for fee lands of Westheimer & Daube and F. E. Watkins.

The discovery well, Sammy Baptiste No. 1, was located by E. L. DeGolyer near the center of the SE.¼ sec. 20, on the west side of the small closure in contours of the surface geology shown in Figure 1. It was commenced in December, 1921, and the first sand was struck at 1,321 feet, January 15, 1922. The first sand was only 4 feet thick and good for about 50 barrels. A second sand at 1,371 feet was good for 20 barrels; and a third, from 1,564 to 1,629 feet, made 90 barrels. This well flowed from the third sand for 3 years before it was put on the pump. These three are the principal sands in section 20, the wells being completed so that they produce either from the first two together by setting a perforated liner through the first sand, or else from the third sand. Two deeper oil sands, called the fourth and fifth, occur locally on the northern and western flanks of the anticline.



Soon after the discovery of the field, Westheimer & Daube completed a well in section 21 in the top of the Ordovician, with "sand" at depths ranging from 1,585 to 1,682 feet, flowing 250 barrels. The Pennsylvanian sands were not productive. Two offsets to this well made 600 to 1,100 barrels, respectively; but the well highest in the producing horizon drained the oil, and all three wells declined rapidly and were abandoned within a year. As the oil was exhausted the sulphur water increased. With the exception of one gas well, other nearby wells drilled into the Ordovician found only sulphur water with more or less sulphur gas.

The field was a disappointment until large wells were found in the north half of section 20 in 1923. By 1924, production seemed to be defined by dry holes. A hand drill was used to locate the axis of the anticline at the surface in sections 28 and 27, and a well was drilled on the Clay farm, in the center of the west line of the NE.¼ sec. 28 on this axis.

Oil was found in a sand from 1,074 to 1,083 feet in Clay No. 1 on October 27, 1924. The well flowed 230 barrels steadily and opened the extension in section 28. The main producing horizon is the second sand. A few wells yield oil from a sand intermediate between the first and second of the original field, but not present there.

A second extension of production, in section 34, near the center of the section, was made in May, 1925, but the wells are very small.

### OIL AND GAS

The oil is green by reflected light and amber by transmitted light, and is similar to other Mid-Continent oil of the same grade. The average gravity in section 20 is 34°; in section 28, 39°; and in section 34, 27.8°. The oil in the last two pools is darker than that of the same gravity in section 20. The gravity of the oil in the fourth and fifth sands is 36°, and the color is lighter. The gravity of the oil in the Ordovician limestone was the same as in the Pennsylvanian sands. Differences in gravity of the oil in the three pools indicate no connection between the sands.

The casinghead gas carries 1½-2½ gallons of gasoline per thousand cubic feet of gas, and the volume of casinghead gas in section 20 is approximately 1,000 cubic feet per barrel of oil, and only half this amount in section 28. It is notable that the oil from the Ordovician was low in sulphur, although the accompanying gas was full of sulphur.

Gas has been found in three wells in Pennsylvanian sands and in one well in the Ordovician limestone. The maximum volume of the first wells did not exceed 3,000,000 cubic feet, but on Ordovician well (Marris No. 2) had a volume of 30,000,000 cubic feet of sulphur gas and caused an artesian flow of salt water of 15,000 barrels a day with about 200 barrels of oil. The rock pressure at Farve No. 9, in section 20 was only 335 pounds at 1,486 feet, instead of a normal pressure of about 500 pounds.

### WATER

Water pressure is very low throughout the field, and this is one of the reasons for the small production. There is bottom water in section 28, and several wells have been plugged back. Edge water has not encroached on the field. Water invariably produces 2-8 per cent of bottom sediment which is treated chemically and settled out.

Water pressure was high in the Ordovician limestone and flowed all the oil out of this limited reservoir. Two of the wells flowed 600 barrels of oil a day, but the producing horizon was so closely connec underground that each well affected the others and all went to water eventually, the highest well structurally being the last flooded. After water appeared in a well it increased very rapidly in quantity. Water and gas from the Ordovician have a strong sulphur odor.

### OIL AND GAS PRODUCTION

All of the wells are drilled with standard tools, and the average time of drilling 1,000 feet is 3 weeks. The spacing is 4 acres to the well.

The productive life of the field will probably be at least 20 years. The maximum production per acre will be 10,000 barrels for the 100 acres of the Farve lease, and 7,000 barrels for the Sammy Baptiste lease south of it. Owing to the fact that there is only one good oil sand in section 28, the production there will be only 5,000 barrels per acre.

The total ultimate yield of the field will be about 3,300,000 barrels from 560 acres, or 5,900 barrels per acre.



*Log of Amerada Petroleum Corp., No. 5, J. Gardner.*

SW.¼ NW.¼ NE.¼ sec. 20, T. 5 S., R. 1 E. Completed June 24, 1924.

| Formation | Top | Bottom |
|---|---|---|
| soil | 0 | 7 |
| gravel | 7 | 9 |
| lime | 9 | 14 |
| clay yellow | 14 | 20 |
| mud blue | 20 | 60 |
| sand, hard, dry | 60 | 70 |
| water sand | 70 | 80 |
| blue shale | 80 | 124 |
| lime | 124 | 134 |
| sand | 134 | 147 |
| blue shale | 147 | 160 |
| water sand | 160 | 169 |
| 7 bailers water per hour | | |
| lime | 169 | 172 |
| blue shale | 172 | 181 |
| lime | 181 | 217 |
| blue shale | 217 | 410 |
| water sand | 410 | 420 |
| 3 bailers water per hour | | |
| blue shale | 420 | 425 |
| sand | 425 | 438 |
| blue shale | 438 | 470 |
| mud blue | 470 | 510 |
| lime | 510 | 530 |
| sand dry | 530 | 552 |
| shale | 552 | 572 |
| water sand | 572 | 590 |
| blue shale | 590 | 596 |
| water sand | 596 | 604 |
| blue shale | 604 | 769 |
| lime blue | 769 | 777 |
| blue shale | 777 | 960 |
| lime | 960 | 1003 |
| sand | 1003 | 1010 |
| shale | 1010 | 1016 |
| lime | 1016 | 1018 |
| dry sand | 1018 | 1020 |
| shale blue | 1020 | 1140 |
| sand | 1140 | 1150 |
| shale blue | 1150 | 1170 |
| sand-show oil | 1170 | 1182 |
| blue shale | 1182 | 1325 |
| sandy shale | 1325 | 1330 |
| sand | 1330 | 1340 |
| sandy shale | 1340 | 1368 |
| sand | 1368 | 1371 |
| sandy shale | 1371 | 1386 |
| sand | 1386 | 1389 |
| sandy shale | 1389 | 1403 |
| sand | 1403 | 1406 |
| show of oil | | |
| sandy lime | 1406 | 1411 |
| sandy shale | 1411 | 1445 |
| gravel | 1445 | 1455 |
| red rock | 1455 | 1469 |
| blue shale | 1469 | 1477 |
| sandy lime | 1477 | 1484 |
| shale | 1484 | 1488 |
| broken sand | 1488 | 1494 |
| show of oil | | |
| shale & sand blue | 1494 | 1506 |
| sand | 1506 | 1520 |
| showing of oil black | | |
| mud blue | 1520 | 1543 |
| shale blue | 1543 | 1610 |
| red bed | 1610 | 1615 |
| lime | 1615 | 1625 |
| oil sand | 1625 | 1660 |
| blue shale | 1660 | 1667 |
| Total Depth | | 1667 |

*Statistical Data on Carter County Oil and Gas Fields.*

| FIELD | DATE OF DISCOVERY | DATE OF PEAK PRODUCTION | PEAK DAILY PRODUCTION (Highest Mo. bbls.) | AVERAGE DAILY PRODUCTION Dec., 1927 (Bbls.) | INITIAL DAILY PRODUCTION (Bbls. per well) | | | TOTAL PRODUCTION TO DEC. 31, 1927 (Oil in Barrels; gas in million cu. ft.) | | PRODUCTIVE AREA (Dec. 31, 1927 Acres) | NUMBER OF PRODUCING WELLS Dec. 31, 1927 | AV. NO. OF AC. PER WELL (Incl. aban. prod.) | TOTAL OIL PRODUCTION PER ACRE (To Dec. 31, 1927) | | GRAVITY OF OIL (A. P. I. Scale) | Av. Price Rec'd. For Flush Prod. (Approx.) | DEPTH OF PAY SAND (Feet) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Gas | Max. | Av. | Oil | Gas | | | | Gas | Oil | | | |
| HEALDTON[1] | Aug. 1913 | Mar. 1917 | 56,000 | 14,403 | ..... | 6,000 | 180 | 148,211,277 | (a) | 7,250 | 1,950 | 3.7 | ..... | 20,443 | 26-42 | 0.60 | 450-2,700 |
| HEWITT | June 1919 | Sept. 1921 | 43,900 | 8,397 | ..... | 14,000 | 300 | 59,474,947 | (a) | 2,780 | 784 | 3.4 | ..... | 21,393 | 33-38 | 3.00 | 1,100-3,530 |
| GRAHAM | Mch. 1922 | Apr. 1924 | 16,800 | 4,706 | 43 | 1,200 | 260 | 15,516,277 | 11,000* | 2,740*e* | 322 | 8.0 | 69 | 6,014 | 27-38 | 1.50 | 1,400-3,400 |
| FOX | Oct. 1918 | Apr. 1922 | 4,400 | 1,828 | 60 | 600 | 125 | 8,522,934 | 37,000* | 1,530*d* | 105 | 9.8 | 83 | 7,678 | 27-35 | 1.00 | 1,800-3,600 |
| BAYOU | Feb. 1921 | 1922 | 2,000* | 250* | ..... | 500 | 175 | 1,867,750* | (a) | 175 | 29* | 6.0 | ..... | 10,673 | 32-36 | 1.80 | 2,200-3,900 |
| BROCK | Jan. 1921 | Aug. 1925 | 2,200 | 919 | ..... | 1,100 | 50 | 2,580,249 | (a) | 480*e* | 130 | 3.8 | ..... | 5,375 | 27-37 | 2.00 | 800-2,100 |
| SHOLOM ALECHEM[1] | Oct. 1923 | June 1927 | 18,628 | 11,560 | 73 | 2,980 | 280 | 8,014,670 | (b) | 2,210*e* | 238*k* | 9.7 | ..... | 4,072 | 27-36 | 1.50 | 1,900-4,000 |
| WHEELER | Oct. 1905 | 1920? | 300 | 100* | 13½ | 68 | 15* | 250,000* | 500* | 640 | 50*f* | 6.0 | ..... | 391* | 17-23 | 0.50 | 860-1,000 |
| WILDCAT JIM | 1917 | Nov. 1926 | 1,590 | 1,017 | ..... | 1,100 | 100 | 770,807*j* | ..... | 410 | 41*g* | 10.0 | ..... | 2,083 | 19-30 | 1.00 | 1,500-2,700 |
| HOMER | 1916 | 1925 | 75* | 40*i* | ..... | 10* | 3* | 5,000* | ..... | 30 | 15*fm* | 1.5 | ..... | 167* | 20* | 0.50 | 40-250 |
| COX | Jan. 1926 | Nov. 1926 | 400 | 244 | ..... | 220 | 52 | 193,602 | ..... | 250 | 25 | 10.0 | ..... | 774 | 20-27 | 1.30 | 1,000-1,400 |
| ROUNDUP | Ma. 1926 | Jan. 1927 | 30 | 20 | ..... | 24 | 25 | 12,071 | ..... | 30 | 3 | 10.0 | ..... | 402 | 26 | 1.50 | 1,025-1,280 |
| SOPASCO | Feb. 1926 | 1926 | 5 | 0 | ..... | 3 | 2 | 500* | ..... | 20 | 2 | 10.0 | ..... | 25* | 11-18 | 0.75 | 165-480 |
| BLUE RIBBON[2] | May 1926 | 1926? | 35 | 2 | ..... | 30 | 25 | 2,300* | ..... | 10 | 2 | 5.0 | ..... | 230* | 27 | 1.55 | 685-700 |
| TATUMS | Jan. 1927 | Future | Future | 500* | ..... | 425 | 212 | 90,000* | (a) | 70 | 7 | 10.0 | ..... | 1,300* | 20-28 | 0.85 | 2,200-2,750 |
| TOTALS | ..... | ..... | 74,000 | 43,997 | ..... | 14,000 | 103 | 245,513,384 | 48,500 | 18,555*l* | 3,381 | 6.2 | 52 | 13,853 | 11-42 | 1.32*h* | 40-4,000 |

**EXPLANATION:**

1. Includes small area in Stephens County.
2. Blue Ribbon School House, sec. 19, T. 4 S., R. 1 W.
* Approximate value.
*a.* Casinghead gas only.
*b.* Used in field only.
*c.* Includes 160 acres yielding only gas.
*d.* Includes 420 acres yielding only gas.
*e.* Includes 220 acres yielding only gas.
*f.* Does not include abandoned wells.
*g.* Includes 4 gas wells.
*h.* Average of all fields.
*i.* Reported capacity; not producing steadily at this rate.
*j.* Listed with Fox prior to 1926; but very small.
*k.* Includes 24 gas wells.
*l.* Less than 3½% of total area of Carter County (532,480 acres).
*m.* Not on steady production.

# KIOWA AND WASHITA COUNTIES

By
Roger W. Sawyer

## AOKNOWLEDGMENTS

The writer has read all available literature pertaining to this area, especially the writings of Chas. N. Gould,[1] Trout and Shannon,[2] R. L. Clifton,[3] Frank C. Greene,[4] Frank Gouin,[5] Gould and Lewis,[6] and Noel Evans,[7] and has discussed it with S. B. Cloyes, O. E. Nordman and O. E. Brown. Glenn Clark furnished correlations of some formations in wells in sec. 3, T. 7 N., R. 17 W., and sec. 13, T. 7 N., R. 16 W. A part of the surface work on the structure map was given to the writer by Clyde Becker and Allen Gray. Chas. N. Gould and C. L. Cooper have aided in preparing the manuscript for publication. The

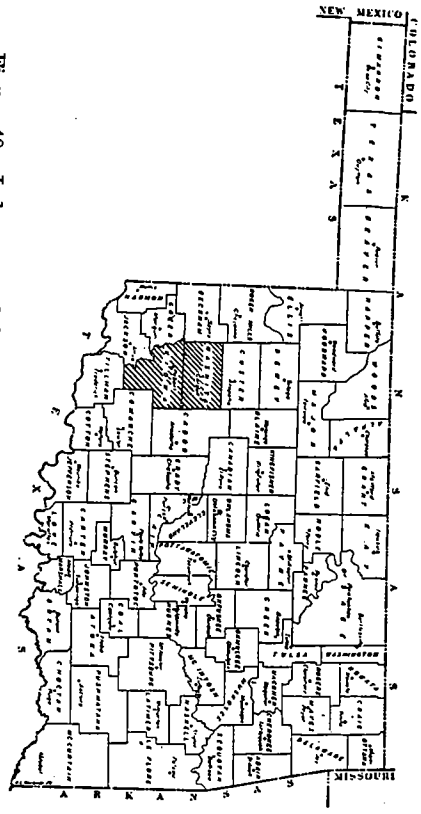



Figure 48.—Index map of Oklahoma showing location of Kiowa and Washita counties.

1. Gould, Chas. N., Index to the stratigraphy of Oklahoma: Oklahoma Geol. Survey, Bull. 35, 1925.
2. Trout, L. E., and Shannon, C. W., Oklahoma Geol. Survey, Bull. 19, Pt. II, 1917.
3. Clifton, R. L., Oklahoma Geol. Survey, Bull. 40-A, 1926.
4. Greene, Frank C., Subsurface stratigraphy of western Oklahoma: Oklahoma Geol. Survey, Bull. 40-D, 1926.
5. Gouin, Frank, Geology of Beckham County: Oklahoma Geol. Survey, Bull. 40-M, 1927.
6. Gould, Chas. N., and Lewis, Frank E., The Permian of Western Oklahoma and the Panhandle of Texas: Oklahoma Geol. Survey, Circ. 13, 1926.
7. Evans, Noel, Notes on the geology of the Weatherford district of Oklahoma: Bull. Amer. Assoc. Pet. Geol., July, 1928.

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writer wishes to express thanks to these men for their assistance, and to the Skelly Oil Company for permission to publish.

## TOPOGRAPHY AND DRAINAGE

The Wichita Mountains trend about N. 50° W. through the center of Kiowa County, consisting for the most part of granite ridges, peaks, and knobs. To the north and south of the mountains are found the red bed plains. These plains extend to the very foot of the mountains, and isolated ridges and peaks are found entirely surrounded by the red beds plains which are nearly level up to the foot of the mountains. In the northern part of Kiowa County, and extending locally into Washita County, are some south-facing escarpments maintained by calcareous sandstones of the Duncan and by dolomite ledges of the Blaine formation. Washita County is largely covered by the Whitehorse sandstone and the Quartermaster formation, into which many small streams have cut deep narrow canyons. The Cloud Chief gypsum, which outcrops over a considerable area, forms rounded hills. In the northeastern part of Washita County, the Weatherford dolomite and dolomitic beds of the Quartermaster form prominent escarpments.

## GEOLOGY

### Stratigraphy

Formations found in this area are shown in the table on page 313. (See also Map No. XXX.)

### PRE-CAMBRIAN

The central and southeastern parts of the Wichita Mountains are composed largely of pre-Cambrian igneous rocks, with minor amounts of older pre-Cambrian sedimentary rocks consisting of quartzite and sandstone.[8] Granite is reported to have been found in at least three wells north of the mountains in sec. 1, T. 5 N., R. 18 W., sec. 2, T. 6 N., R. 10 W., and in sec. 34, T. 8 N., R. 18 W.

### REAGAN SANDSTONE

This formation outcrops in some outlying hills in T. 6 N., R. 14 W., Kiowa County. According to Taff[9], it "is approximately 300 feet thick and is made up of conglomerate composed of porphyry pebbles and included basic rocks, gritty light brown to gray and greenish sandstone, greenish clay shales, and siliceous limestones interstratified. The limy layers contain many species of Cambrian fossils. The conglomerate occurs invariably near the base as local beds or lentils, while the calcareous sandstones and limestone beds are, without exception, in the upper part of the formation."

8. Taylor, C. H., Granites of Oklahoma: Oklahoma Geol. Survey, Bull. 20, 1915.
9. Taff, J. A., Preliminary report on the geology of the Arbuckle and Wichita Mountains in Indian Territory and Oklahoma: Oklahoma Geol. Survey, Bull. 12, p. 75, 1927.



*Table of Formations*

| AGE | FORMATION |
|---|---|
| QUATERNARY AND RECENT | Reworked red beds, river alluvium and sands |
| TERTIARY | Tertiary gravel |
| COMANCHEAN | Outliers of oyster shell beds |
| PERMIAN | Quartermaster formation |
| | Cloud Chief formation |
| | Whitehorse sandstone |
| | Dog Creek shale |
| | Blaine formation |
| | Flower Pot shale |
| | Duncan sandstone |
| | Hennessey shales |
| | Garber sandstone |
| PENNSYLVANIAN | Wellington shale |
| | Panhandle "Big Lime" (predominantly anhydrite) |
| | Pontotoc series |
| ORDOVICIAN | Viola limestone |
| | Simpson formation |
| | Arbuckle limestone |
| CAMBRIAN | Reagan sandstone |
| PRE-CAMBRIAN | Pre-Cambrian sedimentary (?) and igneous rocks |

### ARBUCKLE LIMESTONE

The northeastern part of the Wichita Mountains is formed largely by outcrops of this formation. "In general it may be said that the upper and middle parts consist of limestone, siliceous and shaly in part, and two major and three minor masses of nearly pure dolomite

near the base, the dolomites being separated from each other by limestones and the lower one separated from the Reagan sandstone by limestone in a similar manner."[10]

Thickness of this formation in the Arbuckle Mountains is given as 7,992 feet by Decker and Merritt.

### SIMPSON FORMATION

This formation outcrops in a small area in secs. 20 and 21, T. 6 N., R. 15 W.

Taff's[11] general description of the Simpson formation in the Arbuckle Mountain area is as follows:

> After the Arbuckle limestone was deposited there was a general change in the nature of the sediments. The top of the limestone seems to have been slightly eroded locally and upon the surface were deposited beds of pure sand. At other places the Arbuckle limestone is overlain by shaly and impure lime—the basal beds of the Simpson formation. On these local sandy beds at the base there were deposited greenish shales and then crystalline and shelly limestones interstratified with a number of beds of sandstone, making a total thickness ranging from about 1,200 to 2,000 feet.

The well in sec. 13, T. 7 N., R. 16 W., showed the thickness of this formation to be 1,360 feet.

### VIOLA LIMESTONE

There are a few scattered outcrops of Viola limestone in T. 6 N., Rs. 15 and 16 W. They consist of 500-700 feet of limestones which are thin-bedded to massive. The Viola limestone has been found in several wells in T. 7 N., R. 16 W.

### POST-VIOLA—PRE-PONTOTOC FORMATIONS

There are no outcrops of rocks from Viola to Pontotoc age in this area, nor have they been identified from wells so far as the writer is aware. Representatives of these periods may be present in parts of this area where they may not have been removed by erosion prior to deposition of the late Pennsylvanian and Permian beds.

### PONTOTOC SERIES

Many wells in this area encounter a series of granite wash, arkosic sands, shales, and limestones, which correlate with the Pontotoc terrane of Morgan.[12] Farther away from the mountains this series grades to red, blue, and brown shales and limestones. Production in the Carson County field of the Texas Panhandle is obtained from this

10. Decker, Charles E., and Merritt, Clifford A., Physical characteristics of the Arbuckle limestone: Oklahoma Geol. Survey, Circ. 15, p. 7, 1928.
11. Op. cit., p. 20.
12. Morgan, Geo. D., Geology of the Stonewall Quadrangle: Bureau of Geology, Bull. 2, p. 132, 1924.



series of beds. The thickness of this formation varies greatly. In general it is thin on structurally high areas, and thick on the low areas. The Outhier Petroleum Company No. 1 J. M. McConnell, sec. 34, T. 7 N., R. 20 W., shows 1,580 feet of Pontotoc.

### THE PANHANDLE BIG LIME AND THE WELLINGTON SHALE[13]

These two formations have a combined thickness of 1,360 feet in the Ritter Oil Company well in sec. 21, T. 11 N., R. 19 W. The Panhandle Big Lime, generally logged as a lime, consists of limestone, dolomite, anhydrite, gypsum, and shale. In the Hutchinson County, Texas, and the Sayre, Oklahoma fields the lower part of this formation produces some oil and much gas.

The overlying Wellington shale consists of gray or blue shale with a few lime shells. It is impossible to draw an exact line between the Wellington shale and the Panhandle Big Lime. The contact of the Wellington shale and the superjacent red beds is one of the best markers in well logs in western Oklahoma.

The Panhandle Big Lime and the Wellington shale are very thin or absent on the high areas of Kiowa County.

### GARBER SANDSTONE AND HENNESSEY SHALES

These two formations cannot be separated in the area. They consist of several hundred feet of red shales with a few thin sandstones. In Kiowa County they rest unconformably on older formation from Wellington to Pre-Cambrian. The upper 30 or 40 feet of the Hennessey is locally gray or buff in color.

### DUNCAN SANDSTONE

The Duncan sandstone consists of about 40 feet of gray, calcareous, cross-bedded sandstone, interbedded with red and gray shales. It forms a prominent escarpment north of Lone Wolf, Hobart and Komalty. In the Anadarko basin it is probably red in color and soft, and because of these changes is not recognizable with certainty in well logs.

### FLOWER POT SHALE

The Flower Pot shale consists of about 150 feet of shales, mostly red, with minor amounts of gray shale. There is no sharp boundary between this formation and the Duncan sandstone, the change being gradual from sand to shale. The term Flower Pot is used in preference to the term Chickasha formation, because, in the opinion

13. In using this nomenclature, the writer uses the correlation given by Frank C. Greene in Bulletin 40-D, Oklahoma Geological Survey. Greene considers that the lime series in western Oklahoma is the equivalent of the Panhandle Big Lime, and that the Wellington shale is absent from the Amarillo fold. Some geologists differ with this view, believing that the combined Wellington shale and the underlying lime series in western Oklahoma are together the equivalent of the Panhandle Big Lime.

of the writer, the Chickasha in its type locality at the east end of the Anadarko basin is the near-shore equivalent of the Flower Pot shale, Blaine formation, and the Dog Creek shale. Some geologists differ in this correlation, and consider the Chickasha and the Flower Pot shale equivalent.

### BLAINE FORMATION

This formation contains two dolomite beds, about 40 feet apart, which are very useful in surface mapping. These dolomites thin and disappear just east of the Kiowa County line south of Carnegie. The gypsums of this formation are not conspicuous in the central and eastern parts of Kiowa County, but thicken and increase in number toward the west and are easily seen in the bluffs north of the North Fork of Red River. Most of the logs of wells drilled in the Anadarko basin show the Blaine formation. Its thickness averages about 150 feet.

Below is a section of the Blaine which probably is representative of this formation in the northeastern part of Washita County.

*Section of Blaine Formation, sec. 23, T. 15 N., R. 10 W.*

| | Ft. | in. |
|---|---|---|
| Purplish-white dolomite | .... | 3 |
| Red shale | 4 | 0 |
| Purplish-white dolomite | .... | 3 |
| Red shale | 3 | 6 |
| Red dolomite | .... | 6 |
| Red shale | 5 | 0 |
| White dolomite (sometimes yellow) | .... | 6 |
| Red shale | 8 | 0 |
| Satin spar | .... | 3 |
| Red shale | 8 | 0 |
| Soft gray gypsum | 2 | 0 |
| Red shale | 5 | 0 |
| Soft green gypsum and red shale | 3 | 0 |
| Red shale | 5 | 0 |
| Green gypsum | .... | 6 |
| Red shale | 11 | 0 |
| Gray gypsum | 3 | 0 |
| Fossiliferous dolomite | 2 | 0 |
| Red shale | 46 | 0 |
| Gray gypsum | 2 | 0 |
| Dolomite | 1 | 0 |
| Red shale | 15 | 0 |
| Gypsum | 2 | 0 |
| Red shale | 18 | 0 |
| Gypsum | 2 | 0 |
| Red shale | 6 | 0 |
| Gypsum underlain by thin dolomite | 1 | 0 |
| Total | 154 | 9 |

Base of the Blaine is indefinite. There are a few thin gypsums, apparently lenticular, below this section.



### DOG CREEK SHALES

This formation consists of red shale with a few lenses of fine-grained red and white sand. Its thickness at the outcrop along the Kiowa-Washita County line is estimated to be 150 feet or less. This probably increases toward the north, possibly reaching 300 feet in northeastern Washita County. Observations in Blaine and northern Caddo counties show that it thickens toward the south.

### WHITEHORSE SANDSTONE

Two divisions of this formation can be recognized; a lower, the Marlow member, which consists of red, even-bedded sandstones and red shales, with some regular bands of fine white sand, and much disseminated gypsum; and an upper, the Rush Springs member, which consists almost entirely of red cross-bedded sandstone and has little or no shale or gypsum in this area. The Rush Springs member is the Whitehorse sandstone of Reeves.[14]

In Grady County, thicknesses are 110 feet for the Marlow member and 240-280 feet for the Rush Springs member. The Whitehorse appears to thicken in Washita County. The well in sec. 25, T. 12 N., R. 14 W., just north of Washita County, shows 670 feet of Whitehorse and Dog Creek. To this must be added 120 feet of Whitehorse eroded (since the top of the well is 120 feet below the base of the Cloud Chief) which would give a total of 790 feet. The Dog Creek is probably 300 feet thick, which would give 490 feet of Whitehorse. The contact of the Whitehorse and the Dog Creek shale is a good marker on the surface where erosion is good and would probably be of use in core drill work. Certain dolomite members of the Whitehorse, which outcrop on the hills above Greenfield in Blaine County[15] might also be useful in mapping. These Greenfield dolomites are near the boundary of the Marlow and Rush Springs members. Another dolomite member occurs 40 feet below the top of the Whitehorse. It enters Washita County from the north in sec. 2, T. 11 N., R. 14 W., and is herein referred to as the Weatherford dolomite. Traced northward to Weatherford it disappears and its place is taken by a gypsum bed.[16] It can be traced a few miles south of Colony, and may occur much farther south. It thins out and disappears along the east line of R. 14 W. The term "Day Creek dolomite" of Cragin has been applied to this dolomite, and to the dolomites above the town of Greenfield, in Blaine County, and to the Quartermaster dolomites which are discussed below. It is believed that its continued use will only serve to confuse. The writer does not know what bed, if any, in southwestern Oklahoma, corresponds to the Day Creek of Kansas.

14. Reeves, Frank, Geology of the Cement oil field: U. S. Geol. Survey, Bull. 726, p. 41, 1922.
Greene. F. C., and Sawyer, R. W., Stratigraphy of the middle-Permian.
15. Stephenson, D. C., Observations on the Verden sandstone of southwestern Oklahoma: Bull. Amer. Assoc. Pet. Geol., Vol. IX, No. 2, 1925.
16. Evans, Noel, Notes on geology of the Weatherford district, Oklahoma: Am. Assoc. Pet. Geol. Bull., Vol. 12, No. 7, 1928.

### CLOUD CHIEF FORMATION

This formation, in the type locality near the village of Cloud Chief, consists of massive white or pink gypsums interbedded with red sandstone and shales. Its thickness varies considerably. The well in sec. 23, T. 9 N., R. 17 W. shows 160 feet of gypsum and interbedded sandstones. The Ritter well in sec. 21, T. 11 N., R. 19 W., shows no gypsum. In the south and southwestern parts of Washita County, outcrops of gypsum are not as massive as in the eastern and northeastern parts. These variations are probably due to lenticularity of the gypsum members, to solution, or to a possible post-Cloud Chief—pre-Quartermaster erosional period.

The gypsums of the Cloud Chief slump badly and are not reliable for accurate surface work.

### QUARTERMASTER FORMATION

This formation consists of red shale and red sandstone with white streaks in the lower part, and of hard platy sandstones and shales in the upper part. Total thickness is 400 to 500 feet. This formation is characterized by erratic dips caused by slumping.

Hastings Moore showed the writer an area near Alfalfa where Quartermaster sandstones and shales rest directly on Whitehorse sandstones. Evans has shown that the dolomites capping the Caddo County buttes in Tps. 10, 11, and 12 N., R. 13 W., and the heavy dolomitic beds above the Weatherford dolomite in eastern Washita County are composed of Quartermaster material. These beds of Quartermaster material are found east of the Cloud Chief outcrops, and rest on the Whitehorse. The writer traced the Quartermaster-Whitehorse contact in the northwestern part of T. 9 N., R. 13 W., and recorded elevations along the contact. Contours were drawn on these elevations. The contours thus obtained corresponded closely with the topography. The re-entrants coincided with the creeks and draws and the noses coincided with the divides. This would prove that the unusual position of the Quartermaster material is due largely to slumping rather than to erosional unconformity. The slumping is due to two things: first, inadequate support of the gypsum and Quartermaster by the underlying soft Whitehorse sandstone; and second, the solution and disappearance of the gypsum.

If the Quartermaster material rested on horizons below the top of the Cloud Chief only along the eastern margin of the Quartermaster outcrop, then it would look like a progressive eastward overlap of the Quartermaster. However, in the Washita River Valley, across from Hammon, and thence west, up the valley, there are many localities where Quartermaster material rests on beds below the Cloud Chief Gypsum.



### COMANCHEAN

Comanchean limestone is found on a few hills in Washita County. It is composed largely of fossil oyster shells.

### TERTIARY

On tops of hills beds of coarse gravel are found locally. These gravel beds are referred to the Tertiary. Loose gravel, weathered, from these beds is widely distributed over the area.

### QUATERNARY AND RECENT

The lower beds are often covered with reworked red beds in the valleys of both small and large streams. There is a considerable area covered by alluvium in the valley of the Washita, and by loose sand in the valley of the North Fork of Red River.

## STRUCTURE

The larger structural features of the area are the Wichita Mountains and the Anadarko basin. The mountains occupy the greater part of Kiowa County. Adjacent to the mountains, both on the north and the south, the pre-Pennsylvanian rocks are folded steeply, but the surface red beds which cover them, dip very gently away from the mountains at the rate of 10 to 60 feet per mile. Along the line between Kiowa County and Washita County the red beds dip more steeply northward (100 to 150 feet per mile) into the Anadarko basin. In central Washita County the surface beds dip gently westward and in northern Washita County they dip southwestward 20 to 40 feet per mile. A map in the folder shows structure on the Blaine formation.

## DEVELOPMENT

### THE GOTEBO FIELD

In 1904 the Whitewater Oil and Gas Co. found oil in a well drilled in sec. 27, T. 7 N., R. 16 W. Since that time fifty or sixty wells have been drilled in this field, chiefly in secs. 21, 22, 23, 26, 27, 28, and 34, T. 7 N., R. 16 W. A smaller area which has had several wells drilled lies in secs. 5, 7, 8, and 18, T. 6 N., R. 16 W. and section 12, T. 6 N., R. 17 W.

Production has been in shallow sands, 300-600 feet deep. The oil wells were reported to have from 1 to 15 barrels initial production, most of them being very small. The largest gas wells produced 550,000 cubic feet.

Present production is about 14 barrels per day from 14 wells. At one time the town of Gotebo was supplied with gas from the wells, but these have been exhausted.

On the surface rocks, south dip, which is reverse dip, can be observed in section 27, just south of Gotebo. The area has not been mapped so far as the writer is aware and the relation of surface structure to production is not known.

In section 27 there are about 500 feet of red beds (probably Garber) underlain by about 300 feet of beds recorded as limestone, sandstone, and red and blue shales. This group is probably equivalent to the Pontotoc, though there may be remnants of any post-Viola—pre-Garber formations. Viola limestone is found at 800 feet. Five wells have penetrated the Viola limestone and at least three have passed through it. No commercial production was found in these deep wells.

## RECOMMENDATIONS

The small amounts of oil and gas already obtained in Kiowa County will cause many more wells to be drilled. All of Kiowa county, except that covered by the mountains, and all of Washita County is possible oil territory. There are many sands, already mentioned, which could serve as reservoirs for oil. To summarize, these are: sands of the red beds, which produce at Gotebo, the Panhandle Big Lime which produced at Sayre, the Pontotoc beds which produce in Carson County, Texas, and probably at Gotebo, the upper Pennsylvanian sands, the Viola limestone and the Simpson formation and the porous top of the Arbuckle limestone.

Kiowa County, north of the mountains, has possibilities of commercial shallow production. There has been much folding and some faulting, with possible local structure favorable to accumulation. There are also possible accumulations along unconformities. Prospecting is hazardous, however, due to the possibility of encountering solid granite at shallow depths.

Depths of formations increase in general, northward to central Washita county, and then rise very gradually again toward the north. The deepest part of the Anadarko basin is located in central Washita County.

In Washita County if a well is not to be drilled to pre-Pennsylvanian, it is believed that a surface structure of considerable closure is necessary to warrant a test. Due to unconformities, however, it is possible for favorable pre-Pennsylvanian structures to underlie little or no structure at the surface.

In considering the surface structure it should be remembered that the Cloud Chief formation is not reliable for accurate mapping, and the Quartermaster is not reliable at all. Any supposed structure mapped on these formations should be core-drilled to deeper formations such as the Weatherford or Greenfield dolomites, the base of the Whitehorse sandstone, or the Blaine formation.

*Completed Wells in Kiowa and Washita Counties*

| LOCATION | COMPANY | Total Depth | Top Blaine | Base Red | Top Pontotoc | Top Viola | Top Simpson | Top Arbuckle | Granite | Formation in Bottom of Well | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| SE-SW 1-5-18 | Caudill | 1236 | | 480 | 480 | None | None | None | 1188 | Granite | |
| SE-SW 2-6-19 | Alert Pet. | 1634 | | 878 | 878 | None | None | None | 1404 | Granite | |
| SW-SW-NE 18-6-16 | Obermeyer | 434 | | ? | | | 395? | | | Simpson? | Est. 10-45 bbls. No log above 395. |
| NW-SE 8-7-15 | Hartman | 2310 | | 1102 | None? | 1102? | 1826? | | | Simpson | Shows 1140 and 1850-1920. |
| NE-SE-SW 13-7-16 | Marland | 3230 | | 665 | | 1085 | 1740 | 3100? | | Arbuckle | Shows 545, 675, 1320, 1900-2000, 2821. |
| SW-NW SW-NE 19-7-16 | Conner | 985 | | 766? | 840 | | | | | Pontotoc | Shows 645-770. |
| SE-SW 20-7-16 | Conner | 1130 | | 922? | None | 922 | | | | Viola | Shows 558 and 850. |
| SE-SW 22-7-16 | Nations | 2500 | | 850? | None | 850 | 1425? | | | Simpson | Shows 2140-2255. |
| SW-SW 27-7-16 | Kraer | 2603 | | | | | | | | Simpson? | Upper log missing. |
| SW-SE 27-7-16 | Conner | 1230 | | 825? | None? | 825 | | | | Viola | Shows 605-765. |
| NW-NE-SW 34-7-16 | Conner | 1560 | | 875? | 875? | 1090? | 1442? | | | Simpson? | Shows 600, 900, 1100-1200, 1445. |
| NW-NE-NW 34-7-16 | Conner | 1752 | | | | 1100 | 1640? | | | Simpson? | Shows 1720-1742. |
| SW-NE 3-7-17 | Sunray-Aubyrne | 3737 | | 1875 | | | | | | Penn. | Shows 785, 1220, 2M gas 1080 ft. |
| NW-SW 10-7-20 | St. Louis, Okla. | 3094 | | 1325 | | | | | | ? | Poor log, well may have reached Simpson |
| SE-SW-SW 19-7-20 | C. and O. | 1320 | | 894 | 894 | | | | | Pontotoc? | Oil show 894. |
| SE-NE 34-7-20 | Outhier | 2682 | | 1105? | 1105? | | | | | Pontotoc | Gas show 2600. |
| SE-NW 9-8-15 | Morton | 3130 | 825 | 3027? | | | | | | Wellington? | |
| SW-NE 20-8-16 | Santrock | 3260 | ? | ? | | | | | | | Poor log. |
| SE-SE 33-8-18 | Sunray-Aubyrne | 2185 | | 1112 | 1455 | None | None | None | 2040 | Granite | Gas show 860, 1050. |
| 23-9-17 | Cincinnati | 4141 | 1070 | 3273 | | | | | | "Big Lime" | Gas show 1355. |
| NE 3-10-18 | Roxana | 3034 | 1330 | | | | | | | Garber | |
| SE-SW-SW 21-11-19 | Ritter | 5085 | 1174 | 3430 | 4794 | | | | | Pontotoc | |

# COTTON COUNTY

By
W. F. Cloud

## INTRODUCTION

This report summarizes past and present drilling and production in Cotton County, Oklahoma; describes the surface and subsurface geology as well as it can be ascertained from data available; and gives a general idea of what may be expected as to future development.

This information may be regarded as a composite report of the county. It represents the opinions and conclusions of the writer after spending considerable time in the area, being influenced to a large extent by the written opinions and personal communications of the geologists who have worked in that section of the State.

### Acknowledgments

The writer acknowledges the following individuals who have assisted very much in the compilation of this report: Frank Gouin, Geologist, Duncan, Oklahoma, who furnished pertinent information and suggestions; Dr. Chas. N. Gould and his staff of assistants in the office of the Oklahoma Geological Survey; and numerous geologists, producers, field superintendents, and their assistants who furnished data on production, development, and other miscellaneous information.

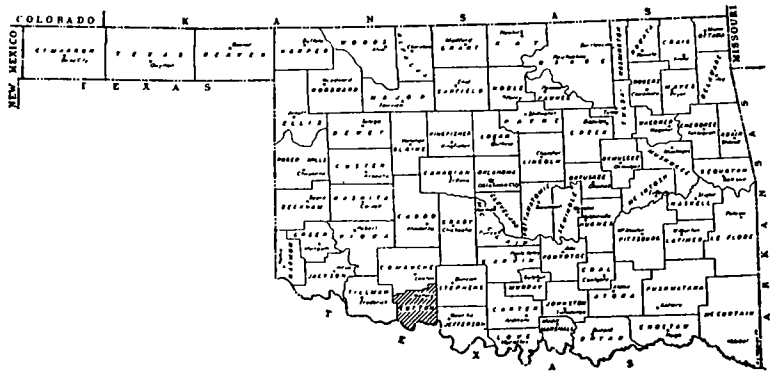


Figure 49.—Index map of Oklahoma showing location of Cotton County.

(Originally published as Bulletin 40-MM, January, 1930)

The geologic and production data compiled in 1920 in the U. S. Bureau of Mines report on the "Underground Conditions in the Walters Oil and Gas Field", by T. W. Swigart has been used to some extent.

Mr. Fred A. Bush, of the Sinclair Oil & Gas Corp., has read the manuscript and offered many helpful suggestions. Dr. Bruce Harlton, of the Amerada, has furnished the report on the Amerada No. 1 Delana well.

### Location

Cotton County is located in southwestern Oklahoma. It includes all or part of the townships included in the area from Tps. 1 to 5 S. inclusive, and from Rs. 9 to 14 W., inclusive. It includes 12 entire townships and parts of 13 others. The total area is approximately 640 square miles. This county is bounded on the north by Comanche County, on the east by Stephens and Jefferson counties, on the west by Tillman County, and on the south by Red River.

### Topography

Cotton County is located in the gently rolling area of the red beds plains. The only native trees in the country are those found along the creeks and streams. Except for several isolated hills capped by resistant sandstone the normal rolling slope is undisturbed throughout the county.

Most of the county is drained toward the south and southeast by tributaries of Red River. The central north-central, western, and most of the southern parts of the county are drained by Cache and Deep Red Run creeks. The northeast part is drained by Beaver Creek which flows southeast through Jefferson County.

## STRATIGRAPHY

### Surface Geology

The surface of the county is composed of Permian sandstones and shales, belonging to the undifferentiated Wichita and Clear Fork formations, which extend northward from north Texas into southern Oklahoma.

The Wichita formation is the oldest of the Permian series. It is probably the equivalent of the Wellington and Garber formations of the Oklahoma section. This formation covers approximately three-fourths of Cotton County. From the Wichita Mountains south it grades from arkosic sandstone through red and chocolate-colored shales and sandstones into blue shale and limestone of the Wichita beds of central west Texas.



The Clear Fork formation is obscurely exposed over part of the northern and northwestern parts of the county. It is composed of red and gray shales and isolated ledges of lenticular red and light gray sandstones. It contains dolomitic beds locally. The Clear Fork has been correlated with the Hennessey of southwest Oklahoma.[1]

Both the Wichita and the Clear Fork grade from red to brown and gray and from shale to limestone westward in the subsurface beds as well as southward where exposed.

The Wichita-Clear Fork contact can not be definitely traced across the entire county, but from the northwest corner of T. 1 S., R. 11 W. it can be traced more or less accurately in a generally southwest direction across approximately two townships. The relationship of the two formations then becomes obscure. But the outcrop of the Clear Fork beds evidently still trends toward the southwest, since the two formations can again be differentiated in southeast Tillman County.

### Surface Structure

While the dip of the surface rocks may vary frequently locally, the general direction of dip is toward the west and southwest.

In the southwest part of the county local variation of dip is discernible. In secs. 30, 31, 32, T. 5 S., R. 12 W., about one mile southeast of the Red River bridge at Burkburnett, the Permian rocks forming the river bluff have a pronounced northeast dip. This is probably an extension of the Burkburnett anticline. Reverse dips are traceable in sections 23, 29, and 32 also. It is possible that the northwest and southeast dips visible in sections 1, 2, 10, and 15 mark the trend of the axis of the Burkburnett structure.

The writer has noted east and west dips in a thin sandstone ledge along the ravines in the Keys gas field, which is located in sections 22, 23, 24, 25, 26, and 27, T. 1 S., R. 10 W. The reverse dips in this area do not exceed twelve degrees.

Couin[2] has mapped a surface structure in the Ahpeatone area which extends over the major parts of T. 1 S., R. 13 W., and Tps. 2 and 3 S., Rs. 12 and 13 W. A check of this reconnaissance work shows the surface "high" to lie in sec. 31, T. 2 S., R. 12 W.

Munn[3] has mapped a dome in the Permian in sec. 6, 7, 8, 9, and 16, T. 4 S., R. 13 W. This is separated from the dome at Grandfield by a flat saddle in the northern part of sec. 2, T. 4 S., R. 14 W.

His report shows also a smaller dome in secs. 25, 26, and 27, T. 4 S., R. 13 W., but owing to lack of outcrops south of this location

1. Willis, Robin Preliminary correlation of the Texas and New Mexico Permian. Amer. Assn. Pet. Geol., vol. 13, no. 8, p. 1001, 1929.
2. Couin, Frank personal communication.
3. Munn, M. J., Reconnaissance of the Grandfield District, Oklahoma: U. S. Geol. Survey Bull. 547, 1914.

the outline can not be definitely determined. From the center of this dome eastward the rocks appear to pitch gradually along the axis of the fold to some point near the center of sec. 26, T. 4 S., R. 12 W., from which they rise slightly to a small dome in secs. 24 and 25, T. 4 S., R. 12 W.

### Subsurface Geology

A correct interpretation of the subsurface geology of Cotton County is difficult because of the scarcity of reliable horizon markers and the lack of descriptions of the strata as to color and texture as recorded in rotary well logs. The problem is made still more difficult because to date only a few deep wells have been drilled in this county. Also, only recently have the operators paid very much attention to a systematic microscopic and paleontologic examination of well cutting and cores.

When the writer undertook the compilation of this report he had thought of preparing a northeast-southwest cross-section through Cotton County across Red River and into north Texas, thus correlating the southern Oklahoma geologic section with that area. But, owing to the time allotted for this report and to the scarcity of correlative information as to the subsurface strata of these two areas, this idea had to be abandoned. However, the correlation on the Amerada No. 1 Delana well gives a comprehensive idea of the subsurface section of the county (see fig. 50). The Sholem Alechem limestone horizon is probably the equivalent of the lower limestone body of the Hoxbar and the limestone of the upper Deese.

### CAMBRIAN AND PRE-CAMBRIAN

It is reasonable to believe that igneous rocks might be encountered at comparatively shallow depths in the north-central part of the county, although to the writer's knowledge no well log to date records having drilled to pre-Cambrian rocks. Since the Reagan sandstone outcrops north and northeast of the Wichita Mountains, and has been found as far east as the Arbuckle Mountains, it is quite possible that it underlies the northern and northeastern parts of Cotton County. This assumption can be proved only by deeper drilling, however, as no well log submitted to date can be interpreted as having drilled into the Reagan.

As was previously mentioned, the Amerada-Delana well in the NW.¼ sec. 31, T. 4 S., R. 9 W., encountered considerable limestone of Cambrian age above granite wash at 3,275 feet, and pre-Cambrian granite at 3,350 feet.

In the north Texas area, to the south and southwest of Cotton County, igneous rocks have been encountered in several wells. The Fain-McGaha No. 1 Mathews, completed in February, 1928, in Foard County, Texas, encountered detrital chlorite and phyllite schist from 2,205 to 2,390 feet, and solid granite from 2,390 to a total depth of 2,585 feet. The Barkley and Meadows No. 1 Stephens in Wilbarger

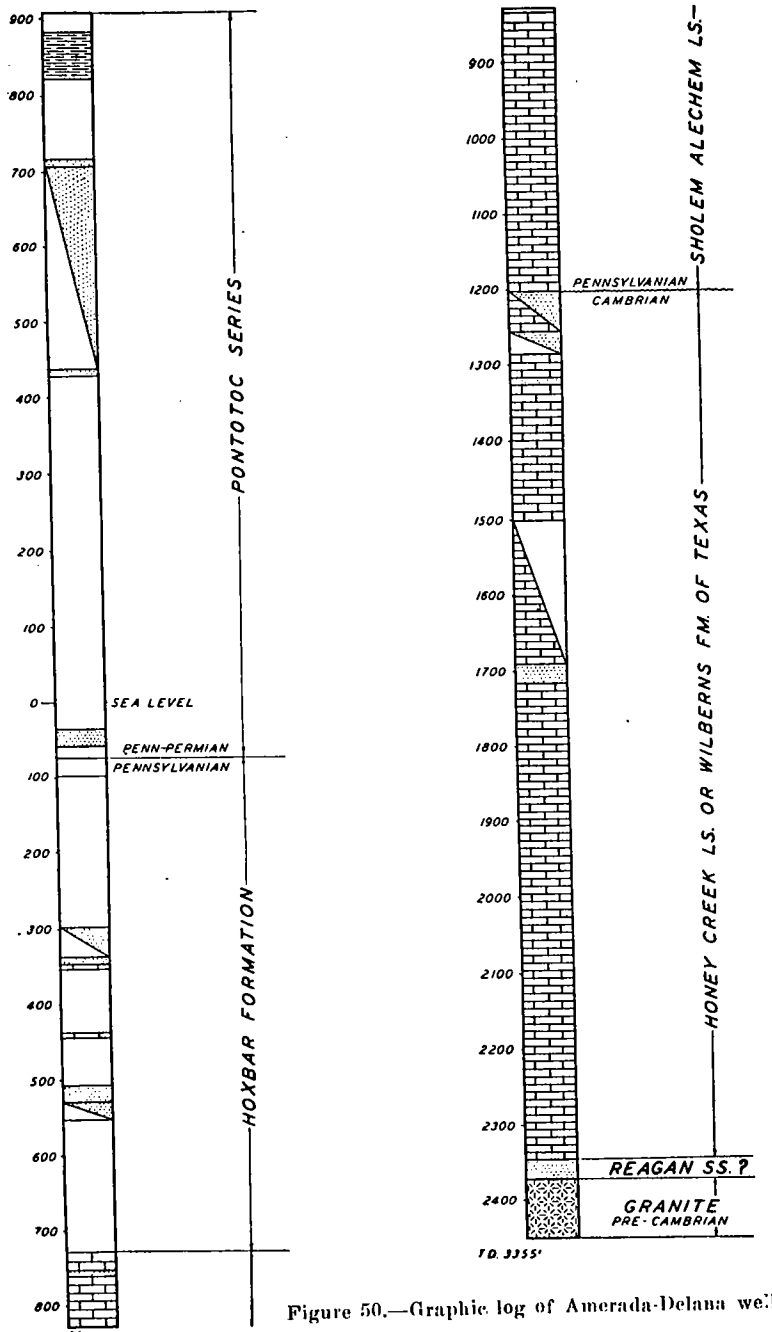


Figure 50.—Graphic log of Amerada-Delana well.

County, Texas drilled into red and black granite at 2,950 feet. The Continental-Magnolia No. 1 Beach, drilled five miles south of Burkburnett, Texas, encountered black arkose and diorite gneiss at 3,020 feet.

The evidence supplied by these three wells, together with that of the Amerada-Delana well in sec. 31, T. 4 S., R. 9 W., provided it did strike solid granite at 3,350 feet, points toward the existence of a buried granite high extending approximately east and west along the southern boundary of Tillman, Cotton, and Jefferson counties.

### CAMBRO-ORDOVICIAN

As has been stated, most of the deep tests drilled in this county have encountered the Arbuckle limestone.

The Magnolia Petroleum Company drilled in to the Arbuckle lime at 3,017 feet in a well in the NE.¼, SW.¼ sec. 25, T. 1 S., R. 9 W., in Stephens County about 12 miles northeast of the Walters field.

Other wells wherein the Arbuckle limestone is reported to have been encountered in Cotton County are listed below:

| LOCATION | DEPTH TO ARBUCKLE |
|---|---|
| NE.¼ sec. 5, T. 2 S., R. 12 W. | 2,150 |
| SE.¼ sec. 21, T. 4 S., R. 9 W. | 3,155 |
| SW.¼ sec. 29, T. 4 S., R. 11 W. | 2,970 |
| NW.¼ sec. 31, T. 2 S., R. 12 W. | 2,680 |
| NW.¼ sec. 31, T. 4 S., R. 9 W. | 3,275(†) |
| NE.¼ sec. 33, T. 2 S., R. 9 W. | 3,340 |
| SE.¼ sec. 32, T. 1 S., R. 10 W. | 4,336 |
| SW.¼ sec. 23, T. 2 S., R. 12 W. | 2,600 |

### ORDOVICIAN

With the possible exception of the northeastern part of the county, the Simpson formation is probably absent in most of Cotton County, the Pennsylvanian strata being directly above the Arbuckle lime. This may be attributed to two causes: (1) block faulting in the region adjacent to the Wichita Mountains; and (2), this area may be presumed to have been a positive element during these periods. So, there possibly was no deposition upon the eroding Arbuckle lime until Pennsylvanian time. To the best of the writer's knowledge only two wells previously referred to have encountered strata younger than the Arbuckle limestone beneath rocks of Pennsylvanian age. If any post-Arbuckle deposits were made in this area they must have been thin and were eroded off and carried away before the encroachment of the Pennsylvanian seas.



### PENNSYLVANIAN

After consulting various geologists who have done work in southern Oklahoma and northern Texas, the writer has concluded that very little exact data are available as to just what part of the Pennsylvanian section is present north of Red River in the area occupied by Cotton County.

According to Dott[4] the southeast part of Cotton County was submerged during upper Caney and Wapanucka time. An examination of several well logs obtained from this area causes the writer to believe that the Cup Coral, Deese, and Hoxbar members of the Glenn formation are present, also. The Amerada-De Lana well in sec. 31, T. 4 S., R. 9 W. shows Hoxbar from 1,005 to 1,346 feet, and Deese from 1,346 to 2,360 feet, with Ordovician strata to the top of the granite wash at 3,275 feet. However, the opinion of geologists is divided as to the age of the strata penetrated in this well. Several hold the opinion that the entire section to 3,275 feet is Permo-Pennsylvanian, and that it was lower Arbuckle lime instead of granite encountered at 3,275 feet.

The total thickness of the Permo-Pennsylvanian section in the area of the Walters field is approximately 3,910 feet. A well drilled in 1927 by the Garvin Drilling Company in sec. 32, T. 1 S., R. 10 W. encountered the Simpson formation from 3,910 to 4,336 feet, and drilled into the Arbuckle lime to a total depth of 4,338 feet. The log of this well is as follows:

*Log of Garvin Drilling Co.'s well, Fink No. 1, SE¼ SE.¼ SE.¼ sec. 32, T. 1 S., R. 10 W.*

| Formation | Top | Bottom |
|---|---|---|
| Red beds and shale | 0 | 34 |
| Sand | 34 | 51 |
| Red beds | 51 | 83 |
| Pack sand | 83 | 155 |
| Red beds and shale | 155 | 339 |
| Pack sand and red beds | 339 | 368 |
| Pack sand, red beds | 368 | 634 |
| Red sandy shale | 634 | 902 |
| Sand | 902 | 908 |
| Shale | 908 | 1041 |
| Sand and shale | 1041 | 1092 |
| Sandy lime-cored | 1092 | 1097 |
| Brown sand and shale | 1097 | 1230 |
| Lime | 1230 | 1232 |
| Hard brown sand and shale | 1232 | 1375 |
| Broken lime | 1375 | 1389 |
| Shale-brown, cored at 1574′ | 1389 | 1575 |
| Lime | 1575 | 1576 |
| Pack sand-cored | 1576 | 1577 |
| Brown sandy shale | 1577 | 1601 |
| Broken lime-cored 1603 | 1601 | 1605 |
| Broken sandy shale-cored 1608 | 1605 | 1649 |
| Broken lime | 1649 | 1654 |
| Brown shale-cored 1679 | 1654 | 1687 |
| Lime-cored | 1687 | 1694 |
| Red and brown shale | 1694 | 1757 |
| Lime | 1757 | 1759 |
| Shale and boulders | 1758 | 1785 |
| Broken hard lime | 1785 | 1796 |
| Brown shale | 1796 | 1851 |
| Hard broken lime | 1851 | 1868 |
| Blue sticky shale and boulders | 1868 | 1934 |
| Cored 1899′ broken lime | 1934 | 1978 |
| Red, blue sandy shale | 1978 | 1968 |
| Cored 1940,-48,-49,-56,-57 | | |
| Sand oil-cored | 1968 | 1978 |

(Continued on page 330).

4. Dott, Robert H., Pennsylvanian paleogeography: Oklahoma Geol. Survey Bull. 40-J, p. 12, 1927.

| Formation | Top | Bottom |
|---|---|---|
| Cored 1969 and 71 blue shale | 1978 | 1986 |
| Broken lime and boulders | 1986 | 2019 |
| Broken shale | 2019 | 2030 |
| Brown and blue shale with lime | 2030 | 2069 |
| Shale and boulders | 2069 | 2100 |
| Oil sand | 2100 | 2112 |
| Sandy shale | 2112 | 2165 |
| Hard lime | 2165 | 2180 |
| Lime | 2180 | 2191 |
| Red shale | 3568 | 3575 |
| Blue sandy lime and red beds | 3575 | 3578 |
| Gray lime | 3578 | 3581 |
| Red | 3581 | 3615 |
| Gray lime shells | 3615 | 3618 |
| Red lime | 3618 | 3622 |
| Gray lime and red rock | 3622 | 3634 |
| Gray lime | 3634 | 3647 |
| Water sand | 3647 | 3664 |
| Hard gray sandy lime | 3664 | 3667 |
| Water sand | 3667 | 3675 |
| Gray sand and sandy lime | 3675 | 3684 |
| Water sand | 3684 | 3712 |
| Red beds and gray lime | 3712 | 3717 |
| Red, gray and white mixtures | 3717 | 3722 |
| Blue shale | 3722 | 3728 |
| Pink shale | 3728 | 3744 |
| Brown shale | 3744 | 3767 |
| Broken lime | 3767 | 3775 |
| Blue shale | 3775 | 3795 |
| Red, blue and brown shale | 3795 | 3840 |
| Broken lime | 3840 | 3843 |
| Brown and blue shale | 3843 | 3866 |
| Lime | 3866 | 3870 |
| Brown shale and lime shells | 3870 | 3900 |
| Lime | 3900 | 3910 |
| Hard water sand | 3910 | 3935 |
| Blue shale | 3935 | 3941 |
| Hard sand | 3941 | 3945 |
| Brown shale and gravel | 3945 | 3948 |
| Brown blue and red sticky shale | 3948 | 3974 |
| Gray lime | 3974 | 4236 |
| Water sand | 4236 | 4237 |
| Lime | 4237 | 4241 |
| Black slate | 4241 | 4245 |
| Sandy lime | 4245 | 4247 |
| Water sand | 4247 | 4250 |
| Black and gray lime | 4250 | 4255 |
| Lime | 4255 | 4269 |
| Lime gray sandy | 4269 | 4275 |
| Black slate | 4275 | 4277 |
| Gray lime | 4277 | 4292 |
| Shale brake | 4292 | 4294 |
| Lime | 4294 | 4299 |
| Sandy lime | 4299 | 4303 |
| Sandy lime carrying water | 4303 | 4314 |
| Black shale | 4314 | 4336 |
| Gray lime | 4336 | 4338 |

In the northern part of Cotton County, sec. 5, T. 2 S., R. 12 W., the drill passed out of Pennsylvanian strata into the Arbuckle lime at 2,150 feet. The thickness of the Pennsylvanian in this section of the county is estimated at 1,200 to 1,350 feet.

In the Randlett area the Pennsylvanian strata are approximately 1,250 feet thick. The section here is very similar to the Cisco and Canyon sections of north Texas.

### PERMIAN

Thickness of the Permian red beds in Cotton County as revealed by well logs is very indefinite, as most of the wells were drilled with rotary tools, and very little attention was paid to proper collection of the cuttings. After examining the logs of most of the wells drilled in the county, the writer has found no formation in the Permian series which may be used as a definite horizon marker.



The Permo-Pennsylvanian contact can not be definitely located in the well logs available. However, there are probably 850 to 1,000 feet of Permian overlying the Pennsylvanian in the Walters field. These beds thicken toward the west and southwest. They are apparently 1,300 feet thick in sec. 15, T. 2 S., R. 11 W. The log of a well drilled one-half mile northeast of Emerson shows approximately 1,350 feet of sandy red shale and gumbo. A well drilled in the NW.¼ sec. 31, T. 2 S., R. 12 W. encountered coarse arkosic sand and gravel from 1,425 to 1,483 feet. This is probably the base of the Permian in this area. Farther west the red beds seem to thin out, as a thickness of only 1,240 feet was logged in a well drilled in the SW.¼ sec. 35, T. 2 S., R. 14 W.

The Amerada-De Lana well, drilled to 3,353 feet in the NW.¼ sec. 31, T. 4 S., R. 9 W., the southeast corner of Cotton County, encountered only 940 feet of strata which are considered Permian.

In the Randlett area the Permian red beds are approximately 1,600 feet thick; whereas, farther west in sec. 36, T. 4 S., R. 13 W., 1,400-1,450 feet seems to be the average thickness.

A well in the NE.¼ sec. 32, T. 4 S., R. 13 W., one and one-half miles southeast of Devol, drilled through only 1,200 feet of what is apparently Permian strata.

The Permian red beds thin toward the north in the general direction of the Wichita Mountains, being 1,250 feet thick in sec. 34, T. 1 S., R. 11 W. Northwest of this location, in sec. 9, T. 1 S., R. 12 W., Comanche County, the log of the Carmichael well shows only 1,040 feet of probable Permian sediment.

After examining approximately 250 well logs from widespread areas of Cotton County, the writer has concluded that there are possibly 1,025 to 1,850 feet of Permian non-marine and Pennsylvanian sediments (mostly marine maroon arkosic shales) underlying that area of Oklahoma. This section is thinnest in the southeast corner of the county and along the central-northern part, included in the south half of T. 1 S., Rs. 11 and 12 W.

Across Red River to the south in Wichita County, Texas, the Permian becomes thin toward the southeast. The Continental-Magnolia No. 1 Beach, drilled five miles south of Burkburnett, encountered only 870 feet of Wichita strata. Whereas, the Fair McCaha-Shell No. 1 Mathews well in Foard County, Texas, drilled through 360 feet of Clear Fork, and drilled into the Cisco at 1,150 feet. This indicates that the Wichita is approximately 800 feet thick in that area, becoming thinner toward the southwest.

## STRUCTURAL RELATIONSHIP

### Wichita Uplift

The earliest known period of folding which might have effected the subsurface structure of Cotton as well as adjoining counties is that associated with the formation of the Wichita Mountains of Comanche County.

The general trend of this uplift is toward the southeast. It is quite possible that the folding associated with it was responsible for the structures favorable for the accumulation of the oil and gas produced in Caddo, Comanche, Stephens, and northeast Cotton counties.

### Arbuckle Uplift

The other major uplift that has evidently aided in molding the subsurface structure of Cotton County is that associated with the formation of the Arbuckle Mountains. This movement evidently occurred in post-Glenn time. Possibly the area previously effected by the Wichita uplift was again subjected to movement when the Arbuckle uplift occurred, although perhaps not as intensively.

### Permian Folding

Surface folds adjacent to the Wichita Mountains indicate that they were subjected to a second disturbance since the deposition of the Wichita-Clear Fork formations. However, an appreciable amount of the folding noted in the surface Permian may be due to faulting, differential settling, and compaction of load in the thick mass of red shales that are present.

The discordance of dip between the Duncan sandstone and the overlying Permian rocks is also suggestive of some degree of disturbance during Permian time.

## OIL AND GAS DEVELOPMENT

A large number of wells have been drilled in Cotton County within the last fifteen years. However, the only commercial production to date was obtained in the Walters field. A little gas and a very small amount of oil were obtained in a few wells drilled in the vicinity west of the city of Walters; however, the sand was very thin in this area, and the wells were soon abandoned. See map No. XXXII for production.

### The Walters Field

#### LOCATION

This oil and gas field is located northeast of Walters, Oklahoma in secs. 29, 31, 32, 33, 34, and 35, T. 1 S., R. 10 W., and secs. 1, 2, 3, 4, 5, 6, 9, and 10, T. 2 S., R. 10 W. A northeast extension of the field, known as the Keys gas field, includes the SW ¼ sec. 19 and the NW.¼ sec. 30, T. 1 S., R. 9 W., and all or parts of secs. 14, 22, 23, 24, 25, 26, and 27, T. 1 S., R. 10 W.



#### HISTORY

The first well drilled was completed as a gas well in February, 1917. It is located in the SE. cor. sec. 22, T. 1 S., R. 10 W. This well flowed about 20 million cubic feet of gas daily from a depth of 2,176 feet. The initial casing-head pressure was 875 pounds per square inch. Within two months this pressure had declined to 385 pounds, due partly to the immediate drilling of offset wells. This well is still producing a small amount of gas at 35 pounds pressure.

The largest gas well in the field was completed across the highway south of the discovery well, in the NE. cor. section 27. The initial gas volume of this well was approximately 40 million cubic feet daily at 880 pounds pressure.

The wells in the Keys area declined rapidly as drilling progressed. In the spring of 1920 the average shut-in pressure was 200 pounds. Since then the pressure decline has been slow. The average pressure in 1925 was 70 to 75 pounds. The average open-flow pressure for the entire gas area at the present time is 35 to 40 pounds. The writer witnessed a shut-in pressure text of 102 pounds made on a well in the SW.¼ SE.¼ sec. 14, T. 1 S., R. 10 W.

It is impossible to estimate how much gas this section of the field has produced to date. There has been very little water produced with the gas in this part of the field.

#### STRUCTURE

The surface structure cannot be mapped satisfactorily in this area. However, in the gas area of the northeast extension of the field the surface high is partially traceable. It is somewhat comparable to the subsurface structure of the Keys gas sand. This is the only part of the field in which any appreciable amount of surface closure can be mapped from the outcrops available.

The subsurface contour map drawn by Swigart[5] on the Priddy sand portrays a low, flat structure composed of small domes and irregular noses. Due to recent development in secs. 34 and 35, T. 1 S., R. 10 W. and in secs. 2 and 3, T. 2 S., R. 10 W., this map can now be extended to show closure on the east side of the field proper. The structure is so flat and spreads out over such a large area that the oil and water have never appeared to have undergone complete gravitational separation in parts of the field. This, in the writer's opinion, accounts for the fact that many of the wells have always produced some water, but have never been troubled much with rapid water encroachment, although the field has been producing for more than ten years.

5. Swigart, T. E., Underground conditions in the Walters oil and gas field: Bull. U. S. Bur. Mines, 1920.

### STRATIGRAPHY

There are a very few isolated outcrops over the range of the entire field. In a few places reddish lenticular sandstones and red shales are exposed along the streams and highways. The surface terrain is largely a red sandy loam belonging to a part of the Wichita formation which is Permian in age.

Well logs show the base of the Permian to be from 850 to 1,000 feet below the surface over the ridge which is responsible for the structure of the Walters field. This estimate is based solely on stratigraphic analyses of well logs and well cuttings, and is therefore debatable. The exact thickness of the Permian is made still more obscure because of the absence of fossils in the well cuttings and cores obtainable.

The only deep test ever drilled in the productive area of Cotton County was the well in the SE.¼ SE.¼ SE.¼ sec. 32, T. 1 S., R. 10 W., by the Garvin Drilling Company in 1926 and 1927. In this well red beds were logged as deep as 3,717 feet. Geologists and paleontologists are not agreed as to how much Permian, Hoxbar, Deese, and Springer sediments were encountered. However, it is quite probable that drilling stopped in the top of the Arbuckle lime.

### PRODUCING SANDS

Past and present productive areas of the entire Walters field comprise approximately 3,000 acres. A few wells flowed 1,000 barrels daily for a very short time but most of them averaged from 100 to 250 barrels and declined rapidly.

The Priddy sand has produced most of the oil in the field. It was encountered at an average depth of 2,100 feet. This sand is loose, coarse, and friable, and contains an appreciable amount of lime fragments locally. It is muddy gray in color, and is about 20 feet thick in section 3, increasing to approximately 30 feet in section 5, where it is very porous.

In a few isolated areas in the field production was obtained from what has been called the "second layer" of the Priddy sand. This is evidently a sand lens in the shale between the Priddy and the Keys sands. It lies approximately 60 feet below the top of the Priddy sand, and where found has an average thickness of 8 to 10 feet. This sand is rather fine-grained and contains more shale than the Priddy sand.

The Keys sand has been encountered at 95 to 100 feet below the top of the Priddy sand. In wells where it has been penetrated the thickness averages 15 to 20 feet. This is a tight sand. It has been logged as containing much lime in many of the wells. This is the sand that has produced most of the dry gas obtained from the northeast part of the Walters field. However, it is probable that it might produce both oil and gas in the central part of the field if the wells were deepened to it, as it has produced an appreciable amount of gas in five or six wells in the SE. ¼ sec. 31, T. 1 S., R. 10 W., which is on the west edge of the field. It is to be noted that the oil produced south and west of these gas wells is coming from the upper layer of the Priddy sand.



The Zypsie sand is located 205 to 230 feet below the top of the Priddy sand. It has produced and is still producing some oil of low gravity in the S. ½ of section 29 and the NE. ¼ of section 32. This sand is probably 20 feet thick, although it has been found in only a few wells. It is harder and contains more quartz than the other sands mentioned above, yet the gravity of the oil is lower, being only 28° A. P. I. corrected to 60° F.

### WELL SPACING

The wells drilled in the Walters field were usually uniformly spaced with four wells on each 40-acre tract. On a few leases as many as six wells were drilled on 40 acres. In a few instances wells were spaced as far as 850 to 900 feet apart at first, then later wells were drilled between these locations.

The gas wells were not so closely spaced as the oil wells. They averaged one well to each 40-acre tract except where immediate lease offsets were drilled.

The wells that have been drilled recently, as well as those drilling at the present time, have been located promiscuously, usually about 300 to 400 feet apart in any direction adaptable to best surface conditions for economic operation.

### DRILLING AND COMPLETION

Practically all of the wells in the Walters field and more than four-fifths of the wildcat wells in Cotton County have been drilled with rotary tools, as cable tools are much slower in the thick shales encountered in this section of the State.

Many of the wells were drilled-in with cable tools and spudding machines. However, the general practice in this field has been to drill-in and complete the well with rotary tools. The companies usually cemented 6 5/8-inch casing above the sand, then "rat-holed" and cored ahead until the sand was encountered. If 8-inch casing was to be cemented above the sand, one or two points of 12½-inch surface pipe were cemented. However, in most of the wells 10-inch surface pipe was used. The tendency at the present time is to use only one joint of conductor pipe, since there is no danger of gas blow-outs.

The last water sand usually encountered lies approximately 125 feet above the top of the Priddy sand. This permits the operators to easily choose a suitable place to land and cement the "oil string" in the

shales above the oil sand. Many of the wells were completed with a 5 3/16-inch perforated liner.

The wells in this field were often drilled and completed within six to eight drilling days. The contract price was usually $2.50 per foot. It costs approximately $9,500.00 to $10,000.00 to drill and complete a well and install pumping equipment.

Most of the old wells are pumped by jacks and power plants. The recently drilled wells and the old wells which are still producing more than the average, as well as the isolated wells, are hooked directly to the beam and are pumped-off once a day.

The writer believes that the inefficient use of rotary tools while drilling-in the wells has been largely responsible for the spotted and erratic production during the early development of the field, as well as at the present time. An example: recently a rotary-drilled well, offsetting a 17-barrel pumping well only 300 feet distant, failed to get production in the Priddy sand which is producing on all four locations surrounding this dry hole. The rock pressure is very low in this area, yet this well was drilled-in with the hole full of mud fluid.

On another lease in sec. 2, T. 2 S., R. 10 W., the recent extension of the field to the east, a rotary-drilled well failed to get production 250 feet from a recently completed well which is pumping 37 barrels of oil daily. The pumper on the lease informed the writer that while the offset was drilling through the "sand" the pumping well gauged five barrels increased production daily. The drillers claimed that they encountered no sand at all in this test, although it was drilled approximately 100 feet deeper than the producing offset well.

It is quite probable that inefficient use of rotary tools may account for the apparent absence of the Priddy sand in the SE. ¼ sec. 31, T. 1 S., R. 10 W., where commercial gas wells were completed in the Keys sand; yet the oil production on the east, south, and west is coming from the Priddy sand. Judging from the logs of the wells in section 31 the upper pay streaks were logged as limestones.

### PRODUCTION DATA

Swigart's report[5] shows approximately 290 producing wells, drilling wells, and locations in the Walters field in March, 1920. This does not include the 19 or 20 wells drilled west and northwest of the city of Walters, only one of which is still producing. Of this total of 290 wells only 145 produced oil in commercial quantities. There were 32 producing gas wells in the field. About 23 of these still produce commercial gas.

Since March, 1920, approximately 70 wells have been drilled in the field. These later wells were drilled in secs. 27, 29, 32, 33, 34,

5. Swigart, T. E., op. cit.



and 35, T. 1 S., R. 10 W., and in secs. 2, 3, 5, and 8 T. 2 S., R. 10 W. Most of these wells are producing small quantities of oil although the wells drilled in section 8 were dry.

Within the last two years wells have been drilled in secs. 34 and 35, T. 1 S., R. 10 W., and in secs. 2 and 3, T. 2 S., R. 10 W. This is the eastern extension of the field. Eight wells are being drilled in this area at the present time. These recently drilled wells when properly and carefully completed initial productions of 33 to 65 barrels daily.

Out of a total of approximately 175 producing oil and gas wells in 1920, approximately 45 or 50 have been abandoned, some of them prematurely, however. All of the old wells are being pumped, as there are no flowing wells in the field. Their average production is 5.5 barrels per well per day. Several of the gas wells are still capable of producing from 2 to 6 million cubic feet per day. The wells recently completed in the eastern extension of the field average 42.6 barrels daily.

Most of the oil is being produced from the Priddy sand. There are 14 wells in the SE. ¼, sec. 29, T. 1 S., R. 10 W., producing 107 barrels daily from the Zypsie sand. According to Swigart's report and available field information this is the only area that ever produced from the Zypsie sand. Apparently the Priddy sand thinned out into shale and limestone in the northwest part of the field.

The peak of average daily production per well was reached in June, 1919. It was 54 barrels at that time. The entire field reached its peak of production, 3,400 barrels per day, in September, 1919. The largest wells in the field produced between 250 and 300 barrels initial, but declined rapidly. Most of the wells had initial production ranging from 100 to 225 barrels per day.

Through the courtesy of several of the companies producing oil in the Walters field the writer has compiled the table showing the production summary of the major leases. (See page 338).

### POSSIBILITY OF FUTURE PRODUCTION

#### The Walters Field

It is quite possible that many commercial wells can be drilled east, north, and northeast of the old wells in this area, if properly completed.

Recently wells have been completed in secs. 33, 34, and 35, T. 1 S., R. 10 W., and in secs. 2 and 3, T. 2 S., T. 10 W.

The writer believes that commercial wells can be obtained by drilling to sands below the Priddy and Zypsie sands in this area.

*Production summary of major leases in Walters field.*

| COMPANY | LOCATION | LESSOR | SIZE OF LEASE (ACRES) | TOT. BBLS. PRODUCED TO 7/1/29 | BARRELS PER ACRE | PRODUCING SAND |
|---|---|---|---|---|---|---|
| Gypsy | NE SE 29-1S-10W | Pruett | 40 | 458,433 | 11,461 | Zypsie |
| Gypsy | SW NW 4-2S-10W | Wilkinson | 40 | 72,462 | 1,812 | Priddy |
| Carter | W½ NE 5-2S-10W | ? | 80 | 167,680 | 2,096 | Priddy |
| Pure | SE NW 29-1S-10W | Kelly | 10 | 13,204 | 1,320 | Zypsie |
| Pure | SE SW 29-1S-10W | McMahon | 40 | 92,509 | 2,313 | Zypsie |
| Pure | W½ SE 29-1S-10W | Zypsie | 60 | 284,175 | 4,736 | Zypsie |
| Pure | NW NE 32-1S-10W | Fink | 40 | 29,893 | 747 | Priddy |
| Pure | SE NW 32-1S-10W | Kassl | 40 | 27,734 | 693 | Priddy |
| Pure | NW SE 32-1S-10W | McQuown | 30 | 46,360 | 1,545 | Priddy |
| Prairie | N½ SW 5-2S-10W | Howell | 80 | 270,320 | 3,379 | Priddy |
| Texas | N½ NW 4-2S-10W | ? | 80 | 214,970 | 2,687 | Priddy |
| McMan | SE 4-2S-10W | B. F. Priddy | 160 | 436,324 | 2,721 | Priddy |
| McMan | S½ SW 3-2S-10W | G. G. Priddy | 120 | 600,462 | 5,004 | Priddy |
| McMan | SW SE 3-2S-10W | G. G. Priddy | 120 | 600,462 | 5,004 | Priddy |
| McMan | NW NE 10-2S-10W | W. D. Priddy | 40 | 55,323 | 1,383 | Priddy |
| McMan | N½ NW 10-2S-10W | Chapman | 80 | 219,823 | 2,748 | Priddy |
| McMan | W½ NE 4-2S-10W | Patterson | 80 | 116,400 | 1,455 | Priddy Keys & |
| McMan | E½ NE 6-2S-10W | Maize | 80 | 112,370 | 1,405 | Priddy |
| McMan | E½ NW 6-2S-10W | Carr | 80 | 94,103 | 1,103 | Priddy |



**Other Parts of The County**

Reference to the oil and gas map of this report will cause one to believe that Cotton County has been fairly well tested for commercial production. Many wildcat tests have been drilled in this county, but to date the results have been disappointing. However, in most of these wells the complete Pennsylvanian section has not been penetrated.

Due to the existence of the Wichita Mountains to the north of the county, the Arbuckle Mountains to the east, and the buried granite ridge to the south extending east and west in the vicinity of Red River, it is apparent that the central portion of Cotton County is occupied by a basin, the axis of which trends approximately east and west. In such an area, therefore, it is not probable that oil and gas exist in commercial quantities.

However, the existence of this basin, viewed in the light of present subsurface information, does not entirely condemn this central area. Minor folds and other petroliferous traps, as well as stratigraphic overlaps from the south, may exist which heretofore have not been located.

# JEFFERSON COUNTY

By

John R. Bunn

## INTRODUCTION

This report summarizes the results of eighteen months surface and subsurface geological study and the actual supervision of some 50,000 feet of structure core-drilling confined entirely to Jefferson County, Oklahoma, in an attempt to locate undiscovered oil and gas structures.

Jefferson County was chosen for this intensive study and exploration because of its geographical location between the prolific fields of southern Oklahoma located in Carter and Stephens counties and the producing fields of north-central Texas included in Wichita, Archer, Clay, Cooke, and Montague counties; making this county as a whole, an area of probable oil and gas territory.

Furthermore, the same general stratigraphy and sedimentary conditions existing in the producing areas of southern Oklahoma and certain parts of northern Texas were thought to occur throughout Jefferson County. Likewise, regional structural highs or trends are known to be present. It would appear, then, that the location of commercial oil and gas deposits in Jefferson County will depend largely upon the discovery and drilling of minor flexures along the major structural highs, where sand conditions and source material are favorable for oil and gas accumulations.

### NATURE OF WORK

Jefferson County is typical of southern Oklahoma in presenting many difficulties to the petroleum geologist. He is handicapped in search for favorable surface structure by lack of surface beds suitable for positive correlation and detail mapping. Subsurface work is likewise difficult, due to unconformity and overlap, scarcity of deep wells, and rather unreliable nature of certain well records. Because of these existing conditions, the geologist must work largely in generalities over a large area. However, the major geological features of Jefferson County are readily interpreted when studied in this manner.

The first steps in the geological survey of the county consisted of a subsurface study and mapping of the present producing areas

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within the county and a study of their relationship with other pools in adjoining areas in southern Oklahoma and northern Texas. All available well records of outlying wells were obtained, plotted graphically, and a general subsurface contour map was drawn on the recorded depth to the base of the red beds. As has been previously pointed out by Burton,[1] and as will be discussed later, this method of determining general regional structure is infallible in the red bed area of southern Oklahoma.

Upon the completion of the subsurface work, a careful study was made of the surface exposures and structural attitude of mappable beds overlying the producing pools to determine the relationship of surface structure to that of the producing horizons. This work showed that in all instances where the surface could be accurately mapped there was a close relationship between surface and subsurface structure; also that the surface stratigraphy overlying the Jefferson County pools, as well as the Loco, Healdton, Hewitt, and other Carter County pools, had a very similar lithologic appearance, with a definite sequence of surrounding younger strata. An attempt was then made to differentiate and classify the surface stratigraphy of the entire county by a close reconnaissance survey. This work was satisfactorily completed after an expenditure of considerable time and effort. From the areal map of the surface stratigraphy, resulting from this work, it was possible to see at a glance the major structural features of the county. Furthermore, the structural features disclosed by the areal mapping coincided with the general structural features shown by the preliminary subsurface investigation.

The economic result of this general surface and subsurface study was the established location and proven existence of several major structural highs or trends, upon which to confine the detail mapping and study in the search for favorable anticlinal structure, the existence of which was to be proved by the structure drill. This method eliminated all but the most favorable and likely territory, cutting down to a minimum the expenditure in time and money for unnecessary and random core drilling. In the majority of cases it also enabled the acreage to be cheaply blocked or assembled on a core-drill contract previous to actual drilling, thus guaranteeing the acreage control should a likely looking structure be discovered.

## LOCATION

Jefferson County is located in south-central Oklahoma. It is bounded on the south and southwest by Red River, which stream forms the boundary between this county and Clay and Montague counties, Texas. It is adjoined by Love and Carter counties, Oklahoma on the east, by Stephens County on the north and by Cotton County on the west. The area is approximately 793 square miles and consists of all or parts of Tps. 3 to 8 S., Rs. 4 to 9 W.

1. Burton, George E., Relation of the base of the red beds to the oil pools in a portion of southern Oklahoma: Bull. Am. Assoc. Pet. Geol. vol. 5, pp. 173-177, 1921.



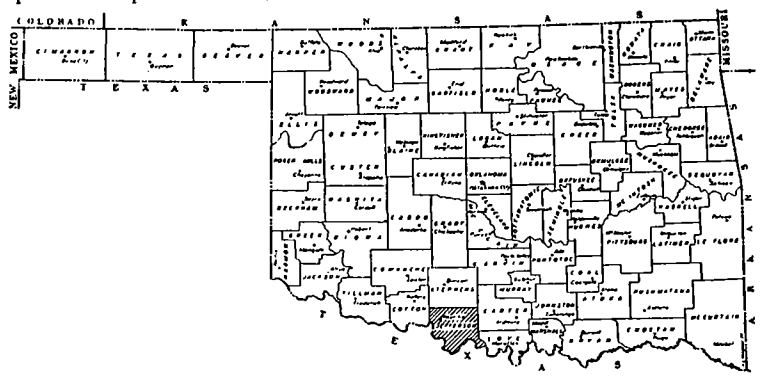



Figure 51. Index map of Okahoma showing location of Jefferson County.

## TOPOGRAPHY

Jefferson County is typical of the red beds plains region of Oklahoma, with a gentle rolling topography. The relief between stream valleys and divides is seldom in excess of 200 feet. Most of the county consists of rolling prairie land ideal for grazing purposes. The timbered areas are confined entirely to the stream valleys and certain sandstone outcrops.

The drainage of the entire area is south or southeast into Red River, which is the master stream of the area. The minor streams are East, West, and North Mud Creeks, Red Creek and Beaver Creek with its lesser tributaries. The surface elevation of the county ranges from 1,100 to 750 feet. The highest elevation is a point on Monument Hill, a few miles east of Addington, approximately 1,110 feet. The lowest point is in the extreme southeast corner of the county along Red River, with an elevation of approximately 720 feet.

Cattle and stock raising is the chief industry in the county. Comparatively little acreage is under cultivation. Cotton, corn, and feed stuff appear to be the principal agricultural products. The ranchmen of the area are high-type individuals, hospitable and inclined toward progressive cooperation.

The county possesses several well-maintained intersecting dirt highways. There are large areas taken in by certain large ranches in which the section lines are not open. However, if one will face the numerous gates of the ranchmen he may go anywhere by automobile.

Waurika is the county seat; other towns of the county are Ryan, Ringling, Addington, Hastings, Terral, and Sugden.

The main line of the Rock Island Railroad crosses the west half of the county in a north-south direction. Ringling, in the northeastern part of the county, is the terminus of a branch line of the Santa Fe from Ardmore. A branch line of the Fort Worth & Denver also runs from Waurika to Wichita Falls, and a branch line of the Rock Island runs from Waurika northwest through Hastings and Walters to Lawton.

## STRATIGRAPHY

### SURFACE FORMATIONS

To the writer's knowledge, there has never been any definite attempt heretofore to differentiate and classify the surface rocks of Jefferson County. These formations have been previously grouped together as an undifferentiated system in the red beds of lower Permian age. Preliminary surface study disclosed the possibility of differentiating the surface beds and showed the great value of this work in determining the general structural conditions.

It was found practical to separate the exposed stratigraphy into five mappable units. Certain of these divisions have a very characteristic appearance and are easily recognized and identified. The differentiation is based on the lithologic characteristics of the strata and regular sequence of certain sandstone and shale intervals. The areal map of the surface formations is shown on Map No. XXXIII. The map is, in general, strictly of a reconnaissance nature, and is to be taken as such, although certain of the areas shown have been closely detailed. In the outcrop tracing it was found parctical to follow along the top of a given sand zone or horizon, rather than attempting to follow any particular bed.

For the sake of clarity and convenience in the following discussions and descriptions, the various divisions have been given local names that were adopted during the course of the field work and detail study.

### POST-PERMIAN

Numerous areas in the county are covered by alluvium, valley fill, and unconsolidated sand and gravel deposits. These deposits have been classified as of Pleistocene, Tertiary, and Comanchean age, depending on type and locality. They are not classified on the accompanying map as their interest to the petroleum geologist lies only in the fact that they act as a blanket obscuring the underlying formations from which possible determinations as to structure could be made.

### PERMIAN

#### ADDINGTON FORMATION

The uppermost member of the red beds exposed in this area has been termed the Addington formation. The outcrop of this unit is



from four to six miles in width, and extends in a northwest and southeast direction across the county. A change in strike occurs in the northwest corner of the county, the outcrop swinging west into Cotton County. The formation is not exposed north of the town of Hastings so the exact point where it enters Cotton County is unknown. It is confined principally to parts of T. 3 S., Rs. 8 and 9 W., T. 4 S., Rs. 5 to 7 W., and T. 5 S., Rs. 4 and 5 W. Typical exposures occur in secs. 3, 4, 8, 9, 28, and 33, T. 5 S., R. 4 W.; secs. 30, 32, and 34, T. 3 S., R. 6 W.; secs. 23, 24, and 26, T. 3 S., R. 8 W.; and secs. 23, 24, and 25, T. 3 S., R. 9 W.

This unit has very definite characteristics and can be easily separated from other exposed strata of the county. It is characterized by the brilliant red and vermilion hues of its shale members, which are often broken by white and light gray shale and sandy shale streaks.

The sandstones are characterized by their black red color and slabby appearence on weathering. The weathered slabs are extremely hard and resistant. When freshly broken they resemble a fine grained reddish quartzite. In general the sandstones of this formation always show a varying amount of pink or red color unless subjected to constant water saturation in which case they are sometimes soft and light colored. The outcrop is especially discernible in wet weather. The shales when wet become exceedingly slick and gummy, causing almost impassable road conditions.

The thickness varies from a comparatively few feet to several hundred, the maximum exposed thickness occurring on the high bluffs just east of Addington. The beds capping the bluffs here are above any exposed to the southeast.

The base of this formation was used in the reconnaissance mapping. It is generally characterized by a thin to massive, resistant, reddish sandstone. There is some evidence that these beds are not entirely conformable with the underlying older strata. The Addington formation contains the only beds in the county that are typical of the lower Permian red beds of Oklahoma.

In Jefferson County the outcrop of this series marks a pronounced synclinal area. Every well located within or adjacent to the outcrop of these beds has recorded a great thickness of red beds which are found low structurally. The occurrence of this formation marks an area in this county that, from all present data, has no oil or gas possibilities.

### RED UPPER PENNSYLVANIAN

#### CLAYPOOL FORMATION

Underlying the Addington formation are several hundred feet of shales and sandy shales in which occur one or more uniform sand-

stone members. This predominant shale series is quite different in lithologic appearance from the overlying formation. The shales are brown, gray, and yellow, predominantly brown with irregular gray and blue mottling. The sandstones are thin-bedded, gray to buff in color, soft, and friable.

The extent of this formation is shown on the accompanying areal map. Certain parts of the area shown in the outcrop of this series through Tps. 4 and 5 S., Rs. 6 and 7 W., warrant more detailed study than has been given. It is possible that certain lower beds have not been recognized in this particular area.

### ASPHALTUM SANDSTONE

The most important sand horizon from the standpoint of areal mapping is the Asphaltum sand. This sand zone is exposed in the vicinity of the town of Asphaltum and occurs through parts of Tps. 3 and 4 S., Rs. 4 and 5 W. It marks the Healdton uplift showing up as a series of inliers along this major structural feature, with the overlying Claypool and Addington formations occurring progressively on either side. In every instance an exposure of this sand zone of any extent along this structural trend is indicative of local anticlinal structure. This sand zone is exposed over or around the Loco pool, the Healdton pool, the Hewitt pool, and other undeveloped anticlinal features along the Healdton uplift.

The Asphaltum consists of a series of gray to buff, yellow, calcareous sandstones, generally massive, friable, and medium-grained, but locally laminated and thin-bedded. The thickness of this sand ranges from 20 to over 50 feet and consists of one or more members, separated by intervening shale beds. A nodular limestone stringer from two inches to one foot in thickness occurs uniformly 12 to 18 feet above the top of the sand throughout parts of Tps. 3 and 4 S., Rs. 4 and 5 W. In parts of Tps. 3 and 4 S., Rs. 4 and 5 W., this sandstone is saturated with asphalt, and several seeps of gas and heavy oil occur. These seeps will be discussed later.

In the area just described this sandstone can be mapped in detail. Also observed local dips in individual beds are generally indicative of true structural dip.

### RYAN SANDSTONE

A sandstone having the same general description and occurring in approximately the same stratigraphic position as the Asphaltum is typically exposed in the scarps immediately southeast and northwest of the town of Ryan. The sandstone here consists usually of one member, massive to thin-bedded, with a thickness of 17 to 28 feet.

The Ryan sandstone is exposed irregularly through parts of Tps. 6 and 7 S., R. 7 W. With very few gaps, it can be traced northwest



through T. 5 S., R. 8 W., and parts of T. 4 S., Rs. 8 and 9 W. It appears to thicken in this direction, and in the bluffs bordering "Dead Man's Gulch" in T. 4 S., Rs. 8 and 9 W., at least three distinct members are present, forming a sand zone with a thickness in excess of 60 feet. The sandstone can be traced irregularly northeast from Ryan through parts of T. 5 S., Rs. 5, 6, and 7 W., the strike gradually swinging in a broad loop, circling the plunging northwest end of the Nocona structural uplift. The sand is poorly exposed through this area, but can be followed by the cuesta-like topography, long dip slopes, sandstone float, and the sandy nature of the soil. It is characteristically exposed again through secs. 14, 15, 22, and 23, T. 6 S., R. 5 W., where the general normal northeast dip into the Ringling Basin can be clearly seen.

The Ryan sand can be correlated rather definitely with the Asphaltum sand previously described. It can be traced by well records across the Ringling Basin into the Asphaltum sand, as shown by the stratigraphic cross-section, Map No. XXXIV. Its general lithologic similarity and the stratigraphic repetition on either side of the Ringling Basin practically assure this correlation.

The Ryan sand makes a fair marker for general detail mapping. It is exposed only over areas structurally high, marking the northwest extremity of the Nocona high, and various anticlinal folds along the Waurika arch.

On the accompanying areal map (No. XXXIII) the Asphaltum and Ryan sands are shown as marking the division between the Claypool beds and the underlying beds above the Oscar sand.

### OSCAR SANDSTONE

This sand series occurs from 100 to 125 feet below the top of the Ryan sandstone. The interval between these sand horizons is largely brown shale, with occasional thin sandy streaks. The surface outcrop is limited to the extreme southern portion of the county marking the higher parts of the Nocona uplift in Oklahoma. All of the members are well exposed at various localities in the high bluffs along the Oklahoma side of Red River. Good exposures occur through the southeast part of T. 7 S., R. 6 W., through T. 7 S., R. 5 W., the south half of T. 6 S., R. 5 W., and along the valley of Red Creek diagonally across T. 6 S., R. 6 W. Isolated exposures of the upper members of this series are thought to occur in and adjacent to secs. 35 and 36, T. 5 S., R. 6 W., where a large anticlinal fold has brought these beds to the surface.

A total stratigraphic section of approximately 300 feet is exposed over the area of outcrop. This section is composed largely of sandstone beds, with intervening beds of brown and gray shales. The individual beds vary from one to over 50 feet in thickness, and are very

lenticular. Certain beds contain conglomerate phases of varied coarseness. The sandstones of this series are massive- to thin-bedded, light gray to brown on fresh exposure, weathering to darker gray, brown, and black. Large brown to black concretions are common in the upper members.

In general, the individual beds are hard and resistant, forming good benches and scarps for detailed mapping. Certain of these bench-forming beds resemble typical Pennsylvanian sandstone beds more closely than any sandstones exposed in the county. The lowest bed stratigraphically of this series is exposed on Ketcham's Bluff along Red River, in sec. 24, T. 7 S., R. 6 W., and the adjoining section to the east. This bed is composed largely of conglomerate. The pebbles are mostly chert fragments; from small grains to pebbles two inches in diameter. Rounded pebbles of pure and impure quartz interbedded with thin stringers of coarse gray sand are also common. This conglomerate bed is ripple-marked and cross-bedded, and attains a maximum thickness of 50 feet or more. The conglomerate phases of the Oscar fade out to the north and northwest and become progressively coarser to the southeast.

The areal mapping of this series (Map No. XXXIII) outlines the top of this general sand series as exposed over the area. It is not to be interpreted as the outcrop of one continuous bed, but rather the top of a sand horizon of fairly uniform stratigraphic position. Part of this areal mapping is by Robinson,[2] who gives more detailed description and discussion of this series.

The interval from the base of the Oscar sandstone to the top of the Pontotoc conglomerate consists of a zone of brown and blue shale and sandy shales, with interbedded sandstone, fine- to coarse-grained with local gravel streaks.

### PONTOTOC CONGLOMERATE

The top of this formation occurs from 650 to 950 feet below the Asphaltum and Ryan formations. It is a series of gravel beds characterized by pronounced conglomerate phases of varying arkosic nature, being quite similar in general description, and correlative with other beds occurring in Carter and Stephens counties which are thought to be the equivalent or part of the Pontotoc series as described by Morgan.[3]

The conglomerate phases of the upper member of this gravel series consist of chert fragments of irregular size, shape, and color, coarse grains of glassy and impure quartz, as well as feldspar, limestone, and hard shale fragments, all interstratified through coarse, loosely cemented to hard, consolidated gray sand. Particles of asphalt of depositional nature have also been observed. This general series appears to be absent over the higher structural points of the Healdton uplift, apparently being cut out by unconformity and overlap. It thickens rapidly off the southwest flank of this uplift into the Ringling basin. Certain wells drilled in the central part of this basin penetrated the top of these gravels at depths of 1,200 to 1,500 feet and recorded red beds and gravel to depths below 2,500 feet. This series thins again to 100-plus feet over the Nocona and Waurika structural highs, but according to present data the upper members are present even on the highest structural points. The conglomerate phases are markedly coarser nearer the major uplifts and are particularly well developed over and around the Nocona arch, but gradually fade out and are less conspicuous to the northwest away from this feature.

2. Robinson, Health M., Geologic structure and oil and gas prospects of a part of Jefferson County, Okla., U. S. Geol. Survey Bull. 726 F, 1921.
3. Morgan, G. D., Geology of the Stonewall Quadrangle: Bur. Geol. Bull. 2, Norman, Oklahoma, 1924.



This series lies unconformably on the more steeply folded strata of the Glenn formation. In Jefferson County it does not appear to be in contact with rocks older than Glenn. This gravel series marks the initial stages of a long period of erosion following the folding and deformation at the close of Glenn time.

### Conclusions Regarding Upper Horizons

Immediately south of Terral, Oklahoma, across Red River in Montague County, Texas, a conspicuous sand zone is exposed in the river bluffs. This sandstone has been traced by Virgil Tims of the Shell Petroleum Corporation, into the Coleman Junction limestone, as exposed in Archer County, Texas.

A group of Wichita Falls geologists later accompanied Tims in a field conference to trace this outcrop and to attempt a correlation across into Oklahoma. It was agreed that the sandstone in the river bluff south of Terral was the equivalent of the Coleman Junction limestone, which marks the top of the Cisco formation in Texas and has generally been taken as the top of the Pennsylvanian section in that state.

A group of southern Oklahoma geologists, including the writer, met the Texas party at Ringgold to satisfy all concerned as to the continuation of the Cisco formation into Oklahoma. It was established that the Ryan sandstone, as previously described, was the equivalent of the Coleman Junction limestone of Texas, or was the first sand series below it. However, it is the writer's opinion that the sandstone in Texas, taken as the top of the Cisco formation, overlies the Ryan sandstone, and is the equivalent of the first sand series above the Ryan sandstone in the overlying Claypool formation previously described. This conclusion is based on the fact that the Ryan sandstone at the closest point to the critical area has a pronounced southwest dip apparently dipping completely under Red River and the Coleman Junction equivalent. Likewise the Coleman Junction can be traced up Red River on the Texas side for several miles until positive correlation is lost. With this approximate correlation established, it is evident that

most of the surface rocks of Jefferson County are uppermost Pennsylvanian age.

The entire section in Jefferson County, with the exception of the Addington formation, including the Claypool, Ryan, Asphaltum, Oscar, and the Pontotoc, appears to be one formation of general similarity; the shales are of very similar nature, predominantly brown, with blue and gray mottling and gradation. The sandstones likewise are quite similar; in general, they are light gray to brown and buff in color, and seem to be composed of the same type of material throughout.

Coarse conglomerates and gravels are more conspicuous and better developed in the lower members of these upper Pennsylvanian beds, but thin gravel streaks of local and irregular nature have been observed throughout the entire section. For this reason, the writer favors placing the entire section described, at least from the Ryan sandstone down, as Cisco in age, and all or part equivalent to the Pontotoc of the Oklahoma section.

## SUBSURFACE FORMATIONS

### Glenn Formation

The series of shales, limestones, and sandstones underlying the basal Pontotoc beds of this county are taken as belonging to the Hoxbar and Deese members of the Glenn formation of middle Pennsylvanian age, and equivalent to the Canyon and Strawn section of Texas. At the present time, there is very little definite information available concerning the exact correlation and extent of the different members of these formations throughout the county.

Unfortunately very few samples of the formations penetrated by the drill have been preserved for study. Furthermore, accurate paleontological work in outlying wells is difficult because of the reworked nature of many of the beds penetrated. This condition is quite confusing when it has been shown that reworked lower Pennsylvanian and Ordovician fossils have been found above younger Pennsylvanian formations.

### Cambrian, Ordovician, and Younger Rocks

It is assumed that the entire Arbuckle Mountain section, including the Reagan sandstone. Arbuckle limestone, Simpson formation, Sylvan shale, Hunton formation, Woodford chert, and Sycamore limestone, or their equivalents, were deposited over all of Jefferson County. These formations are so well developed in the Arbuckle Mountain area, 25 miles from the northeast corner of the county, and are known to exist over such a widespread area in central and eastern Oklahoma, that any sudden termination southwest of the mountains in this short distance is considered unlikely, except by erosion.



Drilling in Carter and Stephens counties has shown Pennsylvanian rocks of Glenn age to rest unconformably upon buried ridges of Ordovician rocks. It would appear that the present extent and occurrence of these older rocks under Jefferson County will depend entirely upon the extent of erosion and degree of unconformity previous to the deposition of Glenn sediments. This information can be obtained only by deep drilling.

Numerous wells drilled at different localities on the Healdton uplift have penetrated massive limestones identified as of Ordovician age. Likewise, many wells located on the Nocona and Waurika structural highs have encountered massive limestones at fairly shallow depths. In most all instances, drilling operations ceased after this lime had been penetrated a few hundred feet. Since these limestones were massive, hard and non-fossiliferous, it has been generally assumed they were likewise Ordovician in age.

Recently a well drilled in sec. 28, T. 5 S., R. 8 W., encountered a limestone series at 3,700 feet, drilled through this series into brown and blue shales at 4,408 feet. Paleontological study has shown this limestone to be of Deese or middle Glenn age, and the approximate equivalent of the Big Lime series of the Sholom Alechem and County Line fields of Carter and Stephens counties, Oklahoma. Reworked Ordovician forms were also observed in the cuttings from this well.

Since massive Pennsylvanian limestones are now known to be present in this area, the limestones encountered in adjoining townships, heretofore taken as Ordovician, may or may not belong to this same Pennsylvanian limestone series.

### Pre-Cambrian Igneous Rocks

Granites and other igneous rocks of the basement complex underlie the entire county at unknown depths. Certain wells drilled on the Nocona uplift in Montague County, Texas, are reported to have penetrated granite; likewise, several wells drilled in T. 7 S., R. 6 W., area and the Spring oil pool in southern Jefferson County on this structural uplift, have reported granite at depths of 3,100 to 3,200 feet. It is certain that in several instances this recorded granite was a granite wash and not a solid granite ridge, as the drill passed out of the granite horizon into underlying shales and limestones.

## STRUCTURE

Surface and subsurface study has shown the existence of three major structural highs or trends through Jefferson County. These highs occur in a general northwest and southeast direction, paralleling other structural features of central-southern Oklahoma. In the following

discussion these features will be referred to as the Healdton uplift, the Nocona uplift, the Waurika arch, and the Ringling basin, all being local names adopted during this course of study and investigation.

### HEALDTON UPLIFT

This pronounced structural trend appears to be a northwest continuation of the Criner Hills uplift of Carter County, Oklahoma. It extends through the southwest part of Carter County, the northeast corner of Jefferson County, thence into the southeast part of Stephens County. On this structural trend a continuous series of *en echelon* anticlinal folds occurs. This includes the Hewitt and Healdton anticlines, at least four anticlinal structures in Tps. 3 and 4 S., Rs. 4 and 5 W., the Loco anticline, and other anticlinal folds into T. 2 S., R. 6 W., Stephens County.

This uplift is clearly shown by a broad arch in the surface rocks and a repetition of the stratigraphic section on either side of the general structural axis. On certain of these minor anticlinal folds, the Asphaltum sandstone is brought to the surface, flanked on either side by the overlying formations. These folds include the Hewitt, Healdton, Loco, and certain other anticlinal structures in Tps. 3 and 4 S., Rs. 4 and 5 W., and possibly other features to the northwest.

The Asphaltum and Claypool formations on the northeast flank dip under typical Permian red beds resembling, and here correlated with, the Addington formation. These beds mark the timbered area of red shales and sandstones through T. 3 S., R. 3 W., that apparently is largely synclinal. All or part of the section exposed over the Healdton uplift is again brought to the surface over the Graham and Fox anticlines. Off the southwest side of this feature these beds dip normally to the southwest into the Ringling structural basin.

Over parts of the Healdton uplift there occurs a general thinning of the so-called red beds, with a very pronounced thinning over the high structural points of the minor folds. This apparent pronounced local thinning has been shown by structure drilling to be in part a color change. This will be discussed later. Ordovician limestones have been encountered at shallow depths along this uplift, showing it to have been a structural high in the older rocks and likewise a topographic ridge, at least during upper and middle Glenn deposition.

### RINGLING BASIN

This geosyncline parallels and separates the adjoining major structural highs. The general axis extends in a northwest-southeast direction across the north half of the county. It is shown on the surface by general dips off the paralleling uplifts and by the outcrop of the Addington formation. Wells drilled in this basin have encountered great thicknesses of red beds, and in no instance have penetrated massive limestones to their total depth.



### NOCONA UPLIFT

The broad structural feature extending from Montague County, Texas, into south-central Jefferson County is here termed the Nocona uplift. This high has a general northwest and southeast axial direction, and is broader and flatter than the Healdton uplift. In Oklahoma, the Grogan anticline, the Oscar anticline, the Spring Pool anticline, the anticline in T. 5 S., R. 6 W., and probably other undrilled and unknown anticlines and structural noses, occur on this feature. This fold brings the Oscar sandstone to the surface. These are the lowest beds stratigraphically of any exposed in the county. The Ryan sandstone extends in a broad loop around this feature on its northwest extremity in Oklahoma.

Map No. XXXIV shows a stratigraphic cross-section of the Nocona arch as interpreted from present information afforded by well records. A study of this cross-section shows that three series of limestones, separated by shale and sandy shale intervals, have been penetrated at various depths depending on structural position of wells. These limestone beds appear to be conformable and occur in regular sequence. There is, however, a thinning of the entire section over the higher structural points. The lower massive lime has generally been accepted as the top of an unconformable buried ridge of Ordovician limestone, presumably Arbuckle. However, since there are no prominent basal contact sand or gravel series recorded immediately above this limestone, it would appear that the upper portion, at least, of this limestone may belong to the same series as the overlying and apparently conformable limestone beds, and therefore it would not be the eroded surface of an older ridge.

Granite has been reported in several wells drilled on the Grogan anticline, and the Spring Pool anticline, also in certain wells in the Nocona pool and in the vicinity of Spanish Fort, Montague County, Texas. As previously stated, this granite occurrence in certain wells on the Oklahoma side has been in the nature of a granite wash. However, it seems certain that buried granite peaks occur in the near vicinity at shallow depths on this uplift.

### WAURIKA ARCH

The Waurika arch is lower structurally, and lies *en echelon* with the Nocona uplift, with which it is closely associated, but not a direct northwest extension. This structural arch trends in a northwest-southeast direction, through T. 6 S., R. 7 W., T. 5 S., R. 8 W., T. 4 S., R. 9 W., and parts of adjoining townships.

The Ryan sandstone is the oldest bed mapped on the surface. However, certain sandstone stringers exposed near Red River through T. 5 S., R. 9 W., may represent the top of the Oscar. The lower Pontotoc beds thin over the entire arch, but there is considerably more

Pontotoc section encountered than on the Nocona and Healdton highs. Several dry holes have been drilled on each flank of this general high. From the recorded logs of these test wells it is possible to gain a general idea of the subsurface conditions. Seven tests in this area have penetrated limestones and suspended drilling operations while still in lime.

The Amerada Petroleum Corporation completed a dry hole in sec. 28, T. 5 S., R. 8 W. This test encountered a broken limestone and sand series at 3,530 feet to 4,008 feet, a massive limestone series was penetrated from this depth to 4,408 feet, where blue and brown shale and slate were penetrated to 4,490 feet. A hole full of water was obtained in a sandy dolomite at 4,512 feet.

The limestone encountered in this test has been correlated from fossil evidence with the Big Lime series of the Sholem Alechem field of Carter and Stephens counties. This limestone overlies the main producing horizons in this field, and is of middle Glenn age, probably Deese.

From surface reconnaissance, this test appears to be located down the southwest flank of this general high. Likewise, the limestone series encountered in this test occurred at a considerably greater depth than a very similar section of broken lime and sand, and massive limestones, recorded in other tests a few miles to the north, northeast, and northwest.

Locations of other tests in the immediate vicinity that encountered limestone series and the depth to the top of these series follow:

*Wells in the vicinity of Waurika arch that encounter limestone series.*

| COMPANY | LOCATION | UPPER SERIES DEPTH | LOWER MASSIVE LIMESTONE DEPTH |
|---|---|---|---|
| Shawer & Sutter | 31-4S-8W | 2175 | 2915 |
| Texas Company | 21-4S-9W | 2390 | 2955 |
| Texhoma | 34-4S-9W | 2180[a] | ..... |
| Knight & Hines | 31-4S-9W | 1880[b] | ..... |
| Amerada | 28-5S-8W | 3530 | 4008 |
| Pauline O. & G. | 17-5S-8W | ..... | ..... |

a. T. D. 2,415. b. T. D. 2,110.

From an oil and gas standpoint the identification of this limestone series in the Amerada well as middle Glenn and not Arbuckle is very important, and changes the aspect of the entire area for deep possibilities, since lower Glenn and Ordovician oil and gas horizons may underlie or flank this structural high, and are as yet untested.



Observed minor folds on this general structural trend include the T. 7 S., R. 7 W. anticline, the Ryan anticline, the anticline in T. 5 S., R. 8 W., undefined anticlinal feature in the bend of Red River adjoining the southeast corner of T. 4 S., R. 9 W., Dead Man's Gulch structure, and a lower parallel anticlinal feature in T. 4 S., R. 8 W.

## OIL AND GAS DEVELOPMENT

To date there are 12 producing gas wells, 118 producing oil wells, and 109 dry holes drilled in this county. The present producing area on the Healdton uplift in Jefferson County includes a small portion of the northwest extremity of the Healdton pool, and one isolated gas well in sec. 21, T. 3 S., R. 4 W.

Three small pools have been developed on the Nocona uplift in Oklahoma; these include the gas area in T. 7 S., R. 6 W., the Oscar pool, and the Spring pool. There are no producing oil or gas wells on the Waurika arch, though several wells have recorded shows of oil and gas.

Of the 109 dry holes drilled in the county, 43 were drilled in outlining the present producing areas, 25 were drilled in or near the lower part of the Ringling basin, where there appears to be little chance for commercial oil or gas production. The remaining 37 holes were drilled at various points on or adjacent to the major structural uplifts. The dry holes drilled in Jefferson County have been comparatively shallow, in general from 2,000 to 3,000 feet in depth. The deepest test in the county, the Amerada well in sec. 28, T. 5 S., R. 8 W., was carried to a total depth of 4,518 feet.

Cable tools were extensively used in the early drilling, but at the present time practically all the production and wildcat drilling is done by rotary tools.

### HEALDTON OIL POOL

Only a small restricted area of production on the northwest extremity of this great Carter County pool lies within Jefferson County. However, since several favorable undeveloped areas are immediately adjacent to this pool in Jefferson County, a brief summary of the salient features of this pool will be given.

*Location.* The Healdton pool occurs in a northwest-southeast direction, diagonally across T. 4 S., R. 3 W. and into the extreme southwest corner of T. 3 S., R. 3 W. This pool has a proven productive area of approximately 7,250 acres.

*History.* The discovery well was drilled in sec. 8, T. 4 S., R. 3 W., and completed in August, 1913 for an initial production of 25 barrels at a depth of 920 feet. The well was drilled on acreage block as-

sembled by Roy M. Johnson, Edward Galt, and Wirt Franklin of Ardmore, Oklahoma. The field was developed during 1914, 1915, 1916, and 1917, with comparatively little drilling since.

*Production.* The Healdton pool is by far the largest in southern Oklahoma in productive area and total yield. It is likewise one of the world's greatest shallow oil pools. The total production to date is approximately 153 million barrels, the peak production being 56,000 barrels per day in March, 1917. The present daily production is about 14,000 barrels, with an extremely low rate of decline. The average total production per acre has been approximately 21,000 barrels, while certain leases located in the northwest portion of the pool, and immediately adjoining Jefferson County, have produced from 80,000 to 100,000 barrels per acre. The oil ranges from 25° to 37°, averaging 31° A. P. I.

*Stratigraphy.* The Asphaltum sandstone is exposed over and around the producing area in this pool. An underlying sand series is exposed over the central portion of the field. A local gravel phase occurs in certain sand members exposed in the eastern portion of the producing area. Well logs show that the lower Pontotoc does not carry over the top of the Healdton field, but overlaps the flanks. Glenn sediments are penetrated at depths from 200 to 600 feet over most of the field showing the extreme thinning of the younger overlying formations..

The chief producing horizon is a series of Pennsylvanian sands occurring from 800 to 1,200 feet in depth, probably Hoxbar in age. Production has been obtained in some instances from still lower Pennsylvanian sands overlapping the Ordovician core.

Ordovician limestone has been encountered at a depth of 800 feet on the highest structural point and occurs at various depths throughout the field. In certain wells, at least, this limestone appears to have been the Viola. Erratic production of high gravity oil has been obtained by a few wells in these Ordovician limestones.

*Structure.* Pronounced dips are shown by surface sandstone beds on the flanks of the structure where good exposures may be observed. These dips coincide closely with the underlying producing sands, but are much flatter.

The subsurface structure shows a distinct anticlinal feature, complicated by minor folding and faulting. The dip of the producing horizons steepens materially off the flanks of the buried Ordovician ridge.

### PRODUCING AREAS ON NOCONA UPLIFT

Three small producing pools have been developed in southern Jefferson County. These pools were discovered in the early part of 1924. The discovery well was in every instance located on the crest of a recognized surface structure. These structures were mapped and are discussed in detail by Heath M. Robinson in U. S. Geological Survey Bulletin 726 F, published in December, 1921.



A brief summary of the general features of these pools follows.

### OSCAR POOL

*Location.* The Oscar pool covers a producing area of approximately 400 acres in parts of secs. 33 and 34, T. 6 S., R. 5 W.

*History.* The discovery well was drilled by the Hambro Oil Company in the early part of 1924. This well was lost in attempting to complete it as a producer. The first completed producing well was drilled by the Humble-Hambro Companies as a twin to the lost hole. This well was located in the SE.¼, NE.¼, SE.¼, sec. 33, T. 6 S., R. 5 W., and was completed May 18, 1924, for an initial production of 120 barrels from sands at 1,247 to 1,264 feet, 1,303 to 1,313 feet, and 1,368 to 1,370 feet.

Previous to the completion of the discovery well, three dry holes had been drilled adjacent to the area that is now the producing field. These tests were located on the flanks of the surface fold and too low for production. Two of these tests were drilled within one-third mile of production.

*Production.* The Oscar pool covers a very restricted area, but has yielded handsome returns to operators of the best located leases. The oil is good gravity, being from 35° to 36° A. P. I. The wells are shallow and completed quickly and economically. In the early development wells of large initial production were completed.

*The sand depth and initial production of the larger wells in the Oscar Pool*

| COMPANY | FARM | INITIAL PRODUCTION IN Bbls. | DEPTH SAND | DATE COMPLETED |
|---|---|---|---|---|
| Gypsy | Arpelar No. 1 | 3600 | 1458-1484 | 9-3-25 |
| Carter | O. W. Seay | 2175 | 1407-1428 | 12-31-25 |
| Carter | Clara Seay | 2560 | 1482-1503 | 12-4-25 |
| Gypsy | Arpelar No. 8 | 1725 | 1444-1472 | 12-4-25 |
| Humble | Seay No. 5 | 200 | 1241-1245 | 11-30-25 |

*The average daily production of all leases in the Oscar pool for the month of November,* 1928

| COMPANY | FARM | LOCATION | NUMBER OF PRODUCING WELLS | TOTAL DAILY PRODUCTION IN BARRELS |
|---|---|---|---|---|
| Prairie | C. Seay | 34-6S-5W | 4 | 120 |
| Prairie | O. W. Seay | 34-6S-5W | 1 | 8 |
| A. C. Brown | | 33-6S-5W | 5 | 115 |
| O. V. Beck | O. W. Seay | 34-6S-5W | 2 | 35 |
| Carter | O. W. Seay | 34-6S-5W | 3 | 95 |
| Carter | D. Seay | 34-6S-5W | 1 | 20 |
| Carter | C. Seay | 33-6S-5W | 2 | 15 |
| Carter | J. Jones | 33-6S-5W | 4 | 110 |
| Hambro | O. W. Seay | 33-6S-5W | 7 | 90 |
| Humble | O. W. Seay | 34-6S-5W | 4 | 70 |
| Gypsy | Arpelar | 33-6S-5W | 34 | 550 |
| Total | | | 67 | 1,246 |

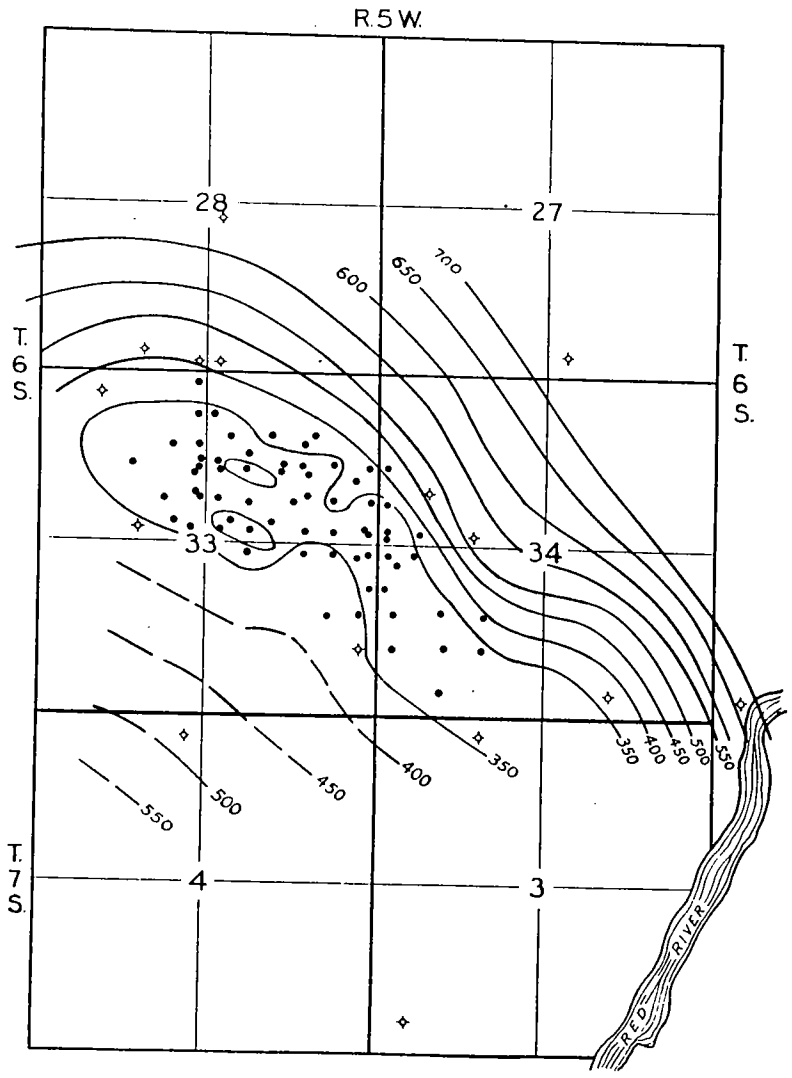
*Stratigraphy.* The surface exposures consist of the upper members of the Oscar sandstone, which form good scarps and benches for detailed mapping. Red beds have been recorded from 300 to 600 feet over the field. However, the base of the Pontotoc probably occurs at a depth of 1,000 feet over the higher parts of the fold, and is represented by the sandy lime and boulder series recorded in certain wells at depths of 1,000 to 1,100 feet.

The top of the first producing sand zone occurs at depths of 1,160 to 1,270 feet. This zone consists of a 200 foot section of irregular sands, with interbedded blue shale members. The upper and lower sand members are the most uniform. A limestone from 2 to 20 feet in thickness occurs above the first oil sand. This lime makes a good datum for structural contouring. It is probably Hoxbar in age.

The second producing horizon occurs approximately 300 feet below the top of the first producing zone, and is recorded in producing wells at depths of 1,450 to 1,560 feet. This horizon is from 50 feet to over 100 feet in thickness. It is recorded as a lime and sandy lime, but is shown by cuttings to be largely a porous limestone. It is also quite fossiliferous.

There has been no deep test drilled within the producing area. A well drilled in the southwest corner of section 35 penetrated an unconformable series composed largely of sand and sandy lime from 1,800 to 3,358 feet.






igure 52. Structure map of the Oscar pool. Contour interval, 50 feet. Contours on datum lime. Datum, sea level.

*Structure.* The surface structure consists of a well-defined structural nose plunging to the northwest, with uncertain closure to the southeast. There is a pronounced northeast dip, amounting to 180 feet in a distance of two miles. The highest point from surface mapping appears to be in the center of the east half of section 33. The subsurface structure, as drawn on the upper producing horizon, follows the surface structure very closely, but is much steeper. A northeast dip of more than 600 feet to the mile is shown in the SE.¼ of section 34.

The subsurface structure consists of an elongated anticline which trends in a general northwest and southeast direction. The highest structural points occur in the center of the N.½ of section 33, and the SW.¼ of section 34. The structure is undefined to the southeast, but appears to close in sec. 3, T. 7 S., R. 5 W. The subsurface structure is shown on figure 52.

### T. 7 S., RS. 5 AND 6 W. POOL

*Location.* The present producing area of this pool is included in parts of secs. 13 and 24, T. 7 S., R. 6 W., and parts of secs. 17, 18, 19, and 20, T. 7 S., R. 5 W.

*History.* The discovery well was drilled in the NE. cor. NW.¼ sec. 19, T. 7 S., R. 5 W. by Humble Oil & Refining Company. This well was completed as a gas well May 5, 1924, for an initial production of 44 million cu. ft. with 300 pounds rock pressure. The top of the gas sand was found at 690 feet and penetrated to a total depth of 702 feet.

Previous to the completion of the discovery well, the Simms Oil Company drilled a dry hole in the SE.¼ sec. 14, T. 7 S., R. 6 W. This well was drilled to a total depth of 2,730 feet, and was abandoned Sept. 1, 1920. Several gas oil showings were recorded.

*Production.* This structure, according to present data, is largely gas bearing. The gas wells at present are shut in as there is no market. The gas has a rather low B. T. U. value, probably because of a fairly high helium content.

*Data on the gas wells of T. 7 S., Rs. 5 and 6 W. Pool*

| COMPANY | FARM | LOCATION | I. P. IN MILLION CU. FT. | DEPTH TOP SAND | TOTAL DEPTH |
|---|---|---|---|---|---|
| Humble | Busby No. 1 | 19-7S-5W | 44 | 690 | 702 |
| Humble | Alexander No. 1 | 19-7S-5W | 40 | 590 | 1890 |
| Humble | Smart No. 1 | 18-7S-5W | 70 | 750 | 1050 |
| Humble | Jones No. 1 | 18-7S-5W | Dry | 790 | 2270 |
| Okla. Southern | Smart No. 1 | 13-7S-6W | 55.8 | 730 | 808 |
| Humble | Smart No. 1B | 18-7S-5W | 14 | 676 | 790 |
| Magnolia | Smith No. 1 | 24-7S-6W | 13.5 | 730 | 803 |
| Hivick | Smart No. 1 | 13-7S-6W | .... | 700 | 850 |
| Gypsy | Busby No. 1 | 18-7S-5W | 45 | 591 | 603 |



The present oil producing area is confined to the S.½ sec. 17 and the N.½ sec. 18, T. 7 S., R. 6 W. The oil of low gravity, around 24° A. P. I. The wells have small initial production and do not flow. However, the production holds up well, and, because of their shallow depths, these wells may be profitably operated.

*Average production of the producing leases for November, 1928*

| COMPANY | FARM | LOCATION | NUMBER OF PRODUCING WELLS | TOTAL DAILY PRODUCTION IN BARRELS |
|---|---|---|---|---|
| Lesh & McCall | Peniston | 20-7S-5W | 13 | 250 |
| McGinley-Sigler | C. Pfile | 19-7S-5W | 7 | 200 |
| McGinley-Sigler | A. M. Clark | 20-7S-5W | 5 | 75 |
| Gypsy | S. Busby | 17-7S-5W | 4 | 50 |
| Total | | | 29 | 575 |

*Stratigraphy.* Surface exposures over this area consist of lower members of the Oscar sandstone. Two core holes drilled in sec. 24, T. 7 S., R. 6 W. give very definite information as to the thickness and nature of the Pontotoc section over this field. The base of the Pontotoc was found at a depth of 920 feet in a core hole drilled in the NE.¼, SE.¼ NE.¼ of this section. This core hole started just above the sand and conglomerate bed exposed in the river bluff south of the location. A section composed largely of gray sand and blue-brown clay shale was penetrated to 450 feet. Two thin nodular, impure limestone stringers were encountered at depths of 460 feet and 535 feet. From this depth to the top of the gas sand at 680 feet, the formation was largely gray shale, mottled with light brown patches but of the same general appearance as the shales immediately below the surface. The gas-bearing horizon from 685 to 920 feet consisted of coarse sand and conglomerates separated by shale beds. The basal conglomerate was extremely hard and consolidated.

The conglomerates of this series were composed largely of chert. The chert fragments were angular to rounded and white, brown, black, gray, and green in color. Fragments of limestone, feldspar, and quartz were also common.

Below 920 feet dark blue and black laminated carbonaceous shales of entirely different character were penetrated. These shales were fossiliferous. The section from 920 feet, as shown by deeper tests, consists of alternating limestone and shale beds to a depth of 1,800 to 2,000 feet. These limestone beds have a recorded thickness of 50 to 100 feet. This section is unconformable with the overlying beds.

Granite or granite wash has been recorded at depths of 1,930 to 2,200 feet in three wells. One of the wells drilled in sec. 14, T. 7 S., R. 6 W. penetrated this wash at 2,200 feet and drilled through it at 2,260 feet into lime and sandy limestone, to a total depth of 2,730 feet. The granite wash occurred in this well at the same stratigraphic point as penetrated in the two other tests which were abandoned after penetrating the granite or wash 30 to 58 feet.

The producing horizons, as development now stands, are confined entirely to the basal Pontotoc. The top of this producing horizon carries gas over the structural area. Oil is being produced on the northeast flank of the structure from a sand horizon occurring approximately 150 feet below the top of the first gas horizon. This sand, however, carries gas in the top of the structure. On the Oklahoma side, no production has been obtained on this structure below the base of the Pontotoc. However, in two of the three deeper tests drilled oil shows have been recorded 50 to 100 feet above the granite or granite wash.

*Structure.* The surface structure of this pool is very pronounced and easily seen. It has been termed the Grogan anticline in U. S. Geological Survey Bulletin 726 F.

The axis of this structure trends in a northwest-southeast direction through the NE.¼ sec. 24 and the center of sec. 13, T. 7 S., R. 6 W., plunging to the northwest. The highest structural point mappable on the Oklahoma side is on or near the center of the east line of section 24.

The fold is open to the southeast and appears to be a direct continuation of the Nocona gas and shallow oil area immediately across Red River in Texas. The southwest dip of this fold through the SE.¼ sec. 24, T. 7 S., R. 6 W., is the most pronounced surface dip observed in the county. A dip of over 100 feet in a distance of one-fourth mile is mappable. There is some indication of a minor fault shown in the river bluff in sec. 19, T. 7 S., R. 5 W.

The subsurface structure drawn on the top of the first gas horizon coincides closely with that shown by the surface beds, but is more pronounced. It is shown on figure 53.

### SPRING POOL

*Location.* This pool includes a small number of producing wells in secs. 23, 24, and 25, T. 6 S., R. 6 W.

*History.* The first well was drilled by Dingwall & Sargent in the early part of 1923, and later carried to a total depth of 3,315 feet by Clarke and Cowden, where the hole was abandoned. The first producing well was a twin to the original well and was completed by Clarke & Cowden in March, 1924, for an initial production of 15 barrels from sand at 2,049 to 2,117 feet. Development was discouraged by the low initial production of the few completed wells and the drilling of several dry holes.



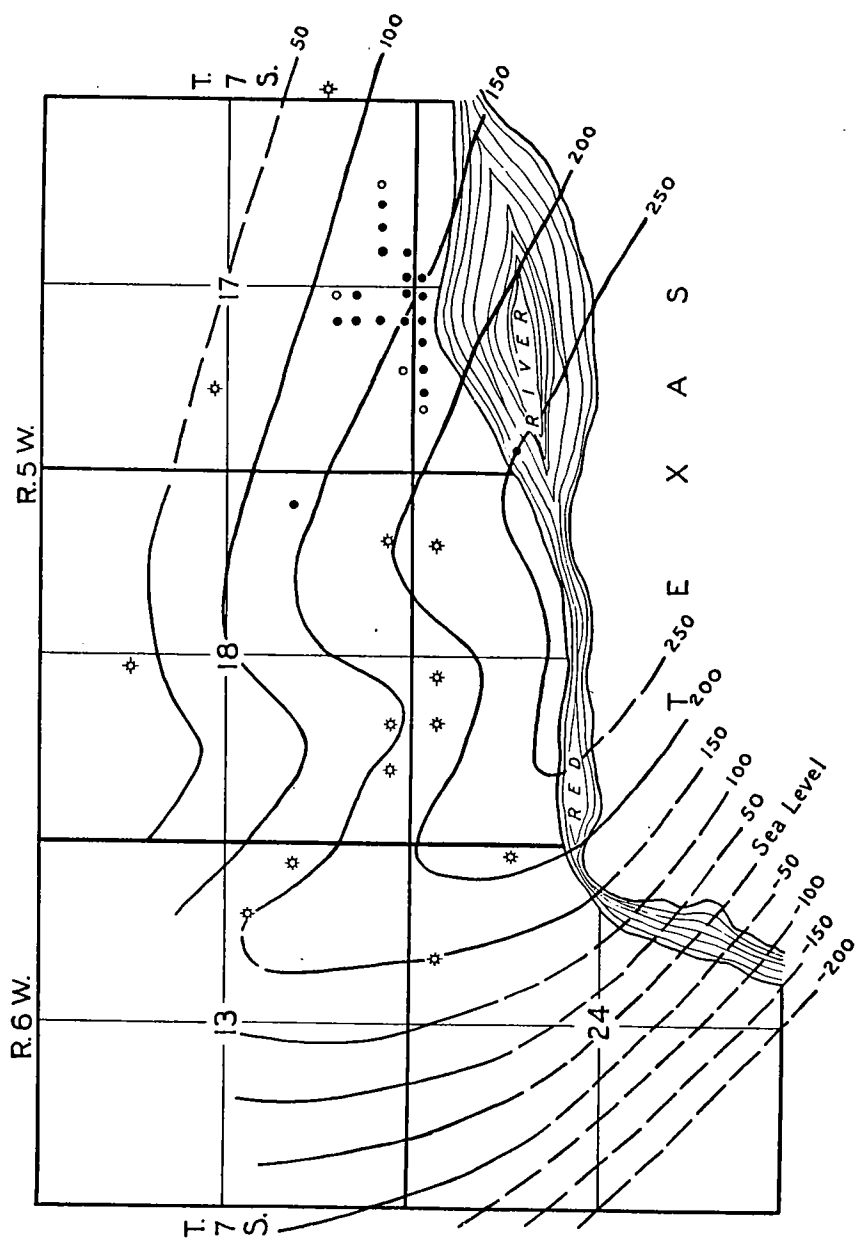



Figure 53. Structure map T. 7 S., Rs. 5 and 6 W. pool. Contour interval, 50 feet. Contours on top of producing gas horizon. Datum, sea level.

In April, 1928, Bridwell & Heydrick completed a 225 barrel well in the NW.¼, SW.¼, SW.¼, sec. 24, T. 6 S., R. 6 W.

*Production.* The first wells completed in this pool produced from a sand 2,050 to 2,110 feet in depth. The wells completed in this sand had small initial production and were not profitable.

Several wells have been completed by Birdwell and Continental Oil Company in the SW.¼, section 24. These wells were completed in an upper sand series found from 1,650 to 1,730 feet in depth. Some of these wells on their inception produced from 100 to 225 barrels.

*Production of Spring pool for the month of November,* 1928

| COMPANY | FARM | LOCATION | NUMBER OF PRODUCING WELLS | TOTAL DAILY PRODUCTION |
|---|---|---|---|---|
| Bridwell-Continental | Earl Spring | 24-6S-6W | 5 | 435 |
| Skelly | Ryan | 23-6S-6W | 2 | 19 |
| Magnolia | Spring | 25-6S-6W | 1 | 5 |
| Magnolia | Ryan | 23-6S-6W | 1 | 11 |
| Total | | | 9 | 460 |

*Stratigraphy.* Upper members of the Oscar sandstone are exposed over the surface of the producing area. Pontotoc beds appear to occur to a depth of at least 1,200 feet from this point. A series of thin lime and sand bodies, separated by blue shale intervals of Hoxbar age, were penetrated to a depth of 2,000 to 2,100 feet. A series of thicker lime and sand bodies was then encountered to around 2,700 to 2,800 feet, where massive limestones were penetrated. Granite wash has been encountered from 3,000 to 3,300 feet in various wells. These lower limes are apparently unconformable.

*Structure.* As a whole, the surface dips of this structure are rather poorly defined. There appear to be good northwest and southwest dips and a poorly defined southeast dip. The beginning of the northeast dip is also uncertain. However, there is good evidence of a small anticlinal fold, with the highest structural point around the NE. cor. sec. 24, T. 6 S., R. 6 W.

The axis of the substructure trends in a northwest and southeast direction through the southwest corner of section 24. The highest structural point, according to present data, appears to be in the SW.¼, SW.¼ section 24. The substructure is open to the southeast, as shown on figure 54.



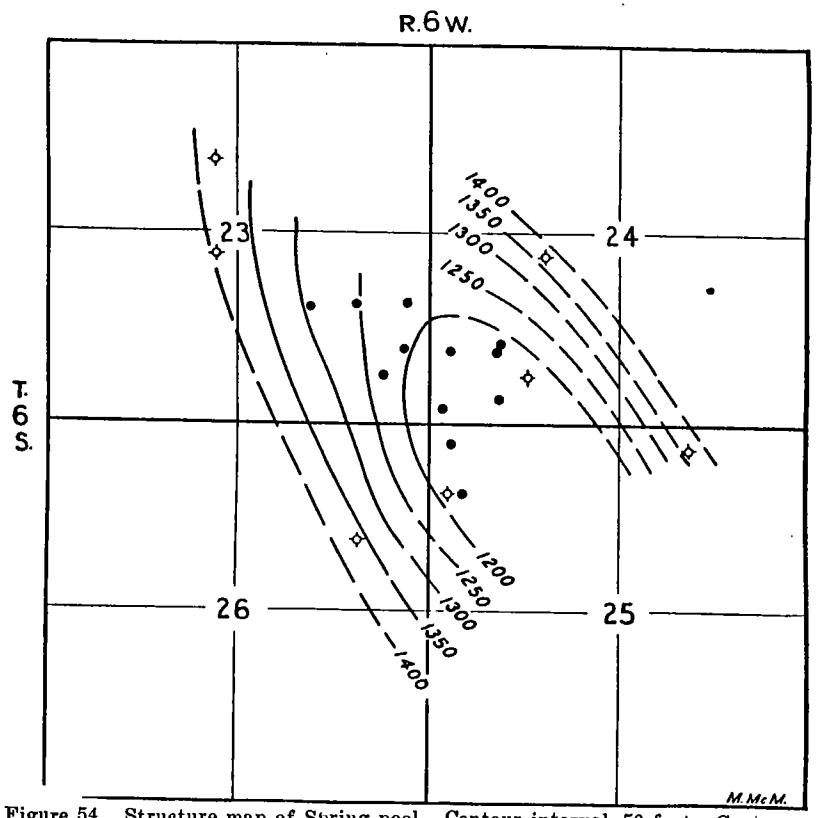



Figure 54. Structure map of Spring pool. Contour interval, 50 feet. Contours on lower producing horizon. Datum, sea level.

## CORE DRILL EXPLORATION

Accurate correlation from structure drilling in Jefferson County is possible only when the core tests are closely spaced and carried to depths of 500 to 1,200 feet. There are no recognizable markers in the upper strata similar to those found in northern Oklahoma and Kansas.

The section drilled to a depth of 800 feet or deeper in most of the county consists entirely of shale and sandstone intervals. The sand intervals, as a zone, are more or less constant, but the individual beds are very lenticular and erratic.

Two methods of structure drilling may be carried on in this area; first, to locate structures in the upper Pennsylvanian red beds; or, secondly, to drill entirely through the Pontotoc section into the underlying Glenn, and to use the contact, or some reliable Glenn bed as a datum. The first method may be used economically over the entire county and will give satisfactory results, if properly conducted. The second method can be carried on over the higher parts of the Healdton uplift, but elsewhere in the county the Glenn is too deeply buried to make this procedure practical.

Since accurate results in this area necessitated the drilling of numerous and deep tests, structure drilling with the conventional type drill, which was designed primarily for hard rock drilling, would be extremely slow and expensive. Accordingly, special machines were designed, combining the speed of the regular type rotary with the portability and accuracy of the diamond drill. These machines materially decreased the cost of exploration. They were equipped with high pressure pumps of large volume that brought the cuttings rapidly to the surface, and also increased drilling speed.

In the core-drill exploration, the soft formations were fishtailed and the hard members cored. Cuttings were taken continually and preserved for study. An accurate record was kept of each individual bit run, as to the time it commenced and finished rotation, the total footage made, and condition of bit when taken from the hole. This information made possible the plotting of a mechanical log, since softer formations drill faster and require fewer bit changes than harder ones. With the mechanical log, the driller's recorded log, and the log made from cuttings, absolute and accurate logs for comparison were insured.

Previous to the core-drill exploration, the surface was mapped in detail, to determine as closely as possible the structural area, so the tests could be located to the best advantage. The first test on a supposed structure was placed on the approximate crest and drilled to 800 feet or deeper; the reverse or critical dip was then proved by a cross-section of closely spaced holes. These first holes were located from one-fourth to one-half mile apart, and later increased up to three-fourths mile, if a constant section were encountered. The tests were always located with reference to some known surface outcrop, and were correlated on the entire section from the surface to the total depth.

Several interesting features were brought out by the structural drilling. It was observed that the sandstones were harder and more consolidated over the apex of the structure. Also, that the sand content in the shales materially increased over a structural high. This was especially apparent over areas of pronounced folding, such as the Grogan anticline, the Johnson anticline in T. 4 S., R. 4 W., and the Cruce anticline in Stephens County.



An interesting feature also observed was the color change in the upper formations over a pronounced structural feature. The brown shale horizons contained a greater percentage of light blue or gray color as the apex of the structure was approached. In a core hole drilled on top of the Grogan anticline, the shale cuttings and circulating fluid were largely light gray from the surface down to the total depth of 1,000 feet, yet these identical formations were recorded in a dry hole three-fourths mile down the structure as red beds, with some shales.

Another observed feature of importance is the occurrence of shallow gas or oil showings encountered over the higher structural points of practically every core-drilled structure found on the Healdton uplift.

## FAVORABLE UNDEVELOPED STRUCTURES

Geologic study and core-drill exploration have disclosed four pronounced and one less pronounced anticlinal structure of positive existence. Seven other surface structures of uncertain nature and extent, but which are worthy of blocking and core-drill investigation, have also been disclosed. A discussion of the general features of these structures follows:

## ANTICLINAL STRUCTURES OF HEALDTON UPLIFT

### JOHNSON ANTICLINE

*Location.* This structure is located a few miles northwest of the town of Ringling, in secs. 28, 29, 32, 33, and 34, T. 3 S., R. 4 W., and secs. 2, 3, 4, 5, 9, 10, 11, 12, 13, 14, and 15, T. 4 S., R. 4 W.

The southeast extremity of the structure is approximately two miles from the northwest edge of production of the Healdton field. The Loco oil and gas field is located 4 miles to the northwest of this area.

*Stratigraphy.* The Asphaltum sandstone is exposed over the higher structural points of this fold. A thin nodular limestone occurs uniformly 17 to 20 feet above the top of this sand horizon where well exposed. This sand is also characterized by local asphalt saturation and tar seeps, pronounced jointing and veining of pyrite, and by steep local dips.

The surface outcrops of the Asphaltum sandstone occur as an inlier surrounded by younger beds. The areal geology is shown in plate I.

To a depth of 660 to 700 feet below the top of the Asphaltum sandstone, the formation consists of mottled brown and blue shales, and fine sandy shales, with intermediate beds of gray and blue sandstones, often capped by thin, hard brown and purplish nodular limestones and coarse, hard sand or gravel. The base of this brown series is marked by a thin, persistent bed of extremely hard, nodular limestone, consoli-

dated conglomerate and blue sand, that is easily identified and makes a reliable datum bed. This bed ranges from five to eight feet in thickness and is generally overlain by a soft blue shale. The top consists of three to five inches of hard brown nodular limestone, 12 to 18 inches of closely consolidated, coarse quartz sand and conglomerate, with angular fragments of limestone, chert, and glassy quartz, grading downward into softer blue sand three to five feet in thickness, and underlain by blue shale or blue sandy shale. The conglomerate member of the datum bed is of such hardness and so consolidated that it has been found impossible to cut through it with a fishtail bit, and no metal alloy set in drill crowns will penetrate it. Only diamonds can be successfully used in coring this bed, and often these stones are broken and shattered in cutting through pebbles of varying hardness.

A study of logs of cable-tool holes in the vicinity shows the presence of a series of blue shales, with interbedded sand bodies and thin limestones, below the formation described above. From all evidence these beds underlie the red and brown series unconformably, and are more highly tilted. Cores taken below the datum bed in some instances have shown 10° to 15° dips.

Heavy limestone beds have been penetrated in several wells in this vicinity at depths around 3,000 feet. Samples of this lime are not available for study, and it is therefore impossible to determine whether this is a Pennsylvanian lime or an extension of the buried Ordovician lime high thought to exist under the Healdton field at a shallow depth.

*Structure.* This anticline is a narrow elongated fold trending in a northwest and southeast direction, and bears the same *en echelon* relationship to the Healdton anticline on its northwest extremity that the Hewitt anticline bears on the southeast extremity.

*Direct evidence of oil and gas accumulation.* Surface evidence of oil and gas accumulation in the area consists of numerous exposures of asphaltic sandstone and tar seeps. An interesting asphalt outcrop occurs in the E.½ sec. 11, T. 4 S., R. 4 W. where there is likewise a pronounced surface reversal into the Healdton field. A large asphalt or tar seep occurs in the bed of Tar Branch in the SE.¼ sec. 31, T. 3 S., R. 4 W. Likewise, many shallow wells drilled for water in this area have encountered heavy oil, gas, and sulphur water.

In practically every core test heavy oil or gas showings have been encountered. In one core test gas encountered below 580 feet blew mud fluid twenty feet into the air as the drill pipe was being extracted. A sand showing lighter oil was also encountered at 835 feet to 840 feet in this test. The sands on the west flank of the structure show the greatest saturation of heavy oil; the saturation also extends farther down this flank. The core tests showing gas have been those located high structurally.



These showings of heavy oil and gas are important, in that similar showings are found in the shallow sands of the red beds overlying every field of Carter County, and adjacent territory, except at Brock where no red series is present. However, sulphur water is encountered on the edge of the Brock field, and asphalt deposits occur on the east flank, where a fault brings the Arbuckle limestone to the surface. The Loco, Healdton, Oil City, and Graham pools were directly located by surface indications, consisting of tar seeps, sulphur water, and shallow oil and gas showings found in drilling for water. These surface indications are also very pronounced in the Hewitt, Fox, and Robberson fields of this general area.

As the dips in the red beds are comparatively flat, the area of saturation in these beds is much broader than the highly concentrated accumulation in the underlying steeply tilted Glenn strata.

*Possible oil and gas horizons.* Possible producing horizons in the Pennsylvanian beds below the red series are in the Healdton and Hewitt producing sand zones, lower Pennsylvanian sands, and the Ordovician.

The Simpson formation of Ordovician age may be present under this structure and not eroded, as may be the case over part of the Healdton Ordovician high, since the Johnson antiline is lower structurally. Should this condition exist, there are possibilities of large production from the Wilcox or Simpson sands, the existence and depth of which can only be determined by the drill.

*Development.* Seven tests for oil and gas have been drilled in the vicinity of the Johnson anticline. Three of these tests were drilled slightly below 3,000 feet but were not located favorably as to structure.

A well drilled near the center of sec. 32, T. 3 S., R. 4 W., to a depth of 2,150 feet is reported to have produced some oil from the lower Healdton sand at a depth of 1,560 feet to 1,660 feet. This well is located down the west flank of the structure. A well drilled to a depth of about 1,650 feet near the center of sec. 15, T. 4 S., R. 4 W., also a showing of oil in the lower Healdton sand zone.

A well drilled along the south line of sec. 20, T. 3 S., R. 4 W., produced gas from shallow sand at 610 feet and obtained a showing of wet gas and oil in the top of a lime topped at 2,400 feet.

The Lone Star Gas Company is operating a well in the NW.¼ sec. 21, T. 3 S., R. 4 W., that is producing gas from a sand at 1,570 feet; also a gas well in the same horizon in the SW.¼ sec. 17, T. 3 S., R. 4 W.

### STALLINGS STRUCTURE

*Location.* This structure is located through secs. 21, 22, 23, 25, 26, and 27, T. 3 S., R. 5 W., and near the old town of Asphaltum.

*Stratigraphy.* The Asphaltum sandstone and possibly lower members are exposed on the surface. These sandstones at various localities on this structure are heavily saturated with asphalt.

*Structure.* It is impossible from existing surface exposures to accurately define this structure. From surface observations, the highest structural point appears to be over the drainage flat in the NW.¼ section 26.

*Production.* There are numerous tar seeps, and the sandstones are heavily impregnated with asphalt on the higher structural points of this fold. This structure might be termed a "fossil" oil field, in that these surface saturated sandstones were once buried oil sands and are now exposed by erosion. The saturation of these upper beds is positive proof of existing structure or the intense shallow accumulation would not have taken place. There has been no observed indication of faulting.

The most prominent tar seeps and asphalt occurrences are in the SW.¼ sec. 24, the central part of sec. 25, near the west line of the NE.¼ sec 26, and in the NW.¼ sec. 27, T. 3 S., R. 5 W.

Some minor gas seeps were observed in section 25, and Mr. Jeptha Stallings, a ranchman who is a pioneer resident of this area, states that numerous and very strong gas seeps show when the flat in the northwest quarter of section 26 is under water. He describes these seeps as a constant agitation, with intermittent stronger flows that would throw water five feet in the air. This structure should be given a core drill investigation to determine the exact location of the higher structural points.

#### OTHER AREAS OF PROBABLE STRUCTURE ON HEALDTON UPLIFT

There is anticlinal folding through secs. 19, 20, 29, and 30, T. 3 S., R. 4 W., as shown by surface and subsurface study. This is likewise an area of asphalt saturation and seeps. Also through secs. 17, 18, 20, and 21, T. 3 S., R. 4 W., there is positive evidence of anticlinal structure. Two producing gas wells have been drilled on this fold by the Lone Star Gas Company. These wells are located in the SW.¼ section 17, and in the NW.¼ section 21 of this township.

The Shell Petroleum Corporation has carried on extensive core-drill explorations over these structural highs, the results of which are not yet available.

### ANTICLINAL STRUCTURES ON NOCONA UPLIFT

#### T. 5 S., R. 6 W., STRUCTURE

*Location.* This anticline is located in secs. 22, 23, 25, 26, 27, 34, 35, and 36, T. 5 S., R. 6 W., and secs. 1, 2, 3, 11, and 12. T. 6 S., R. 6 W.



*Stratigraphy.* The top member of the Oscar sandstone outcrops in erosion cuts on both flanks of this structure. The overlying shale interval between this series and the bottom of the Ryan sandstone occurs around and isolates these lower beds. As shown on the areal map (No. XXXIII) the top member of the Ryan sandstone swings around the northwest extremity of this fold.

The nearest dry hole was drilled in the SW. cor., SE.¼ sec. 34, T. 5 S., R. 6 W. This well recorded red beds to a depth of 950 feet. Thin lime and sand ledges separated by shale intervals were recorded to 1,500 feet. From this depth to 1,700 feet the formation was largely blue shale with some thin sand streaks. A series of limestones and blue shales was found from a depth of 1,710 feet to the total depth of 1,815 feet.

*Structure.* This anticlinal feature is apparent on the surface and stands out as an immense topographic high, with gentle dip slopes from its structural apex. The top member of the Oscar sandstone can be traced up drainage cuts on both flanks of this feature and around its northwest extremity. Definite northeast dip and northwest dip can be observed in these beds. The southeast and south dip is rather poorly defined, but apparent from dip slopes and stratigraphic sequences. The normal dip is north and east.

*Oil and Gas.* There is no surface evidence of oil or gas in this area. The dry hole drilled in section 34 recorded four gas shows of uncertain nature.

Development in the immediate vicinity of this structure consists of an 1,815-foot dry hole located in the SW.¼, SE.¼ sec. 34, T. 5 S., R. 6 W., a dry hole drilled in the E.½ sec. 33, T. 5 S., R. 6 W., to a total depth of 2,118 feet, and a shallow hole drilled in the N.½ sec. 21, T. 5 S., R. 6 W.

### BURNETT RANCH STRUCTURE

*Location.* This structure is located in secs. 29, 32, and 33, T. 5 S., R. 5 W., and secs. 4 and 5, T. 6 S., R. 5 W.

*Stratigraphy.* The Ryan sandstone is well exposed over most of the area of this structure.

Three dry holes drilled in the immediate vicinity of this structure record from 700 to 900 feet of red beds, underlain by an alternating section of sandstones and thin limestones, separated by blue shale intervals. This entire recorded section is quite similar to that observed in the Spring pool, located five miles southwest.

*Structure.* The surface structure may be worked on the top of the Ryan sandstone, where definite northeast, north, and north-

west dips may be defined; the southeast dip is obscure and uncertain. The highest structural point lies in the E.½ sec. 32, T. 5 S., R. 5 W.

*Oil and Gas.* Three dry holes have been drilled on the flank of this structure. All these wells recorded abnormally thin red beds, and appear to be high structurally. Several oil and gas showings were reported in each of these tests. These recorded oil and gas shows, and the existence of a subsurface high, as shown by these wells, were the basis for the surface and core-drill investigation.

## OBSERVED SURFACE STRUCTURES ON NOCONA UPLIFT

### STRUCTURAL NOSE IN T. 7 S., R. 6 W.

*Location.* A pronounced structural nose occurs through secs. 26, 27, 34, and 35, T. 7 S., R. 6 W.

*Stratigraphy.* The top members of the Oscar sandstone are exposed on the surface.

*Structure.* The mappable structure is a pronounced nose plunging to the northwest; definite northeast, northwest, and southwest dips may be observed. The nose is open to the southeast, with no control, as all outcrops are obscured in Red River bottom land. This structural nose occurs as a topographic high, with pronounced dip slopes to the north, northwest, and west. It should be possible to define this nose on the southeast by core drilling.

*Miscellaneous.* There are surface and subsurface indications of a small anticlinal feature of some type through sec. 36, T. 6 S., R. 6 W., and sec. 31, T. 6 S., R. 5 W.

Also structure drilling would probably disclose one or more lower anticlinal folds through Tps. 4 and 5 S., Rs. 6 and 7 W. There is uncertain evidence of a large, board, flat fold in this area.

## ANTICLINAL STRUCTURES ON WAURIKA ARCH

### NEESMITH DOME

*Location.* This structure is located in the northeast corner of T. 7 S., R. 7 W., and several miles southeast of the town of Ryan. The anticlinal axis passes through sections 2, 3, and 12 of this township.

*Core Drilling.* Seventeen core holes were drilled in an area of approximately four sections in defining this structure. These holes were drilled from 500 to 830 feet in depth. Close attention was given the location of these tests as to their starting point in reference to the Ryan sandstone. It was possible to trace this member over the entire structure by drilling, and thus obtain a positive starting point in the correlation of the various core tests.



*Stratigraphy.* The Ryan sandstone is exposed on the surface. The top of the Oscar sandstone occurs approximately 100 feet below the top of the Ryan sandstone which over this structure has a thickness of 18 to 25 feet.

A dry hole drilled near the center sec. 3, T. 7 S., R. 7 W., shows the base of the Pontotoc to have been reached at about 1,500 feet. A limestone and sand series was topped at 2,245 feet in this test.

*Structure.* The surface structure can be worked on the top of the Ryan sandstone, which is exposed in a continuous outcrop on the northwest end of the structure. On the southeast extremity the outcrops are confined to a few isloated exposures, which, previous to the structure drilling, could not be positively identified as the Ryan sandstone. However, good dip slopes and general stratigraphic relation pointed to structural closure in this direction.

The structure is reflected on the surface as a pronounced topographic high, certain points reaching an elevation of 975 feet. The crest of the fold is broken and in the early stages of erosion. The structure as defined by core drilling consists of a rather pronounced anticlinal dome, with approximately 44 feet of closure. It coincides with that part of the surface structure that can be accurately mapped.

### KAURAUFF ANTICLINE

*Location.* This structure is located several miles southwest of the town of Addington and lies in secs. 2, 3, 4, 9, 10, 11, 14, 15, and 24, T. 4 S., R. 8 W. The Comanche and Empire pools are located 10 to 15 miles north of this area.

*Core-drilling.* Nine core tests averaging 950 feet in depth were used in defining this structure. The shallowest test was drilled to a total depth of 760 feet, and the deepest to a depth of 1,428 feet.

From both a mechanical and geological standpoint, this area afforded better drilling results than encountered so far in southern Oklahoma. The thick shale intervals were conducive to rapid drilling, and with the regular occurrence of two hard sandstone ledges, afforded excellent correlations. This is the one spot so far found in southern Oklahoma, that core tests can be placed a mile apart and excellent correlations obtained. In fact, in this block any test will correlate smoothly with any of the other core tests drilled. After the first few wells were drilled it was possible to determine the depth of the lower marker within a few feet from the upper correlations.

*Stratigraphy.* The lower part of the Claypool formation occurs on the surface. A conspicuous sandstone member outcrops at various places over most of this area. This sandstone occurs from 125 to 150 feet above the top of the Ryan sandstone. It occurs at about the same stratigraphic position as the sandstone or the river bluffs in Texas, south of Terral, Oklahoma, which, as previously discussed, has been traced into the Coleman Junction limestone that marks the top of the Cisco formation of Texas.

A dry hole drilled in section 22 to a total depth of 2,745 feet recorded a section of alternating thin limes and good sand bodies, separated by blue shale intervals, from 1,400 feet to the total depth.

*Structure.* This structure is topographically high; the crest, however, is broken and eroded out on the northeast flank.

Conclusive evidence of some type of anticlinal folding is shown on the surface. Southwest, north, and northeast dips can be definitely mapped; the southeast dip is covered, and of uncertain amount and extent. The normal dip is to the northeast off the Waurika arch.

The core-drill structure consists of an elongated dome, the axis trending northwest and southeast, through sections 4, 10, 11, and 14. The reverse or southwest flank dips much steeper than the northeast flank of the fold. This structure has a positive closure of 40 to 50 feet.

### RYAN STRUCTURE

*Location.* An anticlinal structure of uncertain closure occurs in secs. 16, 17, 21, 22, 27, and 28, T. 6 S., R. 7 W., and located on the east edge of the town of Ryan.

*Stratigraphy.* The Ryan sandstone occurs on or very close to the surface over the general area, and forms prominent scarps on the northwest, southwest, and southeast sides of the fold.

*Structure.* This fold trends northwest and southeast, the highest structural point appearing to be near the southwest corner of section 16. Fifty-two feet of northwest dip, 70 feet of southwest dip, and 60 feet of southeast dip may be definitely mapped. The northeast dip is the critical dip in this particular area. There is no definite control in this direction from surface exposures. Core drilling will almost certainly prove a northeast dip and establish closure of some amount.

*Oil and gas.* A dry hole has been drilled to a total depth of 3,300 feet on the east line of the SW.¼ section 16. This well had no oil or gas showings. It is located three-fourths mile east of the highest part of this structure.



### DEAD MAN'S GULCH STRUCTURE

*Location.* This structural feature occurs through secs. 21, 22, 23, 24, 25, 26, 27, 28, 34, 35, and 36, T. 4 S., R. 9 W., and lies several miles west of the town of Waurika.

*Stratigraphy.* The Ryan sandstone occurs on the surface. The lower stratigraphy as shown by dry holes has been discussed previously.

*Structure.* The surface structure, as interpreted by the writer, is shown on figure 55. The anticlinal axis is eroded out, leaving a dissected flat of badland topography. The Ryan sandstone occurs as a rim rock along the northeast flank and swings completely around the northwest extremity of the fold. This line of escarpment stands up above the surrounding country, as a topographic ridge, with cleancut dips sloping away from the anticlinal axis. As shown on figure 55, there is mappable northeast dip, northwest dip, and some amount of southwest and southeast dip.

This structural feature appears to be one of at least three closely related minor folds that make up a tremendous structural feature through Tps. 4 and 5 S., Rs. 8 and 9 W. These minor folds trend in a northwest-southeast direction, with parallel axes and *en echelon* relationship.

From surface observation, the higher structural points of the Dead Man's Gulch structure appear to be in secs. 26, 27, 35, and 36, T. 4 S., R. 9 W. A synclinal sag through section 34 appears to separate this fold from an undefined but similar parallel minor fold to the southwest. The location of this fold is uncertain, but from meager surface evidence the axis appears to pass through parts of secs. 31 and 32, T. 4 S., R. 9 W., and secs. 4, 5, and 9, T. 5 S., R. 9 W., and then across Red River into the river bend area in Texas.

The third closely associated minor fold occurs as a large topographic high diagonally across T. 5 S., R. 8 W. Reconnaissance mapping by the writer shows the anticlinal axis of this minor fold to occur in a northwest-southeast direction, through parts of secs. 8, 9, 15, 16, 22, and 26, T. 5 S., R. 8 W.

*Oil and gas.* There are no surface occurrences of oil or gas over the area of the Dead Man's Gulch structure, or the other associated minor folds on the Waurika arch. However, salt water in shallow water wells is reported to exist over the axial area of the Dead Man's Gulch structure.

Three dry holes have been drilled down the flanks of this structure and eight other tests have been drilled on or adjacent to the other two associated minor folds on the Waurika arch.

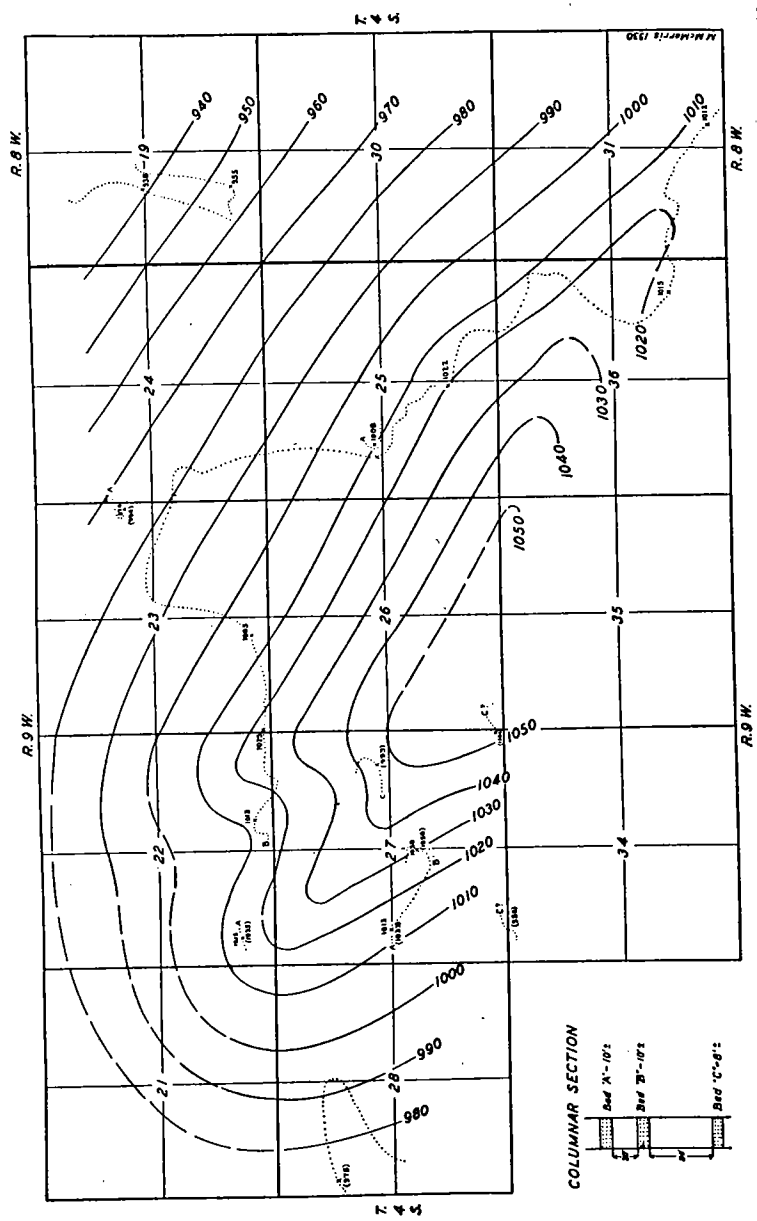



Figure 55. Contoure map of Dead Man's Gulch structure. Contour interval, 10 feet. Contours on top of sandstone "B". Datum, sea level.



While some of these tests were fairly well located structurally, none were located on the highest structural points of these minor folds. With one exception these tests were not carried to sufficient depths to reach lower Glenn or Ordovician producing horizons.

Several tests in this area have recorded showings of oil and gas. A well recently drilled by the Amerada Petroleum Corporation in sec. 28, T. 5 S., R. 8 W., recorded a show of oil at a depth of 3,400 feet. This well appears to be considerably lower structurally than certain other tests drilled in this area.

## POSSIBILITIES OF ORDOVICIAN PRODUCTION

The best possibilities for Ordovician production in Jefferson County are thought to exist over the northeast portion of the county, under folds associated with the Healdton structural uplift. The Simpson formation is known to have been deposited over this area; it may or may not now be present over the higher structural features. Comparatively little is known about the Ordovician section along the Nocona and Waurika arches. It would appear that if the Simpson has not been stripped off by erosion, it is radically different from the Arbuckle Mountain section; at any rate it has not been recognized in drill holes in this area. Regardless of whether the Arbuckle limestone is a source of oil and gas, deep drilling in the Oklahoma City field has shown that immense production can be obtained from the Arbuckle lime reservoirs. Whether or not the oil is indigenous to the lime in this field is uncertain and relatively unimportant. It does demonstrate, however, that unconformable Arbuckle cores are worthy of close consideration and investigation in certain areas, especially when known to be overlapped by younger petroliferous horizons.

A brief discussion of the Simpson formation and Arbuckle limestone as known in this general area follows.

### Simpson Formation

A study of the Simpson formation as exposed in the Arbuckle Mountains with its thick bodies of massive porous sands, in many places heavily impregnated with asphalt on the outcrop, and the prolific production derived from equivalent sands of this formation throughout numerous fields in the Mid-Continent area, causes any geologist or operator with the slightest imagination to seriously consider the probability of Ordovician production on certain of the anticlinal folds south of the Arbuckle Mountains, especially in northeast Jefferson County.

A general study of the Simpson formation from the Ozark uplift to the Arbuckle Mountains shows this formation to thicken from a comparatively few hundred feet in southwest Missouri, to a total thickness of approximately 2,300 feet in certain localities

on the south flank of the Arbuckle Mountains. This thickening occurs throughout the entire section by the addition of shale, lime, and sandy phases. The thickening is especially noticeable from the base of the Viola limestone to the top of the Wilcox sand in a southwest direction from the Seminole area to the Arbuckle Mountains.

Along the south flank of the Arbuckle Mountains the shale interval between the lower Simpson sands and the Viola limestone becomes progressively more sandy from west to east. On the west extremity of the Simpson outcrop the upper 1,000 to 1,200 feet of the Simpson is largely shale with thin limestone shells; the lower sands, however, are present.

Surface exposures in the Criner Hills of Carter County, one isolated outcrop on the north flank of the Wichita Mountains west of Sedan, and the occurrence in certain wells drilled in Kiowa County, prove that the Simpson formation was deposited over a considerable area west and south of the Arbuckle Mountains. In these areas the Simpson formation appears to have the same general characteristics as in the Arbuckle Mountains, with several well developed sand horizons suitable for oil or gas reservoirs.

Several of the deeper holes drilled in T. 2 S., R. 6 W., T. 3 S., R. 5 W., T. 3 S., R. 4 W., T. 4 E., R. 3 W., and T. 4 S., R. 2 W. are known to have penetrated Viola lime and in some instances the upper portion of the Simpson formation. Likewise, a few wells in the Healdton and Hewitt oil fields of Carter County, are thought to be producing from the upper Simpson or lower Viola. The oil is of higher gravity than that which is found in the overlying Pennsylvanian sands.

Recently a well drilled in sec. 30, T. 2 S., R. 6 W., encountered the top of the Viola limestone at 2,922 feet and the top of the Simpson formation at 3,450 feet. This well is shut down at a total depth of 4,500 feet, after penetrating 1,050 feet of Simpson section composed of green shale and thin limestones. This test has not reached the sand members in the lower Simpson, which should be encountered with deeper drilling.

The absence of sand members in the upper Simpson formation, penetrated in this test is to be expected after a study of the outcrop exposed on the western extremity of the Arbuckle Mountains.

### ARBUCKLE LIME

The upper portion of the Arbuckle limestone in the Arbuckle Mountains consists of alternating thin beds of shales and limestone. The limestones are more or less dark colored and bituminous on fracturing and give a petroliferous odor when freshly fractured.



The shales in most instances are dark colored to black. Near Crusher, Oklahoma, globules of free oil can be found in freshly fractured Arbuckle limestone. The upper Arbuckle could be and probably is an important source of oil and gas in certain areas.

A well drilled in sec. 9, T. 2 S., R. 6 W., Wirt Franklin No. 1 Bonner penetrated a limestone formation from 3,450 to 3,939 feet that is undoubtedly Arbuckle. Whether it is present due to faulting, unconformity, or redeposited Arbuckle boulders, is as yet uncertain. Certain cores from this lime show that it contains irregular cavities filled with a very heavy asphaltic oil.

## CONCLUSIONS

### NORTHEASTERN JEFFERSON COUNTY

The anticlinal folds along what has here been termed the Healdton uplift, including the Johnson, Stallings, and associated structures, are thought to offer the best possibilities for commercial oil and gas production of any undeveloped area in Jefferson County. Folds on this general high have excellent possibilities for both shallow and deep production from Pennsylvanian sands and possibly lower sands in the Simpson formation or the Arbuckle limestone.

The cheapest and most efficient method of prospecting the undeveloped northwest portion of the Healdton uplift, would be the drilling of four to six core-drill holes to a depth of 2,500 feet, or the Big Lime series on the higher parts of the minor structures as disclosed by surface mapping and shallow core-drilling. Data derived from these deep core tests would give accurate subsurface information as to the nature of the stratigraphic section, the oil, gas, or water contents of sands penetrated, and furnish excellent samples for identification and correlation of formations.

A deep test should then be drilled upon the most favorable location disclosed by this exploration. If located on the highest structural point this test should be carried at least 600 feet below the top of the Arbuckle limestone before abandonment. Should Ordovician rocks be penetrated at shallow depths and found devoid of oil or gas there would still remain excellent possibilities of production in overlapping lower Pennsylvanian sands on the flanks of the lime core.

### WESTERN JEFFERSON COUNTY

The possibilities of new production in western Jefferson County along the Nocona uplift and Waurika arch are uncertain. Conditions as disclosed by recent drilling are extremely puzzling. During the latter part of 1928 and 1929 this portion of Jefferson County extending northwest into Cotton County was given a very extensive oil play and several critical wells were drilled.

Certain of these wells were located on geophysical information, including torsion balance, seismograph, and magnetometer work. Other tests were drilled on surface and core-drill structures. Certain of these wells ran abnormally high structurally and others ran low. In every case, however, each was abandoned as a dry hole with no appreciable oil or gas show, except in one instance and this well appears to correlate much lower than other tests closly adjacent. (Amerada, Edminson, sec. 28, T. 5 S., R. 8 W.)

Of the core-drill structures on the Waurika arch, discussed in this report, two have now been drilled without favorable results. The Neesmith dome has been tested by a well on the highest structural point to a depth of 3,939 feet. The drill was in Pennsylvanian rocks when abandoned, correlated by White of the Gypsy Oil Company as belonging to the lower Hoxbar..

The Kaurauff anticline has been tested by a well to a total depth of 3,008; this test was not located on the highest structural point on account of lease requirements. It was abandoned in rocks thought to correlate with the lower Hoxbar.

The test wells on both the Neesmith and Kaurauff core-drill structures correlate higher structurally than dry holes previously drilled down their flanks, and conclusively prove that the structure shown in the upper beds continues and increases as normally expected with depth. It would appear then that the undeveloped structures in western Jefferson County, so far tested, are barren of oil or gas or have not been adequately tested by deep drilling.

In this connection it is well to note that only one hole on the Waurika arch is definitely known to have penetrated rocks older than Pennsylvanian. This well, Amerada, Delana No. 1, sec. 31, T. 4 S., R. 9 W., Cotton County, penetrated a thick lime series from 1,534 to 3,200 feet, and encountered igneous material at 3,275 feet. Immediately above the granite Cambrian rocks are thought to have been penetrated. Most of the lime section is thought to be Deese. This well is unquestionably very high structurally. However, there is no reason to believe that this well is located on the very pinnacle of a subsurface high. A pool the size of the Oscar field could easily occur in the vicinity of this well. Core drilling to the top of the lime should be conducted adjacent to this well.

According to the surface structure, as interpreted by the writer, the DeLana well is located down the west and northwest flank of a structural nose open or at least undefined to the southeast. This structural nose appears to be a parallel minor feature off the Dead Man's Gulch structure. The location of the DeLana test is at least 100 feet lower structurally than the higher part of the Dead Man's Gulch anticline, which appears to the major structural high in this area as shown by surface mapping.



The present producing areas in Jefferson County, including, Healdton, Oscar, Spring and T. 7 S., R. 7 W. gas areas are all located on apparent surface structures that closely coincide with the structure of the producing sands. With the exception of Healdton, the production covers a very restricted area and is confined entirely to the highest structural points.

Also in every instance drilling has shown that unconformable older rocks occurring in buried lime hills or cores underlie the producing sands from 100 to 300 feet. The higher the buried hills the shallower and more extensive the area of oil and gas accumulation in the overlying beds. To the writer's mind this fact is evidence that the oil originated in strata below that where it is now accumulated, being derived possibly from overlapping lower Pennsylvanian beds or directly from the Ordovician.

It appears then that future exploration in western Jefferson County should be confined to the highest structural points on positive structures and drilled to a depth sufficient to reach the zone of contact and unconformity with rocks older than middle Pennsylvanian, or to unconformable lime cores.

The only structures discussed in this report that have had tests drilled on or adjacent to the highest structural points are the Neesmith and Kaurauff anticlines. Both of these folds may be considered flank structures as they are lower structurally than the higher parts of the Waurika arch and Nocona uplift. The older rocks should then be expected at much greater depths. It is certain that the tests drilled on these structures quit in formations well up in the Pennsylvanian section and probably did not reach the contact zone above any unconformable core.

The above discussion is made to show that, while development so far in western Jefferson County has been discouraging, there are possibilities of commercial pools in this area. The best possibility left for shallow production is the Dead Man's Gulch structure as this is the highest structural feature on the Waurika arch, and is as yet untested. Deep tests are thought warranted on the closed structures discussed in this report.

# BLAINE, DEWEY, CUSTER, AND ROGER MILLS COUNTIES

By

Ray L. Six

## SUMMARY

This report covers in a rather superficial way over 4,000 square miles of territory in the western part of the State of Oklahoma.

Surface rocks of the area are Permian, Cretaceous, Tertiary and Quaternary in age. Little is known concerning the subsurface formations save through inference from known data on surrounding areas and the definite facts obtained from logs of the few deep wells which have been drilled.

The Anadarko Basin is the regional structural feature of this part of Oklahoma and its axis passes through the southern part of the area under consideration. Dips on the northeastern flank of the basin are low while those on the southern limb are much more steep.

Wildcat drilling has produced much activity in the leasing and royalty business. Most of the wells drilled thus far have been shallow and as yet no commercial product has been discovered.

This area would require many months of detailed field study in order to correctly interpret the stratigraphic and structural relationships. This report is largely a compilation of data obtained from men who have made detailed studies of particular areas and from their published reports.

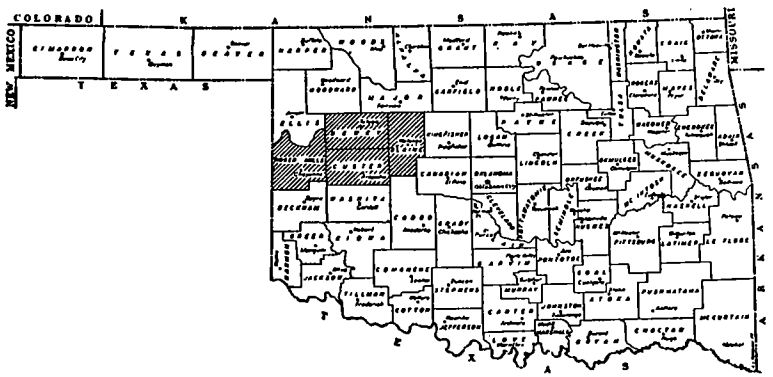



Figure 56. Index map of Oklahoma showing location of Blaine, Dewey, Custer, and Roger Mills counties.

(Originally published as Bulletin 40-UU, May, 1930)

A number of corrections in the areal geology as shown on the State Geologic map have been made on the accompanying map. Much data of a confidential nature in the files of major oil companies is not now available for publication. This, if incorporated in the present report, would greatly enhance its value.

## INTRODUCTION

Blaine, Dewey, Custer, and Roger Mills counties are located in the extreme west-central part of the State. The area lies directly east of the Texas-Oklahoma line, is south of Ellis, Woodward and Major counties, west of Kingfisher and Canadian counties and north of Caddo, Washita, Beckham and a part of Canadian county. It embraces the territory between Tps. 12 to 20 N. inclusive and Rs. 10 to 26 W. inclusive. These counties are drained by the Cimarron, North Canadian, Washita and the North Fork of Red River and their tributaries. These streams have carved four nearly parallel valleys from northwest to southeast through the region.

The geologic formations found on the surface of these counties are, in ascending order, Chickasha, Blaine gypsum, Dog Creek shales, Whitehorse sandstone, Day Creek dolomite, Cloud Chief gypsum, Quartermaster, Cretaceous outliers of the Washita group, Tertiary sand, Quaternary gravels, caliche and alluvium.

Structurally, this area lies within the Anadarko Basin, mostly on the north limb, the axis of the basin passing through the southern part. See figure 57, page 408, for this relationship.

### ACKNOWLEDGMENTS

Inasmuch as sufficient time was not available for detailed field studies on the part of the writer, special acknowledgment is due those whose data helped to make this report possible. The publications of R. L. Clifton and others have been a very helpful source as well as conversations with individuals working in the area and the representatives of various oil companies. The writer is also indebted to Chas. N. Gould and C. L. Cooper of the Oklahoma Geological Survey for assistance in the preparation of maps and manuscript for this report.



## BLAINE COUNTY

Blaine County is the farthest east of the four counties covered in this report and lies just northwest of the center of the state. It embraces Tps. 13-19 N. inclusive and from R. 10-13 W. inclusive. It contains 26 townships and has an area of 936 square miles.

In population it exceeds 20,000 with a density of more than 20 per square mile. The principal towns are Watonga the county seat, (2,000), Geary (1,500), Homestead (500), Darrow (200), Greenfield (350), Hitchcock (100), Okeene (1,500), Eagle City (400), Southard (400), Canton (1,000), and Longdale (300). All of these towns are on railways. Numerous others shown on old maps have ceased to exist.

Blaine County is served by the Rock Island, Frisco, and Orient Railways. The Orient, now a branch of the Santa Fe passes through the northwest part of the county via Longdale and Canton. The Frisco passes through the northwestern part of the county via Okeene, Darrow, Southard and Eagle City. The main line of the Rock Island passes through the southern part of the county and Geary is a division point. A branch line leaves Geary and passes through the eastern part of the county via Greenfield, Watonga, Hitchcock and Okeene. Here the line divides and one branch goes to Enid and the other to Cherokee.

### TOPOGRAPHY

Blaine County is drained by the Cimarron River and its tributaries in the northeastern section and by the Canadian River in the southwestern part. The highland between these two valleys is drained by the North Canadian River. The northeastern part of the county is a gently sloping plain the westward edge of which ends in the Blaine gypsum escarpment. This escarpment has been badly dissected dendritically by the tributaries of the Cimarron. West of this is a westward sloping plain composed of Quaternary sands and covered with Black Jack oak timber. West of North Canadian River is an eastward sloping plain ending in the bottom of North Canadian valley. It also has been badly dissected in many places by tributaries of the same river. This plain is underlaid by the Whitehorse sandstone. In the southern part of the plain west of Greenfield, dolomite beds produce a prominent escarpment which is known as the Greenfield dolomite.

The southwestern part of the county slopes westward into the valley of the North Canadian. Most of this plain is covered with Quaternary sands on which is growing scrub timber. Along the three major stream courses large quantities of alluvium are found. The Quaternary sand deposits found on the northeast valley wall of the North and South Canadian rivers have been reworked into dune topography. These eolian deposits form an elongate area paralleling the rivers and vary in width from one to six miles, being narrowest in the North Canadian River valley.

## GEOLOGY

### Surface formations

The surface rocks of Blaine County are composed of Chickasha formation, Blaine gypsum, Dog Creek shales, and Whitehorse sandstone, all of which are Permian in age. Within the Whitehorse sandstone some 70 feet above the base in the southern part of the county is the Greenfield dolomite whose resistant character forms an escarpment. Lying unconformably upon these formations are found two areas of Quaternary sands and gravels which lie north of and parallel to the North and South Canadian rivers. A smaller area of this same formation lies northeast of Watonga in Tps. 16 and 17 N., R. 11 W. Still smaller areas are found in various other places in the county. Along the stream courses have been deposited large quantities of alluvium.

### CHICKASHA FORMATION

This formation forms the surface of the northeastern third of the county and has a thickness of approximately 175 feet. It is the oldest Permian formation in the county and lies conformably upon the Duncan sandstone found farther east in Kingfisher County. The Chickasha has been correlated with the Double Mountain of Texas and with the Flower Pot, Cedar Hills, and Salt Plain of Kansas. It is composed of red sandstones, sands, shales and mud stone, all of which seem to be lenticular in character. Some of the sands are distinctly cross-bedded. The basal part of the formation is highly arenaceous and the upper part is highly impregnated with gypsum a large portion of which is probably secondary in origin. Northward the formation increases in thickness, reaching 275 feet in Woods County. Southward it thins to only 90 feet in Comanche County and 160 feet at Rush Springs. At this point it is possible to further subdivide the formation into stratigraphic units. Freie[1] considers the Chickasha related to the Duncan sandstone in origin. The Chickasha is 9 to 28 per cent soluble in acid. The sizes of grains in the Chickasha in Blaine County increase as one progresses south toward the apex of the Anadarko Basin. Chickasha deposition is characterized by lenticular, deltaic and shallow water conditions. The source of these materials is probably from the West (The Ancentral Rocky Mountains?).

### BLAINE GYPSUM

The Blaine gypsum lies unconformably upon the Chickasha formation and is overlain conformably by the Dog Creek shales. It has a thickness of over 75 feet and occurs as a dissected escarpment along the western edge of the plain formed by the Chickasha. This escarpment extends from a point eight miles east of the northwest corner of the

1. Freie, A. J., Sedimentation in the Anadarko Basin: Oklahoma Geol. Survey Bull. 48, p. 43, 1930.



county to the southwest corner of Kingfisher County. The formation was first described by Gould in 1902 and its connotation modified by him in 1905. The type locality of this gypsum is on Salt Creek (Henquenet Creek) in the southeast part of T. 18 N., R. 12 W. and in the Roman Nose canyons, secs. 7, 8, 17, and 18, T. 17 N., R. 11 W. Here it is composed of three massive beds of white gypsum separated by red shales. A dolomitic limestone occurs at the base of the two upper members. Both of these are quite fossiliferous and their horizons can be easily traced across the county. The abundance of *Pleurophorous* pelecypods have been described by Beede.[2]

Two excellent collecting grounds for fossils from the above horizons are secs. 3, 11, and 13, T. 15 N., R. 10 E., due west of Okarche of Kingfisher County and the north side of sec. 34, T. 17 N., R. 11 W. just south of the plant of the American Plaster Company. These fossil pelecypods have been observed in the Blaine of other areas in the Anadarko Basin. One place is the NW.¼ sec. 20, T. 7 N., R. 13 W., in a small creek bed, another in the vicinity of Mountain View and a third in the SW.¼ sec. 20, T. 7 N., R. 13 W. Fossiliferous horizons in the Blaine have been reported from Major, Woodward, and Woods counties farther north. Other, but badly preserved forms believed to be brachiopods, cephalopods and ferns are found in these same horizons, Manganese dendrites, "fossil" ice crystal impressions occur in some areas of the dolomite at the base of the middle gypsum member. These three massive gypsums are correlated with the Ferguson, Medicine Lodge, and Shimer of Kansas. These gypsums are thicker and more prominent in the northern part of the county and are mined at Southard and south of Hitchcock and manufactured into a number of products.

The mose picturesque exposures of the Blaine gypsum are to be found in the Roman Nose canyons southwest of Bickford. (See plate VII-A, page 422). These canyons were formerly the winter campgrounds of the Cheyenne Indians and remains of their sweat houses can still be observed. The son of the old Chief Roman Nose still makes his home here.

The following sections of the Blaine formation will illustrate its character in the outcrop.

2. Beede, J. W., Invertebrate paleontology of the red beds: Adv. Bull. 1st Bien. Rept, Geol. Survey Oklahoma, 1902.

### *Glass Mountain Section on the Northwest Side of the Mountain*
(After Gould[3])

| | | Feet |
|---|---|---|
| 11. | Massive, white gypsum (Shimer) | 13 |
| 10. | Fossiliferous dolomite | 1 |
| 9. | Red clay | 15 |
| 8. | Massive, white gypsum (Medicine Lodge) | 18 |
| 7. | Greenish clay | 4 |
| 6. | Red clay | 8 |
| 5. | Gypsum concretions and satin spar | 1 |
| 4. | Red clay | 3 |
| 3. | Bluish dolomite rock, hard | 2/3 |
| 2. | Red clay | 4 |
| 1. | Gypsiferous rock, satin spar | 4 |

### *Section near Watonga, Sec. 32, T. 16 N., R. 10 W.*
(After Suffel[4])

| | | Feet |
|---|---|---|
| 7. | Massive, white gypsum (Shimer) | 4 |
| 6. | Gray, sandy dolomite | 2 |
| 5. | Red clay with conspicuous green bands near the top | 41 |
| 4. | Massive, white gypsum (Medicine Lodge) | 10 |
| 3. | Grayish, sandy dolomite | 1 |
| 2. | Red clay | 13 |
| 1. | Massive, white gypsum (Ferguson) | 3 |

### *Section in NW.¼, Sec. 29, T. 15 N., R. 9 W.*
(After Snider[5])

| | | Feet |
|---|---|---|
| 6. | Medicine Lodge gypsum, pink, top eroded | 4 |
| 5. | Sandy, white dolomite | 2 |
| 4. | Covered, probably shale | 16 |
| 3. | Gypsum, with satin spar immediately underneath | 2 |
| 2. | Covered, probably shale | 16 |
| 1. | Ferguson gypsum | 5 |

### *Section in NW.¼, Sec. 11, T. 18 N., R. 12 W., One Mile East of Southard.*
(After Suffel[6])

| | | Feet |
|---|---|---|
| 11. | Anhydrite, at top of hill | about 4 |
| 10. | Gypsum, white, massive | 5 |
| 9. | Greenish grey sandstone | ½ |
| 8. | Red shale with green bands | 9 |
| 7. | Red and green shale with satin spar and green selenite bands | 11 |
| 6. | Ferguson gypsum, mottled | 7 |
| 5. | Greenish dolomitic sandstone | ½ |
| 4. | Red and green shale | 8 |
| 3. | Green selenite in clay, satin spar | 1½ |
| 2. | Red shale with thin bands of satin spar | 7 |
| 1. | Red and green shale with selenite | 30 |

3. Gould, Chas. N., Geology and water resources of Oklahoma: U. S. Geol. Survey, Water-Supply Paper 148, p. 51, 1905.
4. Suffel, G. G., Dolomites of western Oklahoma: Oklahoma Geol. Survey Bull. 49, p. 72, 1930.
5. Snider, L. C., Gypsum and salt of Oklahoma: Oklahoma Geol. Survey Bull. 11, p. 174, 1913.
6. Suffel, G. G., op. cit., p. 74.



### *Section from south Canyon, Head of Salt Creek, West of Ferguson.*
(After Gould[7])

| | | Feet |
|---|---|---|
| 11. | Red clay | about 40 |
| 10. | Dolomite | about 1 |
| 9. | Red clay | about 30 |
| 8. | Dolomite | about 2 |
| 7. | Red clay | about 25 |
| 6. | Massive, white gypsum (Shimer) | 15 |
| 5. | Soft, sandy dolomite | 1 |
| 4. | Red, gypsiferous clay | 27 |
| 3. | Massive, white gypsum (Medicine Lodge) | 17 |
| 2. | Red clay with bands of selenite | 25 |
| 1. | Pinkish, mottled gypsum (Ferguson) | 4 |

### *Section along the Chicago, Rock Island and Pacific Railway, Four Miles South of Hitchcock.*
(After Suffel[8])

| | | Feet |
|---|---|---|
| 8. | Massive, white gypsum, the Shimer | 8 |
| 7. | Gray, dolomitic sandstone | 1 |
| 6. | Red clay | 45 |
| 5. | White, massive gypsum, the Medicine Lodge | 12 |
| 4. | Gray, dolomitic sandstone | 2 |
| 3. | Red clay shales with greenish bands | 17 |
| 2. | Massive, white gypsum, the Ferguson | 3 |
| 1. | Red clay shales with bands of gypsum | 90 |

### *Section in the NE.¼ Sec. 25, T. 21 N., R. 13 W.*
(After Suffel[9])

| | | Ft. | in. |
|---|---|---|---|
| 14. | Massive gypsum (Ferguson) | 6 | ..... |
| 13. | Dolomite | ..... | 3-4 |
| 12. | Red, earth, gypsiferous shales | 25-30 | ..... |
| 11. | Blue-gray dolomite | ..... | 5 |
| 10. | Blue and gray shale | 9 | ..... |
| 9. | Hard gray dolomitic sandstone, probably local | ..... | 3-10 |
| 8. | Greenish gypsiferous shale | ..... | 16 |
| 7. | Gypsum | ..... | 6-8 |
| 6. | Shale | 9 | ..... |
| 5. | Green, shaly gypsum | ..... | 4 |
| 4. | Shale | 3 | ..... |
| 3. | Gypsum | ..... | 6 |
| 2. | Soft shale | 8 | ..... |
| 1. | Gypsiferous shale with harder greenish capping | 5 | ..... |
| | Unmeasured, bluish-green shale with thin beds of gypsum | | |

### *Cedar Hill Section in SW.¼, Sec. 18, T. 16 N., R. 10 W.*
(After Suffel)

| | | Feet |
|---|---|---|
| 6. | Massive, white gypsum (Shimer) | 12 |
| 5. | Fossiliferous, sandy dolomite | 2 |
| 4. | Red clay with selenite bands | 18 |
| 3. | Massive, white gypsum (Medicine Lodge) | 3 |
| 2. | Red clay with seams of selenite | 17 |
| 1. | Massive, pinkish to white gypsum (Ferguson) | 5 |

7. Gould, Chas. N., op. cit., p. 51.
8. Suffel, G. G., op. cit., p. 74.
9. Suffel, G. G., op. cit., p. 76.

*General Section of the Blaine, applying to the District lying a few Miles NE. of Watonga.*

(After G. D. Putnam[10])

| | | Ft. | in. |
|---|---|---|---|
| 10. | Thin, hard dolomite | | 2-5 |
| 9. | (Concealed) | 40 | |
| 8. | Massive gypsum (Shimer) | 10-15 | |
| 7. | Fossiliferous dolomite | | 8-18 |
| 6. | (Concealed) | about 60 | |
| 5. | Pure gypsum (Medicine Lodge) | 8-10 | |
| 4. | Fairly hard, slightly sandy dolomite | | 18 |
| 3. | (Concealed) | 6-10 | |
| 2. | Gray gypsum (Ferguson) | 2-4 | |
| 1. | (Concealed) | 60-80 | |
| | Base of Blaine formation. | | |

*Section in NE.¼, Sec. 14, T. 15 N., R. 10 W., Two Miles West of Altona.*

(After Suffel)

| | | Feet |
|---|---|---|
| 7. | Medicine Lodge gypsum, top removed by erosion | 3 |
| 6. | White dolomitic sandstone | 2 |
| 5. | Red and green shales | 16 |
| 4. | Gypsum, anhydrite, white satin spar beneath | 3 |
| 3. | Red and green shale | 18 |
| 2. | Ferguson gypsum, selenitic | 3 |
| 1. | Red and green shale | 21 |

The following section of the Blaine formation was taken at the type locality in sec. 23, T. 18 N., R. 12 W., near the head of Salt Creek.[11]

| | | Ft. | in. |
|---|---|---|---|
| 10. | Bed of pure white gypsum | 20 | 0 |
| 9. | Dolomite containing pelecypods | | 8 |
| 8. | Red and gray gypsiferous shale | 25 | 0 |
| 7. | Bed of massive white gypsum | 10 | 0 |
| 6. | Red and gray gypsiferous shale | 20 | 0 |
| 5. | Massive bed of gypsum and shale | 10 | 1 |
| 4. | Gray, sandy dolomite with pelecypods | | 8 |
| 3. | Gray, sandy shale | 2 | 0 |
| 2. | Red shale with streaks of gypsum | 140 | 0 |
| 1. | Very small exposure of gray gypsiferous, sandy shale that looks somewhat like the Chickasha at the head of the basin | 2 | 0 |

Freie reports the basal member in this section as 30 per cent soluble in acid while the other beds are 26 per cent soluble. The shape of the grains is dominantly angular (75 to 90 per cent). Quartz is the most abundant light material and feldspar is practically absent. The Blaine of this county falls into the clay detrital grade. The source of the Blaine was in the West (Ancestral Rockies?). This has not been satisfactorily determined.

10. Putnam, G. D., quoted by Suffel, G. G., op. cit., p. 76.
11. Freie, A. J., op. cit., p. 76.



## DOG CREEK SHALES

The Dog Creek shales occur stratigraphically above and conformably with the Blaine gypsum. The outcrop is a long, narrow band just west of the Blaine escarpment extending from the northwest corner to the extreme southeast corner of the county and lies just north of the North Canadian River. The formation was first observed by Cragin in 1896 at its type locality on Dog Creek in western Barber County, Kansas. The Dog Creek shales consist of from 30 to 400 feet of red clay and shale impregnated with gypsum and dolomite. In Blaine County the thickness approximates 400 feet. In Woodward County to the north they thin to 235 feet while in Caddo and Grady counties to the south Becker reports a thickness of from 90 to 115 feet. In Beckham County to the west they compose 90 feet of the section. Wells drilled in Kiowa County log 400 feet. Good surface exposures of Dog Creek shales are found just northeast of Watonga on the highway to Okeene just above the Blaine escarpment in secs. 32, 33, T. 17 N., R. 11 W. A good exposure with Whitehorse in contact is found in sec. 25, T. 13 N., R. 10 W. It is correlated with the Double Mountain of Texas.

The physical character of the Dog Creek seems variable but the brilliant coloration is unchanged. The Dog Creek is conformable upon the Blaine and is overlain unconformably by the Whitehorse sandstone. The following sections taken in sec. 25, T. 13 N., R. 10 W., by Freie[12] shows the Dog Creek in contact with the Blaine below and the Whitehorse above.

| | | Feet |
|---|---|---|
| WHITEHORSE | | |
| 6. | Thinly bedded red shaly fine sandstone | 11 |
| 5. | Shaly red sandstone beds 4 in. thick and some dolomite | 3 |
| DOG CREEK | | |
| 4. | Shaly sandstones interbedded with ½ in. layers of coarser sands | 5 |
| 3. | Ledge of massive shaly sandstone, bedding obscure | 4 |
| 2. | Resistant shaly massive sandstone beds | 10 |
| 1. | Shaly fine red sandstone in massive beds | 15 |

| | | Feet |
|---|---|---|
| WHITEHORSE | | |
| 5. | Fine light-red sandstone | 2 |
| 4. | Thinly bedded fine red sandstone containing flakes of gypsum and dolomite | 2 |
| DOG CREEK | | |
| 3. | Hard gypsiferous shaly fine sandstone | 2 |
| 2. | Red gypsiferous shaly sandstone containing specks of blue-gray shale | 3 |
| 1. | Fine red shaly siltstone | 3 |

Freie reports samples from this area as 4 to 8 per cent soluble in acid with angular fragments composing 70 to 80 per cent subangular 15 to 25 per cent and round and sub-round less than 5 per cent. Quartz is the most abundant light mineral and feldspar is rare or absent. Lack

12. Freie, A. J., op. cit., pp. 55 and 57.

of sorting, high per cent of soluble material and brilliant coloration are definite characteristics of the entire Dog Creek section.

Freie believes that heavy mineral analyses show insufficient evidence for an unconformity separating the Dog Creek from the overlying Whitehorse.

The source of the Dog Creek shales is to the West (Ancestral Rockies?). In the extreme western part of the area covered by this report the Dog Creek is a shallow marine deposit and to the southeast it is a terrestial deposit. Throughout Blaine County the Dog Creek has a sparse covering of scrub timber and underbrush.

### WHITEHORSE SANDSTONE

The Whitehorse sandstone is the youngest Permian formation in Blaine County. It is found throughout the area south and west of the North Canadian River excepting where covered by Tertiary or Quaternary eolian sand and Recent alluvium. It was first described by Cragin in 1896 as the Red Bluff sandstone, since its type locality is at Red Bluff on Bluff Creek northwest of Protection, Kansas. In 1905 the formation name was changed at the suggestion of Gould to that of Whitehorse sandstone. The type locality in Oklahoma is Whitehorse Springs in Woods County. The following section made there by Clifton[13] is as follows:

| | Feet |
|---|---|
| DAY CREEK | |
| 7. Dolomite | 2 |
| WHITEHORSE | |
| 6. Fine sandstone, poorly cemented | 40 |
| 5. Highly cemented sandstone | 10 |
| 4. Fine sandstone, sands, and sandy shales | 100 |
| 3. Indurated sandstone, thin bed | 5 |
| 2. Sandstones, sands and sandy shales | 125 |
| ~~~~~ Unconformity ~~~~~ | |
| DOG CREEK | |
| 1. Shales | |

This sandstone is correlated with a part of the Double Mountain of Texas. It is one of the most persistent and easily recognized formations of the Permian and is continuously traceable from Protection, Kansas, southward into Oklahoma, around the east end and along the southern flank of the Anadarko Basin; around the western end of the Wichita Uplift and southwestward into Texas as far as Fisher County. Fossils occur in the Whitehorse in numerous localities. Gould's collection from Whitehorse Springs, Okla., and Dosier Mounds, Texas, have been described by Beede[14] as, "marine brachiopods, pelecypods and gastropods."

The unconformity which separates the Dog Creek from the Whitehorse is discontinuous and limited to the border areas of the Dog Creek

13. Clifton, R. L., Uupublished theisis, Univ. of Oklahoma, Norman.
14. Beede, J. W., Inverteb rate paleontology of the upper Permian red beds of Oklahoma and the panhandle of Texas: Kansas Univ. Sci. Bull. 4, pp. 113-171, 1907.



deposition. This condition seems best developed near Wild Cat Mounds in Woods County where Clifton describes the complete removal of Dog Creek and Blaine formations prior to Whitehorse times. In Blaine County disconformities exist and there is a marked increase in coarseness of materials composing the basal Whitehorse where it can be observed in contact with the Dog Creek. The average thickness of the Whitehorse is 200 feet but in Custer, Blaine and Washita counties greater thicknesses are reported. Logs have indicated 425 feet. The Marland Oil Company well in sec. 8., T. 3, N., R. 7 W., logs 212 feet of Whitehorse.

The upper portion of the Whitehorse is composed of highly cross-bedded sands. The lower portion is composed of more nearly continuous massive lenses of sandstone separated by lenticular shales and dolomites. The latter can be observed about 70 feet above the base of the Whitehorse in the vicinity of Geary and Greenfield. They produce escarpments and are known as the Greenfield dolomite. At the top of the Whitehorse and farther west in Dewey and Custer counties the Day Creek dolomite is found. By some geologists this is considered as a distinct formation and by others as a member of the Whitehorse while still others consider it basal Cloud Chief. The upper cross-bedded portion of the Whitehorse is probably wholly, or at least partly, of eolian origin. Some, however, consider it to be an estaurine subaerial delta More detailed studies will reveal the exact origin. The lower portion is, in all probability, deltaic in origin. The following section of lower Whitehorse was taken west of Greenfield.[15]

*General Section near Greenfield, Blaine County.*

| | Feet |
|---|---|
| Whitehorse sandstone | 350 |
| Greenfield dolomite | ? |
| Sandstone | 27 |
| "Twin dolomites" separated by 7 feet of sandstone | ? |
| Sandstone | 110-130 |
| Thin white sandstone seam | ? |
| Dog Creek shales | 185 |

Freie reports the Whitehorse from 18 to 30 per cent soluble in acid. From 80 to 85 per cent of the grains are angular and less than 20 per cent distributed among other shapes. Among the light minerals quartz is the most abundant constituent with feldspar rare or entirely absent.

The Whitehorse of this area was derived from some western source (Ancestral Rockies?). To the southeast in the head of the Anadarko Basin the source seems to have been from the east or southeast, perhaps the Arbuckle Mountains.

### QUATERNARY SAND AND GRAVELS

There are three major occurrences of these deposits. The first occurs as a strip approximately six miles wide which parallels the north

15. Suffel, G. G., Dolomites of western Oklahoma: Oklahoma Geol. Survey Bull. 49, p. 192, 1930.

side of the South Canadian River. It continues from the southwest part of the county to the northwest in the vicinity of Taloga and Dewey County. The second area lies on top of the divide between the North Canadian and Cimarron River valleys and is a band from two to five miles wide extending across the county from northwest to southeast. This particular deposit of gravel is the reservoir for numerous springs at the headquarters of the tributaries of the Cimarron River. Other deposits occur in other parts of the county the most important being northeast of Watonga lying unconformably upon the Whitehorse, Dog Creek, Blaine, and Chickasha formations. These deposits are usually covered with scrub oak.

Along the major drainage lines extensive alluvial deposits occur, A large amount of this material has been blown from the river bottoms to the uplands on the northeast side of the streams which has resulted in the formation of extensive eolian deposits.

### Subsurface geology

Little is known in detail concerning the subsurface formations of Blaine County because few wells have been drilled through the underlying Permian. It is reasonable to suppose that a part or all of the formations outcropping to the eastward underlie this area. In descending order these should be Duncan sandstone, Hennessey shale, Garber sandstone, Wellington shale, and Stillwater formation of the Permian, below which should occur Pennsylvanian, Mississipian, Devonian, Silurian, and Ordovician series.

A study of the following well logs reveals the general subsurface character of the rocks underlying this county and that region directly south.

*Log of W. H. Pringey, Barnett No. 1 well, SW.¼ SW.¼ SW.¼ sec. 23, T. 15 N., R. 11 W., Blaine County.*

(Elevation 1,452)

| Formation | Top | Bottom |
|---|---|---|
| Surface formation | 0 | 14 |
| Quick sand & water | 14 | 50 |
| Red bed | 50 | 80 |
| Lime shell | 80 | 90 |
| Red bed | 90 | 120 |
| Lime shell | 120 | 130 |
| Red bed | 130 | 160 |
| Lime shell | 160 | 170 |
| Red bed—wtr 1 blr per hr. | 170 | 400 |
| Red bed | 400 | 780 |
| Sand—1 blr. wtr. per hr. | 780 | 790 |
| Red bed | 790 | 1772 |
| Sand—3 blrs. wtr. per hr. | 1772 | 1790 |
| Red bed | 1790 | 2089 |
| Blue shale | 2089 | 2095 |
| Red bed | 2095 | 2110 |
| Blue shale & shells | 2110 | 2140 |
| Brown shale | 2140 | 2190 |
| Gray shale | 2190 | 2200 |
| Pink shale | 2200 | 2220 |
| Gray shale | 2220 | 2450 |
| Gray—shelly | 2450 | 2515 |
| Lime | 2515 | 2520 |
| Grey shale—shelly | 2520 | 2630 |
| Lime | 2630 | 2635 |
| Gray shale & shells | 2635 | 2660 |
| Lime | 2660 | 2666 |
| Gray shale | 2666 | 2682 |
| Lime | 2682 | 2688 |
| Gray shale | 2688 | 2716 |
| Lime | 2716 | 2718 |
| Lime | 2775 | 2787 |
| Gray shale | 2787 | 2789 |
| Lime | 2789 | 2797 |
| Gray shale | 2797 | 2803 |
| Lime | 2803 | 2808 |
| Gray shale | 2808 | 2826 |
| Lime | 2826 | 2837 |
| Lime | 2837 | 2840 |
| Shale | 2840 | 2853 |
| Lime | 2853 | 2855 |
| Shale | 2855 | 2861 |
| Lime | 2861 | 2865 |
| Shale | 2865 | 2878 |
| Lime | 2878 | 2894 |
| Shale | 2894 | 2900 |
| Shale | 2900 | 2925 |
| Lime | 2925 | 2930 |
| Shale | 2930 | 2947 |
| Lime | 2947 | 2951 |
| Brown shale | 2951 | 2965 |
| Lime | 2965 | 2966 |
| Shale | 2966 | 2994 |
| Lime | 2994 | 3008 |
| Shale | 3008 | 3026 |
| Lime | 3026 | 3040 |
| Dark shale | 3040 | 3056 |
| Lime | 3056 | 3090 |
| Shale | 3090 | 3096 |
| Lime | 3096 | 3102 |
| Shale | 3102 | 3106 |
| Lime | 3106 | 3180 |
| Shale | 3180 | 3185 |
| Lime | 3185 | 3195 |
| Shale | 3195 | 3200 |
| Lime | 3200 | 3208 |
| Shale | 3208 | 3218 |
| Lime | 3218 | 3222 |
| Shale | 3222 | 3225 |
| Lime | 3225 | 3229 |
| Shale | 3229 | 3231 |
| Lime | 3231 | 3263 |
| Gray shale | 3263 | 3274 |
| Lime | 3274 | 3295 |
| Gray shale | 3295 | 3315 |
| Lime | 3315 | 3323 |
| Gray shale | 3323 | 3326 |
| Lime | 3326 | 3333 |
| Gray shale | 3333 | 3426 |
| Gray shale | 3426 | 3435 |
| Lime | 3435 | 3470 |
| Pink shale | 3470 | 3495 |
| Lime | 3495 | 3542 |
| Shale & shells | 3542 | 3562 |
| Lime | 3562 | 3579 |
| Gray shale | 3579 | 3588 |
| Lime | 3588 | 3645 |
| Pink shale | 3645 | 3651 |
| Lime | 3651 | 3654 |
| Pink shale | 3654 | 3657 |
| Lime | 3657 | 3680 |
| Brown shale | 3680 | 3705 |
| Total depth | | 3705 |

*Log of E. H. Morgan, Chronister No. 1 well, NW.¼ NW.¼ NE.¼ sec. 7, T. 18 N., R. 10 W., Blaine County.*

(Elevation 1,196)

Commencing at 1490' where E. H. Morgan took charge of the well the log runs as follows, to wit: Started by Cozart Oil Co. No record kept.

| Formation | Top | Bottom |
|---|---|---|
| Blue shale | 1490 | 1515 |
| Gray lime | 1515 | 1520 |
| Red rock | 1520 | 1540 |
| Lime shell | 1540 | 1550 |
| Blue shale | 1550 | 1580 |
| Red beds | 1580 | 1615 |
| Gray lime | 1615 | 1645 |
| Blue shale | 1645 | 1660 |
| Lime shell | 1660 | 1675 |
| Brown shale—soft | 1675 | 1705 |
| Broken lime | 1705 | 1715 |
| White slate | 1715 | 1735 |
| Blue shale | 1735 | 1800 |
| Lime | 1800 | 1805 |
| Blue shale | 1805 | 1875 |
| Blue shale—dark | 1875 | 1890 |
| Blue shale—light | 1890 | 2040 |
| Blue ——— | 2040 | 2060 |
| Blue shale | 2060 | 2095 |
| Lime | 2095 | 2100 |
| Blue shale | 2100 | 2110 |
| Blue shale—dark | 2110 | 2148 |
| Lime | 2148 | 2158 |
| Slate, dark | 2158 | 2195 |
| Blue shale | 2195 | 2215 |
| Lime | 2215 | 2225 |

(Continued on page 396)

| Formation | Top | Bottom |
|---|---|---|
| Blue shale | 2225 | 2233 |
| Lime shell | 2233 | 2235 |
| White slate | 2235 | 2270 |
| Lime | 2270 | 2275 |
| Blue shale | 2275 | 2280 |
| Lime | 2280 | 2283 |
| Shale | 2283 | 2290 |
| Lime | 2290 | 2310 |
| White slate | 2310 | 2355 |
| Broken lime | 2355 | 2515 |
| Lime, hard | 2515 | 2560 |
| Broken lime & shale | 2560 | 2635 |
| Blue shale | 2635 | 2660 |
| Lime | 2660 | 2670 |
| Blue shale | 2670 | 2710 |
| Lime | 2710 | 2755 |
| Shale | 2755 | 2865 |
| Red rock | 2865 | 2880 |
| Gray lime | 2880 | 2890 |
| Blue shale | 2890 | 2910 |
| Red beds | 2910 | 2925 |
| Broken lime | 2925 | 2950 |
| Broken lime | 3135 | 3138 |
| Dark slate | 3138 | 3165 |
| Brown shale | 3165 | 3185 |
| Lime shell | 3185 | 3188 |
| Brown shale | 3188 | 3196 |
| Lime shell | 3196 | 3200 |
| Brown shale | 3200 | 3220 |
| Lime | 3220 | 3228 |
| Gray shale | 3228 | 3238 |
| Lime | 3238 | 3269 |
| Red rock | 3269 | 3300 |
| Black slate | 3300 | 3310 |
| Red rock | 3310 | 3340 |
| Gray shale | 3340 | 3355 |
| Red rock | 3355 | 3365 |
| Black slate | 3365 | 3370 |
| Water sand (hole full) | 3370 | 3395 |
| Black slate | 3395 | 3400 |
| Red rock | 3400 | 3405 |
| Gray shale (sharp) | 3405 | 3430 |
| Sandy shale | 3430 | 3433 |
| Blue slate | 3433 | 3436 |
| Lime | 3436 | 3445 |
| Red rock | 3445 | 3452 |
| Lime, hard | 3452 | 3468 |
| Broken lime | 3468 | 3475 |
| Water sand | 3475 | 3480 |
| Lime, hard | 3480 | 3540 |
| Dark shale | 3540 | 3585 |
| Red rock | 3585 | 3590 |
| Shale | 3590 | 3610 |
| Lime | 3610 | 3615 |
| Shale | 3615 | 3625 |
| Red rock | 3625 | 3640 |
| Sand | 3640 | 3646 |
| Shale | 3646 | 3666 |
| Lime, shell, hard | 3666 | 3670 |
| Blue shale | 3670 | 3685 |
| Lime shell | 3685 | 3690 |
| Blue shale | 3690 | 3695 |
| Lime shell | 3695 | 3700 |
| Blue shale | 3700 | 3715 |
| Lime, hard | 3715 | 3725 |
| Blue shale | 3725 | 3760 |
| Lime shell | 3760 | 3765 |
| Blue shale | 3765 | 3790 |
| Red rock | 3790 | 3795 |
| Blue shale | 3795 | 3805 |
| Lime hard | 3805 | 3810 |
| Total depth | 3810 | |

*Bermingham and Keley, West No. 1 well, SW.¼ SW.¼ NE.¼ sec. 8 T. 11 N., R. 12 W., Caddo County.*

(Elevation 1,728)

| Formation | Top | Bottom |
|---|---|---|
| Red sand clay | 0 | 84 |
| Red sand rock | 84 | 305 |
| Red sand rock | 305 | 355 |
| Sand gravel | 355 | 362 |
| Hard sand | 362 | 375 |
| Quick sand | 375 | 385 |
| Hard sand | 385 | 395 |
| Sand rock | 395 | 410 |
| Hard sand & sand rock | 410 | 421 |
| Hard sand | 421 | 440 |
| Red clay | 440 | 450 |
| Broken sand | 450 | 465 |
| Red shale | 465 | 530 |
| Clay | 530 | 538 |
| Red shale | 538 | 590 |
| Sticky clay | 590 | 595 |
| Red shale | 595 | 670 |
| Lime rock | 670 | 674 |
| Gyp rock | 674 | 680 |
| Broken sand & clay | 680 | 693 |
| Lime shell | 693 | 696 |
| Red shale | 696 | 720 |
| Lime shell | 720 | 724 |
| Sandy red shale | 724 | 733 |
| Lime rock hard | 733 | 738 |
| Sandy shale | 738 | 778 |

(Continued on page 397)



| Formation | Top | Bottom |
|---|---|---|
| Lime rock | 778 | 789 |
| Gumbo & gravel | 789 | 800 |
| Lime rock | 800 | 806 |
| Shale, clay & gravel | 806 | 823 |
| Blue & red gumbo | 823 | 878 |
| gumbo | 878 | 940 |
| Gumbo | 940 | 946 |
| Blue & brown hard shale | 946 | 965 |
| Gumbo & gravel | 965 | 980 |
| Gumbo & shale | 980 | 1025 |
| Shale & gravel | 1025 | 1045 |
| Sandy shale, blue brown | 1045 | 1083 |
| Gumbo | 1083 | 1090 |
| Shale & gumbo | 1090 | 1120 |
| Sandy shale | 1120 | 1170 |
| Shale & gumbo | 1170 | 1190 |
| Gumbo | 1190 | 1210 |
| Sticky shale, blue-red | 1210 | 1240 |
| Gumbo | 1240 | 1250 |
| Shells & shale | 1250 | 1258 |
| Gumbo & shale | 1258 | 1280 |
| Red rock & gumbo | 1280 | 1315 |
| Lime, sand & gumbo | 1315 | 1345 |
| Sand, salt & shale | 1345 | 1365 |
| Shale & gumbo | 1365 | 1370 |
| Shale & gumbo | 1370 | 1390 |
| Sandy shale, blue & brown | 1390 | 1415 |
| Lime & gyp & gumbo | 1415 | 1450 |
| Hard shale & gumbo | 1450 | 1466 |
| Sand broken formation | 1466 | 1483 |
| Gumbo & shale | 1483 | 1510 |
| Sandy lime (broken) | 1510 | 1520 |
| Gumbo | 1520 | 1535 |
| Gumbo | 1535 | 1540 |
| Sandy lime | 1540 | 1544 |
| Gumbo, tough | 1544 | 1551 |
| Gumbo & gyp, tough | 1551 | 1565 |
| Hard shale | 1565 | 1585 |
| Blue & brown Gumbo | 1585 | 1607 |
| Gumbo | 1607 | 1630 |
| Shale | 1630 | 1645 |
| Hard & brown Gumbo | 1645 | 1655 |
| Sandy hard shale | 1655 | 1665 |
| Hard shale & gumbo | 1665 | 1715 |
| Sandy shale | 1715 | 1722 |
| Shale & gumbo | 1722 | 1745 |
| Red sand | 1745 | 1749 |
| Shale gumbo, boulders | 1749 | 1790 |
| Water sand | 1790 | 1794 |
| Shale & gumbo | 1794 | 1810 |
| Gumbo | 1810 | 1830 |
| Sandy shale & gumbo | 1830 | 1837 |
| Gumbo | 1837 | 1850 |
| Shale & gumbo | 1850 | 1853 |
| Gumbo gyp & lime | 1853 | 1885 |
| Hard shale | 1885 | 1915 |
| Sand, gumbo-lime | 1915 | 1925 |
| Lime, gyp & gumbo | 1925 | 1965 |
| Shale & gumbo | 1965 | 1995 |
| Gumbo | 1995 | 2132 |
| Shale & gumbo | 2132 | 2170 |
| Shale & boulders | 2170 | 2198 |
| Sandy shale | 2198 | 2250 |
| Gumbo | 2250 | 2269 |
| Gumbo & shale | 2269 | 2295 |
| Lime gyp & gumbo | 2295 | 2312 |
| Gumbo | 2312 | 2352 |
| Shale | 2352 | 2364 |
| Shale | 2364 | 2385 |
| Gumbo | 2385 | 2410 |
| Brown gumbo | 2410 | 2440 |
| Brown sticky shale | 2440 | 2475 |
| Gumbo & boulders | 2475 | 2488 |
| Gumbo | 2488 | 2515 |
| Blue & brown shale | 2515 | 2551 |
| Brown shale | 2551 | 2560 |
| Gumbo | 2560 | 2575 |
| Blue & brown shale | 2575 | 2588 |
| Sandy lime soft | 2588 | 2600 |
| Gumbo & boulders | 2600 | 2626 |
| Brown shale | 2626 | 2645 |
| Gumbo | 2645 | 2690 |
| Brown shale | 2690 | 2710 |
| Blue & brown shale | 2710 | 2737 |
| Gumbo & gyp | 2737 | 2750 |
| Shale & gumbo | 2750 | 2775 |
| Gumbo | 2775 | 2790 |
| Hard lime | 2790 | 2793 |
| Sandy lime & slate | 2793 | 2827 |
| Gumbo | 2827 | 2835 |
| Lime | 2835 | 2838 |
| Blue shale | 2838 | 2846 |
| Lime | 2846 | 2848 |
| Blue sandy shale | 2848 | 2860 |
| Gumbo | 2860 | 2874 |
| Lime rock | 2874 | 2878 |
| Blue shale | 2878 | 2881 |
| Lime rock | 2881 | 2883 |
| Blue shale | 2883 | 2886 |
| Lime | 2886 | 2895 |
| Blue shale | 2895 | 2901 |
| Lime | 2901 | 2903 |
| Blue shale | 2903 | 2910 |
| Lime | 2910 | 2913 |
| Blue shale | 2913 | 2924 |
| Lime | 2924 | 2928 |
| Blue shale | 2928 | 2935 |
| Gumbo & lime | 2935 | 2940 |
| Blue shale | 2940 | 2944 |
| Gumbo | 2944 | 2950 |

(Continued on page 398)

| Formation | Top | Bottom |
|---|---|---|
| Slate | 2950 | 2953 |
| Gumbo blue | 2953 | 2963 |
| Hard shell | 2963 | 2966 |
| Sticky blue shale | 2966 | 2974 |
| Blue gumbo | 2974 | 2979 |
| Sandy lime | 2979 | 2982 |
| Gumbo slate | 2982 | 2987 |
| Shale gumbo lime | 2987 | 2998 |
| Broken lime | 2998 | 3008 |
| Sand | 3008 | 3010 |
| Shale gumbo | 3010 | 3019 |
| Lime rock | 3019 | 3023 |
| Hard shale | 2023 | 3026 |
| Gumbo | 3026 | 3032 |
| Lime gumbo, shale | 3032 | 3041 |
| Hard shale | 3041 | 3050 |
| Lime rock | 3050 | 3051 |
| Lime & gumbo | 3051 | 3063 |
| Lime rock | 3063 | 3064 |
| Blue shale | 3064 | 3067 |
| Slate rock | 3067 | 3073 |
| Blue gumbo | 3073 | 3080 |
| Slate | 3080 | 3093 |
| Shale slate | 3093 | 3100 |
| Shale & lime | 3100 | 3105 |
| Sandy lime | 3105 | 3112 |
| Blue gumbo | 3112 | 3115 |
| Shale & lime | 3115 | 3123 |
| Shale | 3123 | 3131 |
| Lime | 3131 | 3132 |
| Shale lime | 3132 | 3146 |
| Gumbo lime | 3146 | 3152 |
| Gumbo | 3152 | 3160 |
| Slate | 3160 | 3161 |
| Lime | 3151 | 3167 |
| Shale & slate | 3167 | 3172 |
| Blue slate | 3172 | 3180 |
| Shale & gumbo | 3180 | 3196 |
| Slate | 3196 | 3202 |
| Shale & gumbo | 3202 | 3215 |
| Sticky shale | 3215 | 3224 |
| Sand shale lime | 3224 | 3234 |
| Shale & gumbo | 3234 | 3251 |
| Sand lime & shale | 3251 | 3264 |
| Sandy lime | 3264 | 3267 |
| Shale lime, slate | 3267 | 3284 |
| Hard sand | 3284 | 3289 |
| Shale & lime | 3289 | 3298 |
| Hard lime | 3298 | 3302 |
| Shale | 3302 | 3310 |
| Lime shell | 3310 | 3312 |
| Gumbo & lime | 3312 | 3325 |
| Shale sticky | 3325 | 3334 |
| Blue gumbo | 3334 | 3339 |
| Gumbo shale | 3339 | 3349 |
| Lime & slate | 3349 | 3355 |
| Shale slate | 3355 | 3365 |
| Gumbo slate | 3365 | 3375 |
| Slate & boulders | 3375 | 3381 |
| Lime & slate | 3381 | 3390 |
| Sandy lime shale | 3390 | 3393 |
| Shale & gumbo | 3393 | 3401 |
| Gumbo | 3401 | 3406 |
| Sticky shale | 3406 | 3416 |
| Shale hard | 3416 | 3425 |
| Slate | 3425 | 3427 |
| Shale lime | 3427 | 3437 |
| Gumbo blue | 3437 | 3450 |
| Shale blue | 3450 | 3463 |
| Shale | 3463 | 3466 |
| Lime | 3466 | 3467 |
| Shale & gumbo | 3467 | 3508 |

### Structural geology

Blaine County lies on the northeast limb of the Anadarko Basin. The strike of the formations is northwest-southeast. The regional dip is southwest in the southern part of the county and west in the northwestern part of the county. Map No. XXXV shows the general surface relationships of the rocks of this county. Map No. XXXVI shows the general subsurface relationships. A number of irregularities were noted in various parts of the county but time did not permit detailing these. One of these is in the vicinity of secs. 8, 9, 16, and 17, T. 15 N., R. 10 W. Another is in the southwestern portion of T. 15 N., R. 11 W. in the vicinity of Greenfield, and a third is in the southeast portion of T. 15 N., R. 12 W. Still another is in secs. 16, 17, 18, 19, and 20 T. 15 N., R 12 W. Test wells have been drilled on each of these irregularities but none were drilled sufficiently deep to encounter known producing horizons. To reach such horizons, wells would need to be drilled to a depth of 8,000-10,000 feet unless there are structural and topographic highs in Paleozoic rocks of that area. Such probabilities are unknown to date.



### DEVELOPMENT

The table on page 430 gives a list of the wells that have been or are being drilled in this area.

## DEWEY COUNTY

Dewey County is the northernmost of the two central counties of the area covered in this report. It lies directly west of Blaine County, south of Major and Woodward, east of Ellis and Roger Mills and north of Custer. It is a rectangle of 24 by 42 miles and extends from Tps. 16 to 19 N., inclusive and from Rs. 14 to 20 W., inclusive. Along the northern boundary of the county is a long, narrow irregular strip of land marking the fractional area between the Cherokee strip and this county. The county covers approximately 1,008 square miles. A branch line of the Frisco from Enid to Clinton crosses the extreme southeastern part of the county. The Orient also serves this portion of the county via Oakwood and Nobscot. The Wichita Falls and Northwestern passes through the extreme western tier of townships entering the county at Vici, crossing the South Canadian River at Camargo and continuing south toward Elk City in Beckham County through Trail and Leedey. The county seat Taloga has no rail connection.

The population of the county is approximately 20,000 which is an average of 20 per square mile. The principal towns are Taloga (800), Leedey (200), Tray (150), Camargo (300), Vici (1,500), Oakwood (200) and Seiling (400). In addition to these there are numerous trading posts and postoffices such as Cestos, Lenora, Webb, Oakley, Rhea, Aledo, Putnam, and Fay.

### TOPOGRAPHY

Dewey County lies in the Gypsum Hills and High Plains provinces. It is drained by the North Canadian River and its tributaries in the northeastern part. The central and eastern portion is drained by South Canadian and the extreme southern and southwestern part by the tributaries of Washita River. The eastern part of the county is a rolling plain covered partially with black jack timber. The northwestern part is a fairly level plain composed of Quaternary gravel. This is an eastward extension of the High Plains province. That part of the county along the South Canadian River is very rough and broken. The North and South Canadian rivers have been superimposed upon the present land surface by the removal of the once overlying Tertiary and Quaternary gravels.

## GEOLOGY

### Surface formations

The surface formations of this county are composed of Whitehorse sandstone, Day Creek dolomite, Cloud Chief gypsum and Quartermaster sandstone of Permian age and numerous scattered erosional remnants of Cretaceous oyster beds and Quaternary gravel, alluvium, and eolian deposits. Quaternary gravel is found in the eastern part of the county as a band some six to eight miles wide paralleling the north bank of the South Canadian River; in the northeastern part of the county north of North Canadian River; in the southwestern part north of Leedey and south of the South Canadian and in the northwestern part extending from Vici to the vicinity of Webb. Recent alluvial deposits are found along the main stream valleys.

#### WHITEHORSE SANDSTONE

The Whitehorse sandstone occurs as a wide band from northwest to southeast through the eastern third of the county. The character of this Whitehorse is the same as that previously described under Blaine County. Directly above the Whitehorse sandstone and perhaps a part of it, occurs the Day Creek dolomite. This was first described by Cragin in 1896 at its type locality along Day Creek in Clark County, Kansas. It varies in thickness from one to five feet and is continuously traceable from Clark County, Kansas, southward into Oklahoma around the Anadarko Basin. It forms conspicuous buttes in northwestern Oklahoma in Woods county and in the northern part of Dewey County. After crossing the river west of Taloga in Dewey County, it continues southwestward to the vicinity of Weatherford as a low escarpment. In the western portion of Blaine County near Eagle City some buttes occur one of which has three or four dolomites. One of these has been correlated with the Day Creek of Custer County which in turn has been correlated with the Double Mountain of Texas. Some consider all of these as Cloud Chief gypsum.

#### CLOUD CHIEF GYPSUM

The Cloud Chief forms the surface of approximately one-third of Dewey County and it lies geographically west of and stratigraphically on the Day Creek dolomite. North of the South Canadian River it forms a band about five miles in width around the Quaternary gravel deposits which lie unconformably upon it. South of the South Canadian it covers most of the surface area west of Tps. 16 and 17 N., R. 16 W. A long finger-like projection of this same area extends northwestward between Leedey and the river and disappears beneath the Quaternary gravel only to reappear along the South Canadian River valley in northeastern Roger Mills County. Numerous names have been applied to this formation but Gould's nomenclature of 1924 has been accepted as the authentic name. The thickness varies up to 1,500 feet and



its outcrops are traceable from their type locality in Kansas south through Oklahoma and on to the northwestern part of Texas below the Panhandle. The type locality in Oklahoma for the Cloud Chief gypsum is at Cloud Chief in eastern Washita County. It appears as heavy gypsum ledges interbedded with shale all of which are lenticular. The red shales are impregnated with gypsum and satinspar occurs in joints and along the bedding plains.

The Cloud Chief lies unconformably upon the Whitehorse sandstone and is also unconformable below the Quartermaster formation. The character of this unconformity will be discussed under "Custer County."

#### QUARTERMASTER FORMATION

The Quartermaster formation outcrops in the southwestern portion of the county in the vicinity of Leedey a few miles north of its type locality along Quartermaster Creek in Roger Mills County. It lies unconformably upon the Cloud Chief gypsum and consists of red shale, compacted muds, sandstone, dolomite, and lentils of gypsum. The whole formation is impregnated with gypsum and one of the outstanding characteristics is the white, sandy streaks imbedded in the shale and sandstone. Irregular erratic dips and cross-bedding further characterize it. The thickness varies from 150 to 300 feet in most places yet some well logs have recorded as little as 60 feet. The formation was first named by Gould in 1902 and is the youngest Permian formation exposed in Oklahoma unless some of the red beds of the Panhandle now referred to the Triassic prove later to be Permian. The three following sections taken farther south show the essential characteristics of the formation.

*Section 6 miles southwest of Elk City in Headwaters of Elk Creek, northwest Beckham County*
(After Freie[16])

| | | Ft. | in. |
|---|---|---|---|
| 7. | Ledge of very fine shaly, red-gray sandstone, bedding 1-6 inches | 4 | 6 |
| 6. | Red sandy shale thinly bedded | 11 | 0 |
| 5. | Gray-red shaly sandstone thinly bedded | 2 | 0 |
| 4. | Red sandy shale thinly bedded (Bed of gray shale separates beds 4 and 5) | 8 | 0 |
| 3. | Red shale thinly bedded | 12 | 0 |
| 2. | Gray and red sandy shale alternating 3-inch beds | 1 | 6 |
| 1. | Yellowish-red shaly sandstone | 4 | 0 |

*Section three miles east of Clinton, Custer County, Oklahoma*
(After Freie)

| | | Feet |
|---|---|---|
| 3. | Red, shaly, uniformly and horizontally bedded very fine sandstone | 60 |
| 2. | Red, shaly, horizontally bedded very fine sandstone | 75 |
| 1. | Red, hard, firmly cemented massive beds of shaly siltstone | 50 |

16. Freie, A. J., up. cit., pp. 66, 67, and 69.

*Section in southern Washita County three miles east of No. 41 Gin*
(After Freie)

| | | Ft. | in. |
|---|---|---|---|
| 6. | Red cross-bedded sandstone | 10 | 0 |
| 5. | Red irregularly cross-bedded sandstone containing streaks of coarse sand | 5 | 6 |
| 4. | Gray sandy shale horizontally bedded | | 1 |
| 3. | Fine red sandy shale | 10 | 0 |
| 2. | Red finely cross-bedded shale | 4 | 0 |
| 1. | Red gypsiferous sandy shale with the gray sandy streaks characteristic of the Quartermaster | 5 | 0 |

Freie described the Quartermaster as being about 20 per cent soluble in acid. Of the relatively large proportion of light minerals, quartz and feldspar are the chief constituents. The heavy mineral content of Quartermaster is quite variable. Detailed study seems to indicate that the source of the material in the Quartermaster came from the west (Ancentral Rockies?).

### CRETACEOUS FORMATIONS

Erosional remnants of Cretaceous occur in three general areas of this county. One is in the vicinity of Seiling and Cestos in the north central part and south of the North Canadian River. A second occurs between Webb and Lenora in the west central part of the county and north of the South Canadian while the third makes its appearance along the southern border of the county. Some of the remnants along the South Canadian River north of Rhea and Aledo suggest that this river valley is pre-Cretaceous in age.

The following is a section of the lower Cretaceous outlier in the NE.¼ sec. 17, T. 19 N., R. 17 W., about two miles east of Cestos, Oklahoma, taken by Bullard.[17] This shows the physical and paleontologic character of the Cretaceous rocks of this area.

(This exposure occurs along the north bank of a small creek where the material has slumped into the stream valley and the creek later cut through the slumped material. None of the material is **in situ**, but clean cut exposures are available and an estimated section based on this exposure is as follows:)

| | | Ft. | in. |
|---|---|---|---|
| 3. | Shell bed, yellowish shell limestone, composed of large and well preserved **Gyphea navia** Hall and **Gryphea corrugata hilli** Cragin, **Turritella** sp., and **Oxytropidoceras** (Marcou); occurs in large slabs and blocks up to 15 feet square | 3 | 0 |
| 2. | Light blue to gray, limestone, hard nodular, weathers white, contains **Cyprimeria** sp., a small **Gryphea cf. corrugata hilli** Cragin, **Turritella** sp., and **Oxytropidoceras cf. acutocarainatum** (Shumard) | 6 in. to 1 | 6 |
| 1. | Blue clay grading into yellowish brown clay, impossible to estimate its thickness accurately, but appears to be rather prominent | 5 to 10 | 0 |

PERMIAN (Cloud Chief gypsum)

17. Bullard, F. M., Lower Cretaceous of western Oklahoma: Oklahoma Geol. Survey, Bull. 47, p. 77, 1928.



### QUATERNARY DEPOSITS

The location of these has been described above. Their physical character is similar to those described in Blaine County.

#### Subsurface geology

Very little is known concerning the subsurface relationships of Dewey County excepting that which is revealed by the few wells that have drilled there. It is reasonable to suppose that the same formations underlying Blaine County underlie this area but at a greater depth. Map No. XXXVI shows general subsurface relationships revealed by well logs. A study of these logs indicate in more detail the characteristics of the underlying rock. The third log is that of the Sharon well north of Vici in sec. 25, T. 21 N., R. 21 W. in Woodward County and shows the subsurface relationships northwest of the county.

*Log of Small & Kinnison, Ball No. 1 well, sec. 34, T. 20 N., R. 20 W., Dewey County.*

| Formation | Top | Bottom |
|---|---|---|
| Clay | 0 | 60 |
| Red beds | 60 | 136 |
| Red beds & sand | 136 | 221 |
| Red beds & sand | 221 | 225 |
| Sand | 225 | 256 |
| Sand | 256 | 264 |
| Pack sand | 264 | 282 |
| Sand rock | 282 | 300 |
| Red rock | 300 | 335 |
| Lime shell | 335 | 336 |
| Red beds | 336 | 377 |
| Sand | 377 | 392 |
| Rock | 392 | 399 |
| Sand | 399 | 420 |
| Sand rock | 420 | 423 |
| Sand | 423 | 462 |
| Clay & hard sand | 462 | 537 |
| Gumbo | 537 | 560 |
| Broken lime | 560 | 610 |
| Gumbo | 610 | 622 |
| Hard lime | 622 | 625 |
| Blue shale | 625 | 627 |
| Hard lime | 627 | 658 |
| Gumbo | 658 | 752 |
| Hard lime | 752 | 756 |
| Gumbo | 756 | 788 |
| Shale | 788 | 800 |
| Gumbo | 800 | 890 |
| Blue shale & bldrs. | 890 | 924 |
| Hard dry sand | 924 | 925 |
| Rock salt | 925 | 927 |
| Gumbo | 927 | 938 |
| Gumbo | 938 | 943 |
| Shale & bldrs. | 943 | 955 |
| Sandy lime | 955 | 959 |
| Shale | 959 | 965 |
| Broken lime | 965 | 998 |
| Lime rock | 998 | 1002 |
| Broken lime | 1002 | 1060 |
| Hard lime | 1060 | 1076 |
| Broken lime | 1076 | 1082 |
| Hard sandy lime | 1082 | 1089 |
| Hard sandy lime | 1089 | 1097 |
| Show gas & oil | | |
| Gray sand | 1097 | 1126 |
| Red Gumbo | 1126 | 1131 |
| Shale & bldrs. | 1131 | 1134 |
| Water sand | 1134 | 1147 |
| Gumbo & red shale | 1147 | 1152 |
| Hard sandy lime | 1152 | 1157 |
| Sandy lime | 1157 | 1165 |
| Gumbo | 1165 | 1169 |
| Lime rock | 1169 | 1183 |
| Gumbo | 1183 | 1211 |
| Lime shell | 1211 | 1212 |
| Hard sdy. lime | 1212 | 1228 |
| Sandy shale | 1228 | 1243 |
| Hard lime | 1243 | 1245 |
| Sandy shale | 1245 | 1283 |
| Sandy lime | 1283 | 1294 |
| Lime shell | 1294 | 1330 |
| Sandy shale | 1330 | 1333 |
| Sticky shale | 1333 | 1347 |
| Sandy lime | 1347 | 1354 |
| Broken lime | 1354 | 1397 |
| Shale | 1397 | 1433 |
| Hard lime | 1433 | 1434 |
| Lime rock | 1434 | 1435 |

(Continued on page 404)

| Formation | Top | Bottom |
|---|---|---|
| Shale & slate | 1435 | 1449 |
| Lime rock | 1449 | 1476 |
| Hard sandy lime | 1476 | 1486 |
| Sandy lime | 1486 | 1490 |
| Red gumbo | 1490 | 1500 |
| Shale & bldrs. | 1500 | 1526 |
| Rock salt | 1526 | 1553 |
| Shale | 1553 | 1565 |
| Bkn. lime & shale | 1565 | 1580 |
| Shale | 1580 | 1672 |
| Sandy shale | 1672 | 1673 |
| Sandy-show gas | 1673 | 1683 |
| Hd. sand & shale | 1683 | 1691 |
| Blue & brown shale | 1691 | 1706 |
| Broken sand & shale | 1706 | 1722 |
| Lime & shale | 1722 | 1733 |
| Shale & sand | 1733 | 1753 |
| Sandy shale | 1753 | 1765 |
| Shale & bldrs. | 1765 | 1799 |
| Sandy shale | 1799 | 1805 |
| Blue & brown shale | 1805 | 1830 |
| Shale & bldrs. | 1830 | 1880 |
| Sandy shale | 1880 | 1910 |
| Gumbo | 1910 | 1920 |
| Blue shale | 1920 | 1945 |
| Gumbo & bldrs. | 1945 | 1956 |
| Salt rock | 1956 | 1964 |
| Salt water sand | 1964 | 1985 |
| Gumbo | 1985 | 1999 |
| Gumbo & bldrs. | 1999 | 2010 |
| Sandy shale | 2010 | 2025 |
| Gumbo & bldrs. | 2025 | 2058 |
| Blue shale | 2058 | 2070 |
| Blue & Brown shale | 2070 | 2094 |
| Sandy shale | 2094 | 2125 |
| Hard Gumbo | 2125 | 2152 |
| Gumbo & bldrs. | 2152 | 2211 |
| Gyp | 2211 | 2214 |
| Red Gumbo | 2214 | 2223 |
| Gray gyp | 2223 | 2226 |
| Gumbo & bldr. | 2226 | 2311 |
| Dark lime | 2311 | 2320 |
| Gumbo | 2320 | 2485 |
| Red shale | 2485 | 2500 |
| Set 8-1/4" pipe | | |
| Brown & blue shale | 2500 | 2550 |
| Blue shale | 2550 | 2610 |
| Blue shale | 2610 | 2623 |
| Lime | 2623 | 2627 |
| Blue shale | 2627 | 2645 |
| Lime | 2645 | 2653 |
| Light shale | 2653 | 2670 |
| Lime | 2670 | 2673 |
| Blue shale | 2673 | 2690 |
| Lime | 2690 | 2694 |
| Blue shale | 2694 | 2704 |
| Lime | 2704 | 2715 |
| Blue shale | 2715 | 2728 |
| Lime | 2728 | 2732 |
| Blue shale | 2732 | 2750 |
| Lime formation | 2750 | 2775 |
| Shale | 2775 | 2795 |
| Cavy formation | 2795 | 2882 |
| Bad cave | 2882 | 2920 |
| Blue shale | 2920 | 2935 |
| Cavy formation | 2935 | 2965 |
| Gypsy lime or selenite | 2965 | 2985 |
| Gypsy lime | 2985 | 2995 |
| Broken shale & shell | 2995 | 3050 |
| Broken shale & shell | 3050 | 3065 |
| Broken and caving | 3065 | 3085 |
| Shale | 3085 | 3095 |
| Shale & shell | 3095 | 3115 |
| Shale & shell (shell) | 3115 | 3175 |
| Shale & shell (dark) | 3175 | 3275 |
| Shale | 3275 | 3315 |
| Shale & shell | 3315 | 3330 |
| Hard gray lime | 3330 | 3670 |

*Log of Sharon Oil Co., Elmore No. 1 well, sec. 25, T. 21 N., R. 21 W., Woodward County.*

(Elevation 2,038.8)

| Formation | Top | Bottom |
|---|---|---|
| Surface clay and sand | 0 | 27 |
| Sand | 27 | 40 |
| Shale | 40 | 80 |
| Quick sand | 80 | 100 |
| Hard packed sand | 100 | 104 |
| Gummy shale | 104 | 113 |
| Red Bed | 113 | 130 |
| Red clay or shale | 130 | 160 |
| Red clay or shale | 160 | 190 |
| Red clay or shale | 190 | 210 |
| White lime | 210 | 230 |
| Red clay or shale | 230 | 300 |
| White lime | 300 | 316 |
| Red beds and streaks of lime | 316 | 440 |
| Lime rock | 440 | 450 |
| Red beds | 450 | 474 |
| Lime | 474 | 526 |

(Continued on page 405)



| Formation | Top | Bottom |
|---|---|---|
| Red beds | 526 | 535 |
| Lime | 535 | 539 |
| Hard lime | 539 | 584 |
| Lime | 584 | 590 |
| Red beds | 590 | 603 |
| Shale bluish green | 603 | 635 |
| Blue gummy shale | 635 | 663 |
| Gummy shale | 663 | 703 |
| Blue & brown shale | 703 | 734 |
| Gummy shale red & blue | 734 | 774 |
| Brown shale | 774 | 803 |
| Red & brown gummy shale streaks of lime shell | 803 | 845 |
| Brown & red shale with streaks of lime shell | 845 | 905 |
| Red & brown shale | 905 | 950 |
| Red & brown shale sticky & hard by streaks, some streaks of lime shell | 950 | 1010 |
| Red & brown shale | 1010 | 1013 |
| Very hard lime | 1013 | 1033 |
| Rock salt | 1033 | 1057 |
| Brown shale | 1057 | 1075 |
| Brown shale, streaks of hard lime and gummy streaks | 1075 | 1101 |
| Salt rock | 1101 | 1110 |
| Lime | 1110 | 1115 |
| Red shale | 1115 | 1120 |
| Brown shale with streaks of hard lime shell | 1120 | 1164 |
| Lime & salt in streaks | 1164 | 1172 |
| Shale & streaks of lime | 1172 | 1190 |
| Salt & lime streaks | 1190 | 1200 |
| Brown shale & shell lime | 1200 | 1220 |
| Salt rock | 1220 | 1230 |
| Shale & shell lime | 1230 | 1244 |
| Gray lime | 1244 | 1250 |
| Salt rock | 1250 | 1282 |
| Hard salt rock | 1282 | 1292 |
| Salt rock, very hard & flinty | 1292 | 1299 |
| Brown & blue shale & shell lime | 1299 | 1308 |
| Salt rock | 1308 | 1327 |
| Brown & blue shale, streaks of lime | 1327 | 1354 |
| Salt rock | 1354 | 1392 |
| Salt rock—some shale | 1392 | 1408 |
| Salt rock | 1408 | 1417 |
| Red beds & streaks of lime | 1417 | 1457 |
| Core | 1457 | 1460 |
| Blue shale — salty — streaks of lime | 1457 | 1469 |
| Very hard lime | 1469 | 1476 |
| Hard lime | 1476 | 1480 |
| Salt rock (core at 1481) | 1480 | 1493 |
| Red & blue shale, salt salt rock & gyp | 1493 | 1507 |
| Red rock, streaks blue shale & salt | 1507 | 1515 |
| Red rock & streaks blue shale | 1515 | 1538 |
| Salt rock quite hard | 1538 | 1563 |
| Blue & brown shale & streaks hard rock | 1563 | 1595 |
| Blue & brown shale & streaks lime | 1595 | 1655 |
| Salt rock | 1655 | 1662 |
| Blue & brown shale & streaks slate | 1662 | 1712 |
| Blue & brown shale, streaks of salt & salt rock | 1712 | 1750 |
| Blue shale & streaks lime | 1750 | 1780 |
| Blue shale — gummy — streaks lime | 1780 | 1835 |
| Sticky shale & streaks lime | 1835 | 1890 |
| Hard shale & slate | 1890 | 1900 |
| Gummy shale | 1900 | 1952 |
| Hard brown shale—Gummy | 1952 | 1975 |
| Red & blue shale—Gummy streaks | 1975 | 2017 |
| Red & blue shale—Thin streaks hard lime | 2017 | 2076 |
| Blue shale—gummy—& streaks lime | 2076 | 2101 |
| Blue shale—very hard & very gummy in streaks also streaks of hard lime | 2101 | 2115 |
| Blue shale—hard streaks hard red rock & lime | 2115 | 2136 |
| Blue gummy & hard shale—some hard, almost black, shale, red rock in 1 to 2 ft. streaks & some lime | 2136 | 2153 |
| Hard gummy shale & streaks lime | 2153 | 2215 |
| Hard shale & streaks of lime | 2215 | 2222 |
| Lime in 1 to 2 ft. streaks, brown shale between | 2222 | 2242 |

(Continued on page 406)

| Formation | Top | Bottom |
|---|---|---|
| Lime streaks & gummy shale | 2242 | 2250 |
| Thicker lime streaks, slightly sandy at bottom | 2250 | 2257 |
| Streaks of lime & shale | 2257 | 2293 |
| Hard gray shale | 2293 | 2298 |
| Hard lime | 2298 | 2306 |
| Hard gray shale | 2306 | 2318 |
| Dark lime | 2318 | 2323 |
| Hard gray shale | 2323 | 2335 |
| Hard lime rock | 2335 | 2342 |
| Rock | 2342 | 2349 |
| Rock & gumbo | 2349 | 2356 |
| Lime | 2356 | 2366 |
| Lime rock & gumbo | 2366 | 2378 |
| Hard lime rock | 2378 | 2387 |
| Hard lime rock | 2387 | 2395 |
| Hard lime rock | 2395 | 2399 |
| Gumbo | 2399 | 2407 |
| Gumbo with streaks hard lime rock | 2407 | 2419 |
| Gummy shale | 2419 | 2431 |
| Hard lime | 2431 | 2434 |
| Rock lime | 2434 | 2447 |
| Gumbo with streaks of shell | 2447 | 2454 |
| Shale with streaks lime | 2454 | 2483 |
| Shale with hard lime streaks | 2483 | 2495 |
| Gummy shale (?) | 2495 | 2503 |
| Shale, streaks of lime | 2503 | 2550 |
| Slaty shale | 2550 | 2559 |
| Gummy shale | 2559 | 2572 |
| Hard shale streaks of lime | 2572 | 2580 |
| Gummy shale, streaks of lime | 2580 | 2615 |
| Hard shale, streaks of lime | 2615 | 2626 |
| Slaty shale, streaks of lime | 2626 | 2643 |
| Hard slaty shale, streaks of lime | 2643 | 2662 |
| Hard crystal | 2662 | 2668 |
| Hard crystal lime | 2668 | 2678 |
| Gummy shale | 2678 | 2681 |
| Gummy shale & streaks of lime | 2681 | 2688 |
| Shale, streaks of lime | 2688 | 2703 |
| Slaty shale, thin streaks lime | 2703 | 2729 |
| Hard lime | 2729 | 2735 |
| Shale, thin streaks of lime | 2735 | 2755 |
| Shale, streaks of lime | 2755 | 2767 |
| Hard lime | 2767 | 2772 |
| Hard lime | 2772 | 2777 |
| Hard lime | 2777 | 2782 |
| Hard lime | 2782 | 2786 |
| Very hard lime | 2786 | 2790 |
| Hard lime | 2790 | 2795 |
| Hard lime | 2795 | 2796 |
| Hard shale | 2796 | 2799 |
| Hard lime | 2799 | 2812 |
| Hard lime | 2812 | 2816 |
| Salt shale | 2816 | 2819 |
| Hard shale | 2819 | 2822 |
| Hard lime with streaks of hard shale | 2822 | 2832 |
| B..... lime with shale | 2832 | 2839 |
| Hard lime | 2839 | 2842 |
| ..... lime ..... shale | 2842 | 2853 |
| Broken lime | 2853 | 2867 |
| Broken lime .....shale | 2867 | 2874 |
| Scaly shale .....shells | 2874 | 2887 |
| Gyp rock | 2887 | 2898 |
| Gyp rock | 2898 | 2902 |
| Hard lime | 2902 | 2907 |
| Hard lime | 2907 | 2914 |
| Hard shale | 2914 | 2920 |
| Lime rock | 2920 | 2932 |

*Log of Morton & Co., Jessie Elder No. 1 well, cen. SE.¼ sec. 22, T. 16 N., R. 18 W., Dewey County*

(Elevation 2,035)

| Formation | Top | Bottom |
|---|---|---|
| Red shale red | 0 | 55 |
| Gyp lime white | 55 | 78 |
| Shale red | 78 | 83 |
| Gyp rock white | 83 | 90 |
| Gyp rock white | 100 | 105 |
| Red mud red | 105 | 125 |
| Sand rock red | 125 | 145 |
| Red mud red | 145 | 180 |
| Red rock (HFW) red | 180 | 230 |
| Quick sand red | 230 | 388 |
| Red rock red | 388 | 525 |
| Shale red | 525 | 600 |
| Gyp rock white | 600 | 620 |
| Red rock red | 620 | 625 |

(Continued on page 407)



| Formation | Top | Bottom |
|---|---|---|
| Gyp rock white | 625 | 640 |
| Shale red | 640 | 644 |
| Red rock red | 644 | 665 |
| Gyp rock white | 665 | 670 |
| Red rock red | 670 | 690 |
| Gyp rock white | 690 | 700 |
| Slate blue | 700 | 720 |
| Red rock red | 720 | 740 |
| Gyp rock white | 740 | 750 |
| Red rock red | 750 | 780 |
| Red rock red | 780 | 1830 |
| Gyp rock white | 1830 | 1835 |
| Red rock red | 1835 | 1925 |
| Blue mud blue | 1925 | 1950 |
| Brown mud brown | 1950 | 2000 |
| Red rock red | 2000 | 2698 |
| Shale blue | 2698 | 2750 |
| Gyp rock white | 2750 | 2757 |
| Shale blue | 2757 | 2802 |
| Shale red | 2802 | 2823 |
| Shale blue | 2823 | 2962 |
| Gyp rock white | 2962 | 2970 |
| Shale blue | 2970 | 3049 |
| Shale light | 3049 | 3070 |
| Shale light | 3070 | 3092 |
| Shale light | 3092 | 3109 |
| Lime light | 3109 | 3118 |
| Shale light | 3118 | 3124 |
| Broken lime | 3124 | 3242 |
| Shale & lime shells | 3242 | 3296 |
| Shale light | 3296 | 3350 |
| Shale—lime shells | 3350 | 3390 |
| Broken lime | 3390 | 3420 |
| Shale—lime shells | 3420 | 3483 |
| Lime | 3483 | 3506 |
| Total depth | | 3506 |

### Structural geology

Dewey County lies on the north limb of the Anadarko Basin and the accompanying figure shows the structural relationships of this area to the basin. The strike of the formations is northwest-southeast with the regional dip to the west and southwest, similar but not so steep as in Blaine County. Numerous structural irregularities have been mapped in this county but time did not permit the checking or detailing of these.

The Day Creek dolomite, a very persistent marker through this area, is difficult upon which to map structural details. This is due to the tremendous amount of slumping in the buttes and escarpments. The underlying shale also allows the dolomite to slump in such a manner as to produce dips varying in all degrees of angle and direction. As yet, wells have not been drilled sufficiently deep to encounter any known producing horizons but small shows of oil and gas have been reported from various wells drilled in the county. Inasmuch as the area is near to the axis of the Anadarko Basin it would be necessary to drill through some 7,000 feet of sediments to encounter known producing horizins. The structural relationship of underlying Pennsylvanian formations may be such as to bring these producing horizons nearer the surface. As yet we know of no surface indications to justify such a belief.

## DEVELOPMENT

To date no production in commercial quantities has been found in Dewey County. The table on page 430 gives a list of wells which have been drilled.

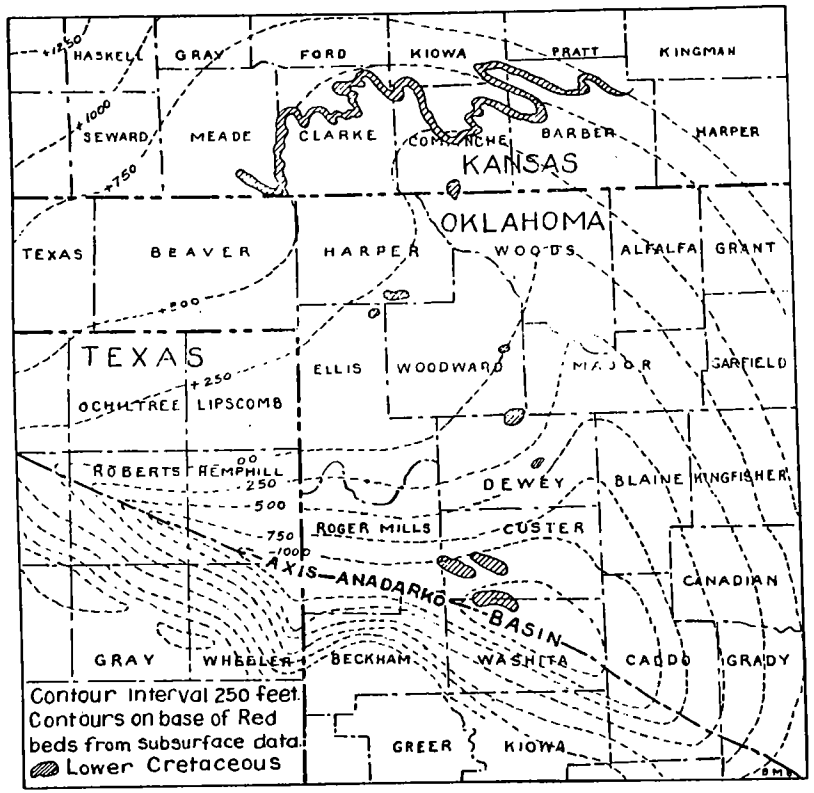



Figure 57. Map showing the relation of the lower Cretaceous outliers to the Anadarko Basin. (After Bullard and Clifton.)

## CUSTER COUNTY

Custer county is the southern of the two central counties covered by this report. In shape it is rectangular and has 28 townships from Tps. 12 to 15 N., inclusive and Rs. 14 to 20 W., inclusive, an area of approximately 1,008 square miles. It lies within the valleys of the South Canadian and the Washita rivers and their tributaries.

The main line of the Rock Island traverses the southern part of the county, the Frisco and Orient the eastern part, and a branch line of the Santa Fe serves the Washita Valley from Clinton west. The Wichita and Northwestern crosses the extreme western part.

The county has a population of approximately 30,000 and Arapaho with a population of 500 is the county seat. Clinton is the largest and most important city with 6,000 population. Four of the five railroads



intersect at this point. Other places of importance are Custer City (1,500), Thomas (400), Weatherford (4,000), and Butler (300). Weatherford is the site of the Southwestern State Teachers College.

### TOPOGRAPHY

The northern part of Custer County is a rolling plain drained by the northern tributaries of the Washita and Deer Creek which is a tributary of the South Canadian. The eastern part of the county slopes gently toward the South Canadian River. The southeastern part is a badly dissected plain. Streams have cut deep, canyon-like valleys in the Whitehorse sandstone and Cloud Chief formations. The southwestern part slopes northeast into the valley of the Washita. The streams which have eroded the surface are largely intermittent due to light rainfall which averages only 25 inches annually. The timber along the streams presents a semi-park landscape.

### GEOLOGY

#### Surface formations

Surface formations of this county are the Whitehorse sandstone, Day Creek dolomite, Cloud Chief gypsum, Quartermaster formation, Cretaceous oyster beds (as outliers) and Quaternary gravels and sands. Alluvium is very abundant along the South Canadian and Washita rivers.

#### WHITEHORSE SANDSTONE

The Whitehorse sandstone outcrops in the eastern part of the county, forming a wide band south and west of South Canadian River. Deer Creek and its tributaries have carved their valleys into this formation, the character of which has been described under Blaine County.

#### DAY CREEK DOLOMITE

The Day Creek dolomite forms a low escarpment just west of the Whitehorse area and can be traced from the northern boundary of the county down to the Weatherford area. The character of this formation has been described under Dewey County. Outliers are found in the vicinity of Thomas, lying upon Whitehorse. Northwest of Eagle City in Blaine County it occurs(?) as one of the series of dolomites and gypsums which form a prominent outlier.

#### CLOUD CHIEF GYPSUM

The Cloud Chief gypsum forms the surface of the central half of the county and wider in the northern than in the southern part. That along the southern border is very similar to that in the type locality of Cloud Chief in Washita County. The character of this formation has been described under Dewey County.

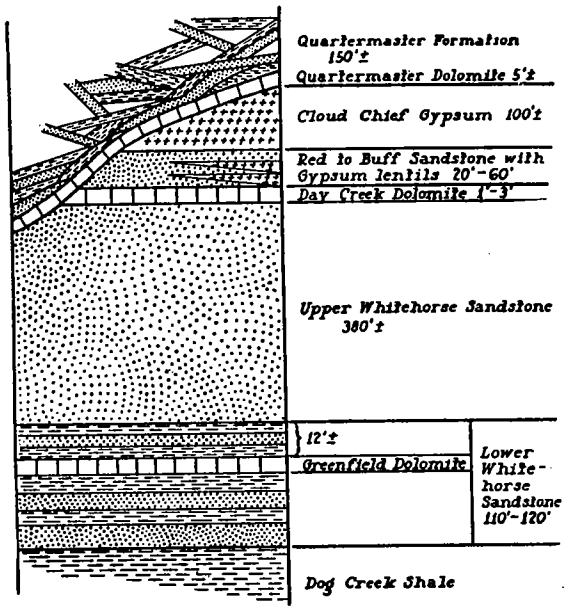



Figure 58. Section showing the stratigraphy of the Weatherford district (Evans, 1928, p. 708).

### QUARTERMASTER FORMATION

This formation outcrops in the northwestern and southwestern parts of the county and lies unconformably upon the older Permian rocks. Gypsum or dolomite forms the basal portion of the formation and is well developed in the southeastern part of the county between Clinton and Weatherford. The above section made by Evans shows the relationships between the Quartermaster and the underlying Permian formations. It is interesting to note that the Quartermaster caps the buttes in Caddo County to the southeast and rests unconformably upon the Whitehorse.

The following figure shows the stratigraphic relationships of the Weatherford area as interpreted by Noel Evans.[18]

18. Evans, Noel, Stratigraphy of the Weatherford area: Bull. Am. Assoc. Pet. Geol. vol. 12, fig. 12, 1928.



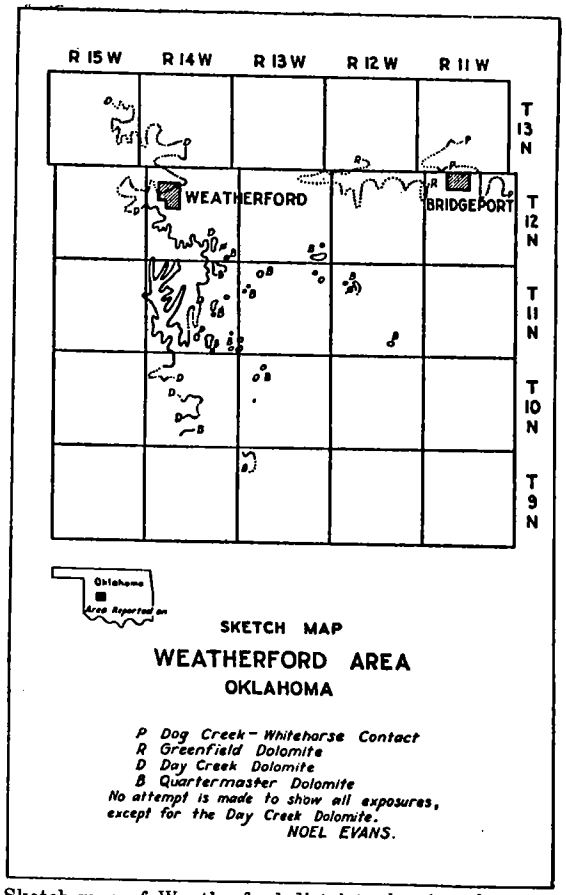



Figure 59. Sketch map of Weatherford district, showing the chief occurrences of the Day Creek and Quartermaster dolomites.

The map above, figure 59, shows the distribution of the various dolomites in this area described by Evans.[19] A great deal of detail work needs to be done in this county to clarify the structural relationships of the existing formations.

### CRETACEOUS FORMATIONS

The Cretaceous formations in Custer County occur as erosional remnants in widely scattered areas throughout the northern, central and southern portions and they rest unconformably upon the older formations. Most of the cretaceous formations are but a few acres in extent. In the southwestern part near Butler and Foss they form low lying

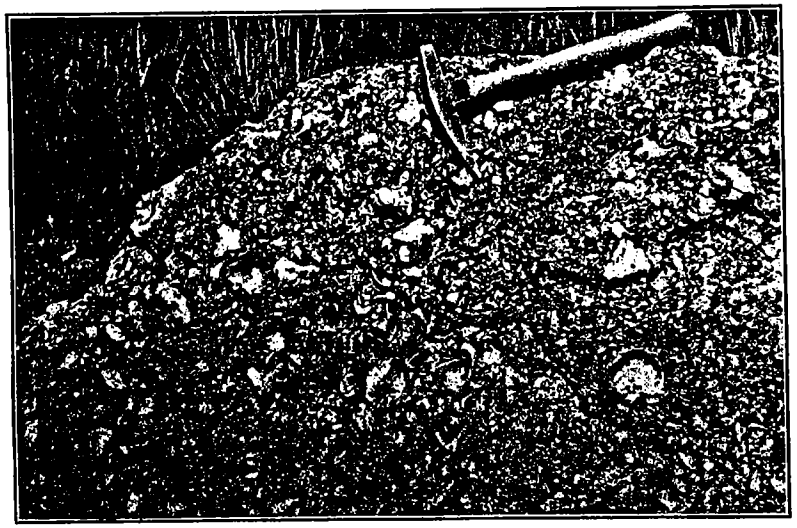
19. Evans, Noel, op. cit., p. 706.

hills. The following section made by Bullard[20] at the NW. cor. sec. 9, T. 11 N., R. 19 W., three miles west of Foss, Oklahoma and just north of the Custer County line sets forth the character of these formations.

| | Ft. | in. |
|---|---|---|
| Shell bed, yellowish brown shell conglomerate composed of **Gryphea corrugata** Say, **Gryphea navia** Hall, and **Oxytropidoceras belknapi** (Marcou) | 3 | 0 |
| Yellowish clay, blue and yellow mottled | 10 | 0 |
| Coarse sand, conglomeratic and locally quartzitic | 3 to 5 | 0 |
| PERMIAN (Quartermaster formation) | | |

As in other parts of the Cretaceous area, that of this county is correlated with the Washita group by Bullard. The following photograph shows the physical character of the *Gryphea corrugata* zone of these rocks in secs. 13, T. 13 N., R. 20 W. and is characteristic of this entire region.[21]

OKLAHOMA GEOLOGICAL SURVEY PLATE VI



Close view of the "Shell Bed," **Gryphea corrugata** zone. Sec. 13, T. 13 N., R. 20 W.

### Subsurface Formations

The rocks underlying Custer County are, perhaps, the same as those underlying Dewey and Blaine counties but lie at a greater depth due to their nearness to the axis of the Anadarko Basin. Most of the wells drilled in this county are shallow and reveal little concerning the subsurface character of formations in which production might be expected.

20. Bullard, F. M., op. cit., p. 79.
21. Bullard, F. M., op. cit., p. 85, pl. VI B.



The following series of well logs show the general character of underlying rocks. The one drilled by the Day Oil Company in the SE.¼ SE.¼ sec. 21, T. 14 N., R. 17 W., in 1923, may be considered the type log of this area.

*Log of Empire Gas & Fuel Co., Stone No. 1 well, SE.¼ SE¼ SW.¼ sec. 25, T. 12 N., R. 14 W., Custer County.*

(Elevation 1,685)

| Formation | Top | Bottom |
|---|---|---|
| Formation | Top | Bottom |
| Sandy soil | 0 | 22 |
| Hard sand | 22 | 30 |
| Very hard sand | 30 | 36 |
| Red sand | 36 | 105 |
| Water sand—coarse | 105 | 150 |
| Hard sand | 150 | 156 |
| Red sand—shale | 156 | 400 |
| Red sand | 400 | 520 |
| Red shale | 520 | 580 |
| Sticky red shale | 580 | 673 |
| Gyp—lime | 673 | 683 |
| Gumbo | 683 | 708 |
| Gyp—lime | 708 | 716 |
| Red shale | 716 | 722 |
| Gyp | 722 | 727 |
| Gumbo | 727 | 770 |
| Gyp—lime | 770 | 775 |
| Gyp | 775 | 785 |
| Sticky red shale | 785 | 819 |
| Gyp | 819 | 823 |
| Gumbo | 823 | 861 |
| Sticky red shale | 861 | 938 |
| Very fine blue sand | 938 | 942 |
| Red shale | 942 | 976 |
| Sandy red shale | 976 | 984 |
| Sticky red shale | 984 | 1093 |
| Chalky red shale | 1093 | 1097 |
| Red shale | 1097 | 1128 |
| Hard sandy shale | 1128 | 1173 |
| Red shale | 1173 | 1258 |
| Sandy shale | 1258 | 1278 |
| Red shale | 1278 | 1356 |
| Gumbo | 1356 | 1364 |
| Gyp | 1364 | 1374 |
| Hard red shale | 1374 | 1379 |
| Gyp | 1379 | 1389 |
| Hard red shale | 1389 | 1397 |
| Sticky red shale | 1397 | 1417 |
| Hard red-gray shale | 1417 | 1427 |
| Gyp | 1427 | 1447 |
| Hard red shale | 1447 | 1513 |
| Very fine gray sand | 1513 | 1423 |
| Red shale | 1523 | 1543 |
| Sandy gray shale | 1543 | 1552 |
| Broken sand | 1552 | 1572 |
| Red shale | 1572 | 1592 |
| Sandy shale | 1592 | 1617 |
| Soft red shale | 1617 | 1653 |
| Red shale | 1653 | 1738 |
| Sticky red shale | 1738 | 1797 |
| Red shale | 1797 | 1811 |
| Sand gray fine | 1811 | 1816 |
| Gyp | 1816 | 1826 |
| Sandy shale | 1826 | 1874 |
| Gumbo | 1874 | 1911 |
| Hard red shale | 1911 | 1936 |
| Sticky red grey shale | 1936 | 1995 |
| Hard red shale | 2015 | 2055 |
| Red shale-gyp | 2055 | 2075 |
| Gyp—red shale | 2075 | 2105 |
| Red—brn. shale | 2165 | 2220 |
| Red shale | 2220 | 2230 |
| Hard red shale—brn. grey | 2230 | 2260 |
| Red—brn. shale | 2260 | 2305 |
| Red shale | 2305 | 2330 |
| Red brown shale | 2330 | 2342 |
| Sandy red shale | 2342 | 2364 |
| Red shale | 2364 | 2377 |
| Broken gyp | 2367 | 2384 |
| Gyp | 2384 | 2395 |
| Red shale—bldrs. | 2395 | 2416 |
| Gyp | 2416 | 2417 |
| Broken gyp | 2417 | 2427 |
| Red shale | 2427 | 2447 |
| Sticky red shale | 2447 | 2457 |
| Red shale—bldrs. | 2457 | 2484 |
| Gyp—bldrs. | 2484 | 2491 |
| Red shale | 2491 | 2508 |
| Red shale | 2508 | 2543 |
| Gyp | 2543 | 2548 |
| Red shale—bldrs. | 2548 | 2564 |
| Red shale | 2564 | 2566 |
| Broken gyp | 2566 | 2578 |
| Red shale | 2578 | 2584 |
| Red—brn. shale | 2584 | 2588 |
| Red—shale—bldrs. | 2588 | 2622 |
| Red shale | 2622 | 2630 |
| Gyp | 2630 | 2642 |

(Continued on page 414)

| Formation | Top | Bottom |
|---|---|---|
| Red shale | 2642 | 2650 |
| Gyp | 2650 | 2660 |
| Hard gyp | 2660 | 2670 |
| Red shale | 2670 | 2692 |
| Gyp | 2692 | 2700 |
| Red shale | 2700 | 2704 |
| Gyp | 2704 | 2712 |
| Measured pipe in hole | | |
| 31 fourbles 2622-10′ | | |
| 1 double 42′8″ | | |
| Kelly down 22′ drill collar 6′ | | |
| T. D. | 2693′6″ | |
| Gyp | 2693 | 2702 |
| Broken sand | 2702 | 2707 |
| Blue shale | 2707 | 2727 |
| Red—blue shale | 2727 | 2734 |
| Red shale | 2734 | 2742 |
| Gyp—hard | 2742 | 2750 |
| Gyp | 2750 | 2753 |
| Red shale | 2753 | 2766 |
| Gyp | 2766 | 2770 |
| Red—blue shale | 2770 | 2785 |
| Broken sand—gas | 2785 | 2787 |
| Gyp | 2787 | 2790 |
| Red sticky shale | 2790 | 2792 |
| Red—blue shale | 2792 | 2806 |
| Blue shale | 2806 | 2826 |
| Lime | 2826 | 2829 |
| Cherty lime | 2829 | 2831 |
| Blue shale | 2831 | 2852 |
| Lime | 2852 | 2856 |
| Blue sticky shale | 2856 | 2860 |
| Lime | 2860 | 2869 |
| Blue shale | 2869 | 2870 |
| Lime | 2870 | 2871 |
| Sticky blue shale | 2871 | 2873 |
| Lime | 2873 | 2879 |
| Blue shale | 2879 | 2880 |
| Broken lime—shale | 2880 | 2890 |
| Broken lime | 2890 | 2892 |
| Blue sticky | 2892 | 2904 |
| Bldts. shale—sticky | 2904 | 2892 |
| Blue shale | 2904 | 2905 |
| Broken lime—bldrs. | 2905 | 2920 |
| Lime | 2920 | 2922 |
| Blue shale | 2922 | 2929 |
| Broken lime | 2929 | 2935 |
| Gumbo | 2935 | 2940 |
| Blue shale | 2940 | 2950 |
| Broken lime | 2950 | 2960 |
| Lime | 2960 | 2969 |
| Lime—sandy shale | 2969 | 2972 |
| Lime | 2972 | 2973 |
| Gumbo | 2973 | 2977 |
| Blue shale | 2977 | 2980 |
| Sandy shale | 2980 | 2982 |
| Lime | 2982 | 2985 |
| Shale—bldrs. | 2985 | 2995 |
| Gumbo | 2995 | 2998 |
| Sticky blue shale | 2998 | 3008 |
| Some gas—bldrs. | | |
| Broken shale—lime | 3008 | 3023 |
| Sticky blue shale | 3023 | 3034 |
| Gumbo | 3034 | 3044 |
| Broken shale—sand | 3044 | 3054 |
| Gumbo | 3054 | 3069 |
| Sand | 3069 | 3071 |
| Lime | 3071 | 3072 |
| Broken wht. sand | 3072 | 3074 |
| Broken—lime—shale | 3074 | 3081 |
| Hard shale—bldrs. | 3081 | 3105 |
| Blue shale | 3105 | 3132 |
| Gumbo | 3132 | 3138 |
| Lime | 3138 | 3140 |
| Blue shale | 3140 | 3151 |
| Hard lime | 3151 | 3155 |
| Blue shale | 3155 | 3161 |
| Lime | 3161 | 3164 |
| Broken lime—shale | 3164 | 3169 |
| Blue shale | 3169 | 3183 |
| Gumbo | 3183 | 3187 |
| Blue shale—brkn. lime | 3187 | 3196 |
| Blue shale—bldrs. | 3196 | 3203 |
| Lime | 3203 | 3204 |
| Broken lime—shale | 3204 | 3213 |
| Cherty grey lime | 3213 | 3220 |
| Broken lime—blue shale | 3220 | 3246 |
| Lime | 3246 | 3250 |
| Blue shale | 3250 | 3265 |
| Lime | 3265 | 3267 |
| Sticky blue shale | 3267 | 3270 |
| Brkn. lime—blue shale | 3270 | 3281 |
| Gumbo | 3281 | 3291 |
| Fine wht. sand | 3291 | 3293 |
| Lime | 3293 | 3294 |
| Shale—bldrs. | 3294 | 3308 |
| Blue shale | 3308 | 3310 |
| Hard chalky shale | 3310 | 3312 |
| Lime | 3312 | 3317 |
| Blue shale | 3317 | 3321 |
| Blue shale—bldrs. | 3321 | 3332 |
| Chalky blue shale | 3332 | 3338 |
| Sticky blue shale | 3338 | 3343 |
| Gumbo | 3343 | 3369 |
| Chalky shale | 3369 | 3371 |
| Blue shale | 3371 | 3375 |
| Blue shale—bldrs | 3375 | 3386 |
| Sticky blue shale | 3386 | 3391 |
| Blue shale—gumbo | 3391 | 3404 |
| Broken lime | 3404 | 3405 |
| Blue shale | 3405 | 3409 |
| Lime | 3409 | 3414 |

(Continued on page 415)



| Formation | Top | Bottom |
|---|---|---|
| Sticky blue shale | 3414 | 3424 |
| Chalky shale | 3424 | 3434 |
| Chalky shale | 3434 | 3436 |
| Sticky blue shale | 3436 | 3442 |
| Lime | 3442 | 3448 |
| Sticky blue shale | 3448 | 3475 |
| Chalky shale | 3475 | 3480 |
| Lime | 3480 | 3482 |
| Chalky shale | 3482 | 3483 |
| Sticky blue shale | 3483 | 3489 |
| Blue shale | 3489 | 3496 |
| Lime | 3496 | 3497 |

*Log of Day Oil Co., Miller No. 1 well, SE.¼ SE.¼ sec. SE.¼ 21, T. 14 N., R. 17 W., Custer County.*

[Elevation 1,773 (1,770)]

| Formation | Top | Bottom |
|---|---|---|
| Red sand | 0 | 10 |
| Hard pack sand | 10 | 13 |
| Hard sharp sand | 13 | 35 |
| Hard rock | 35 | 51 |
| Red clay | 51 | 69 |
| Hard pack sand | 69 | 78 |
| Hard red sand | 78 | 89 |
| Gyp rock | 89 | 104 |
| Hard sand rock | 104 | 124 |
| Hard red sand | 124 | 137 |
| Cavity | 137 | 140 |
| Gyp rock | 140 | 150 |
| Sand | 150 | 180 |
| Red clay | 180 | 196 |
| Sand | 196 | 218 |
| Red bed | 218 | 221 |
| Red sand | 221 | 230 |
| Rock | 230 | 238 |
| Red sand water sand | 238 | 321 |
| Quick sand | 321 | 384 |
| Rock | 384 | 386 |
| Gravel sand | 386 | 390 |
| Quicksand | 390 | 406 |
| Gyp rock | 406 | 419 |
| Hard sand | 419 | 430 |
| Red clay | 430 | 450 |
| Sand | 450 | 478 |
| Shale sand | 478 | 502 |
| Sand | 502 | 518 |
| Rock | 518 | 526 |
| Shale red | 526 | 534 |
| Clay red | 534 | 568 |
| Clay red | 568 | 588 |
| Gyp rock | 588 | 592 |
| Clay | 592 | 594 |
| Hard sand | 594 | 607 |
| Mud blue | 607 | 617 |
| Shale red | 617 | 650 |
| Gumbo red | 650 | 667 |
| Red gumbo clay mixed | 667 | 671 |
| Shells, gray shale | 671 | 691 |
| Hard rock | 691 | 699 |
| Shale sand | 699 | 705 |
| Hard lime rock | 705 | 715 |
| Hard shale shells | 715 | 720 |
| Lime rock hard | 720 | 731 |
| Sticky shale shells | 731 | 754 |
| Hard lime rock | 754 | 766 |
| Shale blue | 766 | 778 |
| Lime shell | 778 | 780 |
| Red gumbo | 780 | 792 |
| Hard lime rock | 792 | 798 |
| Hard white flint lime | 798 | 800 |
| Hard lime rock | 800 | 801 |
| Hard shell | 801 | 803 |
| Red clay | 803 | 809 |
| Red gumbo | 809 | 814 |
| Shale blue | 814 | 818 |
| Lime rock | 818 | 820 |
| Shale brown | 820 | 825 |
| Red gumbo | 825 | 830 |
| Salt rock show gas on ditch | 830 | 833½ |
| Red gumbo | 833½ | 841 |
| Lime shell | 841 | 844 |
| Blue gumbo | 844 | 845 |
| Oil sand dry | 845 | 847 |
| Red gumbo | 847 | 870 |
| Hard gray shale | 847 | 874 |
| Red gumbo | 874 | 890 |
| Shale gray | 890 | 898 |
| Red gumbo | 898 | 922 |
| Red blue gumbo | 922 | 945 |
| Shell | 945 | 946 |
| Red gumbo | 946 | 956 |
| Shell | 956 | 957 |
| Red gumbo | 957 | 975 |
| Shale gray | 975 | 983 |
| Red gumbo | 983 | 1000 |
| Hard sand | 1000 | 1003 |
| Red gumbo | 1003 | 1014 |
| Shell | 1014 | 1016 |
| Red gumbo | 1016 | 1021 |
| Shell | 1021 | 1023 |

(Continued on page 416)

| Formation | Top | Bottom |
|---|---|---|
| Hard sand | 1023 | 1027 |
| Red gumbo | 1027 | 1030 |
| Red shale | 1030 | 1034 |
| Shell red gumbo | 1034 | 1040 |
| Shell | 1040 | 1042 |
| Shale blue | 1042 | 1050 |
| Red gumbo | 1050 | 1054 |
| Cong. lime, blue shale | 1054 | 1061 |
| Gumbo, boulders | 1061 | 1080 |
| Hard sand | 1080 | 1083 |
| Cong. of gumbo, bldrs. shale | 1083 | 1099 |
| Hard sand rock | 1099 | 1109 |
| Red gumbo | 1109 | 1117 |
| Hard sand | 1117 | 1126 |
| Gumbo, boulders | 1126 | 1135 |
| Lime sandy | 1135 | 1140 |
| Gumbo boulders | 1140 | 1147 |
| Red gumbo | 1147 | 1192 |
| Lime sandy | 1192 | 1196 |
| Red gumbo boulders | 1196 | 1228 |
| Hard sand | 1228 | 1230 |
| Gumbo bldrs. | 1230 | 1240 |
| Lime sandy | 1240 | 1242 |
| Hard sand broken | 1242 | 1248 |
| Red gumbo bldrs. | 1248 | 1250 |
| Sand | 1250 | 1252 |
| Hard sand | 1252 | 1256 |
| Hard sand rock | 1256 | 1258 |
| Red gumbo | 1258 | 1270 |
| Hard bldrs. gumbo | 1270 | 1276 |
| Red gumbo | 1276 | 1308 |
| Rock | 1308 | 1309 |
| Red gumbo | 1309 | 1310 |
| Hard sand | 1310 | 1312 |
| Gumbo bldrs. | 1312 | 1323 |
| Hard gray gumbo | 1323 | 1335 |
| Hard sand | 1335 | 1337 |
| Gumbo | 1337 | 1347 |
| Hard rock | 1347 | 1348 |
| Gumbo, flint, bldrs. | 1348 | 1360 |
| Gray sand | 1360 | 1364 |
| Gumbo, flint, bldrs. | 1364 | 1367 |
| Hard rock | 1367 | 1370 |
| Hard gray sand | 1370 | 1372 |
| Hard sand | 1372 | 1389 |
| Red gumbo | 1389 | 1424 |
| Lime sandy | 1424 | 1426 |
| Gumbo, bldrs. | 1426 | 1431 |
| Hard sand rock | 1431 | 1502 |
| Hard rock | 1502 | 1503 |
| Sand | 1503 | 1508 |
| Gumbo bldrs. | 1508 | 1512 |
| Hard sand rock | 1512 | 1537 |
| Gumbo flint bldrs. | 1537 | 1550 |
| Hard sandy lime | 1550 | 1555 |
| Gumbo bldrs. | 1555 | 1560 |
| Hard sand rock | 1560 | 1563 |
| Gumbo bldrs. | 1563 | 1568 |
| Sand rock | 1568 | 1576 |
| Hard sand rock | 1567 | 1586 |
| Red gumbo | 1586 | 1589 |
| Gumbo bldrs. | 1555 | 1560 |
| Sandy shale | 1589 | 1600 |
| Hard sand | 1600 | 1604 |
| Gumbo bldrs. | 1604 | 1621 |
| Hard sand | 1621 | 1623 |
| Sandy lime rock | 1623 | 1639 |
| Gumbo shale | 1639 | 1655 |
| Lime rock | 1655 | 1661 |
| Gumbo | 1661 | 1665 |
| Rock | 1665 | 1668 |
| Soft gray sand | 1668 | 1670 |
| Gumbo bldrs. | 1670 | 1677 |
| Sand rock | 1677 | 1686 |
| Gumbo bldrs | 1686 | 1688 |
| Gumbo | 1688 | 1690 |
| Hard pack sand | 1690 | 1693 |
| Hard sand rock | 1693 | 1695 |
| Red gumbo | 1695 | 1698 |
| Hard sand rock | 1698 | 1700 |
| Hard pack sand | 1700 | 1708 |
| Red gumbo bldrs. | 1708 | 1721 |
| Gumbo | 1721 | 1723 |
| Red gumbo | 1723 | 1726 |
| Gumbo | 1726 | 1757 |
| Sand gray | 1757 | 1760 |
| Red gumbo | 1760 | 1773 |
| Rock | 1773 | 1775 |
| Gumbo red | 1775 | 1786 |
| Shale sticky | 1786 | 1793 |
| Red gumbo | 1793 | 1818 |
| Shale | 1818 | 1829 |
| Rock | 1829 | 1833 |
| Red gumbo | 1833 | 1837 |
| Rock | 1837 | 1839 |
| Gumbo | 1839 | 1843 |
| Shell | 1843 | 1844 |
| Sand rock | 1844 | 1855 |
| Sand rock | 1855 | 1864 |
| Red gumbo | 1864 | 1871 |
| Red sand | 1871 | 1874 |
| Red gumbo | 1874 | 1888 |
| Hard rock | 1888 | 1891 |
| Hard sand rock | 1891 | 1892 |
| Red rock bldrs. | 1892 | 1899 |
| Red gumbo | 1899 | 1903 |
| Red rock bldrs. | 1903 | 1909 |
| Red gumbo | 1909 | 1923 |
| Shale sticky | 1923 | 1930 |
| Hard gumbo bldrs. | 1930 | 1935 |
| Hard sand | 1935 | 1942 |

(Continued on page 417)



| Formation | Top | Bottom |
|---|---|---|
| Hard gumbo bldrs. | 1942 | 1947 |
| Red rock bldrs. | 1947 | 1956 |
| Lime rock | 1956 | 1968 |
| Cong. | 1968 | 1971 |
| Blue gumbo | 1971 | 1973½ |
| Gumbo shale | 1973½ | 1978 |
| Hard gray sand | 1978 | 1980 |
| Gumbo blue | 1980 | 1987 |
| Shale bldrs. | 1987 | 2000 |
| Gumbo bldrs. | 2000 | 2004 |
| Shale gray | 2004 | 2010 |
| Gumbo red | 2010 | 2016 |
| Gumbo | 2016 | 2020 |
| Sand hard | 2020 | 2022 |
| Gumbo bldrs. | 2022 | 2033 |
| Hard sand | 2033 | 2035 |
| Gumbo bldrs. | 2035 | 2039 |
| Gumbo blue | 2039 | 2052 |
| Hard sand | 2052 | 2054 |
| Blue gumbo bldrs. | 2054 | 2058 |
| Shell | 2058 | 2059 |
| Blue gumbo bldrs. | 2059 | 2067 |
| Blue gumbo | 2067 | 2074 |
| Gray sandy shale | 2074 | 2079 |
| Blue gumbo | 2079 | 2102 |
| Shale | 2102 | 2120 |
| Gumbo blue | 2120 | 2145 |
| Shale sticky | 2145 | 2165 |
| Blue gumbo bldrs. | 2165 | 2173 |
| Gumbo | 2173 | 2207 |
| Shale | 2207 | 2229 |
| Gumbo | 2229 | 2236 |
| Shale | 2236 | 2245 |
| Gumbo | 2245 | 2251 |
| Shale | 2251 | 2268 |
| Shale sticky | 2268 | 2276 |
| Shale sticky | 2276 | 2281 |
| Gumbo | 2281 | 2296 |
| Shale sticky | 2296 | 2312 |
| Gumbo | 2312 | 2338 |
| Shale sticky | 2338 | 2358 |
| Gumbo | 2358 | 2363 |
| Shale mixed | 2363 | 2383 |
| Gumbo | 2383 | 2388 |
| Lime sandy | 2388 | 2392 |
| Shale | 2392 | 2401 |
| Gumbo | 2401 | 2428 |
| Gumbo tough | 2428 | 2444 |
| Shale sticky | 2444 | 2454 |
| Shell | 2454 | 2455 |
| Gumbo | 2455 | 2460 |
| Shale | 2460 | 2466 |
| Shale blue | 2466 | 2492 |
| Shale | 2492 | 2493 |
| Shale blue | 2493 | 2510 |
| Lime rock | 2510 | 2512 |
| Gumbo blue | 2512 | 2522 |
| Lime rock | 2522 | 2527 |
| Cong. | 2527 | 2531 |
| Gumbo | 2531 | 2537 |
| Lime rock | 2537 | 2540 |
| Gumbo | 2540 | 2548 |
| Shale | 2548 | 2556 |
| Gumbo | 2556 | 2563 |
| Shale | 2563 | 2570 |
| Gumbo | 2570 | 2580 |
| Gumbo blue | 2580 | 2596 |
| Shale blue | 2596 | 2606 |
| Gumbo bldrs. | 2606 | 2610 |
| Gumbo | 2610 | 2630 |
| Shale | 2630 | 2646 |
| Gumbo | 2646 | 2650 |
| Gumbo thin shell | 2650 | 2660 |
| Gumbo lime shell | 2660 | 2667 |
| Brown sand sandy shale | 2667 | 2669 |
| Lime | 2669 | 2687 |
| Brown shale | 2687 | 2704 |
| Brown slate | 2704 | 2714 |
| Brown shale | 2714 | 2740 |
| Blue slate | 2740 | 2745 |
| Brown shale caving | 2745 | 2750 |
| Slate blue | 2750 | 2765 |
| Shale brown | 2765 | 2775 |
| Slate blue | 2775 | 2793 |
| Lime broken | 2793 | 2798 |
| Slate blue | 2798 | 2805 |
| Blue shale soft | 2805 | 2821 |
| Blue mud cavy | 2821 | 2835 |
| Shale blue | 2835 | 2865 |
| Lime | 2865 | 2870 |
| Shale blue | 2870 | 2875 |
| Lime shells blue shale | 2875 | 2880 |
| Shale blue | 2880 | 2904 |
| Shale blue, lime shell | 2904 | 2920 |
| Lime shell blue shale | 2920 | 2938 |
| Slate blue | 2938 | 2947 |
| Shale blue | 2947 | 2965 |
| Slate shells | 2965 | 2978 |
| Shale blue | 2978 | 2988 |
| Lime | 2988 | 2990 |
| Shale | 2990 | 2991 |
| Lime hard | 2991 | 2993 |
| Slate blue | 2993 | 2998 |
| Shale blue | 2998 | 3000 |
| Lime hard | 3000 | 3004 |
| Slate | 3004 | 3012 |
| Shale blue | 3012 | 3026 |
| Shale pink | 3026 | 3030 |
| Shale blue | 3030 | 3035 |
| Lime | 3035 | 3040 |
| Shale blue | 3040 | 3085 |

(Continued on page 418)

| Formation | Top | Bottom |
|---|---|---|
| Slate gray | 3085 | 3097 |
| Shale blue | 3097 | 3174 |
| Lime shell | 3174 | 3178 |
| Lime | 3178 | 3185 |
| Shale blue | 3185 | 3192 |
| Lime | 3192 | 3195 |
| Shale blue | 3195 | 3210 |
| Shale blue, lime | 3210 | 3228 |
| Shale blue | 3228 | 3240 |
| Lime | 3240 | 3245 |
| Slate blue | 3245 | 3250 |
| Shale blue | 3250 | 3258 |
| Lime | 3258 | 3265 |
| Shale gray | 3265 | 3270 |
| Shale blue | 3270 | 3280 |
| Shale gray | 3280 | 3290 |
| Shale blue | 3290 | 3310 |
| Lime | 3310 | 3335 |
| Shale gray | 3335 | 3390 |
| Lime | 3390 | 3395 |
| Lime hard | 3395 | 3405 |
| Lime | 3405 | 3415 |
| Shale blue | 3415 | 3430 |
| Lime | 3430 | 3435 |
| Shale blue | 3435 | 3460 |
| Lime | 3460 | 3473 |
| Shale blue | 3473 | 3480 |
| Lime | 3480 | 3490 |
| Slate soft | 3490 | 3508 |

*Log of J. H. Santrock, Robert Ruth No. 1 well, cen. SE.¼ NW.¼ sec. 1, T. 15 N., R. 15 W., Custer County.*

[Elevation 1,699 (1,705)]

| | | |
|---|---|---|
| Surface sand red | 0 | 18 |
| Red sand | 18 | 45 |
| Water sand | 45 | 52 |
| Red rock | 52 | 125 |
| Red sand—water | 125 | 175 |
| Hard red rock | 175 | 260 |
| Soft red rock | 260 | 455 |
| Grey lime | 455 | 475 |
| Red rock | 475 | 515 |
| Hard white lime | 515 | 535 |
| Red rock | 535 | 560 |
| Lime | 560 | 687 |
| Gravel | 687 | 699 |
| Red rock | 699 | 700 |
| Lime | 700 | 705 |
| Sandy lime | 705 | 710 |
| Red rock | 710 | 860 |
| Lime shell | 860 | 863 |
| Red rock | 863 | 940 |
| Lime | 940 | 945 |
| Sand | 945 | 955 |
| Red rock—lime shell | 955 | 1250 |
| Red rock | 1250 | 1670 |
| Brown shale | 1670 | 1680 |
| Red rock | 1680 | 1690 |
| Brown shale | 1690 | 1705 |
| Sand | 1705 | 1715 |
| Red rock | 1715 | 1770 |
| Blue shale | 1770 | 1820 |
| Red rock | 1820 | 2115 |
| Lime | 2115 | 2120 |
| Red rock | 2120 | 2150 |
| Blue shale | 2150 | 2165 |
| Dark red rock hd. | 2165 | 2380 |
| Red rock cavy | 2380 | 2490 |
| Brn. shale—lime shell | 2490 | 2950 |
| Light brn. sand | 2950 | 2962 |
| Brn. shale | 2962 | 3005 |
| Blue shale—lime shell | 3005 | 3308 |
| Grey lime | 3308 | 3334 |
| Blue slate | 3334 | 3338 |
| Grey lime | 3338 | 3342 |
| Blue shale | 3342 | 3347 |
| Grey lime | 3347 | 3385 |
| Blue shale | 3385 | 3399 |
| Grey lime | 3399 | 3406 |
| Sandy lime | 3406 | 3490 |
| White lime | 3490 | 3505 |
| Blue shale | 3505 | 3545 |
| White lime | 3545 | 3570 |
| Blue shale | 3570 | 3585 |
| Grey lime | 3585 | 3595 |
| White lime | 3595 | 3630 |
| Black slate | 3630 | 3675 |
| Grey sand | 3712 | 3722 |
| Grey lime | 3722 | 3735 |
| Black slate | 3735 | 3740 |
| Black sandy shale | 3740 | 3778 |
| Dark grey sand | 3778 | 3817 |
| Blue shale | 3817 | 3838 |
| Dark grey sand | 3838 | 3860 |
| Black sand | 3860 | 3875 |
| Sandy grey lime | 3875 | 3890 |
| Hard grey sandy lime | 3890 | 3925 |
| Grey sand | 3925 | 3960 |
| Broken grey lime | 3960 | 4005 |
| Hard grey lime | 4005 | 4040 |
| Broken lime | 4040 | 4060 |
| Hard sandy lime | 4060 | 4080 |
| Blue shale—lime shell | 4080 | 4163 |
| Hard grey lime | 4163 | 4185 |
| Red mud | 4185 | 4212 |



*Log of Homaokla Oil Co., W. H. Wasman No. 1 well, NW.¼ SW.¼ SE.¼ sec. 21, T. 13 N., R. 14 W., Custer County.*

(Elevation 1,683)

| Formation | Top | Bottom |
|---|---|---|
| Soil | 0 | 15 |
| Sand rock | 15 | 85 |
| Sand red rock | 85 | 165 |
| Sand rock | 165 | 195 |
| Sand rock packed | 195 | 245 |
| Red clay | 245 | 250 |
| Packed sand | 250 | 270 |
| Coarse sand red | 270 | 285 |
| Packed red sand | 285 | 295 |
| Packed sand | 295 | 325 |
| Red clay | 325 | 367 |
| Quick sand | 367 | 370 |
| Red clay | 370 | 580 |
| Hard sandy lime | 580 | 600 |
| Red clay | 600 | 650 |
| Lime—gyp rock | 650 | 670 |
| Red shale | 670 | 712 |
| Lime—dolomite very hard | 712 | 720 |
| Red shale | 720 | 795 |
| Dolomite | 795 | 815 |
| Red shale | 815 | 884 |
| Dolomite | 884 | 885 |
| Red shale | 885 | 960 |
| Sandy shale—show wtr. | 960 | 970 |
| Broken salt sands sandy shale | 970 | 975 |
| Salt sand, shale making 4 bbls. | 975 | 1000 |
| Salt sand—shale | 1000 | 1020 |
| Sandy shale | 1020 | 1035 |
| Red shale | 1035 | 1080 |

### Structural Geology

The strike of Quartermaster formations in this county is north south. The dips are very low and generally west by south. A number of small structures are reported to have been mapped here and considerable leasing has resulted. A number of companies have procured large holdings.

The general and historical relationships of the surface to sub-surface formations of this area are graphically presented in the following series of diagrams taken from Bullard.[22]

Map No. XXXV shows the areal relationships of this county and Map No. XXXVI the general relationships as revealed by type logs taken in this portion of Oklahoma. Inasmuch as Custer County lies mainly in the bottom of the Anadarko Basin, producing horizons known north and east of here would lie, perhaps, at prohibitive depths Conditions, however, may exist similar to those in the Sayre field in Beckham County to the southeast, but this is hypothetical as yet.

### DEVELOPMENT

The table on page 431 gives a list of wells drilled or now drilling in Custer County up to date. No production has as yet been found in Custer County.

22. Bullard, F. M., op. cit., fig. 7.

## ROGER MILLS COUNTY

Roger Mills County is located in the extreme western part of the state and its western boundary is a part of the Oklahoma-Texas boundary line, the 100th meridian west of Greenwich. The South Canadian River forms the northern boundary, Dewey and Custer counties the eastern boundary, and Beckham the southern boundary. This county contains 25 complete townships and parts of 16 others. The area is approximately 1,160 square miles.

A branch line of the Santa Fe extends from Pampa, Texas, to Clinton, Oklahoma and follows the Washita River valley through Roger Mills County. The county has a population of 15,000 and Cheyenne, the county seat and pricipal town has about 1,200.

### TOPOGRAPHY

The northern part of Roger Mills County is drained by the South Canadian River and its tributaries and the central portion by the Washita River and its many tributaries, most important of which are Quartermaster, Nine Mile, Wild Horse, Dead Indian, Turkey, Rush, Croton, Broken Leg, Sergeant Major, Beaver Dam, Sandstone, Kiowa, and White Shield creeks. The southern part is drained by Meridian, Freezeout, Sweetwater, Buffalo, and Starvation creeks which flow into North Fork of Red River. With the exception of Washita River all of the streams of this county are intermittent due to light rainfall which averages only 22 inches annually. Timber is conspicuously absent.

The topography may be divided into two parts. The eastern two-thirds of the county is a plain broken by low lying sandstone hills while the eastern third is a sandy plain sloping gently southeast. The most important topographic features are the Antelope Hills (See plate VII-B) and the Twin Hills which rise approximately 100 feet above the surrounding plains. These are flat topped buttes capped by High Plains Tertiary rocks and caliche. The Twin Hills are located in the SE.¼ sec. 9, and the SW.¼ sec. 10, T. 16 N., R. 25 W., on the divide between the Washita and the Canadian rivers. The Antelope Hills are located in secs. 32 and 33, T. 17 N., R. 35 W., in the first northward bend of the Canadian River inside the Oklahoma line. These hills are the most characteristic landmarks in this portion of Oklahoma. A government benchmark and triangulation point of primary importance is found on the top of the highest and largest of these hills.

### GEOLOGY

#### Surface Formations

The following formations outcrop in Roger Mills County; Cloud Chief gypsum, Quartermaster formation, Cretaceous outliers, Tertiary gravel, possibly of Miocene and Pliocene age, and Quaternary gravels, sands, and caliche.



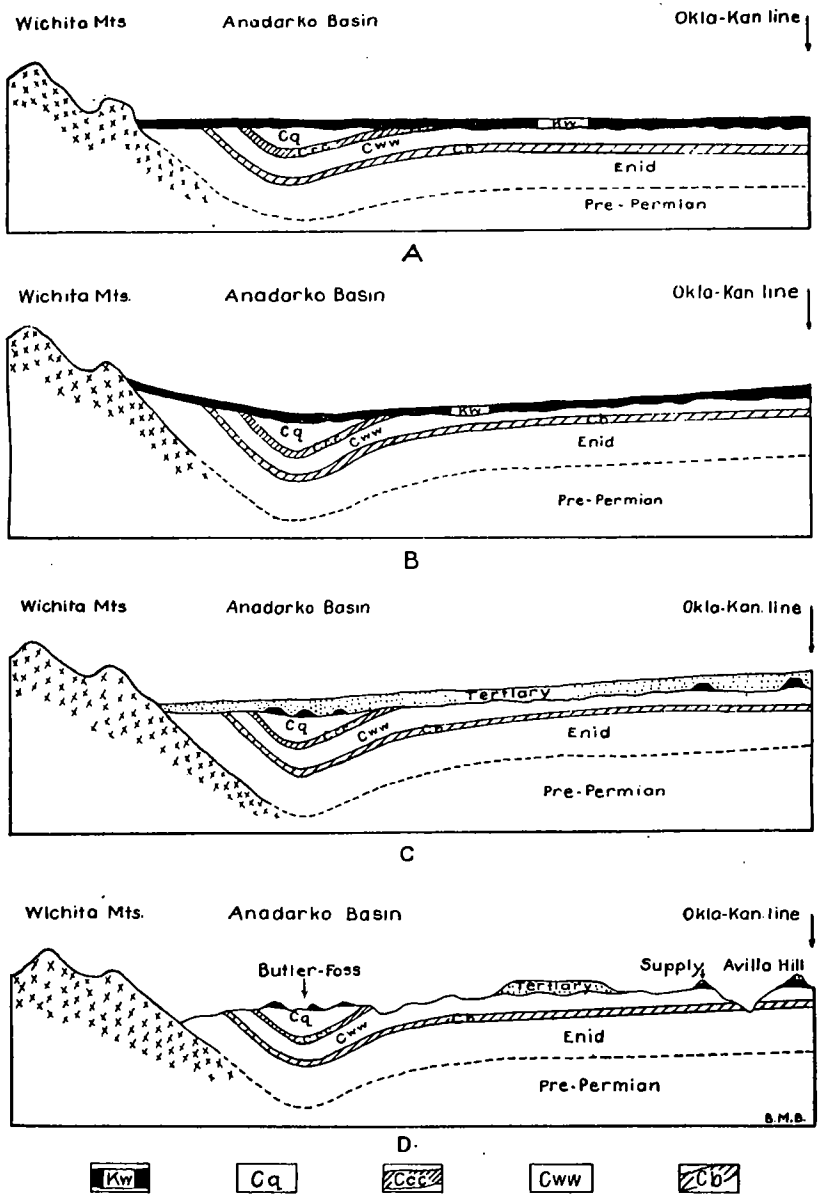
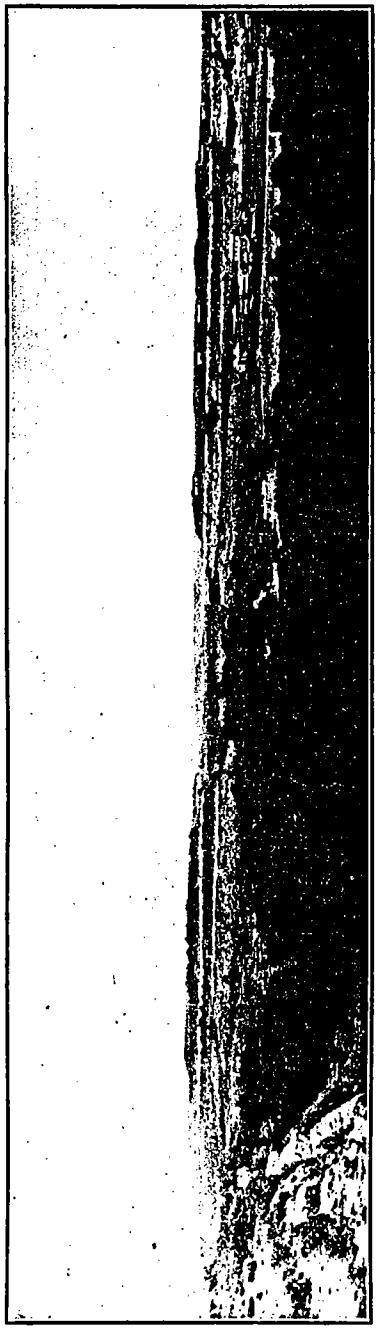
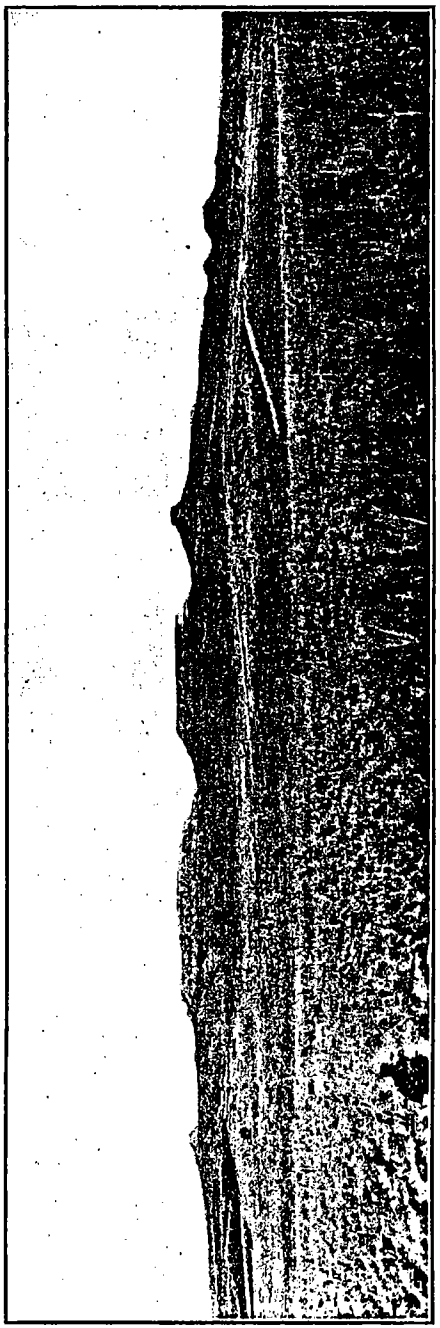



Figure 61. Diagrammatic representation of the stages in the geologic history of the Lower Cretaceous of western Oklahoma. (After Bullard)



A. BLAINE GYPSUM ESCARPMENTS IN ROMAN NOSE CANYON, BICKFORD, OKLA.



B. ANTELOPE HILLS IN ROGER MILLS COUNTY.





### CLOUD CHIEF FORMATION

This formation outcrops in the northern edge of the county and in the breaks south of the South Canadian River in the northeast portion in T. 16 N., R. 21 W. and in the eastern portion in the valleys of the Washita and its tributaries. Outcrops follow the Washita River valley as far west as Tps. 13 and 14 N., R. 24 W. The Cloud Chief has been described under Dewey County.

### QUARTERMASTER FORMATION

This formation is composed of dolomite at the base, massive lenticular sandstones in the central part and highly cross-bedded sandstones and shales in the upper part. It comprises the surface of most of the county and lies unconformably upon the Cloud Chief. Due to the physical character of the formation and the climatic environment, erosion has produced a characteristic topography. The red sandstone hillocks resulting are known as "haystack" topography. The surface is practically barren of vegetation.

### CRETACEOUS OUTLIERS

These occur as erosional remnants in the eastern part of the county near Hamon and Carpenter and are similar in every way to those described under Custer County and lie unconformably upon the Quartermaster.

### TERTIARY GRAVELS

These occur in at least two areas, one in the northeast part of the county in secs. 3, 4, 9, and 10, T. 16 N., R. 21 W., and on the northwest slope of the largest of the Antelope Hills. In these gravel deposits *Equus* and *Elephas* remains have been found which are probably Miocene. Other isolated outcrops of these gravels may occur.

### QUATERNARY SAND AND GRAVELS

Quaternary formations occur as gravel deposits along the western edge of the county and cover the divides eastward between South Canadian, Washita, and North Fork of Red rivers. The surface of these deposits is covered with scrub timber. Recent alluvium is abundant in the Washita Valley and also the valley of the South Canadian. These gravel deposits are a source of "sweet" water. As in other areas of western Oklahoma most of the water is saline or gypsiferous. The character of these deposits of gravel is similar to that described under Blaine County except that they are coarser.

## Subsurface Geology

Very little is known concerning the subsurface stratigraphy of Roger Mills County for the few wells drilled have not reached any

producing horizon to this date. Those formations which have producing horizons occurring to the northeast and south of this area should lie at great depths since this county lies in the bottom of the Anadarko Basin. The interpretation of subsurface conditions from data available at the surface is difficult to interpret because of the complex cross-bedding and slumping within the Quartermaster and the absence of mapable horizons in the overlying Quaternary gravels and sands.

The following series of logs of wells drilled in this county reveal the general character of the subsurface formations.

*Log of Principle Oil Co., Barker No. 1 well, SE.¼ NW.¼ SW.¼ sec. 3, T. 13 N., R. 26 W., Roger Mills County.*

[Elevation 2,248 (2,387)]

| Formation | Top | Bottom |
|---|---|---|
| Sand shale gyp & red bed | 0 | 600 |
| Brown shale | 600 | 660 |
| Gyp | 660 | 706 |
| Sandy lime & gyp | 706 | 848 |
| Crystalized sand rock | 848 | 908 |
| Broken sand shale and salt | 908 | 974 |
| Hard shale & lime | 974 | 1087 |
| Gumbo & boulders | 1087 | 1308 |
| Hard sand & salt | 1308 | 1497 |
| Gumbo | 1497 | 1548 |
| Brown shale & rock salt | 1548 | 1601 |
| Crystalized sand rock | 1601 | 1628 |
| Sandy shale & lime | 1628 | 1758 |
| Gumbo & boulders | 1758 | 1768 |
| Hard lime & sandy shale | 1768 | 1889 |
| Red rock & shale | 1889 | 1932 |
| Sandy lime | 1932 | 1992 |
| Shale & gumbo | 1992 | 2016 |
| Sandy lime | 2016 | 2045 |
| Hard shale | 2045 | 2080 |
| Sand rock | 2080 | 2100 |
| Broken lime | 2100 | 2143 |
| Gumbo | 2143 | 2197 |
| Sandy black shale | 2197 | 2208 |
| Hard sand show of oil | 2208 | 2222 |
| Rock salt & brown shale | 2222 | 2230 |
| Blue shale & ? ? | 2230 | 2248 |
| Broken shale & rock salt | 2248 | 2600 |
| Gumbo shale & boulders | 2600 | 2789 |
| Shale & shells | 2789 | 2814 |
| Sandy shale & shells Trace of gas | 2834 | 2898 |
| Blue shale gumbo & shells | 2898 | 3000 |
| Hard lime | 3000 | 3010 |
| Blue shale | 3010 | 3200 |
| Slate | 3200 | 3243 |
| Sandy lime | 3243 | 3267 |
| Blue shale | 3267 | 3340 |
| Slate | 3340 | 3360 |
| Blue shale | 3360 | 3400 |
| Total depth | | 3400' |

*Log of Porter Syndicate, Kendall No. 1 well, SW.¼ SE.¼ SE.¼ sec. 28, T. 14 N., R. 23 W., Roger Mills County.*

(Elevation 1,910)

| Formation | Top | Bottom |
|---|---|---|
| Quick sand | 0 | 56 |
| Pack sand—shale | 56 | 80 |
| Hard shale | 80 | 106 |
| Hard red sand | 106 | 255 |
| Red shale | 255 | 290 |
| Boulders—shale | 290 | 365 |
| Gyp—lime | 365 | 440 |
| Lime rock | 440 | 500 |
| Sandy lime rock | 500 | 540 |
| Lime—gyp | 540 | 594 |
| Broken sandy lime | 594 | 639 |
| Red rock | 639 | 692 |

(Continued on page 425)



| Formation | Top | Bottom |
|---|---|---|
| Sandy lime rock | 692 | 760 |
| Blue—red shale | 760 | 799 |
| Tough gumbo | 799 | 871 |
| White rock | 871 | 889 |
| Sandy lime rock | 889 | 900 |
| Hard shale | 900 | 972 |
| Gumbo—bldrs. | 972 | 1000 |
| Tough sticky shale | 1000 | 1057 |
| Hard red shale | 1057 | 1088 |
| Gumbo—bldrs. | 1088 | 1102 |
| Rock salt | 1102 | 1125 |
| Sand rock | 1125 | 1150 |
| Hard dry shale | 1150 | 1269 |
| Hard rock white | 1269 | 1314 |
| Hard sand rock | 1314 | 1397 |
| Rock salt | 1397 | 1410 |
| Blue lime rock | 1410 | 1450 |
| Hard red rock | 1450 | 1509 |
| Hard sand rock | 1509 | 1565 |
| Hard white rock | 1565 | 1625 |
| Boulders | 1625 | 1634 |
| Gumbo | 1634 | 1641 |
| Hard rock | 1641 | 1664 |
| Red sand rock | 1664 | 1672 |
| Hard sand rock | 1672 | 1689 |
| Blue shale | 1689 | 1696 |
| Hard white rock | 1696 | 1715 |
| Blue shale—bldrs. | 1715 | 1724 |
| Blue lime | 1724 | 1740 |
| Hard lime | 1740 | 1758 |
| Blue shale—bldrs. | 1758 | 1763 |
| Hard sandy shale | 1763 | 1772 |
| Sand lime | 1772 | 1774 |
| Blue sand shale | 1774 | 1780 |
| Gumbo | 1780 | 1800 |
| Sandy shale | 1800 | 1830 |
| Sticky mud | 1830 | 1840 |
| Fresh water sand | 1840 | 1849 |
| Hard sand | 1849 | 1853 |
| Water sand | 1853 | 1858 |
| Blue—red shale | 1858 | 1894 |
| Broken blue lime | 1894 | 1923 |
| Hard sandy shale | 1923 | 1956 |
| Gyp—lime | 1956 | 1968 |
| Water sand | 1968 | 1980 |
| Blue—red shale | 1980 | 1995 |
| Red sandy shale | 1995 | 2002 |
| Hard shale lime | 2002 | 2040 |
| Red—blue shale | 2040 | 2055 |
| Blue lime | 2055 | 2070 |
| Lime shell | 2070 | 2076 |
| Lime—shale | 2065 | 2080 |
| Blue—red shale | 2084 | 2092 |
| Brown sand | 2092 | 2098 |
| Blue—brown shale | 2098 | 2102 |
| Blue—red shale | 2102 | 2112 |
| Sandy lime—gyp | 2112 | 2130 |
| Brown shale | 2130 | 2140 |
| Sandy lime | 2140 | 2157 |
| Chocolate clay | 2157 | 2160 |
| Blue sandy lime | 2160 | 2165 |
| Brown sand | 2165 | 2168 |
| Chocolate clay—sand | 2168 | 2170 |
| Brown sand | 2170 | 2172 |

*Log of Morton & Co., L. Dean No. 1 well, NW.¼ NW.¼ NW.¼ sec. 32, T. 16 N., R. 22 W., Roger Mills County.*

| Formation | Top | Bottom |
|---|---|---|
| Red rock | 100 | 120 |
| Red sand | 120 | 150 |
| 25 bailers water | | |
| Rer rock | 150 | 165 |
| Red sand | 165 | 180 |
| 3 bailers water | | |
| Red shale | 180 | 200 |
| Red sand HFW | 200 | 300 |
| Red rock | 300 | 360 |
| Gyp rock | 360 | 362 |
| Red rock & shells | 362 | 450 |
| Sand red | 450 | 480 |
| Sand is dry | | |
| Red rock | 480 | 624 |
| Gyp lime white | 624 | 675 |
| Red rock | 675 | 680 |
| Gyp rock | 680 | 715 |
| Red rock | 715 | 760 |
| Blue shale | 760 | 767 |
| Gyp lime | 767 | 771 |
| Red shale | 771 | 825 |
| Blue shale | 825 | 852 |
| Red rock | 852 | 864 |
| Blue shale | 864 | 898 |
| Red rock | 898 | 1174 |
| Gyp rock | 1174 | 1175 |
| Red rock | 1175 | 1195 |
| Gyp shell | 1195 | 1197 |
| Red rock | 1197 | 1880 |
| Brown shale | 1880 | 1884 |
| Red shale | 1884 | 2019 |
| Blue shale | 2019 | 2060 |
| Red shale—T. D. | 2060 | 2365 |

The hole was not finished caused from fishing job loosing one jt. 10 pipe & 2 jts. 8¼ pipe which is the reason for plugging same.

*Log of Mutual Oil Co. Wilson No. 1 well, cen. S.½ N.½ NE.¼ SE.¼ sec. 1, T. 16 N., R. 21 W., Roger Mills County.*

(Elevation 2,266)

| Formation | Top | Bottom |
|---|---|---|
| Surface | 0 | 67 |
| Sand | 67 | 97 |
| Red beds | 97 | 140 |
| Red beds | 140 | 170 |
| Red beds | 170 | 230 |
| Red rock | 230 | 240 |
| Red beds | 240 | 265 |
| Red rock | 265 | 275 |
| Red beds | 275 | 300 |
| Sand rock | 300 | 307 |
| Gyp | 307 | 310 |
| Red beds | 310 | 314 |
| Rock | 314 | 365 |
| Broken rock | 366 | 376 |
| Red beds | 376 | 382 |
| Rock | 382 | 385 |
| Pack sand | 385 | 391 |
| Red bed | 391 | 410 |
| Rock | 410 | 426 |
| Red rock | 426 | 437 |
| Red sand | 437 | 445 |
| Red bed | 445 | 451 |
| Rock | 451 | 466 |
| Red bed | 466 | 475 |
| Rock | 475 | 490 |
| Soft sand | 490 | 535 |
| Rock | 535 | 538 |
| Sand rock | 538 | 547 |
| Red beds | 547 | 565 |
| Soft sand | 565 | 576 |
| Rock | 576 | 585 |
| Red bed | 585 | 591 |
| Rock | 591 | 595 |
| Red bed | 595 | 600 |
| Rock | 600 | 610 |
| Red beds | 610 | 615 |
| Hard rock | 615 | 641 |
| Soft sand | 641 | 644 |
| Rock | 644 | 674 |
| Lime | 674 | 780 |
| Rock | 780 | 806 |
| Gyp | 806 | 809 |
| Gumbo | 809 | 815 |
| Red bed | 815 | 820 |
| Gyp & rock | 820 | 837 |
| Hard rock | 837 | 839 |
| Gypsum | 839 | 879 |
| Hard red shale | 879 | 1008 |
| Hard red bed | 1008 | 1133 |
| Red bed & gyp | 1133 | 1207 |
| Gumbo | 1207 | 1218 |
| Blue shale and shell | 1218 | 1226 |
| Red shale hard | 1226 | 1259 |
| Rock | 1259 | 1264 |
| Red bed | 1264 | 1301 |
| Red bed & shale | 1301 | 1369 |
| Rock | 1369 | 1378 |
| Hard limy shale | 1378 | 1418 |
| Hard sandy shale broken | 1418 | 1502 |
| Brown shale | 1502 | 1508 |
| Broken lime & sandy shale | 1508 | 1564 |
| Red bed | 1564 | 1588 |
| Shale & shell | 1588 | 1610 |
| Rock | 1610 | 1617 |
| Broken & sandy shale | 1617 | 1640 |
| Sandy lime & hard shale | 1640 | 1680 |
| Sandy shale & red bed | 1680 | 1688 |
| Gypsum | 1688 | 1692 |
| Sandy shale | 1692 | 1704 |
| Sandy shale & red hard beds | 1704 | 1730 |
| Broken red beds & hard shale | 1730 | 1747 |
| Hard red bed | 1747 | 1793 |
| Hard sand & red bed | 1793 | 1811 |
| Brown shale | 1811 | 1820 |
| Hard sandy shale | 1820 | 1835 |
| Red shale | 1838 | 1840 |
| Hard sand | 1840 | 1847 |
| Sandy shale & hard sand | 1847 | 1861 |
| Hard sand | 1861 | 1866 |
| Broken shale & shell | 1866 | 1878 |
| Hard shale | 1878 | 1890 |
| Shale & red bed | 1890 | 1905 |
| Gumbo | 1905 | 1911 |
| Red bed | 1911 | 1922 |
| Hard sand | 1922 | 1929 |
| Hard shale & shell | 1929 | 1940 |
| Hard sand | 1940 | 1948 |
| Red bed | 1948 | 1959 |
| Hard sand | 1959 | 1968 |
| Broken red bed | 1968 | 1996 |
| Brown shale | 1996 | 2027 |
| Hard shale | 2027 | 2100 |
| Gumbo | 2100 | 2106 |
| Hard sandy shale | 2106 | 2136 |

(Continued on page 427)



| Formation | Top | Bottom |
|---|---|---|
| Shale | 2136 | 2160 |
| Gumbo | 2160 | 2188 |
| Shale | 2188 | 2206 |
| Red bed | 2206 | 2260 |
| Shale & slate | 2260 | 2279 |
| Red bed | 2279 | 2290 |
| Shale & shell | 2290 | 2303 |
| Red bed | 2303 | 2363 |
| Hard slate | 2363 | 2368 |
| Red bed | 2368 | 2396 |
| Broken shale & shell | 2396 | 2409 |
| Red bed | 2409 | 2556 |
| Red bed & gyp | 2556 | 2582 |
| Red shale & hard sand | 2582 | 2587 |
| Red bed | 2587 | 2593 |
| Red shale & sand | 2593 | 2633 |
| Hard shale & slate | 2633 | 2794 |
| Hard shale & gyp | 2794 | 2864 |
| Sand & slate | 2864 | 2866 |
| Hard shale & gyp | 2866 | 2934 |
| Lime | 2934 | 2941 |
| Hard shale & lime | 2941 | 2963 |
| Lime | 2963 | 2967 |
| Hard shale | 2967 | 2972 |
| Lime | 2972 | 2976 |
| Hard shale | 2976 | 2985 |
| Lime | 2985 | 2992 |
| Hard shale | 2992 | 2995 |
| Broken lime shell & shale | 2995 | 3026 |
| Lime | 3026 | 3041 |
| Broken shale | 3041 | 3045 |
| Broken lime | 3045 | 3054 |
| Lime | 3054 | 3077 |
| Gumbo | 3077 | 3080 |
| Shale | 3080 | 3088 |
| Lime | 3088 | 3096 |
| Shale | 3096 | 3108 |
| Broken lime | 3108 | 3116 |
| Broken lime & shale | 3116 | 3146 |
| Broken shale & shell | 3146 | 3180 |
| Sand rock | 3180 | 3190 |
| Gumbo & shale | 3190 | 3205 |
| Lime | 3205 | 3208 |
| Shale & lime shell | 3208 | 3228 |
| Sand rock | 3228 | 3235 |
| Gumbo & shale | 3235 | 3240 |
| Sand rock | 3240 | 3242 |
| Broken & lime | 3242 | 3287 |
| Rock broken | 3287 | 3319 |
| Blue shale | 3319 | 3321 |
| Rock | 3321 | 3383 |
| Viola rock | 3383 | 3386 |
| Rock—T. D. | 3386 | 3526 |

*Log of Roxana Pet. Corp., Selba well, CWL. NE.¼ NE.¼ sec. 9, T. 16 N., R. 21 W., Roger Mills County.*

(Elevation 2,219)

| Formation | Top | Bottom |
|---|---|---|
| Red shale | 0 | 310 |
| Gypsum | 310 | 325 |
| Red shale | 325 | 540 |
| Red sand | 540 | 567 |
| Gypsum | 567 | 569 |
| Red sand | 560 | 650 |
| Red shale | 650 | 690 |
| Blue shale | 690 | 700 |
| Red shale | 700 | 740 |
| Gypsum | 740 | 747 |
| Red brown shale | 747 | 765 |
| Gypsum | 765 | 795 |
| Red shale | 795 | 805 |
| Gypsum | 805 | 858 |
| Blue shale | 858 | 875 |
| Red shale | 875 | 895 |
| Blue shale | 895 | 905 |
| Red shale | 905 | 970 |
| Gypsum | 970 | 972 |
| Red shale | 972 | 1085 |
| Gyp & red shale | 1085 | 1090 |
| Red shale | 1090 | 1150 |
| Blue shale | 1150 | 1165 |
| Red shale | 1165 | 1270 |
| Red rock | 1270 | 1435 |
| Red mud | 1435 | 1950 |
| Red blue bands | 1950 | 1970 |
| Hard brown shale | 1970 | 2100 |
| Red and blue shale | 2100 | 2130 |
| Brown shale | 2130 | 2250 |
| Blue shale | 2250 | 2332 |
| Red shale | 2332 | 2345 |
| Brown shale | 2345 | 2352 |
| Blue shale | 2352 | 2381 |
| Brown shale | 2381 | 2725 |
| Hard gray lime | 2725 | 2726 |
| Brown shale | 2726 | 2750 |

(Continued on page 428)

| Formation | Top | Bottom |
|---|---|---|
| Brown & blue shale | 2750 | 2885 |
| Blue shale | 2885 | 2985 |
| Hard lime | 2985 | 3005 |
| Lime shell | 3005 | 3009 |
| Blue shale | 3009 | 3090 |
| Lime | 3090 | 3095 |
| Blue shale | 3095 | 3115 |
| Lime | 3115 | 3120 |
| Blue shale | 3120 | 3270 |
| Blue shale & shell | 3270 | 3325 |
| Blue shale | 3325 | 3330 |
| Blue shale & shell | 3330 | 3345 |
| Blue shale | 3345 | 3360 |
| Blue shale & shell | 3360 | 3375 |
| Blue shale & black shell | 3375 | 3385 |
| Blue shale & shells | 3385 | 3435 |
| Lime and shale breaks | 3435 | 3450 |
| Gray white lime | 3450 | 3570 |
| Lime & shale | 3570 | 3595 |
| Gray lime & shale | 3595 | 3655 |
| Blue shale & shells | 3655 | 3730 |
| Gray lime | 3730 | 3890 |
| Blue-black shale | 3890 | 3900 |
| Gray lime | 3900 | 3930 |
| Blue shale | 3930 | 3940 |
| Gray lime—T. D. | 3940 | 4055 |

*Log of Bu-Co-Oil Ref. Co., Garnett No. 1 well, SE.¼ SW.¼ SE.¼ sec. 27, T. 17 N., R. 21 W., Roger Mills County.*

(Elevation 2,175)

| Formation | Top | Bottom |
|---|---|---|
| Surface | 0 | 40 |
| Sand and gravel | 40 | 132 |
| Sand & rock | 132 | 156 |
| Red sand | 156 | 306 |
| Rock | 306 | 310 |
| Red sand | 310 | 420 |
| Rock | 420 | 430 |
| Sand | 430 | 440 |
| Rock | 440 | 445 |
| Sand | 445 | 493 |
| Rock | 493 | 500 |
| Soft rock | 500 | 560 |
| Soft rock layers & sand rock | 560 | 575 |
| Gyp rock | 575 | 580 |
| Rock sand & layers of rock | 580 | 615 |
| Rock sand & layers | 615 | 625 |
| Rock | 625 | 632 |
| Sandstone | 632 | 688 |
| Sand | 688 | 700 |
| Gyp rock | 700 | 705 |
| Sand | 705 | 710 |
| Rock chalk | 710 | 763 |
| Soft sand rock | 763 | 870 |
| Gumbo sand rock | 870 | 875 |
| Small showing of gas at 811' Approx 1,000,000. | | |
| Soft sand rock | 875 | 900 |
| Gumbo | 900 | 915 |
| Shale & sand | 915 | 950 |
| Sand rock | 950 | 985 |
| Shale | 985 | 1014 |
| Sand rock | 1014 | 1047 |
| Shale | 1047 | 1085 |
| Gumbo | 1085 | 1243 |
| Hard gray rock | 1243 | 1251 |
| Sand rock | 1251 | 1293 |
| Gumbo | 1293 | 1309 |
| Hard gray rock | 1309 | 1438 |
| Shale & sand | 1438 | 1498 |
| Hard gray rock | 1498 | 1527 |
| Hard rock | 1527 | 1532 |
| Shale & shell rock | 1532 | 1600 |
| Shell & Gumbo | 1600 | 1640 |
| Rock | 1640 | 1670 |
| Shell & rock | 1670 | 1890 |
| Rock | 1890 | 1900 |
| Shale | 1900 | 2008 |
| Rock | 2008 | 2010 |
| Shale | 2010 | 2153 |
| Total depth | | 2153 |

### Structural Geology

Roger Mills County lies at the bottom of the Anadarko Basin and most of it north of the axis. Accurate regional dips are difficult to determine for they are very low. They dip southwest in the northern part of the county and northeast in the southwestern part.



Numerous structural irregularities have been mapped and some wells have been drilled but most of those drilled have proved dry or have disappeared in depth. A large structure is reported to have been detailed in the southern portion of the county in the vicinity of Berlin, Grimes, and Sweetwater. Due to the proximity of this area to the Sayre field in Beckham County there has been considerable interest manifested. Smaller structures have been reported in the north and northwestern part of the county. Time alloted for field work in this and other counties covered by this report permitted only a superficial checking of reported structures.

### DEVELOPMENT

Numerous wells have been drilled in Roger Mills County with reported shows of gas and oil at various horizons and at shallow depths. These were, no doubt, drilled with the hope of encountering shallow producing horizons similar to those found in the Sayre field of Beckham County. Known producing horizons of surrounding areas should lie at great depths in this county because of reason mentioned before.

The table on page 431 gives a list of the wells drilled or drilling in this county up to date.

*Wells Drilled in Blaine County*

| COMPANY AND FARM | LOCATION | DEPTH Feet | ELEVATION Feet | RESULT |
|---|---|---|---|---|
| Deitz Co. Matthew's No. 1 | SE SE NW 20-15N-12W | 887 | 1,762 | Dry |
| Okomo Oil Co. Enlennein No. 1 | SE SE SW 21-15N-10W | 2,519 | 1,540 | Dry |
| | | 2,702 ? | | |
| Morgan Drilling Co. F. L. Chronister No. 1 | NW NW NE 7-18N-10W | 3,810 | 1,196 | Dry |
| The Ima Oil & Gas Co. Eberhart No. 1 | SW SW SW NW 7-18N-10W | 2,285 | 1,190 | Dry |
| Cozart No. 1 | NW NW NE 7-18N-10W | 1,542 | | Dry |
| Pingery et al. Barnett No. 1 | SW SW SW 23-15N-11W | 3,705 | 1,452 | Dry |
| | | 3,708 ? | | |
| Lowen & others. Unknown No. 1 | NW cor. SW NW 17-16N-11W | Spudded in | | Renewing leases shut down |
| Washoma Oil Co. et al. Phillips No. 1 | C NW SW 13-19N-10W | 2,935 | | Shut down |
| Watonga Oil Co. | NW NW 10-16N-11W | 1,021 | | Dry |
| Donnally Bros. (dt 10) Bought | SE SE 26-15N-12W | 3,215 | | Dry |
| | | 4,500 ? | | |

*Wells Drilled in Dewey County*

| COMPANY AND FARM | LOCATION | DEPTH Feet | ELEVATION Feet | RESULT |
|---|---|---|---|---|
| Morton & Co. Bartelsville Jessie | C. SE 22-16N-18W | 3,500 | 2,035 | Dry |
| Elder No. 1. | | 3,506? | | |
| McCoy et al. | NE 9-18N-15W | 4,500 ? | | Dry |
| | | 4,000 | | |
| ? | NE 16-9N-20W | 800 | 2,450 | Dry |
| ? | T. 16 N. R. 14W | ? | | |
| Garfield Oil Co. Enid | NW cor. 36-19N-30W | 730 ? | | |
| Kinnson & Small, Dallas, Texas | NW NW NE 34-20N-20W | 3,800 | | Gas at 1,100 |

*Wells Drilled in Custer County*

| COMPANY AND FARM | LOCATION | DEPTH Feet | ELEVATION Feet | RESULT |
|---|---|---|---|---|
| Parker et al, Robt. Ruth No. 1 | C SE NW 1, 15N-15W | 4,212 | 1,699 | Dry |
| Price and others | SW 36, 15N-18W | 4,000 ? | 1,705 ? | |
| | | 4,000 | | Through red beds |
| C. N. Lainard, Wichita, Kansas | SW SW 22, 15-N16W | ? | | |
| | SE NE 30, 13N-16W | 600 ? | | |
| Empire Oil and Gas, Stone No. 1 | SE SE SW 24-12N-14W | 3,497 | 1,685 | |
| Homaokla Oil Co. Wasman No. 1 | SW SW SE 21-13N-14W | 1,080 | 1,683 | |
| Clay et al. | SW 21-13N-14W | 1,100 ? | | |
| Clay et al. | NE 23-13N-14W | | | |
| W. E. Witt et al Wellman No. 1 | SW SE 1-14N-14W | | | Location |
| Day Oil Co. Miller No. 1 | SE SE SE 21-14N-17W | 3,508 | 1,770 | Rig & Tools |
| | | | 1,773 ? | |

*Wells Drilled in Roger Mills County*

| COMPANY AND FARM | LOCATION | DEPTH Feet | ELEVATION Feet | RESULT |
|---|---|---|---|---|
| Principle Oil Co. Barker No. 1 | 3-13N-26W | 3,400 | 2,248 ? | Dry |
| Porter Syndicate J. H. Kendall No. 1 | SW SE SE 28-14N-23W | 2,172 | 2,387 ? 1,910 | Dry |
| Morton & Co. L. Dean No. 1 | 32-16N-22W | 2,365 | 1,795 ? | |
| Mutual Oil Co. Wilson No. 1 | C. S½ N½ NE ? | | | Dry |
| Roxana Petroleum Co. W. E. Selba No. 1 | CWL NE NE 9-16N-21W | 4,055 | 2,219 | Dry |
| Bu-Co Oil Co. Garnett No. 1 | SE SW SE 27-17N-21W | 2,153 | 2,175 | Dry |
| | | 2,175 ? | | |
| Bucy and Stone, Williams No. 1 | C SW 23-12N-24W | 2,245 | | |
| L. C. Hivick, Davis No. 1 | C NW NE 4-11N-26W | 2,905 | | Drilling |
| J. J. Rook, Shotwell No. 1 | 4-11N-26W | 2,316 | | Shut Down |

# OKLAHOMA COUNTY

By

A. Travis

## INTRODUCTION

During the last year Oklahoma County has attracted the interest and attention of oil men as a large oil producing area. The Oklahoma City field has had a total recovery, to March 1, 1930, of 15,473,973 barrels of oil under a stringent proration program. This curtailment has been in effect almost from the beginning of development. Production is now prorated at 16 2/3 per cent of initial flow. The production in the county is almost entirely from the Oklahoma City pool. The gravity of the oil is 38° to 42° A. P. I. The several wildcat tests now being drilled in the county, when completed, will indicate future prospects of Oklahoma County as an oil producing area.

Figure 61. Index map of Oklahoma showing location of Oklahoma County.

The study of geology in Oklahoma County has been along the most modern methods. Oil companies have established subsurface departments, micro-paleontological departments, and so on.

This paper is not a complete one but summarizes the information obtainable to April 16, 1930.

The writer has been aided in gathering ideas and facts by numerous geologists. He gratefully acknowledges the assistance and guidance of Dr. G. E. Anderson of the School of Geology, University of Oklahoma. He also is greatly indebted to Mr. Robert Whiteside, Mr. Charles Love, and Mr. R. D. Jones of the Shell Petroleum Corp.; to Mr. Hubert E. Bale of the Atkinson Oil Co.; to Mr. J. T. Richards of the Gypsy Oil Co.; to Mr. Frederick Bush of the Sinclair Oil and Gas

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Co.; and to Mr. Glenn Grimes of the Wirt Franklin Petroleum Corp. He also wishes to thank the Indian Territory Illuminating Oil Company for permission to publish the surface structure map accompanying this report.

## HISTORY OF DEVELOPMENT[1]

It very often happens that differences of opinion arise regarding the discovery of the structure of an oil field. The Oklahoma City field is no exception. I have been at some pains to endeavor to sift out the claims of the different geologists who have been connected with the finding of the structure at Oklahoma City. The statements herewith represent my best judgment in the matter.

The first well drilled for oil in Oklahoma County which reached a depth of over 500 feet was located one-fourth mile south of Spencer. The company which financed the well was organized by E. J. Streeter, a hardware merchant in Oklahoma City, who was the moving factor of the organization. L. C. Hivick was the contractor. The well was drilled in 1903, and reached a reported depth of 2,002 feet.

From time to time other wells were drilled in Oklahoma and adjoining counties. Six wells drilled in Oklahoma County are reported in Bulletin 19, pt. 2, Oklahoma Geological Survey, published in 1917, (p. 365).

All these wells were located without geological advice and for the most part were drilled by promoters and financed by local capital.

The two geologists who first observed a favorable oil structure near Oklahoma City were probably Geo. D. Morgan and Jerry B. Newby. The exact dates when these first observations were made seem to have been lost. Morgan says, "In either 1917 or 1919, and I can not remember which year, I worked out the structure at Oklahoma City." Everett Carpenter, to whom Morgan referred me, says, "I am of the opinion it was about 1917." Jerry B. Newby, who also worked out the structure, says, "My work north and northeast of Oklahoma City was done in the early part of 1919."

L. E. Trout, in the fall of 1919 maade a reconnaissance of the area and "Late in 1920 or early in 1921," mapped an area in southern Oklahoma and northern Cleveland counties in what is now the southern part of the Oklahoma City field. This seems to have been the first structure map prepared of the region. With Trout were associated S. H. Woods, Claude Dalley, and L. R. Trout. In 1925 a well located by Trout in sec. 36, T. 11 N., R. 2 W., near the Cleveland County line, was drilled to a depth of 4,480 feet. Several minor shows of oil were reported.

In 1925 John R. Bunn worked out a surface high north of the State Capitol and a deep test (7,180 feet) drilled by Cromwell-Franklin,

1. Gould, Chas. N., Personal communication; the quoted material in this discussion of the history of development in Oklahoma County is from letters on file at the Oklahoma Geological Survey.



Thompson No. 1, (SE.¼ NE.¼ sec. 15, T. 12 N., R. 2 W.) found water in the Wilcox. This well had several minor shows in shallower horizons. An earlier well drilled not far away is the discovery well of Oklahoma County.

E. A. Paschal in 1926, while employed by the Coline Company traced the Hennessey-Garber contact and recognized the presenqe of a fold south of Oklahoma City. Upon the recommendation of C. T. Moore, then chief geologist of the company, three leases were purchased in the area, all of which are now producing.

So the presence of a structure lying north, northeast, and southeast of Oklahoma City has been a matter of general geologic knowledge for several years, and a number of geologists not mentioned herewith have at various times noted the structure.

In 1927 Dr. G. E. Anderson, working independently while doing reconnaissance work for the Indian Territory Illuminating Oil Company, reported a southward projecting nose running through Oklahoma City. He outlined this nose on the Garber-Hennessey contact, and it is shown in the surface geologic map accompanying this report (Map No. XXXIX). Following Anderson's report, the detailed geology of Tps. 10 and 12 N., Rs. 2 and 3 W., was structurally mapped for the geological department of the Indian Territory Illuminating Oil Company in February, 1928, by C. L. Wagner, under the supervision of J. H. Derden and C. W. Roop; and this work was approved by R. J. Riggs, chief geologist.

The Indian Territory Illuminating Oil Company then blocked approximately 10,000 acres on this structure. A location was made in the SE.¼ SE.¼ sec. 24, T. 11 N., R. 3 W., and drilling began in June, 1928. This well had several showings, the most important ones being 3,997 to 4,012 feet where 25,000,000 cubic feet of gas was encountered, and another at 4,805 to 4,816 feet where 47,000,000 cubic feet of gas was encountered. Passing out of Pennsylvanian rocks at 6,100 feet, the well went into Ordovician and was completed as a producer of approximately 5,000 barrels of 39° oil per day, at a depth of 6,355 to 6,498 feet in a porous dolomite. This well was called the I. T. I. O.-Foster, Oklahoma City No. 1. This well has since passed the million barrel mark and is still making about 370 barrels per day. This produces, completed December 4, 1928, started a tremendous drilling campaign and at this date of writing there are more than 200 oil and gas wells in the Oklahoma City area, with a potential production of over a million barrels per day.

## GENERAL FEATURES

Oklahoma County covers an area of 720 square miles and geographically is located approximately in the center of the State. It includes Tps. 11 to 14 N., Rs. 1 E. to 4 W.

### Drainage and Relief

There are three general drainage areas in the county. The largest drainage system is in the southern part of the county. The North Fork of Canadian River flows east, draining this southern area. This river heads in the northern part of New Mexico and flows in a general southeastern direction, draining into Canadian River. It has wide, flat alluvial valleys. An interesting feature of this river is that it is 200 feet higher than the drainage system north of it, Deep Fork of Canadian River. This tributary of the Canadian flowing northeast, drains the northeastern part of the county, and where it leaves the county (northeastern part) is the lowest point in the area, NE.¼, NE.¼, SE.¼ sec. 12, T. 14 N., R. 1 E., at an elevation of 870 feet. This drainage pattern extends as far southwest as Bethany, and trends to the northeast into Canadian River in the eastern part of the State. The northwestern part of the county drains to the north into Cottonwood Creek which in turn drains into the Cimarron River. This threefold drainage system has many well developed short tributaries.

The highest point, 1,390 feet above sea level, is in the southwestern part of the county. The topography, which represents a mature stage of erosion, consists of low rounded hills, prairie flats, and Recent stream deposits of sand and alluvium.

The soil is chiefly sandy and shaly, and much of the land is not cultivated. Wheat, cotton, alfalfa, and corn are the main crops. Scrub oaks in great number are found growing in the sandy phases of the county, but are not found in the shale areas.

Soft water is found in the Garber sandstone of the Permian rocks while hard water is found in the Hennessey shale.

## GEOLOGY

### Surface Formations

The surface rocks of the county belong to the Enid group of the Permian, which is the lower part of the Permian found in Oklahoma. The Enid group of Oklahoma correlates with the lower part of early Permian of Germany, the Rotliegende formation. Unconsolidated gravels cap the hills, Recent alluvium is found in the river flats, especially in the North Fork of Canadian River. Sand dunes are also found along the banks of this river. Wind blown sand may be found at a distance of 4½ miles from the river, mainly on the north side due to prevailing south winds.

ENID GROUP
- Chickasha
- Duncan
- Hennessey
- Garber
- Wellington
- Stillwater



The Enid formation is divided into six members, Stillwater being the oldest and Chickasha the youngest.[1]

In going from west to east across Oklahoma County, the following members of the Enid outcrop: Duncan, Hennessey, Garber, and Wellington. An areal map of the county shows the extent of each formation. These formations have a general north-south strike and dip to the west at the rate of approximately 30 to 35 feet per mile. They are apparently conformable.

### RECENT SEDIMENTS

The river valley flats have large deposits of alluvial material, especially on the north side of the North Fork of Canadian River. Wind blown sand is found covering the adjacent country several miles away from the river, due to the prevailing south winds. Dunes having a height of 20 feet are found. Along the Deep Fork of Canadian River the deposits are much thinner and less widespread.

### DUNCAN SANDSTONE

The Duncan sandstone conformably overlies the Hennessey. It is found only in the extreme southwestern corner of the county, near Wheatland. The base is composed of massive red sandstone, soft and friable. The total thickness of the Duncan ranges from 100 to 300 feet, but in Oklahoma County only the lower 50 feet are exposed.

### HENNESSEY SHALE

The Hennessey shale rests upon the Garber and is overlain by the Duncan sandstone. Both upper and lower contacts are apparently conformable. The Hennessey covers the western one-third of the county and is characterized by predominately red shales. The shales generally thin and weather to a grayish brown loam, which is rather easy to follow along the outcrop. The Hennessey at the type locality[2] has been divided into two members, a lower member, the Fairmont shale, and an upper member, the Bison. The Fairmont is composed chiefly of deep red clay shale, laminated. It has scattered thin white or greenish bands, which have the same composition and character. The Fairmont is composed of alternating hard and soft layers of clean sandstone which, on erosion, leave ridges or shoulders. The Bison banded member is composed of red shales not quite as deep a red as the Fairmont member. Another distinguishing characteristic is the occurrence of white or greenish bands of shale, which are, in places, sandy or limy. These divisions of the Hennessey are not indicated on the areal map. The thickness of the Hennessey is about 650 feet in Oklahoma County, and it weathers to a dark soil, giving a relatively smooth topography.

1. Aurin, F. L., Officer, H. G., and Gould, Chas. N., The subdivision of the Enid formation: Bull. Am. Assoc. Pet. Geol. vol. 10, pp. 786-799, 1926.
2. Aurin, F. L., Officer, H. G., and Gould, Chas. N. The subdivisions of the Enid formation; Bull. Am. Assoc. Pet. Geol., vol. 10, no. 8, pp. 786-799, 1926.

*Generalized geologic section, Oklahoma County*

| SYSTEM | FORMATION | | THICKNESS | TYPE OF ROCK |
|---|---|---|---|---|
| QUATERNARY | Recent | | 0–60 | Alluvium, sand, and clay |
| PERMIAN | Duncan ss. | | 50± | Massive red sandstone |
| | Hennessey sh. | | 650± | Red shales |
| | Garber ss. | | 300± | Massive red and orange sandstone, interbedded with thin red shales |
| | Wellington fm. | | 500± | Red sandstone with interbedded shale |
| | Stillwater fm.* | | 800± | Red and gray sandstones and red shales |
| PENNSYLVANIAN | Pontotoc group | | 1,350± | Red and brown shales with a few thin limestones |
| | Pawhuska fm. | | 350± | Light gray limestones with intervening shale |
| | Hoover series | | 600± | Brown and gray sands |
| | Oread ls. | | 100± | Limestone with a little sand and shale |
| | Tonkawa series | | 500± | Brown and gray shale |
| | Layton series | | 500± | Sandstone series with interbedded thin limestones |
| | Checkerboard ls. | | 90± | Limestone with small shale break |
| | Uncorrelated sec. | | 700± | Dark shales |
| | Oswego ls. | | 40± | Thin limestone with interneving shale |
| | Cherokee sh. | | 100-300 | Dark shale with few limestones and sandstones; "Prue Sand" near top. |
| | | | | "Detrital Zone" |
| MISSISSIPIAN | Mayes ls. | | 0–35 | Gray cherty limestone |
| | Woodford sh. | | 0–60 | Black shale, with chert |
| SILURO-DEVONIAN | Hunton fm. | | 0–350 | Limestone, buff in color |
| ORDOVICIAN | Sylvan sh. | | 0–130 | Green shale. |
| | Viola ls. (Fernvale) | | 0–40 | Coarsely crystalline limestone, light buff in color |
| | Upper Simpson | Simpson Formation | 0–200 | Dense limestone with dolomite break below |
| | Wilcox sand horizon | Simpson Formation | 0–250 | Chiefly sand; may have shale interstratified; productive. |
| | Lower Simpson | Simpson Formation | 0–490 | Sandstone and shale members. Productive |
| | Arbuckle ls. | | 500 | Chiefly dolomite. Productive |
| CAMBRIAN | | | | |

*NOTE: Formations down to the Stillwater outcrop.



### GARBER SANDSTONE

The Garber sandstone is overlain by the Hennessey shale and underlain by the Wellington formation. Both contacts are apparently conformable. However, the actual contact of the Garber and Wellington is only approximately shown on the areal map because of the wind blown sand which blankets the outcrops along North Fork of Canadian River. The Garber sandstone covers the middle one-third of the county and weathers to rough, hilly topography.

The Garber, approximately 300 feet thick, is characterized by massive red and orange sandstone lenses interbedded with thin shales. The lower part of the Garber is principally red shale with some lenticular red sandstones, especially at the base where a rather prominent red sandstone is found. At the type locality the Garber has been differentiated into two members.[3] The lower member, chiefly shale, has been called the Lucien shale, a portion of the Garber composed largely of red clay shales with several ledges of red sandstone interfingered. The upper member of the Garber has been called the Hayward sandstone member. This member, composed of massive red sandstone is cross-bedded and interstratified with thin beds of red shale. This upper sandstone enables one to differentiate the Garber from the overlying Hennessey. Above this sandstone occurs a red shale, which maintains a rather constant thickness of 5 feet. The writer places the top of the Garber at the top of this 5-foot shale bed. The difficulty of remaining on the same sandstone member has caused a great deal of uncertainty in the surface work in the county.

Above this 5-foot shale occurs a dolomitic red conglomerate one to three feet in thickness. Overlying this is a sand member about 14 feet thick. Then succeeds a red shale containing small dolomite concretions about ¼- to ½-inch in diameter, having a thickness of about 30 feet. Overlying this is a red sandstone, 2 to 6 feet thick, with finely laminated red shales. This sandstone forms escarpments in the basal Hennessey. Above this is found another red shale with white dolomite streaks running through it. It has a thickness of about 30 feet. Overlying this is found a 4-foot red sandstone having white, thin dolomite streaks. Figure 62 is a diagram showing the relationships of the above described beds.

The Garber-Hennessey contact crosses the south county line in sec. 35, T. 11 N., R. 2 W., continues north very irregularly to sec. 14, T. 12 N., R. 2 W., where it abruptly turns southwest to the SE.¼ sec. 7, T. 11 N., R. 2 W. From there the trend is directly south to the center of sec. 30, T. 11 N., R. 2 W., where it swings around to the north, until it reaches the Oklahoma City city limits in the northwest part of sec. 11, T. 11, N., R. 3 W. It then swings west through the city, coming out just north of the State Capitol where it takes an irregular trend east of Britton and the eastern part of Edmond, then north to sec. 1, T. 14 N., R. 3 W., where it abruptly swings west to the

3. Aurin, F. L., Officer, H. G., and Gould, Chas. N., op. cit.

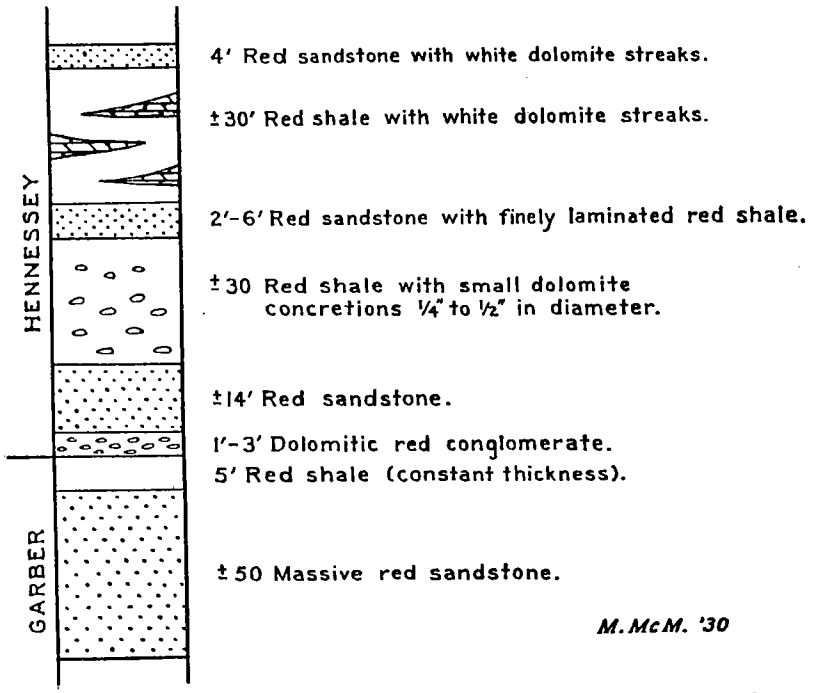



Figure 62. Ideal section of Garber sandstone overlain by sandstone members of lower Hennessey.

southwest part of sec. 3, T. 14 N., R. 3 W. Thence south to sec. 29 T. 14 N., R. 3 W., where it swings north, making another large protuberance. It crosses the north county line in sec. 5, T. 14 N., R. 3 W. (See Map No. XXXVII.)

### WELLINGTON FORMATION

The Wellington formation, underlain by the Stillwater and overlain by the Garber, occupies the eastern one-third of the county and is composed of essentially red sandstone with interbedded shale. At the base of the formation is the Herington limestone which outcrops north and east of Oklahoma County. The sandstone is massive, red to gray in color, and fine grained. The shales are usually red but may vary to gray or black, and are moderately thick. The sandstones are covered with timber, chiefly scrub oak, though the shales are quite barren. The sandstones are cross-bedded and barite crystals (roses) are found at several horizons in the sandstone phases of the formation. The Wellington correlates with the Wellington shale of the Kansas section of the Permian, but the character is different. In Kansas it is made



up chiefly of gray-blue shales and has the Herington limestone at the base. The Wellington has a strike approximately north-south and dips to the west at the rate of 30 to 35 feet per mile. It has an approximate thickness of 500 feet. The contact of the Wellington and Stillwater is not well defined and becomes increasingly obscure southward.

## Subsurface Formations

## PERMIAN

### STILLWATER FORMATION

The Stillwater formation underlies the Wellington and it is found outcropping in Lincoln County. It is a series of red and gray sandstones and red shales. The base of the formation is the base of the Cottonwood limestone which is used as the Pennsylvanian-Permian contact by the U. S. Geological Survey. The top of the formation is the top of the Herington limestone, which occurs as a limestone north into Kansas. Neither the base nor the top of the Stillwater has been accurately mapped at this time. The thickness is believed to be approximately 800 feet.[4]

## PENNSYLVANIAN

Pennsylvanian rocks vary in thickness in the Oklahoma City area from 4,000 to 4,100 feet, and are first encountered at a depth of approximately 2,000 feet. In the northeastern part of the county the Pennsylvanian is reached at about 1,400 feet below the surface. The Pennsylvanian sediments dip approximately 50 feet per mile to the west. These rocks are composed chiefly of shale with about equal quantities of sandstone and limestone. In one Pennsylvanian section (in the Oklahoma City area) 75 per cent is shale, 13 per cent sandstone, and 12 per cent limestone. At the present time this section can not be subdivided into its various formations with certainty due to the differences in lithology, thickness, and additional beds that do not correspond with exposed outcrops. Therefore the Pennsylvanian correlations are generalized and by no means final. At the present time the Pennsylvanian-Permian contact cannot accurately be drawn. Only an approximation can be used because, in going east across the strike of the Garber and Wellington, the base of the Wellington is not distinguishable from the top of the Stillwater formation. The same is true with the Stillwater formation and the Pontotoc group.

### PONTOTOC GROUP

The Pontotoc group as defined by Morgan,[5] consists of three formations, in ascending order; the Vanoss, Stratford, and Konawa. The Konawa consists chiefly of red shales, while the Stratford and Vanoss are composed of drak brown shales with a few thin limestones. The combined thickness of the group in Pontotoc County is 1,400 feet. The

4. Aurin, F. L., Officer, H. G., and Gould, Chas. N., op. cit.
5. Morgan, George D., Geology of the Stonewall quadrangle: Bureau of Geology, Bull. 2, pp. 132-141, 1924.

age, according to Morgan is upper Pennsylvanian and lower Permian.[6] The upper Pontotoc is the time equivalent of the Stillwater to the north.

The correlation of the Pennsylvanian formations in Oklahoma County with Pennsylvanian sections to the east and to the north do not check in detail. From the east the general correlation is higher, while from the north the subsurface correlation seems to fit better if shifted some 200 feet lower.

The general correlation used in this bulletin is after Bush who was the first to correlate the entire section in the Oklahoma City area with a section from the east.[7]

### PAWHUSKA FORMATION

Below the Pontotoc group is the Pawhuska formation. This formation consists of three limestones generally light gray, with intervening brown and gray shales. White massive sand and some white tripoli are also found in the formation. It has an approximate thickness of 350 feet, and correlates with the lower part of the Shawnee formation of the Kansas section.

### HOOVER SERIES

Underlying the Pawhuska formation is a series of sediments called Hoover, consisting generally of a sand zone at the top, shale in the center, and another sand zone at the base. The sands are brown and gray, even grained, subangular, and loosely cemented. The shales are brown and gray. A few thin light gray and platy limestones are found at the top of the sands. At the base of the Hoover series are more limestone beds which are dark brown and oolitic. The series has a thickness of about 550 to 600 feet. It is upper Pennsylvanian in age and correlates with the lower part of the Shawnee and the upper part of the Douglas formations of the Kansas section.

### OREAD LIMESTONE

The Oread limestone is immediately below the Hoover series and at the top has a limestone member 20 feet thick. It is white, finely arenaceous, containing the microfossil *Triticites*. Fine sand and shale make up the lower part of the formation. It has a total thickness of approximately 100 feet. The age is Conemaugh, correlating with the upper part of the Douglas formation of the Kansas section.

### TONKAWA SERIES

Underlying the Oread is the Tonkawa series which is essentially brown and gray shale with some sandstone and limestone members at the top. The sands are loosely cemented, fairly porous, buff colored,

6. Morgan, George D., op. cit., pp. 132-141.
7. Bush, F. A., personal communication.



and the grains are angular. The shales are intercalated with red clays. The limestones which occur in the upper portion of the series are drab gray in color, finely crystalline, intercalated with dark brown clay shale. The series has an average thickness of about 500 feet. The age of the Tonkawa series is Conemaugh and it correlates with basal Douglas and all of the Lansing formation in the Kansas section.

### LAYTON SERIES

The Layton series is below the Tonkawa series. It is primarily a sandstone with shale and intercalated limestone. At the top of the series are some thin platy limestones which are white to drab in color. The shales found at the top and at the base are dark brown. The sandstones might be placed in four zones, the uppermost being about 60 feet thick, a fine subangular sand, well cemented. Below this is another zone which is sandy shale, being an arenaceous light gray shale and sand with gray arenaceous bond, about 60 feet thick. The third zone is a massive light brown, well bonded, quartzose sand about 70 feet thick. The lowest sandstone, composed of subangular and well assorted grains, is about 20 feet thick. This series has been found to contain gas production in the upper or first sand zone and oil shows in the lower zone. The age of the Layton series is Conemaugh and correlates with the upper Kansas City formation of the Kansas section. The Layton has a thickness of about 500 feet.

### CHECKERBOARD LIMESTONE

Below the Layton series is the Checkerboard limestone in the Oklahoma City area. Gould[8] describes the Checkerboard as a member of the Coffeyville formation lying near the base, having a thickness of 2½ to 3 feet thick, fine grained, and fossiliferous. In Oklahoma County the lithology and microfossil evidences are the same, but position and thickness are different. Bush believes that the Checkerboard limestone is placed just as correctly there (as is known in the Oklahoma City field) as anywhere lower. Several Oklahoma City geologists believe it is lower in the section some 200 feet, because it fits in better with a section traced from the northern part of the State. It is essentially a limestone, light gray, medium crystalline to a buff, finely crystalline, and slightly porous. The upper limestone is about 60 feet thick under which is a shale ten feet thick. Below the shale is another limestone, dark, dense, and intercalated with dark gray shale. The lower limestone member has a thickness of 20 feet and the approximate total thickness of the Checkerboard limestone is therefore 90 feet. It is of Conemaugh age and correlates with the lower part of the Kansas City formation in the Kansas section.

### UNCORRELATED BEDS

Below the Checkerboard limestone and above the Oswego limestone are a group of shales with a few thin limestone and sandstone

8. Gould, Chas. N., Index to the stratigraphy of Oklahoma: Oklahoma Geol. Survey Bull. 35, p. 73, 1925.

members. The shales are dark gray in color. The interval between the base of the Checkerboard limestone and the base of the Oswego limestone correlates with the Marmaton formation of the Kansas section. A closer subdivision of this section is very difficult to make at this time. Bush suggests in his original log of the Oklahoma City area that approximately 150 feet below the base of the Checkerboard (composed chiefly of shale with several thin bedded limestones) occurs what should be called the Coffeyville formation, and the remaining 550 feet of dark shales should be referred to as the Nowata shale.[9] However, the Coffeyville formation, as described by Gould at its type locality, has the Checkerboard limestone near the base of the formation.[10] It will be very difficult to correlate these beds with other sections due to additions or thickening of members such as are described above. The Marmation formation is Allegheny in age.

#### OSWEGO LIMESTONE

Below the uncorrelated section occurs the Oswego limestone which has, at the top, a limestone member which is dark in color and finely crystalline. In the middle portion the Oswego limestone has a thin, dark shale member. At the base occurs a dense fossiliferous limestone. The Oswego has a thickness of about 40 feet. It is known as the Fort Scott limestone at the base of the Marmaton group in the Kansas section. It is of Allegheny age.

#### CHEROKEE SHALE

Below the Oswego limestone is the Cherokee shale which is mostly dark shale, and has a varying thickness according to its relation to structure. Near the top of the formation is an oil-stained, subangular, loosely bonded, micaceous sandstone which is known as the "Prue sand" in the Oklahoma City area. Near the base are several thin limestone shells which are light gray in color, dense to coarsely crystalline, and dolomitic, with some included sand. The Cherokee shale is the basal formation of the Pennsylvanian, and it corresponds to late Pottsville and early Allegheny time. It has a thickness of 100 to 300 feet and correlates with the Cherokee shales of the Kansas section.

#### "DETRITAL ZONE"

At the base of the Pennsylvanian rocks is a large unconformity which indicates that at some time later than Mayes the whole area (around Oklahoma City) was uplifted and remained a positive element while erosion truncated the Mayes limestone, Woodford, Hunton, Sylvan, Viola, Simpson, and approximately 300 feet of Arbuckle limestone before invasion by the Pennsylvanian sea. A sheet of detrital material of varying thickness was spread over the truncated sediments. The detritus is composed almost wholly of reworked Simpson material.

9. Bush, F. A., personal communication.
10. Gould, Chas. N., Index to the stratigraphy of Oklahoma: Oklahoma Geol. Survey Bull. 35, p. 72, 1925.



The zone shows no bedding and is poorly sorted as to size and character of material. The term "detrital zone" was started and is current in the Oklahoma City pool. It should no doubt receive a name just as the Sylamore sandstone (also called Misener sand) in northeastern Oklahoma. The nature of deposition and stratigraphic relation of the Sylamore sandstone are somewhat analagous to the "detrital zone".

### MISSISSIPPIAN

#### MAYES LIMESTONE

Mississippian rocks are found in several wells off the Oklahoma City structure. They are not present on structure due to their removal by erosion. In the Slick-Banta No. 1 well a thickness of about 22 feet of Mayes limestone was found. It is a gray cherty limestone, of Chester age or older, and correlates with the lower part of the Caney shale. The Cherokee shales lie unconformably on this Mayes section.

#### WOODFORD SHALE

Below the Mayes is found the Woodford which is primarily a black shale with several interstratified chert beds and disseminated pyritic material. In the Martin well, sec. 13, T. 13 N., R. 1 W., it has a thickness of 42 feet. It is probably basal Mississippian in age and is generally correlated with the Chattanooga shale.

### DEVONIAN-SILURIAN

#### HUNTON FORMATION

The Hunton limestone is found below the Woodford, but it is not differentiated into its members in wells in this area. In the Martin well, sec. 13, T. 13 N., R. 1 W., it had a thickness of 70 feet. At the top it is a buff-colored, dense, weathered limestone, which grades into a white, dense limestone with coarse calcite crystals near the middle. It becomes finely crystalline and at the base it is white and pink, coarsely crystalline, and marly. In the Slick-Prairie-Phillips No. 1 Sudik, sec. 8, T. 10 N., R. 2 W., there are 300 feet of Hunton limestone. In the Prairie-Slick No. 1 Banta, sec. 18, T. 11 N., R. 2 W. there are 350 feet of Hunton. In age the Hunton limestone may represent Alexandrian and Niagaran of Silurian and Helderbergian time of Devonian.

### ORDOVICIAN

#### SYLVAN SHALE

Underlying the Hunton is the Sylvan which is a light green and gray in color, flaky, splintery, soft shale containing graptolites. In the Martin well, sec. 13, T. 13 N., R. 1 W., there are 95 feet of Sylvan; in the Sudik well, sec. 8, T. 10 N., R. 2 W., 130 feet. In age it is Richmond time of the Ordovician. However some consider the Richmond to be the lower part of the Silurian system.

### VIOLA LIMESTONE

Below the Sylvan shale is the Viola limestone which has a thickness of 0 to 40 feet. It is white to pink in color, coarsely crystalline, and contains few fossils. Fanny C. Edson[11] states that the Viola limestone in the Mid-Continent region has two members, the upper one a coarsely crystalline limestone which she calls Richmond bed, and a lower bed, buff and dense, which she calls lithographic bed of probable Black River age.

Underlying the coarsely crystalline limestone is a light gray to drab dense limestone which is considered to be the top of the Simpson in this area. This dense limestone is also called the top of the Simpson in Seminole County.[12]

White[13] states that the Viola limestone observed in east-central Oklahoma is the Richmond phase of the Viola limestone of the Arbuckle Mountains and correlates with the Fernvale limestone of Arkansas.

Whether the dense limestone is a member of the Viola is questionable and either interpretation may be correct. It is considered the top of the Simpson by most of the men working in the Oklahoma City area.

In the Arbuckle Mountains, the Fernvale phase of the Viola is separated from the Simpson by 500 to 600 feet of middle Viola limestone. This horizon is not present in Oklahoma County, probably due to erosion.

### SIMPSON FORMATION

The Simpson formation underlies the Viola limestone unconformably and has a total thickness of 813 feet in the Martin well in sec. 13, T. 13 N., R. 1 W., this being the only well going through the entire section of Simpson.

The Simpson has recently been subdivided into several divisions by Decker and Merritt,[14] in the Arbuckle Mountains. The writer has divided the Simpson formation in Oklahoma County into three parts for convenience in description and cross-sections:

3. Upper Simpson (all Simpson above Wilcox)
2. Wilcox sand horizon
1. Lower Simpson (all Simpson below Wilcox)

The upper Simpson is 72 feet thick in the Martin well, sec. 13, T. 13 N., R. 1 W., and is composed of a dense lithographic limestone member at the top 30 feet thick and probably correlative with the dense

11. Edson, Fanny C., Ordovician correlation in Oklahoma: Bull. Amer. Assn. Pet. Geol. Vol. 11, pp. 968-970, 1927.
12. Levorsen, A. I., Geology of Seminole County, Oklahoma: Geol. Survey Bull. 40-BB, p. 25, 1928.
13. White, L. H., op. cit. p. 18.
14. Decker, Chas. E., and Merritt, C. A., Subdivisions of the Simpson formation: Oklahoma Geol. Survey, mimeographed pamphlet.



limestone member of the Seminole section. The remaining 42 feet of alternating limestone and dolomite cannot be as readily correlated with the Seminole section. The dolomite is buff in color and dense. Near the base of the upper Simpson is a thin bed of white dense chert. In the Sudik well, sec. 8, T. 10 N., R. 2 W., a thickness of 200 feet of upper Simpson is found which shows the extent of lateral gradation and southward divergence of the Simpson section as compared with the Martin well.[15] The age of the Simpson above the Wilcox (upper Simpson) is Black River.

The second division or Wilcox sand horizon has a thickness of 250 feet in the Martin well and is composed of sand, white in color, loosely bonded with frosted, rounded, and subangular grains. There are a few thin pyrite seams disseminated in the sand section. However, in the Sinclair School Land 67, sec. 36, T. 11 N., R. 3 W. No. 1, the Wilcox is not found as an entire sand body but has thin green shales interbedded through it. The age of the Wilcox is basal Black River (Ordovician).[16]

The Wilcox sand horizon has been proved productive of oil in the south end of the Oklahoma City pool and probably will be found productive elsewhere in the county.

The third division or lower Simpson has a thickness of 489 feet in the Martin well. The upper portion is sandy with interbedded bright green splintery shale beds, and a little dolomite. Under this occurs a series alternating maroon and green, soft splintery shales including some rounded and frosted sand, and intercalated with thin sand shells. This is probably the Tyner member as described by Weirich.[17] The Tyner correlates with the McLish division of the Simpson and is upper Chazy in age.[18] Below this is a sand 45 feet thick, white in color, subangular, and frosted which may be the Burgen sandstone. The Burgen sandstone occurs at the base of the McLish division of the Simpson and is Chazy in age.[19] Below the sandstone is a broken series of sandstone, dark green shale, sucrose dolomite, and limestone. This series has a thickness of 110 feet in the Martin well. A sandstone having a thickness of 55 feet occurs below the broken series. The sand is white in color, rounded, frosted, subangular, loosely cemented, poorly assorted, and has a little dolomite. The broken series and this sandstone probably belong to the Oil Creek division of the Simpson formation, the age of the Oil Creek being lower Chazy, as proposed by Decker and Merritt.[20]

15. Weirich, T. E., Features of the Simpson formation: Oil and Gas Journal, April 24, 1930.
16. Decker, C. E., and Merritt, C. A., Correlation table of formations of the Simpson group: Oklahoma Geol. Survey, mimeograph pamphlet.
17. Weirch, T. E., op. cit.
18. Decker, C. E., and Merritt, C. A., op. cit.
19. Decker, C. E., and Merritt, C. A., op. cit.
20. Decker, C. E., and Merritt, C. A., op. cit.

The attempted subdivision of the lower Simpson is from the Martin well in sec. 13, T. 13 N., R. 1 W., which went through a complete section of the Simpson and into the Arbuckle. A finer division in the Oklahoma City field would be difficult, due to an incomplete section and changes in lithology. Therefore, the writer has made the general subdivision "lower Simpson" which is merely indicative of position in reference to the Wilcox sand.

### ARBUCKLE LIMESTONE

The Arbuckle limestone which lies below the Simpson formation is composed essentially of dolomite, light brown to buff in color, highly porous, coarsely sucrose, massive, and intersected by many small fissures. As found exposed in the Arbuckle Mountains the Arbuckle limestone has a measured thickness of 7,872 feet.[21] The Arbuckle limestone is probably thinner in the Oklahoma City area due to erosion.

In the Arbuckle Mountains the upper part of the Arbuckle is limestone while the lower part is dolomitic. This leads to the question as to what part of the Arbuckle is found below the Simpson in the Oklahoma City field. White[22] indicates a considerable truncation of the Arbuckle in northern Oklahoma. However, at the present time there are not enough deep wells between the Arbuckle Mountains and the Oklahoma City field to definitely correlate the Arbuckle limestone which is found in this county. The age of the Arbuckle limestone, according to Ulrich[24] is upper Cambrian and lower Ordovican.

### GEOLOGIC HISTORY

During lower and middle Cambrian time, Oklahoma was undergoing erosion and the area must have been low and relatively peneplained. Deposits of residual material resulted from erosion of igneous bedrock. As upper Cambrian seas invaded Oklahoma, they came primarily by the way of the Sonoric embayment from the southwest across Texas and joined the Ouachitaic embayment from the east and probably covered the entire State.[25] Wilson also suggests that the clastic sediments of the Reagan sandstone were the first deposits formed as the invading sea worked over the residual material of the igneous bedrock and that the seas cleared and the Arbuckle limestone was then laid down.

At the close of the Arbuckle limestone deposition, there was a complete emergence and the seas next invaded from the east through the Ouachitaic embayment.[26] This places an unconformity between the

21. Decker, C. E., and Merritt, C. A., Physical characteristics of the Arbuckle limestone: Oklahoma Geol. Survey Cir. 15, p. 15, 1928.
22. White, Luther H., Subsurface distribution and correlation of the pre-Chattnooga ("Wilcox" sand) series of northeastern Oklahoma: Oklahoma Geol. Survey Bull. 40-B, p. 11, 1926.
23. White, Luther H., op. cit., p. 11.
24. Ulrich, E. O., Revision of Paleozoic systems: Bull. Geol. Soc. America, vol. 22, pl. 27, p. 608, 1911.
25. Goull, Chas. N., and Wilson, R. A., Upper Paleozoics of Oklahoma: Oklahoma Geol. Survey Bull. 41, p. 34, 1927.
26. Gould, Chas. N., and Wilson, R. A., op. cit.



top of the Arbuckle limestone and the Simpson formation. The erosion taking place during this unconformity would account for the drainage channel or sink hole that is found in the Arbuckle limestone in the Gildden No. 1, and No. 2 wells in sec. 13, T. 11 N., R. 3 W., which reached the top of the Arbuckle some 400 feet lower than in the north, south, and east offsets. (See figure 67, page 460.)

Evidence that erosion removed some of the Arbuckle limestone is found in the northeastern part of Oklahoma. Following deposition of the Arbuckle limestone and previous to early Simpson time, the Ozark area was uplifted and subjected to erosion. The beds were truncated more to the north than to the south.[27]

Morgan discovered evidence of this period of erosion in studying the Simpson formation in the Stonewall quadrangle. Describing the thickness and character of the Simpson, he states,[28]

> The absence of the lower portion of the Simpson formation to the north and the more clastic nature of subsequent portions of the formation in that direction, suggest an Ordovician land mass to the north of the Arbuckle area over which the Simpson sea gradually encroached.

The highly porous upper part of the Arbuckle limestone also suggests that it was exposed to weathering.

Following deposition and erosion of the Arbuckle limestone the advance of the Simpson sea, with minor oscillations, from the east through the Ouachitaic embayment deposited the lower Simpson, Wilcox, and upper Simpson. Weirich[29] suggests that during Tyner time (lower Simpson) subaerial conditions controlled deposition and that the presence of maroon shales suggests a possible unconformity existing in the middle of the Tyner. At the end of deposition of the upper Simpson a retreat of the sea resulted in the erosion of a part of the upper Simpson. This break is not very clearly defined in the Oklahoma City area, a difference in thickness of upper Simpson in the Martin well, sec. 13, T. 13 N., R. 1 W., as compared with the much greater thickness in the Sudik well, sec. 8, T. 10 N., R. 2 W., might indicate the break. In the Seminole area Levorsen states:[30]

> Locally the Viola limestone is apparently conformable on the underlying Simpson formation but over broad areas it overlaps the entire middle and lower Viola and the upper Simpson section.

The Richmond sea next invaded Oklahoma, coming from the southeast, and it was during this time that the maximum Richmond invasion of North America occurred. This invasion caused deposition of the

27. White, Luther H., Op. cit., p. 11.
28. Morgan, Geo. D., Geology of the Stonewall quadrangle; Bureau of Geol. Bull. 2, p. 26, 1924.
29. Weirch, T. E., op. cit. p. 112.
30. Levorsen, A. I., Geology of Seminole County: Oklahoma Geol. Survey Bull. 40-BB, p. 24, 1928.

coarsely crystalline Viola member which is at the top and called the Richmond bed by Edson.[31] The sea also deposited the Sylvan shale, which is conformable with the Viola limestone throughout the state. White[32] suggests that the upper part of the Viola limestone, being so much more widespread than the lower and thicker portions of the formation, and conformity of the Viola-Sylvan contact, indicate that the Ordovician-Silurian boundary should be placed below Richmond.

A deepening of the Sylvan sea caused deposition of the Hunton limestone. In Oklahoma County, so far as known, the Hunton overlies the Sylvan conformably; but some wells in the future will probably discover Sylvan in contact with Pennsylvanian, because in the Oklahoma City area there are formations both above and below the Sylvan that have unconformable contact with Pennsylvanian rocks. However, this unconformity would not indicate that the Hunton limestone was laid down unconformably on Sylvan, but that after conformable deposition., erosion truncated the Hunton down to the Sylvan. At the end of Hunton time the sea retreated to the northeast and the Hunton limestone was exposed to erosion. The amount eroded is variable; in the Slick-Banta No. 1 well in sec. 18, T. 11 N., R. 2 W., there is 350 feet, while in the Martin well in sec. 13, T. 13 N., R. 1 W., there is 65 feet of Hunton limestone. This period of erosion lasted until lower Mississippian time when seas coming from the northeast deposited Woodford shale and the overlying Mayes limestone. Whether the Mayes is conformable on Woodford is questionable. The Mayes limestone which is correlated with the base of the Caney shale is the uppermost Mississippian formation found in the county. At the close of Mayes limestone deposition the Oklahoma City area was uplifted and subjected to erosion sufficient to expose the Arbuckle limestone, or until the invasion of the Cherokee sea. All of the State except the southeastern part became elevated during upper Mississippian or at the end of Caney time. The gentle downwarping in the southeast due to the Ouachitaic embayment and relative elevation of the rest of the State, exposed a large part of Oklahoma to erosion. The great unconformity in the Oklahoma City area was the result of this widespread erosion at the close of the Mississippian.

This uncomformity represents a time interval from post-Mayes to early Pennsylvanian. The unconformity is very marked in the Oklahoma City area due to erosion debris left on the eroded surface This represents, in part, what has been called "detrital zone" in the Oklahoma City field. A thin blanket of this detrital material is found in contact with the Arbuckle, Simpson, Viola, Hunton, and with Mayes. The material was derived chiefly from the Simpson formation.

Contemporaneous with uplift or soon after a large normal fault with its axis trending approximately N. 35° W. occurred. A line

31. Edson, Fanny Carter, Ordovician correlation in Oklahoma: Bull. Am. Ass'n. Petr. Geol., Vol. 11, pp. 968-970, 1927.
32. White, Luther H., op. cit., p. 18.



drawn through the northwest corner of sec. 18, T. 11 N., R. 2 W. and continued through the southeast corner of sec. 10, T. 11 N., R. 2 W. will approximate the strike of this fault. (see fig. 67).

The fault is found in subsurface correlation and does not find expression at the surface, but passes into a fold and is reflected as a steep east dip. The Prairie-Slick Hiddleston No. 2 penetrated the top of the Hunton at -5,433 feet while one location south the Shell Petty No. 3 found the top of the Arbuckle at -4,863 feet, giving the Hunton an average thickness of 150 feet (it varies from 50 to 350 feet) and the section below the Hunton to the top of the Arbuckle a thickness of 950 feet (taken from the Martin well) would give a throw of 1,700 to 1,800 feet. Another contact which shows the fault clearly is the Slick Banta No. 1 in sec. 18, T. 11 N., R. 2 W., which had the top of the Hunton at -5,531 feet and the I. T. I. O. Farley No. 3 which is 1,220 feet west and 660 feet south had the top of the Arbuckle at -4,805. This comparison gives a throw of about 1,800 feet. The length or extent of the fault is not now known, but it is at least 2½ miles long and probably longer. (see fig. 67).

The upthrow of the fault raised the west side and allowed erosion to act rapidly whereas the east side was relatively much lower and suffered little or no erosion. This erosion removed the Mayes, Woodford, Hunton, Sylvan, Viola, Simpson, and about 300 feet of Arbuckle limestone. By projecting the Arbuckle limestone, it is estimated that 300 feet was removed.

The early Pennsylvanian seas which deposited the Wapanucka limestone and upper Caney did not invade Oklahoma County for they were too far south. The Hunton arch and Ozark arch further restricted the lower Pennsylvanian seas to the southeast during Atoka, Hartshorne-McAlester-Winslow time.[33]

A complete submergence of the Ozark arch at the close of Winslow time began the Cherokee, or Pennsylvanian, sediments in Oklahoma County.

A series of minor oscillations throughout the remainder of the Pennsylvanian deposition may have caused minor unconformities but the Pennsylvanian sea as a whole remained over Oklahoma County until middle Wabaunsee time when a great area in southeastern Oklahoma, Arkansas, and northwest Louisiana was uplifted, causing a recession of the Pennsylvanian sea to the west and south.[34] This allowed rapid erosion and deposition of large quantities of clastic sediments on the northwest flank known generally as the red beds. It was during this time that the Pontotoc, Stillwater, Wellington, and Garber formations

33. Dott, Robert H., Pennsylvanian paleography: Oklahoma Geol. Survey, Bull. 40-J, 1927.
34. Anderson, G. E., Geology of Cleveland and McClain counties: Oklahoma Geol. Survey Bull. 40-N, p. 16, 1927.

were deposited.[35] In the sea to the west and north their marine equivalents are interfingered with the red beds during minor oscillations of sea. The Hennessey shale was then deposited over the Garber and this was followed by deposition of the Duncan sandstone. The Duncan was the last Permian bed to be deposited in Oklahoma County. Part of the Wellington, all of the Garber, and Hennessey, and part of the Duncan are found outcropping in the county and overlying each other to the west. After the Permian deposition in the county, elevation and erosion has been taking place from Permian to Recent.

## STRUCTURE

### Surface Structure

Structurally, the surface formations in Oklahoma County form a gentle west-dipping monocline. The formations become progressively younger to the west, all of them being apparently conformable. The strike of the Permian surface formations is slightly west of north, and the beds have a normal west dip of 30 to 35 feet per mile.

This west-dipping monocline, as a whole, is quite uniform. However, there are irregularities which may cover an area of several miles. The arching or flexure of the Garber sandstone south of Oklahoma City shows an abnormality in the occurrence of an east dip. Taking a point on top of the Garber approximately 7 miles east of the Oklahoma City structure, the elevation is 1,200 feet. Going west, the top of the Garber at the highest point on structure should be (using normal west dip of 30 to 35 feet per mile) 230 feet below surface. On top of the structure the top of the Garber, however, is found at an elevation of 1,325 feet, which, in elevation, is 125 feet higher than the top of the

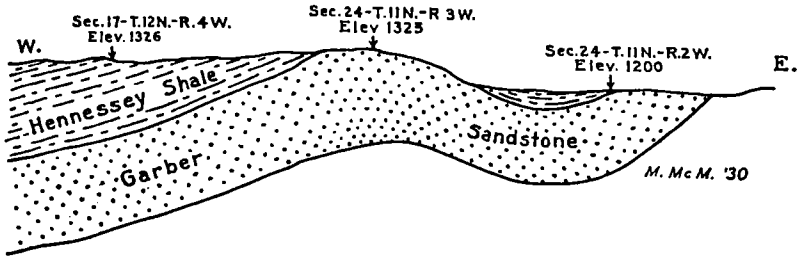



Figure 63. Generalized cross-section showing the arching of the Garber sandstone from east to west across the Oklahoma City field.

Garber 7 miles to the east. This 125 feet plus 230 feet that should be allowed for a normal west dip, gives the Garber an arching of 360 feet. Going north and west to the Bethany well, sec. 17, T. 12 N., R. 4 W.

35. Idem.



the top of the Garber was reported some 200 feet below surface and the elevation approximately the same as on the Oklahoma City structure. This would represent a normal west dip. (see fig. 63).

The arching south of Oklahoma City shows 120 feet of closure on the Garber sandstone at the surface. (see fig. 64). This fold may be classed as a dome and is the only one which has been proved in the county.

There are other surface and subsurface structures reported in the county, but data on these are still held confidential by the oil companies.

A subsurface fault striking in a northwest-southeast direction on the east side of the Oklahoma City structure finds no surface expression as a fault, but the fault is reflected in a steepening of the east dip on the surface structure (note steepening on surface structure, fig. 64).

The beds that are used as key beds in maping surface structure in the county are the massive sandstone at the top of the Garber, and the three sandstone members in the base of the Hennessey (described under Surface Formations). These beds seem to maintain a fairly constant interval and can be traced from the northern part to the southern part of the county.

### Subsurface Structure

The subsurface structure may best be discussed if divided into two parts, early Paleozoic and late Paleozoic; the former to include all sediments up to Pennsylvanian and the latter to include Pennsylvanian and Permian.

#### LATE PALEOZOIC STRUCTURE

The Permian and Pennsylvanian rocks that are found below the surface dip west at approximately 50 feet per mile. The entire Pennsylvanian section reflects the surface structure the same as the surface, but shows more closure than the surface beds. (Note structure maps on Pawhuska formation and Checkerboard limestone, figs. 65 and 66).

#### EARLY PALEOZOIC STRUCTURE

In general, the members of early Paleozoic formations are parallel and reflect the structure nearly the same as the Pennsylvanian-Permian section. The thickening of the Simpson to the south and variable thickness of the Hunton would tend toward divergence. Also the complete removal of all the early Paleozoic sediments down to the Arbuckle limestone gives a convergence.

The total structural relief of the Arbuckle limestone in Oklahoma County can not be determined accurately at this time due to lack of data. However, the estimated relief is about 2,400 feet. A structural contour map on the Arbuckle is shown in figure 67.

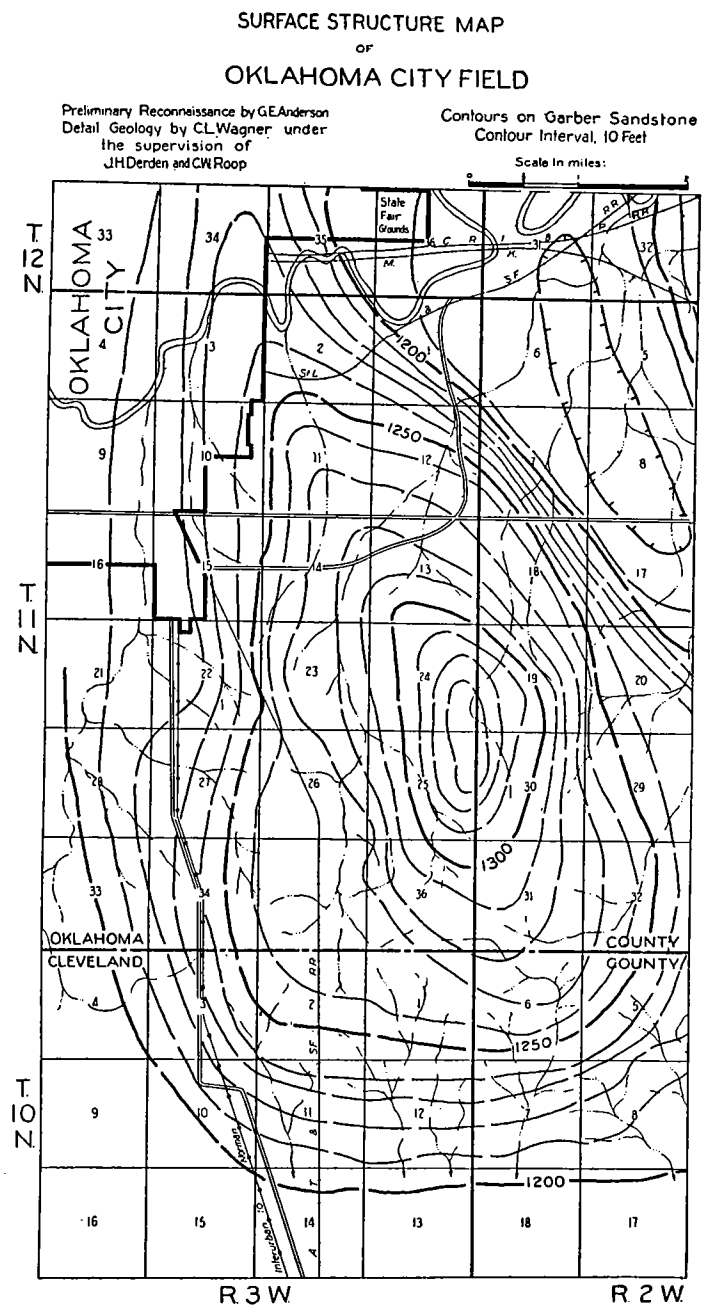



Figure 64. Surface map of the Oklahoma City field. Contours on the Garber sandstone. Contour interval, 10 feet. Map used through courtesy of I. T. I. O., R. J. Riggs, Chief Geologist.



### Origin of Oklahoma City Structure

The rocks thus far found in Oklahoma County are of sedimentary origin. However their original attitude has been changed and, through deep well records, some idea of the geological history is derived. The present structure of the Oklahoma City pool is believed to have developed in the following manner.

The first determinable structural movement that affected the region probably came at the close of Mayes time when the Oklahoma City area was uplifted. During or immediately following this uplift, base leveling occurred and the formations were eroded from the structurally high area. This truncation included Mayes, Woodford, Hunton, Sylvan, Viola, Simpson, and approximately 300 feet of Arbuckle limestone. These truncated surfaces, excluding the Arbuckle limestone, are found successively underneath the Pennsylvanian formations on the flanks of the field with a covering of the detrital material. During or immediately following this post-Mayes uplift, a large normal fault was developed on the east side of the structure causing the downthrow side (east side) to retain a full section while the upthrow side was exposed and truncated. As the erosion neared base level the Cherokee sea advanced, depositing material first on the flanks, and then over the crest, giving a much thicker section on the margins of the structure.

Another structural movement of major importance that is evidenced by subsurface records is between Oswego and Checkerboard times. Contouring the top of the Oswego limestone there is an offset of 400 feet in wells 660 feet apart (Slick-Hiddleston No. 2, and Shell, Petty No. 3). Although this was not as great as the first one, it tends to show that the structural high was not derived by a single uplift.

The Oklahoma City structure shows a decrease in closure progressively higher in the section, so that at the surface a closure of about 125 feet is found as compared to the 450 feet (and probably more) of known closure on the Arbuckle limestone.

There was perhaps much post-Permian deformation, but it probably was not as great a deformation as that which occurred at the close of the Mississippian or in early Pennsylvanian.

## DEVELOPMENT

### Oklahoma City Field

The first and most prolific oil horizon found in the Oklahoma City pool was the Arbuckle limestone. Production is generally found at different horizons in the upper 400 feet of the formation. Production comes chiefly from a porous dolomite found at approximately 6,000 to 6,500 feet in depth.

Above the Arbuckle limestone and on the flanks, production is found in the sand horizons of the lower Simpson. These wells, while

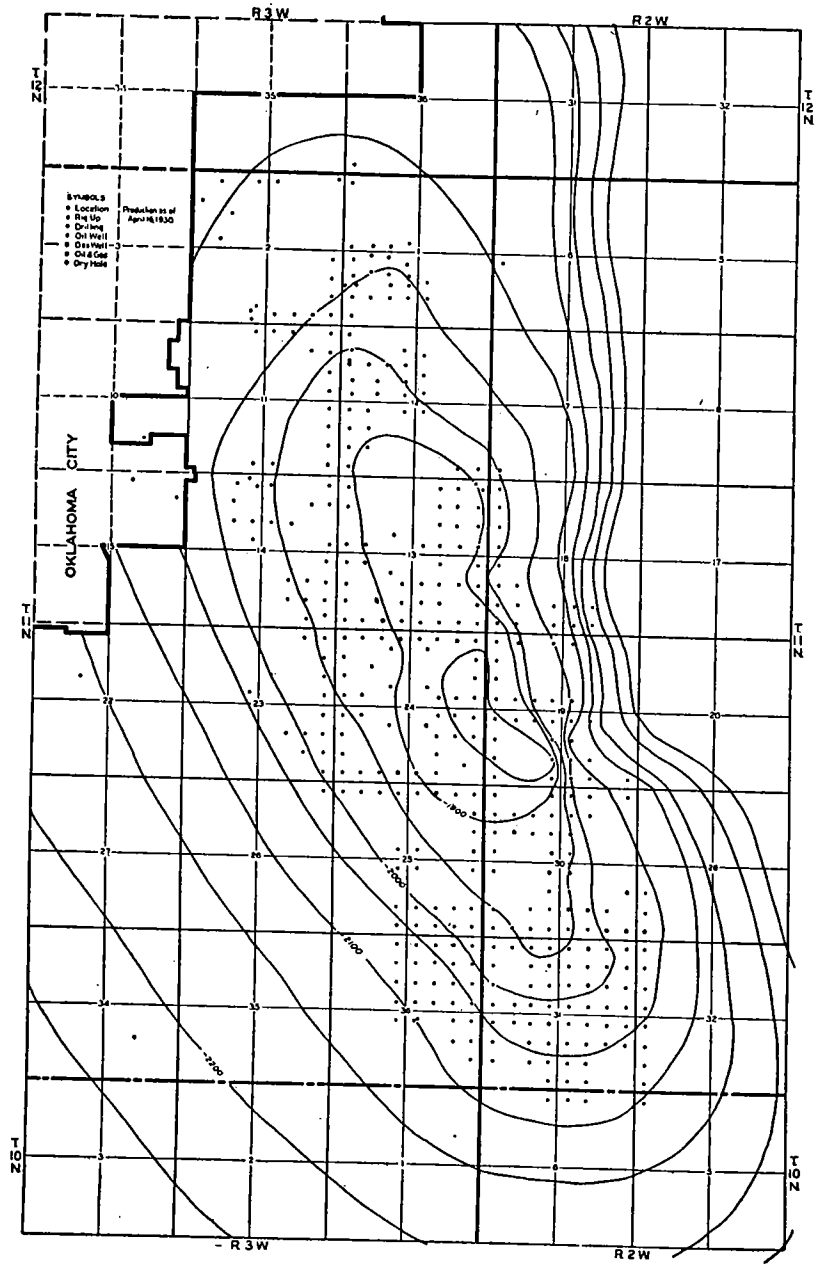



Figure 65. Subsurface map of the Oklahoma City field. Contours on top of the Pawhuska limestone. Contour interval, 50 feet.



not quite as large in their flush production, do not show water as do the wells in the Arbuckle limestone.

Above the lower Simpson production still farther out on the flanks of the structure production is found in the Wilcox sand horizon. As yet, only a few wells are completed in this sand, but these have been very prolific.

The above three horizons are the chief producers in the field and most wells are drilled to one or more of these horizons.

There are a few shallow horizons that are productive of oil and gas.

A good show of oil was found in several wells at approximately 6,250 feet in the Prue sand.

Gas was found in considerable abundance at 5,500 feet in an oolitic limestone below the Checkerboard limestone.

In the Checkerboard lime, found at 5,200 feet, a trace of oil and 1,000,000 cubic feet of gas were found. This productive horizon was found in several wells.

Gas is found in both the upper and lower parts of the Layton series, which is encountered at approximately 4,700 feet in depth. The upper Layton sand produced 47 million cubic feet of gas in the discovery well. The I. T. I. O.-Foster Trosper No. 1 well tested 200 barrels per day in the Layton.

Above the Layton, gas is found in both upper and lower parts of the Tonkawa series. This series is found at approximately 4,200 feet.

In the Hoover series, which is above the Tonkawa, the I. T. I. O.-Foster Oklahoma City No. 1, found 25,000,000 cubic feet of gas in the lower part of the series. The Hoover series is found at approximately 3,600 feet.

In addition to these oil and gas horizons, numerous shows are found in the shallower horizons but are not commercial.

## DRILLING AND PRODUCTION METHODS

The first few shallow wells in the county were drilled with cable tools. Later the rotary was used down to the Arbuckle limestone where it was standardized and the wells drilled in with cable tools. This change always caused a great amount of trouble and expense and the chances for fishing jobs increased due to drilling into high pressure gas zone. Now the general practice is to drill the wells complete with rotary tools.

Three strings of casing are generally used. The surface pipe (15½-inch) is cemented at 200 to 300 feet with 400 to 600 sacks of

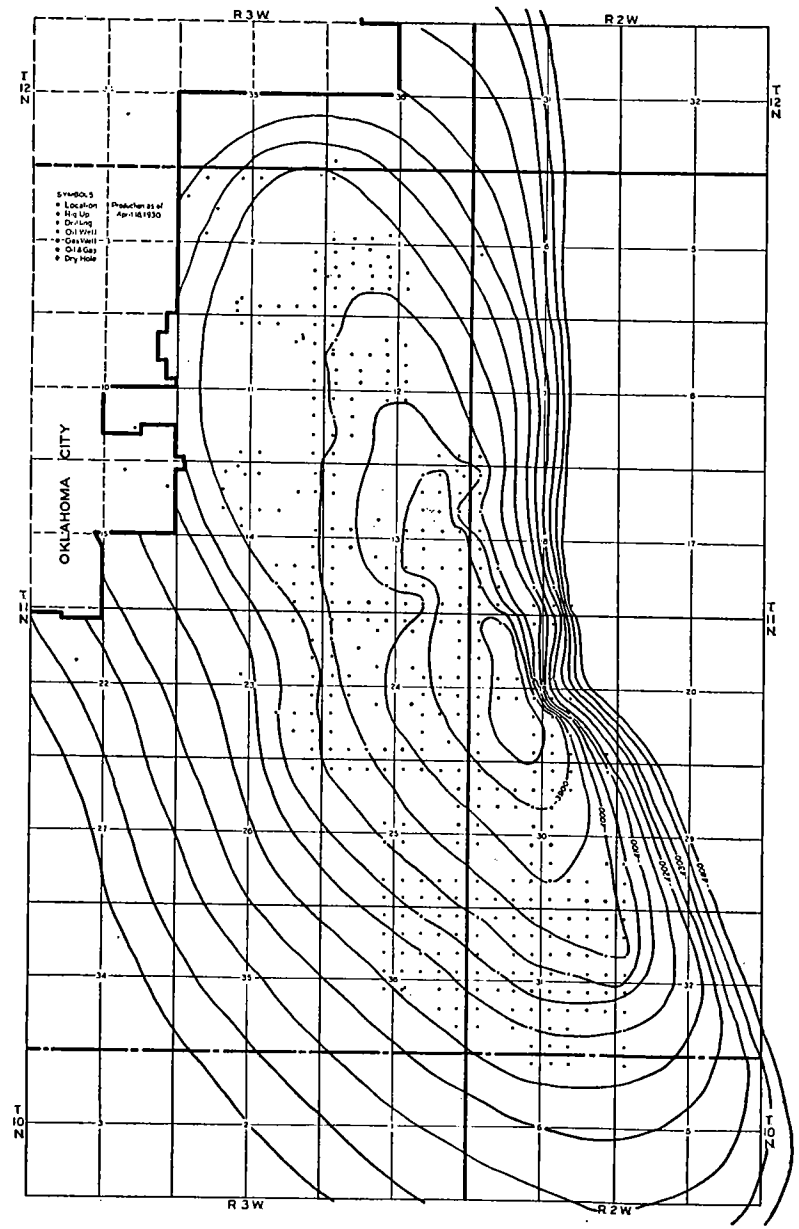



Figure 66. Subsurface map of the Oklahoma City field. Contours on top of the Checkerboard limestone. Contour interval, 50 feet.



cement, cementing to the surface. The 9 5/8-inch is then carried to the Checkerboard limestone, or 5,200 feet, and is cemented with 1,500 sacks of cement. The hole is generally completed with 7-inch casing which is cemented on top of the producing horizon (6,000 to 6,400 feet in depth) with 250 sacks of cement. The cement is allowed to set for 7 days and then the plug is drilled out. The drilling in continues with 3½-inch drill pipe and rotary bit. Rotary mud averaging 10 to 12 pounds per gallon is generally used at this depth. The hole is then bailed to test. If the well shows oil while bailing, the tools are pulled out and the well is allowed to flow to clean itself. If nothing shows, the well is drilled deeper. Most of the wells in the field flow natural due to the enormous gas pressure. The gas in the field ranges from 20,000,000 to 100,000,000 cu. ft. per day with rock pressure averaging 2,300 pounds. The oil wells range from 10,000 to 40,000 barrels per day. The oil flow from the wells goes to separators, then to tanks. A few wells have been put on gas lift.

## GENERAL COST OF DRILLING AND EQUIPMENT

1. The general contract price for drilling is $11.00 per foot.

2. An amount of 48,000,000 to 52,000,000 cu. ft. of gas is needed to complete an average well.

3. Approximately 150,000 barrels of water are used in each well. More water is used in the upper part of the hole, where drilling speed is more rapid, than in the lower part.

4. Two slush ponds are needed, which are generally 90 feet long, 20 feet wide, and 6 feet deep.

5. Surface equipment includes four 125 horsepower steam boilers which have a working pressure of 250 to 300 pounds.
Slush pumps are of duplex steam driven type.

6. Lease equipment, camps, roads, and general miscellaneous material which must be charged to each well.

The total cost of drilling and completing a well averages $155,000.00. Average drilling time (including drilling in) is 114 days.

The wells in the Oklahoma City pool are, with few exceptions, drilled one well to ten acres, with a spacing of 660 feet, or 330 feet from property lines.

## FUTURE OUTLOOK

At the present time there are numerous wildcat wells being drilled throughout the county which will assure Oklahoma County of receiving a complete test for oil and gas production.

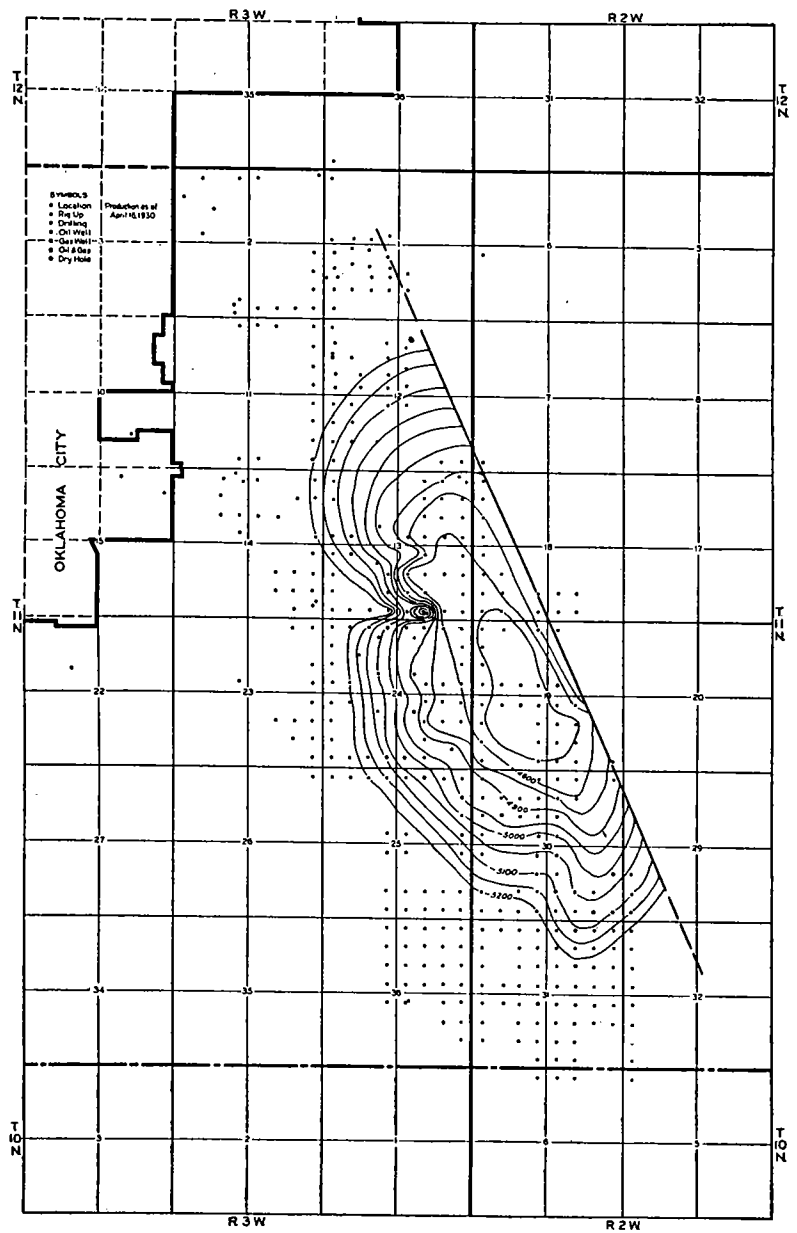



Figure 67. Subsurface map of the Oklahoma City field. Contours on top of the Arbuckle limestone. Contour interval, 50 feet.

## BEAVER, TEXAS, AND CIMARRON COUNTIES

By

Ray L. Six

## INTRODUCTION

### LOCATION

Beaver, Texas, and Cimarron Counties are located in the extreme northwestern portion of the State. They form the area formerly called "No Man's Land" and in territorial days "Beaver County". After statehood it was divided into three approximately equal parts and "Beaver" was retained for the eastern third. This area is sometimes referred to as the "Panhandle" of Oklahoma and for obvious reasons.

This area embraces Tps. 1 to 6 N., inclusive, and Rs. 1 to 28 E., C. M., inclusive; and lies between 36° 30′ and 37° 00′ N. Latitude and 100° and 103° W. Longitude. Its northern boundary is the state lines of Colorado and Kansas; its eastern is Harper and Ellis counties of Oklahoma; its southern is the Texas line and its western is the New Mexico state line. This series of counties lies in the Great Plains phy-

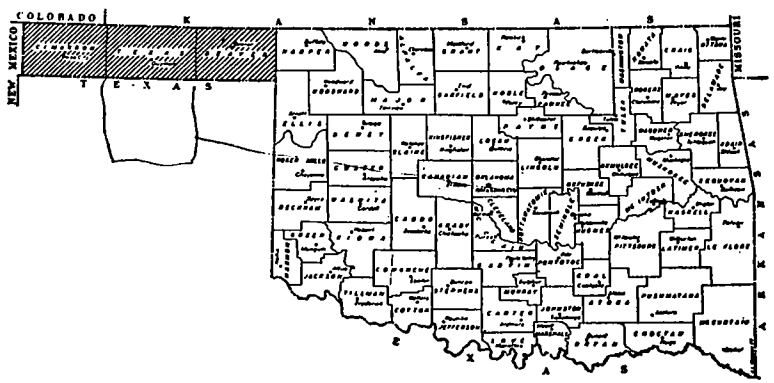



Figure 68. Index map of Oklahoma showing location of Beaver, Texas, and Cimarron counties.

siographic province. With the exception of shallow, saucer-like depressions and two stream valleys the area is a featureless plain drained by the Cimarron and the North Canadian Rivers and the tributaries. The former has carved a series of beautiful canyons in northwestern Cimarron County near Kenton and its environs. After flowing two-thirds of the way across this county this river flows north into Kansas then returns to Oklahoma just east of the center of the north line of Beaver County. The North Canadian enters Oklahoma in southwestern Cimarron County and flows almost across the southern part of the county before it flows into Texas. It reenters Oklahoma just a few miles west of the southeast corner of Texas County and continues eastward through central Beaver County. This stream is extremely interesting in that it flows in a valley grooved out of the top of the divide between the Cimarron and the South Canadian Rivers.

The geology of this region is simple excepting for some stratigraphic relationships in northwestern Cimarron County. There is need of much detailed field work to clarify these relationships. This comment also applies to the relationships of the Tertiary gravels.

The following generalized geologic column presents the writer's understanding of these stratigraphic relationships of these three counties in May, 1930. Map No. XL of the report shows the general areal relationships. A number of corrections have been made on previous maps of the area but many inaccuracies still exist.

**ACKNOWLEDGMENTS**

Inasmuch as sufficient time was not available for detailed field studies of this very interesting area on the part of the writer, especial thanks are due those whose data has made parts of this report possible. The publications of Gould and Lonsdale,[1] Rothrock, Lee, Darton, Stanton, and many others have been very helpful. The writer is also deeply indebted to Mr. R. C. Tate of Kenton for personally conducting him to the places of geologic interest in the northwestern part of Cimarron County and its environs. The Oklahoma Geological Survey prepared the maps for this report.

Structurally this area lies within the monoclinal province east of the southern Rocky Mountains. The western part of Cimarron County is broken by a series of undulations whose axes are nearly parallel to that of the Rockies to the west. These folds are probably related to the orogenic disastrophism of these mountains.

1. Gould, Chas. N., and Lonsdale, John T., Geology of Beaver County: Oklahoma Geol. Survey Bull. 38, 1626.



## BEAVER COUNTY

### Location

Beaver County is the eastern one of the three Panhandle counties. It is rectangular and includes all of forty townships and four-sixths of nine others. It embraces Tps. 1 to 6 N., Rs. 20 to 28 E., C. M. The northern boundary is the Oklahoma-Kansas line. On the east it is bounded by Harper and Ellis counties, on the south by the Texas line, and on the west by Texas County of Oklahoma. It has an area of 1,728 square miles.

The W. F. & N. W. Ry. enters the county at Gate and follows the divide between the Cimarron River and Beaver Creek westward to Forgan. From here it runs due west to Hooker in Texas County. At Forgan a branch line known as the B. M. & E. Ry., connects it with Beaver City, which is the county seat, on the south bank of Beaver Creek six miles south or Forgan.

The population of Beaver County is approximately 17,000 which is an avearge of about 10 per square mile. Important towns are Beaver City with a population of 1,500, Forgan 700, Gate 250, and Knowles 225.

### Topography

Beaver County lies on the eastern edge of the Great Plains province. The surface is a plain which slopes gently eastward. The northeastern part of the county is dissected and drained by the Cimarron River and its tributaries. The central and southern portions of the county are drained by Beaver Creek (North Canadian River) and its tributaries, the most important of which are Kiowa, Duckpond, Clear and Jackson Creeks. The North Canadian and its tributaries drain approximately five-sixths of the county.

### GEOLOGY

#### Surface Formations

The following formations outcrop in Beaver County; Whitehorse sandstone, Day Creek dolomite(?), and Cloud Chief Gypsum of Permian age; Cretaceous oyster beds(?); late Tertiary volcanic ash, limestones, and clays; later Tertiary sands and gravels; and Quaternary alluvium and dune sand.

#### WHITEHORSE SANDSTONE

This formation outcrops in the eastern and central portions of the county along Kiowa and Camp Creeks and the North Canadian River and the valleys tributary to it from the south. It is also found along the Cimarron River in the northeastern part of the county. The Day Creek dolomite is probably present in the same areas separating it from

the overyling Cloud Chief. The Cloud Chief gypsum is found in the valleys of Camp and Kiowa Creeks along the south wall of the North Canadian and in practically all of the tributary valleys from the south and also in a number of those from the north.

### CRETACEOUS OYSTER BEDS

These beds occur in isolated localities in the county and are composed largely of *Gryphea* shells of Lower Cretaceous age. Judging from the water-worn character of these shells they may be transported Cretaceous material, Tertiary in age. They may be observed in T. 3 N., R. 24 E., C. M., along Clear Creek, in the SW. cor., T. 3 N., R. 25 E., C. M., and in the NW. cor., T. 4 N., R. 25 E., C. M..

### TERTIARY VOLCANIC ASH

These deposits may be found in many localities. A typical one is found north of Gate in sec. 10, T. 5 N., R. 28 E., C. M., one and one-half miles west of another deposit of the same material. The first deposit is approximately 10 feet in thickness and 120 by 450 feet in extent. A deposit 12 feet in thickness occurs in the NW.¼ sec. 1, T. 5 N., R. 27 E., C. M., Numerous other deposits of the same will be found listed and described by Frank Buttram.[2]

Later Tertiary sands and gravels cover approximately four-fifths of the surface area of the county. Within or under these gravel deposits in many areas are found limestone and fine clay deposits containing fossil leaf and fish remains. These are most abundant in the east-central part of the county north and south of North Canadian River. Three deposits are found south of Cline and one 2½ miles west of Zelma. Two others are found 4 miles northwest of this along Kidd's Creek in sec. 23, T. 4 N., R. 26 E., C. M. An extensive deposit occurs one mile north of Riverside in secs. 3 and 10, T. 3 N., R. 25 E., C. M. Udden, Berry, Darton, Gould, and others have described fossil leaves from these localities.

### LATE TERTIARY SANDS AND GRAVELS

These deposits belong, perhaps, to the Loup Fork (Miocene), Goodnight(?), and the Blanco (Pliocene) of the Texas Panhandle Tertiary. This subdivision of the Tertiary in the Panhandle of Texas is based upon vertebrate fossils as identified by Cummins and Cope. Quaternary alluvial deposits occur along the Cimarron and North Canadain Rivers. A strip of fine sand varying in width from one to five miles lies north of the North Canadian. Northwest of Beaver City and southwest of Floris dunes are found to reach their maximum development. In a number of localities the Tertiary gravel or "mortar beds" yield abundant *Equus* and *Elephas* remains. The "mortar beds" and the Tertiary gravels cover most of the county.

2. Buttram, Frank, Volcanic dust in Oklahoma: Oklahoma Geol. Survey Bull. 13, 1914.



### Subsurface Geology

Our knowledge of subsurface conditions in this county is wholly dependent upon logs of the few wells that have been drilled here and in adjacent areas. Deep wells drilled in northwestern Oklahoma within the last two years have revealed a practically complete section of Permian and old rocks as far as the Mississipian. The deep well drilling in sec. 14, T. 26 N., R. 24 W., Harper County, has revealed much more Mississippi limestone than was expected, over 800 feet. Fossils from this section indicate that the Mississippian seas came from the Cordilleran region. Map No. XLI shows the general subsurface relationships of the underlying Permian and the older rocks. The following logs of wells drilled in this county indicate the detailed character of underlying sediments.

*Log of Gate Well, Sec. 33, T. 5 N., R. 28 E., Cimarron Meridian*

| Formation | Top | Bottom |
|---|---|---|
| Soil | 0 | 5 |
| Sand clay | 5 | 25 |
| Red rock | 25 | 40 |
| Water sand | 40 | 48 |
| Red rock | 48 | 83 |
| Water sand | 83 | 90 |
| Red rock | 90 | 170 |
| Water sand | 170 | 178 |
| Red rock | 178 | 265 |
| Sandy lime | 265 | 268 |
| Red rock | 268 | 275 |
| Sand | 275 | 300 |
| Red rock | 300 | 350 |
| Sandy lime | 350 | 353 |
| Red rock | 353 | 362 |
| Lime and gyp | 362 | 395 |
| White lime | 395 | 412 |
| Blue shale | 412 | 420 |
| Brown shale | 420 | 450 |
| Sandy lime | 450 | 467 |
| Salt | 467 | 567 |
| Red rock | 567 | 572 |
| Salt | 572 | 585 |
| Red rock | 585 | 620 |
| Salt | 620 | 630 |
| Red rock | 630 | 670 |
| Salt | 670 | 720 |
| Red rock | 720 | 740 |
| Sand | 740 | 743 |
| Red rock | 743 | 840 |
| Sand | 840 | 842 |
| Red rock | 842 | 860 |
| Sandy lime | 860 | 865 |
| Red rock | 865 | 890 |
| Sand | 890 | 892 |
| Red rock | 892 | 905 |
| Blue slate | 905 | 910 |
| Red rock | 910 | 970 |
| Lime | 970 | 978 |
| Red rock | 978 | 985 |
| Sandy lime | 985 | 1000 |
| Red rock | 1000 | 1005 |
| Lime | 1005 | 1015 |
| Red rock | 1015 | 1045 |
| Salt | 1045 | 1048 |
| Sandy lime | 1048 | 1065 |
| Red rock | 1065 | 1067 |
| Sandy lime | 1067 | 1080 |
| Red rock | 1080 | 1085 |
| Sandy lime | 1085 | 1100 |
| Red rock | 1100 | 1123 |
| Red lime | 1123 | 1130 |
| Red rock | 1130 | 1140 |
| Sandy lime | 1140 | 1155 |
| Red rock | 1155 | 1160 |
| Salt | 1160 | 1166 |
| Gray lime | 1166 | 1177 |
| Red rock | 1177 | 1187 |
| Blue lime | 1187 | 1203 |
| Red rock | 1203 | 1215 |
| Lime | 1215 | 1240 |
| Red rock | 1240 | 1250 |
| Salt | 1250 | 1288 |
| Red rock | 1288 | 1290 |
| Salt | 1290 | 1395 |
| Blue slate | 1395 | 1405 |
| Salt | 1405 | 1430 |
| Red rock | 1430 | 1510 |
| Blue slate | 1510 | 1528 |
| Red rock | 1528 | 1548 |
| Blue slate | 1548 | 1563 |
| Red rock | 1563 | 1575 |

(Continued on page 466)

| Formation | Top | Bottom |
|---|---|---|
| Brown slate | 1575 | 1600 |
| Red rock | 1600 | 1625 |
| Brown slate | 1625 | 1650 |
| Red rock | 1650 | 1725 |
| Blue slate | 1725 | 1765 |
| Lime | 1765 | 1770 |
| Blue slate | 1770 | 1775 |
| Lime | 1775 | 1780 |
| Blue slate | 1780 | 1795 |
| Lime | 1795 | 1820 |
| Blue slate | 1820 | 1823 |
| Lime | 1823 | 1840 |
| Blue slate | 1840 | 1855 |
| Lime | 1855 | 1895 |
| Slate | 1895 | 1900 |
| Lime | 1900 | 1905 |
| Slate | 1905 | 1915 |
| Lime | 1915 | 1918 |
| Slate | 1918 | 1943 |
| Lime | 1943 | 1958 |
| Salt | 1958 | 1975 |
| Lime | 1975 | 1990 |
| Salt | 1990 | 1997 |
| Slate | 1997 | 2015 |
| Salt | 2015 | 2020 |
| Lime | 2020 | 2035 |
| Salt | 2035 | 2040 |
| Sandy lime | 2040 | 2050 |
| Salt | 2050 | 2063 |
| Limey salt | 2063 | 2087 |
| Lime | 2087 | 2092 |
| Lime and slate | 2092 | 2102 |
| Lime | 2102 | 2107 |
| Salt | 2107 | 2165 |
| Lime | 2165 | 2170 |
| Salt | 2170 | 2190 |
| Slate | 2190 | 2205 |
| Lime | 2205 | 2245 |
| Slate | 2245 | 2248 |
| Lime | 2248 | 2365 |
| Sandy lime | 2365 | 2370 |
| Salt | 2370 | 2395 |
| Lime | 2395 | 2505 |
| Lime | 2505 | 2665 |
| Gray slate | 2665 | 2667 |
| Sandy lime | 2667 | 2750 |
| Water sand | 2750 | 2765 |
| Slate | 2765 | 2770 |
| Water sand | 2770 | 2775 |
| Red slate | 2775 | 2780 |
| Sandy lime | 2780 | 2832 |
| Slate | 2832 | 2837 |
| Lime | 2737 | 2862 |
| Asphalt | 2862 | 2893 |
| Brown sand | 2893 | 2903 |
| White lime | 2903 | 2908 |
| Lime and sand | 2908 | 2918 |
| Gray lime | 2918 | 2940 |
| Black lime | 2940 | 3005 |
| Gray lime | 3005 | 3014 |
| Blue shale | 3014 | 3020 |
| Lime, gray | 3020 | 3030 |
| Brown sand | 3030 | 3040 |
| Lime and much sand | 3040 | 3049 |
| Pink lime | 3049 | 3060 |
| Gray shale | 3060 | 3065 |
| Coarse sand | 4065 | 3068 |
| Brown shale | 3068 | 3073 |
| Gray lime | 3073 | 3079 |
| Black lime | 3079 | 3099 |
| Gray lime | 3099 | |

*Log of Skear Well, Sec. 17, T. 3 N., R. 23 E., Cimarron Meridian*

| Formation | Top | Bottom |
|---|---|---|
| Soil | 0 | 10 |
| Red beds | 10 | 250 |
| Sand and water | 250 | 265 |
| Red beds | 265 | 300 |
| Sand and water | 300 | 310 |
| Red beds | 310 | 400 |
| Quick sand | 400 | 425 |
| Red beds | 425 | 600 |
| Salt | 600 | 640 |
| Red beds and blue shale | 640 | 692 |
| Blue shale | 692 | 712 |
| Sand (dry) | 712 | 720 |
| Red beds | 720 | 840 |
| Red beds and salt, mixed | 840 | 860 |
| Brown shale | 860 | 1140 |
| Soft red beds | 1140 | 1500 |
| Hard gray lime | 1500 | 1540 |
| Red beds | 1540 | 1600 |
| Brown shale | 1600 | 1810 |
| Soft cavy red beds | 1810 | 2000 |
| Brown shale | 2000 | 2018 |
| Hard blue shale | 2018 | 2030 |
| Hard white lime | 2030 | 2040 |
| Lime and blue shale, mixed | 2040 | 2072 |
| Sandy lime, good showing oil | 2072 | 2075 |
| Hard blue shale | 2075 | 2102 |
| Hard gray lime | 2102 | 2105 |
| Blue shale | 2105 | 2120 |

(Continued on page 467)



| Formation | Top | Bottom |
|---|---|---|
| Brown shale | 2120 | 2123 |
| Blue shale | 2123 | 2250 |
| Black shale, soft | 2250 | 2262 |
| Light blue shale | 2262 | 2272 |
| Hard sandy lime | 2272 | 2287 |
| Black shale, soft | 2287 | 2295 |
| Hard sandy lime, gray | 2295 | 2300 |
| Sand (dry, gray) | 2300 | 2312 |
| Black shale, mixed with soft white formation | 2312 | 2318 |
| Blue shale | 2318 | 2340 |
| Dark shale (fine) | 2340 | 2370 |
| Blue shale mixed with soft white formation | 2370 | 2385 |
| Mixture of lime, salt and sand | 2385 | 2410 |
| Soft blue shale | 2410 | 2427 |
| Coarse dark blue shale and soft white formation | 2427 | 2450 |
| White lime, not very hard | 2450 | 2465 |
| Black shale | 2465 | 2475 |
| Hard lime and blue slate mixed | 2475 | 2522 |
| Hard white lime | 2522 | 2810 |
| Sandy brown lime | 2810 | 2915 |
| Sand and water, about 600 feet water in hole | 2915 | 2985 |
| Brown sandy lime | 2985 | 3005 |

*Log of Empire Well, Sec. 6, T. 1 N., R. 20 E., Cimarron Meridian*

| Formation | Top | Bottom |
|---|---|---|
| Soft red surface | 0 | 19 |
| Soft red mud | 19 | 79 |
| Hard red shell | 79 | 82 |
| Soft red sand | 82 | 85 |
| 1 bbl. water per hr. | | |
| Soft red mud | 85 | 125 |
| Hard white lime | 125 | 140 |
| Soft red mud | 140 | 180 |
| Soft red sandy shale | 180 | 195 |
| 15 bbls. water at 185′ | | |
| Soft red mud | 195 | 255 |
| Soft red sandy shale | 255 | 270 |
| Soft red mud | 270 | 331 |
| Soft red quick sand | 331 | 336 |
| Soft red mud | 336 | 367 |
| Soft red quick sand | 367 | 374 |
| Soft red mud | 374 | 395 |
| Hard red shell | 395 | 402 |
| Soft red sand | 402 | 406 |
| Soft red mud | 406 | 409 |
| Soft red sand, ½ HFW | 409 | 416 |
| Soft red mud-hole cave | 416 | 430 |
| Soft sandy red rock | 430 | 436 |
| Soft red mud | 436 | 447 |
| Soft red mud | 447 | 502 |
| Soft red shell gyp | 502 | 506 |
| Soft red mud | 506 | 512 |
| Hard white rock gyp | 512 | 530 |
| Hard red shell | 530 | 540 |
| Hard white gyp | 450 | 550 |
| Soft red mud | 550 | 580 |
| Hard red shell | 580 | 588 |
| Soft red mud | 588 | 653 |
| Hard white shell | 653 | 670 |
| Soft red rock | 670 | 685 |
| Boulders at 685′ | | |
| Hard red shell | 685 | 690 |
| Soft red rock | 690 | 785 |
| Soft red mud | 785 | 820 |
| Hard red shell | 820 | 825 |
| Soft red mud | 825 | 885 |
| Soft red salt | 885 | 895 |
| Soft red mud | 895 | 1040 |
| Hard red sand | 1040 | 1065 |
| Soft red mud | 1065 | 1165 |
| Soft red shale | 1165 | 1175 |
| Soft red mud | 1175 | 1275 |
| Hard sandy shell | 1275 | 1290 |
| Soft red mud | 1290 | 1340 |
| Soft red sandy mud | 1340 | 1360 |
| Soft red sandy shale | 1360 | 1450 |
| Soft red mud | 1450 | 1480 |
| Soft gray lime mud | 1480 | 1490 |
| Hard gray lime | 1490 | 1535 |
| Soft red mud | 1535 | 1595 |
| Hard gray shell | 1595 | 1610 |
| Soft red mud | 1610 | 1620 |
| Hard white salt-caving | 1620 | 1695 |
| Soft red mud | 1695 | 2040 |
| Soft red shale | 2040 | 2085 |
| Hard white lime | 2085 | 2090 |
| Soft gray shale | 2090 | 2115 |
| Soft red mud | 2115 | 2145 |
| Hard gray shell | 2145 | 2148 |
| Soft gray slate | 2148 | 2175 |
| Soft blue slate | 2175 | 2200 |
| Hard white lime slate | 2200 | 2320 |
| Hard white lime | 2320 | 2350 |
| Hard white salt | 2350 | 2355 |
| Hard white lime | 2355 | 2385 |
| Soft blue slate-lime | 2385 | 2530 |
| Hard white lime | 2530 | 2850 |
| Hard white sandy lime | 2850 | 2855 |
| Hard white lime | 2855 | 2860 |

(Continued on page 468)

| Formation | Top | Bottom |
|---|---|---|
| Hard brown sand | 2860 | 2905 |
| Soft brown sandy lime | 2905 | 2940 |
| Hard white lime | 2940 | 2975 |
| Soft white sand | 2975 | 2980 |
| Hard white sandy lime | 2980 | 3012 |
| Hard white lime | 3012 | 3037 |
| Soft blue slate | 3037 | 3040 |
| Hard white lime | 3040 | 3050 |
| Soft white sandy lime | 3050 | 3060 |
| Hard white sand | 3060 | 3083 |
| Hard white lime | 3083 | 3107 |
| Soft blue slate | 3107 | 3110 |
| Hard white lime | 3110 | 3119 |
| Soft white sand | 3119 | 3129 |
| Soft blue slate | 3129 | 3132 |
| Soft white sand | 3132 | 3140 |
| Hard white sandy lime | 3140 | 3147 |
| Hard white lime | 3147 | 3150 |
| Hard white sandy lime | 3150 | 3205 |
| Hard black lime | 3205 | 3245 |
| Hard gray lime | 3245 | 3290 |
| Hard red mud | 3290 | 3295 |
| Hard white sandy lime | 3295 | 3385 |
| Soft white sand | 3385 | 3392 |
| Hard white lime | 3392 | 3415 |
| Hard black lime | 3415 | 3423 |
| Hard white sandy lime | 3423 | 3475 |
| Hard gray lime | 3475 | 3537 |

## STRUCTURE

The structure of the surface rocks of Beaver County is a monocline dipping gently to the east. The Tertiary and Quaternary rocks covering most of the county show little, if any, underlying structure of this area. It is only along the valleys of the Cimarron and North Canadian rivers and the lower portions of their tributaries that mapable horizons are found. A comparison of logs of wells drilled in this county reveals a marked similarity to those drilled at Texhoma, Oklahoma, and in Liberal, Kansas as well as in the northern part of the Panhandle of Texas. In all of these places oil or gas has been found in commercial quantities. Figure 69 shows the general structure of this region and its relation to the Anadarko Basin.

## DEVELOPMENT

Thus far only three wells have been drilled in Beaver County. The logs of these are given under "Subsurface Geology" of this county.

*Location of wells drilled in Beaver County.*

| WELL | LOCATION | DEPTH Feet | REMARKS |
|---|---|---|---|
| Gate | Sec. 33, T. 5 N., R. 28 E., C.M. | 3,099 | Dry |
| Skeer | Sec. 17, T. 3 N., R. 23 E., C.M. | 3,055 | Dry (1924) |
| Empire | Sec. 6, T. 1 N., R. 20 E., C.M. | 3,537 | Dry (Sept. 1925) |

Considerable interest has been manifested in this county due to commercial production of natural gas in Clark County, Kansas, at Texhoma in Texas County and both petroleum and natural gas in the Texas Panhandle. Producing horizons known to the east of the county should be nearer the surface in the western part of Beaver County than in the extreme northwestern part of Oklahoma east of the Panhandle.



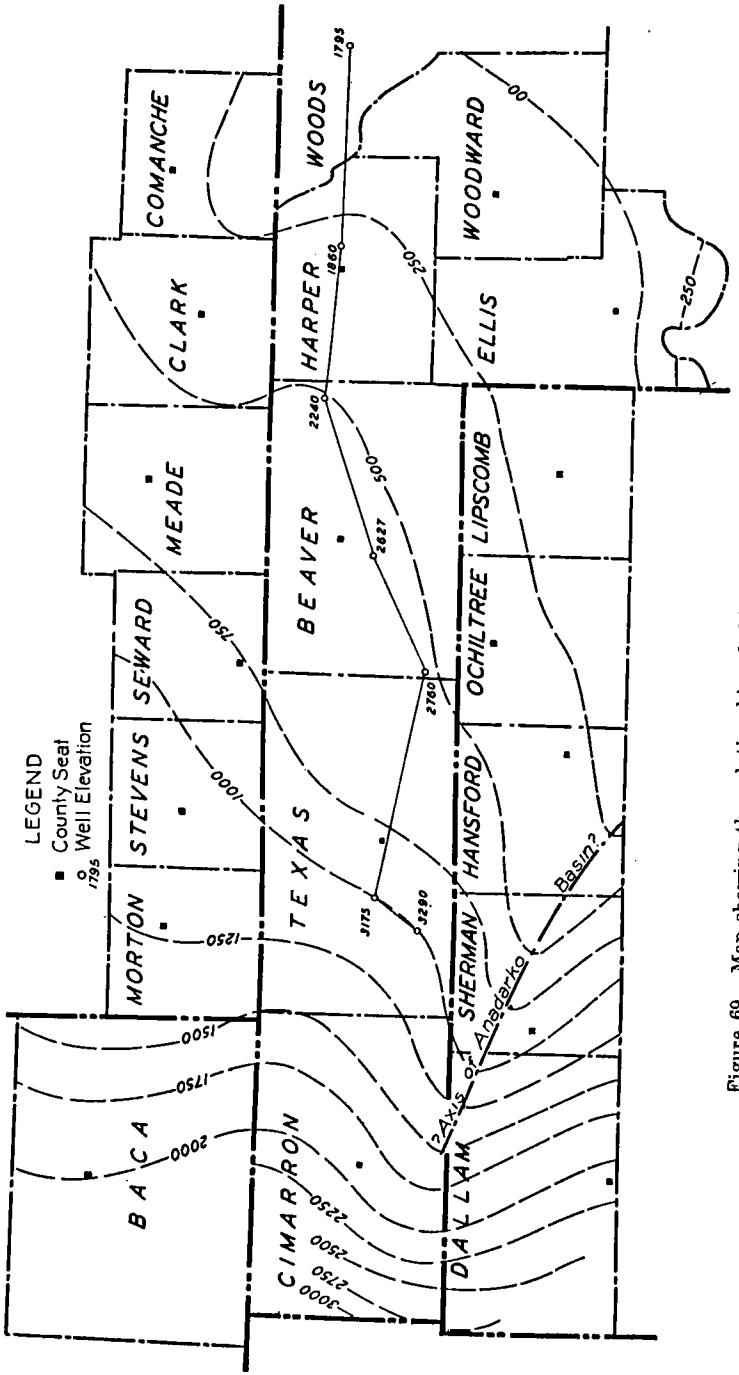



Figure 69. Map showing the relationship of this area to the Anadarko Basin. Contours on the base of the red beds.

The western part of Beaver County is composed of a portion of the High Plains the subsurface rocks of which dip eastward. Core drilling and geophysical methods would give more accurate information to guide prospecting in the area. Inasmuch as Beaver County lies along the northern rim of the Anadarko Basin and along the west rim of what is believed to be a structural high, it would not be surprising to find production in this area. The exact nature of the structure of the producing areas in Kansas on the north and in Texas County to the west is in question. So far as the writer is informed, these producing areas were not determined from surface indications.

*Generalized geologic section of surface rocks of Beaver, Texas, and Cimarron Counties, Oklahoma*

| ERA | SYSTEM | FORMATION |
|---|---|---|
| RECENT | Quaternary | Alluvium and eolian deposits |
| CENOZOIC | Pliocene | Black Mesa Basalt and Volcanic ash |
| | Angular unconformity | |
| | Pliocene and Miocene | Limestones, clays, sands and gravels |
| MESOZOIC | Cretaceous | Benton shales and limestones<br>Dakota sandstone |
| | Comanchean | Purgatoire formation<br>Morrison formation<br>Exter sandstone<br>Unnamed varigated shales<br>Red beds |
| | Triassic | Red beds |
| PALEOZOIC | Permian | Quartermaster (?)<br>Cloud Chief formation<br>Day Creek dolomite (?)<br>Whitehorse sandstone |

## TEXAS COUNTY

### Location

Texas County is the central one of the Oklahoma Panhandle counties. It is rectangular in shape and includes all of fifty townships and two-thirds of ten others. The area embraces Tps. 1 to 5 N., inclusive and four miles of Tps. 6 N., Rs. 10 to 19 E., C. M., inclusive. (From the base-line on the 36° 30′ parallel N. Lat.) The northern boundary of the county is the Oklahoma-Kansas line, and the southern is the Oklahoma-Texas line. To the east is Beaver County and to the west is Cimarron County. The area of Texas County is approximately 2,065 square miles.



The main line of the Rock Island enters the county near the northeast corner and runs southwest through Tyrone, Hooker, Optima, Guymon, Goodwell, and Texhoma where it enters Texas. The B. M. & E. Ry. enters the county one and one-half miles north of the southeast corner T. 5 N., R. 19 E., C. M. and runs due west through Baker, Hooker, and Mouser to Hough, a distance of 34 miles. Another branch of the Rock Island enters the county at the northeast corner and runs southwest through Baker, Adams, and Hardesty and across the Texas-Oklahoma line at Hitchfield. A branch line of the Santa Fe from Elkhart, Kansas to Boise City in Cimarron County crosses the northwest corner of the county.

The population of Texas County is approximately 20,000 which is an average density of 10 per square mile. The principal towns are Guyman, the county seat, with 1,600 in population, Goodwell, Hooker, Tyrone, and Texhoma. The Panhandle State Agricultural College has an excellent plant at Goodwell.

### Topography

This county is in the High Plains physiographic province and consequently has little relief. The elevation varies between 2,900 feet at the eastern side of the county to 3,700 feet at the northwest corner. Beaver Creek (North Canadian River) with its tributaries drains the county. The principal tributaries are Paloduro, Hackberry, Coldwater, Pony, Goff, Tepee, South Fork and North Fork of Beaver Creeks. Owing to light rainfall these creeks are dry during the greater part of the year. The average rainfall is only twenty inches. Water is obtained from wells drilled into the Tertiary gravels which cover most of the area of the county.

With two exceptions the county is an unbroken plain sloping gently to the east. The North Canadian and its tributaries have carved a shallow valley through the central portion of the county and the valley of Poloduro Creek presents a rough, broken terrain. Most of the county is without drainage lines. The stream valleys are usually small canyons. In the northern and western parts of the county are a number of shallow, saucer-like depressions without surface drainage outlets which form shallow lakes after rains. These lakes seem to be characteristic of High Plains topography and their origin is problematical. Springs occur at the base of the Tertiary gravels where streams have cut through into the underlying red beds.

## GEOLOGY

### Surface formations

The oldest rock occurring on the surface is the Cloud Chief gypsum of Permian age. This formation and overlying "mortar beds" form the precipitous valley walls of Paloduro Creek and its tributaries

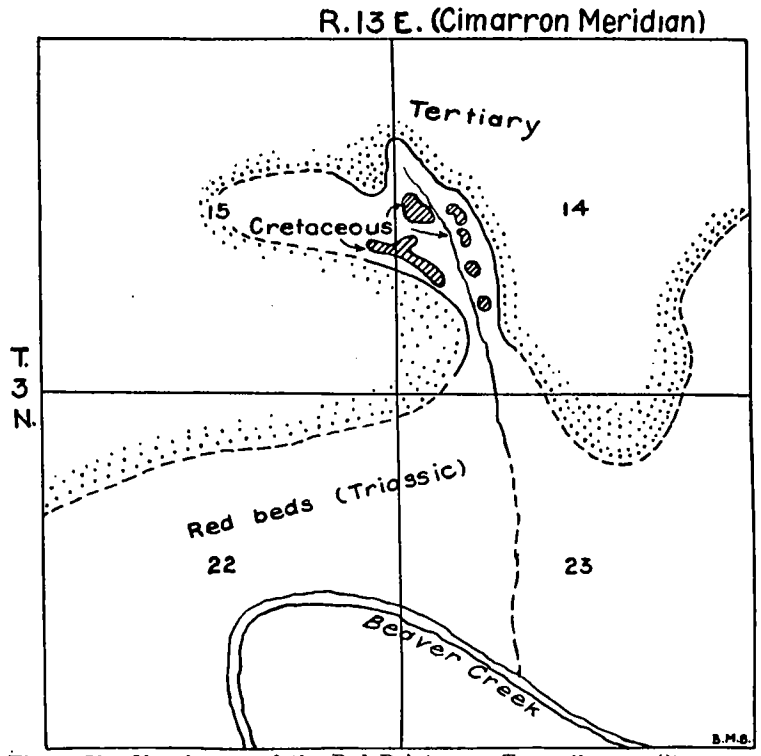



Figure 70. Sketch map of the Red Point area, Texas County, Oklahoma. (After Bullard)

in the southeast part of the county in the vicinity of Range and Grand Valley in Tps. 1 and 2 N., Rs. 18 and 19 E., C. M. The thickness of the Cloud Chief gypsum just east of the Range postoffice is approximately 70 feet. Gypsum beds form a prominent part of the Cloud Chief formation at only one point in the area and that is about one mile east of the Range postoffice in the valley wall of Paloduro Creek. At other places the formation is composed of red, gray, and green shales with some red sandstone lentils. A concretionary sandstone member lies about 25 feet above the gypsum member previously mentioned. It occurs in sec. 17, T. 1 N., R. 19 E., C. M., about 2½ miles east of Range. The thickness of this member is about 8 feet and it is buff to brown in color and very fine grained. Within it are numerous dendritic-shaped, concretionary aggregates averaging one-sixteenth of an inch in diameter and numbering about 10 to the square inch of rock surface. These are dark in color which is due, perhaps, to the presence of manganese oxide. There are numerous concretions of iron



oxide spherical in shape and ranging in size from small shot to the size of a pea. These are, no doubt, pyrite or marcasite altered to limonite. This sandstone member is similar to the Hackberry and Big Basin of the Kansas Permian. It is possible that a part of this area mapped as Cloud Chief is really Whitehorse.

Two areas of red beds occur in this county, one near Red Point on the North Canadian River in T. 3 N., R. 13 E., C. M. and another along Tepee Creek in T. 3 N., Rs. 11 and 12 E., C. M. These beds are Triassic in age.

Six Lower Cretaceous outliers are found in secs. 14 and 15, T. 3 N., R. 13 E., C. M. They rest directly upon the Triassic red beds and are composed of soft, white to yellow-brown sandstone which, due to its ferruginous content, weathers to dark red. This is very similar in color to the underlying Triassic and Clifton[3] was the first to differentiate between the red Tertiary and the red Triassic. For a detailed discussion of this area the reader is referred to Bullard's[4] report embracing this area, and to the following map (fig. 70) for the areal relationships of the rocks of this area.

The Tertiary rocks cover more than nine-tenths of the surface area of this county and lie unconformably upon the older rocks. They vary in thickness from 300 to 500 feet. The following log taken from a well drilled at Optima in the north-central part of the county reveals the general character of the Tertiary of the area.

*Log of the Optima well, Texas County.*

| Character | Thickness | Depth |
|---|---|---|
| Sandy shale | 100 | 100 |
| Reddish Clay | 15 | 115 |
| Sandy clay | 114 | 229 |
| Red clay | 64 | 293 |
| Dark clay | 56 | 349 |
| Blue clay | 4 | 353 |
| Yellow clay | 20 | 373 |
| Yellow sand | 15 | 388 |
| Dry sand | 10 | 398 |
| Brown sand | 5 | 403 |
| Sand clay | 3 | 406 |
| Blue shale | 80 | 486 |
| Sandy gravel and shale | 12 | 498 |

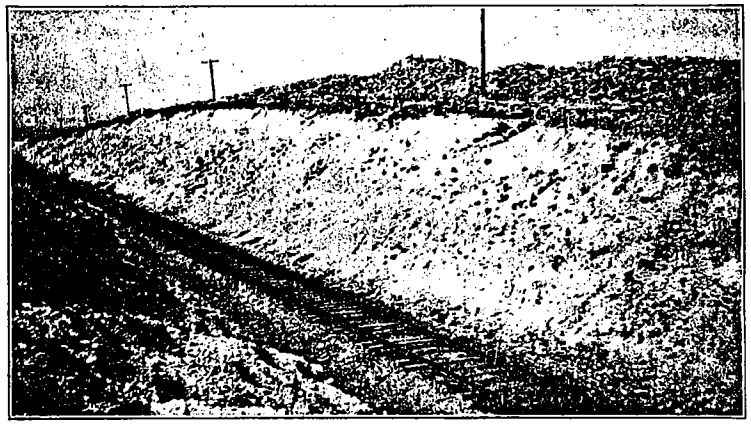
The Tertiary rocks of this portion of the High Plains present a very complex problem, and the differentiation and correlation of these gravels with the Tertiary of the northern and southern Great Plains has not yet been accomplished. Fragments as large as one foot in diameter are found in Texas County over 100 miles from their nearest known source. The streams which transported these clastics were very different from those now existing in this region. On the surface the clastics have a mortar-like appearance, hence the name, "mortar beds."

Overlying these Tertiary deposits and widely distributed throughout this portion of the Great Plains are caliche deposits which are usually overlain by gray, calcareous soil. This caliche varies from one

3. Clifton, R. L., personal communication to Chas. N. Gould, 1925.
4. Bullard, Fred M., Lower Cretaceous of western Oklahoma: Oklahoma Geol. Survey Bull. 47, 1928.

to 20 feet in thickness and occasionally one observes two or more accumulations, one above the other. It is the same as the "cap rock" of the Texas Panhandle and the tops of the Antelope and Twin Hills of Roger Mills County. Excellent exposures of the caliche and underlying Tertiary gravels may be observed in the Rock Island railroad cuts between Guymon and Optima. Remains of vertebrates are obtainable in the railway cut on the north side of North Canadian River about two miles southwest of Optima. Plate VIII is a photograph taken at this location which shows the deposit. The University of California has made extensive collections here of several species of horses, camels, elephants, saber tooth tigers, and ruminants. Extensive collections have been made from numerous other localities in this county.

OKLAHOMA GEOLOGICAL SURVEY BULLETIN 40 PLATE VIII



Caliche in railroad cut between Guymon and Optima.

For detailed description of the previously mentioned caliche deposits, the reader is referred to work of Gould and Lonsdale[5] on Texas County.

The Quaternary system of rocks in this area is represented by alluvial and dune deposits, the latter occurring in the broad, flat bottoms of the canyon-like valleys of the major drainage lines. Dune sand occurs north of North Canadian River in the southeastern part of the county. This is a westward continuation of the eolian deposits of Beaver County. The height of these dunes reach as much as sixty feet, length a quarter of a mile, and width fifty yards.

### Subsurface Geology

The subsurface formations are Cretaceous and older. These and the Triassic rocks outcrop in the vicinity of Red Point in the west-central part of the county in the vicinity of Range. Of pre-Permian formations little is known. It is reasonable to suppose, however, that the same formations which underly Beaver County to the east also underlie Texas County at shallower depths. The regional dip of rocks is a gentle monocline to the southeast. Very little diagnostic criteria relating to the structure of the pre-Cretaceous rocks is available as they are overlain unconformably by Tertiary and Quaternary sands and gravels. A considerable number of wells have been drilled in the county in recent years and the following logs reveal the general character of subsurface horizons to a depth of about 3,000 feet. The use of the core drill and geophysical instruments will reveal more. Core drill holes should be drilled to exceed 300 feet since the Tertiary deposits are almost that thick.

5. Gould, Chas. N. and Lonsdale, John T., Geology of Texas County: Oklahoma Geol. Survey Bull. 37, pp. 30, 33, 1926.



The following well logs show the general character of the subsurface formations in the southern and west central portions of the county.

*Log of Texhoma well sec. 4, T. 1 N., R. 1 E., C. M.*

(Elevation, 3,500 feet?)

| Formation | Top | Bottom |
|---|---|---|
| Sandy soil | 0 | 15 |
| Sand and gravel | 15 | 174 |
| Hard sand | 174 | 200 |
| Red rock | 200 | 315 |
| Sandy shale | 315 | 355 |
| Red shale | 355 | 400 |
| Lime shale | 400 | 420 |
| Flint rock | 420 | 425 |
| White lime | 425 | 433 |
| Red brake | 433 | 480 |
| Red sand | 480 | 510 |
| Red shale | 510 | 600 |
| Sandy shale | 600 | 640 |
| Red shale | 640 | 700 |
| Red water sand | 700 | 760 |
| Red shale | 760 | 775 |
| Gyp rock | 775 | 800 |
| Red brake | 800 | 825 |
| Hard lime | 825 | 860 |
| Red shale | 860 | 875 |
| Salt rock | 875 | 900 |
| Red shale | 900 | 910 |
| Red sand | 910 | 930 |
| Salt rock | 930 | 985 |
| Red shale | 985 | 1000 |
| Soft sand | 1000 | 1025 |
| Hard red sand | 1025 | 1100 |
| Soft red sand | 1100 | 1220 |
| Red shale | 1220 | 1280 |
| Red sand | 1280 | 1300 |
| Red shale | 1300 | 1400 |
| Red sand | 1400 | 1425 |
| Red shale | 1425 | 1450 |
| Red sand | 1450 | 1467 |
| Red shale | 1467 | 1500 |
| White lime | 1500 | 1525 |
| Sandy lime | 1525 | 1575 |
| Salt rock | 1575 | 1650 |
| Gyp rock | 1650 | 1655 |
| Black lime | 1655 | 1670 |
| Red shale | 1670 | 1700 |
| Red sand | 1700 | 1740 |
| Red shale | 1740 | 1750 |
| Broken sand | 1750 | 1800 |
| Lime shale | 1800 | 1825 |
| Red mud or shale | 1825 | 1860 |
| Broken sandy | 1860 | 1880 |
| Sandy hard lime | 1880 | 1910 |
| Red shale | 1910 | 1950 |
| Red shale | 1950 | 2125 |
| Red cave | 2125 | 2160 |
| Sandy shale | 2160 | 2180 |
| Hard lime | 2180 | 2190 |
| Blue shale | 2190 | 2200 |
| Sandy shale | 2200 | 2210 |
| Red shale | 2210 | 2220 |
| Hard lime | 2220 | 2240 |
| Red cave | 2240 | 2250 |
| Lime hard | 2250 | 2260 |
| Shale red | 2260 | 2270 |
| Lime hard | 2270 | 2275 |
| Blue shale | 2275 | 2280 |
| Lime white hard | 2280 | 2290 |
| Blue shale | 2290 | 2300 |

(Continued on page 476)

| Formation | Top | Bottom |
|---|---|---|
| Lime dark | 2300 | 2310 |
| Blue shale | 2310 | 2340 |
| Lime and shale | 2340 | 2400 |
| Blue shale | 2400 | 2450 |
| Lime hard | 2450 | 2475 |
| Blue shale | 2475 | 2500 |
| Black lime hard | 2500 | 2520 |
| Blue shale | 2520 | 2545 |
| Lime shale | 2545 | 2555 |
| Red shale | 2555 | 2560 |
| Lime white | 2560 | 2570 |
| Red shale | 2570 | 2580 |
| Lime white hard | 2580 | 2590 |
| Blue shale | 2590 | 2620 |
| Lime broken | 2620 | 2630 |
| Blue shale | 2630 | 2670 |
| Lime black | 2670 | 2695 |
| Gas sand | 2695 | 2707 |
| Lime | 2707 | 2720 |
| Blue shale broken | 2720 | 2735 |
| Red shale | 2735 | 2740 |
| Lime hard | 2740 | 2750 |
| Water sand | 2750 | 2760 |
| Lime hard | 2760 | 2775 |
| Shale red | 2775 | 2780 |
| Shale blue | 2780 | 2800 |
| Lime shale | 2800 | 2825 |
| Soft sand no water | 2825 | 2850 |
| Blue shale | 2850 | 2875 |
| Black and white lime | 2875 | 2900 |
| Red shale | 2900 | 2925 |
| Lime white | 2925 | 2950 |
| Red and blue shale | 2950 | 2980 |
| Lime white | 2980 | 2990 |
| Red shale | 2990 | 3020 |
| Red cave—Total depth | 3020 | 3040 |

*Log of Zea no. 1, sec. 28, T. 3 N., R. 13 E., C. M., Near Redpoint*

(Elevation, 3,167 feet)

| Formation | Top | Bottom |
|---|---|---|
| Surface soil | 0 | 20 |
| Sand and clay | 20 | 50 |
| Sandy clay | 50 | 150 |
| Sand and clay | 150 | 170 |
| Clay | 170 | 200 |
| Sand rock | 200 | 218 |
| Sand and red clay | 218 | 375 |
| Hard sand | 375 | 425 |
| Lime | 425 | 430 |
| Broken lime | 430 | 445 |
| Lime | 445 | 470 |
| Red shale | 470 | 575 |
| Broken lime | 575 | 580 |
| Red shale and clay | 580 | 655 |
| Shale and clay | 655 | 765 |
| Broken sand and lime | 765 | 775 |
| Red bed | 775 | 800 |
| Red shale | 800 | 825 |
| Gyp | 825 | 835 |
| Gyp rock | 835 | 855 |
| Gyp and red shale | 855 | 890 |
| Gyp and shale | 890 | 945 |
| Broken gyp rock | 945 | 955 |
| Sand rock | 955 | 973 |
| Gyp rock | 973 | 975 |
| Gyp | 975 | 976 |
| Red shale | 976 | 1150 |
| Sandy shale | 1150 | 1260 |
| Red shale | 1260 | 1425 |
| Red shale and sand | 1425 | 1498 |
| Gyp rock | 1498 | 1500 |
| Red rock | 1500 | 1505 |
| Shale | 1505 | 1555 |
| Gyp | 1555 | 1585 |
| Lime | 1585 | 1600 |
| Broken lime | 1600 | 1608 |
| Gyp and shale | 1608 | 1634 |
| Broken sand and shale | 1634 | 1654 |
| Shale | 1654 | 1708 |
| Salt | 1708 | 1710 |
| Broken sand and gyp | 1710 | 1728 |
| Lime shell | 1728 | 1732 |
| Broken sand, gyp | 1732 | 1783 |
| Shale | 1783 | 1796 |
| Gyp broken | 1796 | 1798 |
| Broken gyp and shale | 1798 | 1888 |
| Broken sand and shale | 1888 | 1935 |
| Sandy lime, shale | 1935 | 1937 |
| Broken sand, shale | 1937 | 1950 |
| Shale | 1950 | 1995 |
| Shale, gyp, sand | 1995 | 2025 |
| Broken lime | 2025 | 2035 |
| Gyp rock | 2035 | 2045 |
| Broken gyp shale | 2045 | 2055 |
| Broken sand and shale | 2055 | 2075 |
| Shale, sand and gyp | 2075 | 2105 |
| Gyp | 2105 | 2110 |
| Gyp and shale | 2110 | 2125 |
| Gyp and shale | 2125 | 2133 |
| Gyp | 2133 | 2135 |
| Gyp | 2135 | 2143 |
| Gyp and shale, broken | 2143 | 2155 |
| Shale | 2155 | 2184 |
| Gyp shell | 2184 | 2185 |
| Red shale | 2185 | 2190 |
| Broken gyp and shale | 2190 | 2201 |
| Gyp rock—Total depth | 2201 | 2204 |



## STRUCTURE

Very little is known as yet concerning the structure of this county except through inference. The rocks on the surface are largely unconsolidated and do not contain well defined mappable horizons. The Tertiary and Quaternary deposits cover all of the county excepting Range and Red Point like a huge blanket. The nature of the structure at Texhoma is problematic.

Figure 69 shows the general relationships of Texas County to the Anadarko Basin. Contours are drawn by Clifton on the base of the red beds. In the Red Point area there are local variations in dip. At Texhoma a monocline(?) represents the structural relationships.

## DEVELOPMENT

Either petroleum or gas has been found in paying quantities in the Panhandle region of Texas to the south, in the vicinity of Liberal, Kansas, to the north and at Texhoma and Red Point in this county. Consequently, Texas County may be regarded as potential oil and gas territory.

The well at Taxhoma was begun by the Home Development Company of Texhoma, November 15, 1922 and completed at a depth of 3,040 feet on December 3, 1923. It is located in the NW.¼ SW.¼ sec. 4, T. 1 N., R. 11 E., C. M. It has been furnishing Texhoma with gas for a number of years. Another well drilled by the same company just one location to the east and drilled to approximately the same depth had produced gas but was not being used when the writer visited the well in the summer of 1929. Exact data regarding the initial production of this well was not available but various estimates range from 5 to 30 million cubic feet. The production comes from the "Big Lime" of the Texas Panhandle which is of Wichita-Albany age (?). The thickness of the producing horizon is 15 feet. It will be observed from examination of the log that the Tertiary rocks were passed through at a depth of 200 feet and the Permian(?) red beds at 2,275 feet with the well ending in the Pennsylvanian.

The well drilled by the H. F. Wilcox Oil and Gas Company in sec. 8, T. 3 N., R. 13 E., C. M. is known as the Zea No. 1. It was begun on September 27, 1925 and completed at 2,204 feet in gypsum which apparently is still in the Permian section. Gas was reported at 2610 feet (3 M. cu. feet) and at 2,680 feet (½ M. cu. ft.) The upper producing horizon (Cottonwood ?) is 50 feet in thickness and the lower is 20 feet thick.

The discovery of gas at Texhoma and at Red Point gave impetus to the lease and royalty business and to drilling activities. Most major oil companies obtained blocks of leases and some have drilled. About fourteen wells have been located or drilled. Texas County has received more play than all the rest of the Oklahoma Panhandle.

*Wells drilled in Texas County*

| COMPANY | LOCATION | DEPTH Feet | RESULTS |
|---|---|---|---|
| Wilcox Oil and Gas Co., F. W. Zea No. 1 | SW SE 28, 3N-13E, CM. | 4,025 | 2,685 gas show |
| Wilcox Oil and Gas Co., Geo S. Honey No. 1 | SE SE 21, 4N-14E, CM. | 4,400 | 2,680 gas show |
| M. M. Valeruis No. 1 | NW SW 18, 3N-12E, CM. | 4,000 | |
| Dilard Easterwood M. M. Valerius No. 2 | SE 32, 5N-12E, CM. | 4,001 | Gas at 2,690<br>Gas at 3,339<br>Gas at 3,940 |
| (Frantz) Reiter-Foster Hurliman No. 1 | NW SW 9, 3N-15E, CM. | 3,500 | 1,000,000 cu. ft.<br>7,000,000 cu. ft. gas, 2,635 |
| Allison-Garber-Pulse Allison No. 1 | NW SW 4, 1N-12E, CM. | 3,040 | 15,000,000 cu. ft. gas |
| (Kugle-Hargrove) Reiter-Foster | Cen. NE 10, 2N-11E, CM. | 3,500 | Abandoned |
| H. & H. Oil Co. | NW NW 25, N- E, CM. | Drilling at 200 Ft. | |
| N. Panhandle Oil Co. | SW 24, 2N-18E, CM. | Drilling at 300 Ft. | |
| Three Way Oil Co. | NW 11, 1N-18E, CM. | Drilling at 2,200 ft. | |
| North Panhandle Oil Co. | NW 5, 1N-19E, CM. | Spudded in | |
| Huddilleson Gas Co. | SE 15, 2N-11E, CM. | 3,503 | |
| Texas Co., Gas Co. No. 1 Boone | NE NE 17, 3N-15E, CM. | | |
| Skaer, Hitch No. 1 | NW cor. 25, 1N-15E, CM. | 250 | Shut down |
| Argus Prod. Co. No. 1 Ralston | C SW 23, 6N-14E | Rig on ground | |



Map No. XLI shows the general east-west subsurface relationships based on well logs. Most wells drilled have been too shallow for thorough tests.

The opposite list includes all wells drilled or located in this county to May, 1930.

## CIMARRON COUNTY

### Location

Cimarron County is the extreme western of the Oklahoma Panhandle counties. It is rectangular in shape and includes all of 45 townships and two-thirds of 9 others making a total area of 1,836 square miles. It embraces Tps. 1 to 5 N., inclusive and four miles of T. 6 N., from the base line 36° 30′ N. Latitude and from Rs. 1 to 9 E., C. M., inclusive. It is bounded on the west by the New Mexico-Oklahoma line, 103° W. Longitude; on the north by the Kansas-Oklahoma line; on the east by Texas County and on the south by the Texas-Oklahoma line.

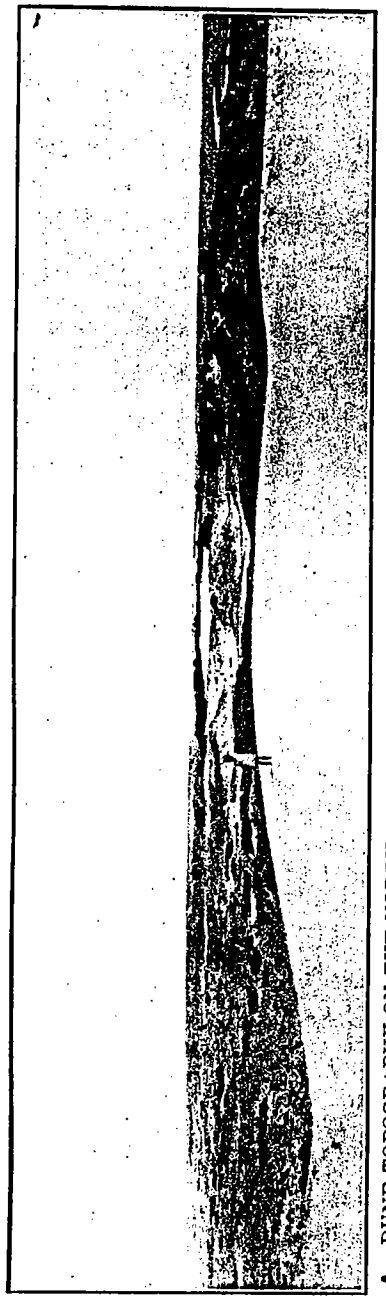
The southern or "dry" Santa Fe Trail from Dodge City, Kansas to New Mexico crosses this county from northeast to southwest and can still be traced across the prairies. (See the geologic map of this county for location.) A branch line of the Santa Fe from Elkhart, Kansas has been built southwest through the county to Felt in sec. 12 T. 1 N., R 2 E., C. M. and connects it with Keyes and Boise City which is the county seat.

The population of Cimarron County is approximately 5,000 which is slightly more than four persons per square mile. Boise City has the largest population with Felt and Kenton next in size. There are numerous stores and trading posts throughout the county.

### Topography

Cimarron County lies within the High Plains physiographic province and, with the exception of the area around Kenton and east along the Cimarron River, it is a gently sloping plain. The area around Kenton, Black Mesa, and Cimarron River Valley presents a beautiful, mature topography. It is replete with historical romance dating from the days of the Basket Makers through the Spanish occupation and the days of the cattle men to the present.

The northwestern part of the county is drained by the Cimarron River and its tributaries the Cold Spring arroyo, South Carrizzo, Tesesquite, West Carrizzo and Gillenas creeks. The eastern part of the county is drained by Goff Creek and North Fork of Beaver. The southern part is drained by North Canadian River and its tributaries Agua Frio, Cieneguilla, and Curumpa creeks. Throughout the central and southern portions many saucer shaped depressions occur similar to



A. DUNE TOPOGRAPHY ON THE NORTH SIDE OF BEAVER CREEK, SOUTH OF NEW FLORIS, BEAVER COUNTY.

B. THE HIGH PLAINS NORTHWEST OF TEXAS COUNTY, ROAD CROSSES ONE OF THE BROAD SAUCER-LIKE UNDRAINED DEPRESSIONS CHARACTERISTIC OF THE PLAINS.



those in Texas County except that they are larger and deeper. Some are two or three miles in diameter and approximately 175 feet deep and many are occupied by intermittent lakes. These depressions are characteristic of the High Plains topography and their origin is as yet problematical.

## GEOLOGY

### Surface formations

The generalized columanar section on page 470 indicates the formations which occur at the surface of this county. (Those above the Paleozoic only).

#### TRIASSIC RED BEDS

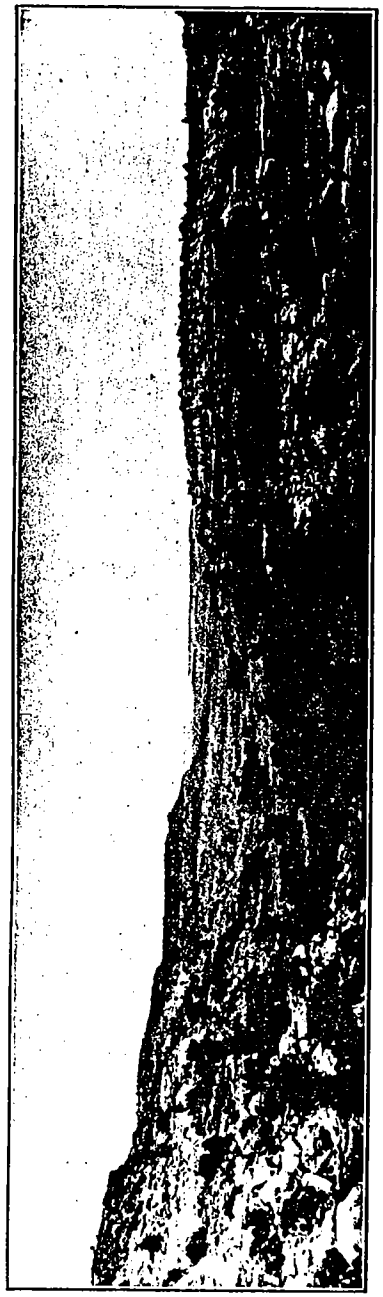
The Triassic red beds are the oldest surface rocks in the county. These outcrop along the Cimarron River in Tps. 5 and 6 N., R. 6 E., C. M. in the valley of the Cimarron River. An excellent exposure is found in secs. 4, 9, and 16, T. 5 N., R 6 E., C. M., on the Burnette Ranch. This exposure is due to the dissection of a small, elliptical fold by one of the tributaries of the Cimarron. Other outcrops of this same formation are found in the valleys of the tributaries of the Cimarron near by. In thickness these red beds are approximately 20 feet in the surface of the exposures. The total thickness in this locality is perhaps as much as 2,000 feet (Rothrock.) A well drilled four miles north of Liberal, Kansas in the SE. cor. sec. 20, T. 33 S., R. 33 E., which is sixty miles east of Cimarron County reports 1,640 feet of red beds. A well drilled fifty miles to the south, near Channing, Texas, shows at least 2,500 feet of red beds. In the Rocky mountains 180 miles to the west, Lee has measured 14,000 feet of red Beds. He suggests, however, that this great thickness may be due to duplication by faulting. If these three localities represent the same stratigraphic horizon as the red beds of Cimarron County, a rapid thickening can be expected to the westward. A well drilled in T. 4 N., R. 1 E., C. M., Cimarron County, logs the red beds 1,670 feet thick.

The character of these Cimarron County red beds is indicated by the following section which was masured by Rothrock.[6]

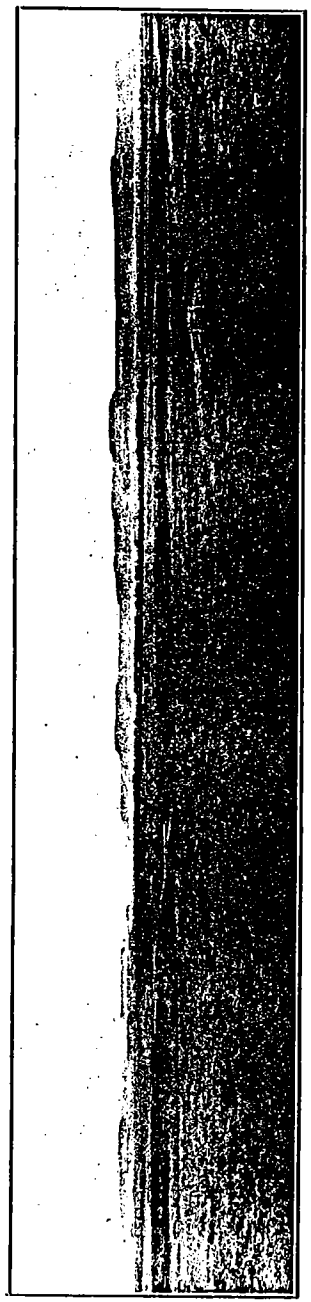
*Section of red beds, cen, sec. 9, T. 5 N., R. 6 E., C. M.*

| | Ft. | in. |
|---|---|---|
| Sandstone, buff, in beds 1 foot thick. Much tiny crossbedding | 5 | 6 |
| Soil, brick red, on slope between benches, typical red bed sandstone exposed at this horizon 200 feet to the west | 8 | 6 |
| Sandstone, buff to red, makes a ledge | 5 | 6 |
| Soil, red, indicating red sandstone | 19 | 6 |

6. Rothrock, E. P., Geology of Cimarron County: Oklahoma Geol Survey Bull 34, pp. 29, 30, 1925.



A. DAKOTA SANDSTONE TOPOGRAPHY EAST OF KENTON IN THE CIMARRON RIVER VALLEY, PURGATOIRE AND MORRISON FORMATIONS UNDERLIE THE SCARP-FORMING DAKOTA SANDSTONE



B. CIMARRON RIVER VALLEY AND BLACK MESA, WEST OF KENTON, OKLA.





The surface character of this formation is indicated in the following well log.

*Well drilled by the Empire Gas and Fuel Co., sec. 22, T. 5 N., R. 5 E., Cimarron County, Oklahoma.*

Drilling commenced April 27, 1917. Date of completion not given.

| Formation | Thickness | Depth |
|---|---|---|
| Soft red shale | 130 | 130 |
| Gray sand | 40 | 170 |
| Gray lime | 15 | 185 |
| Soft red sand | 20 | 205 |
| Soft red shale | 60 | 265 |
| Hard lime | 15 | 280 |
| Soft sandy lime | 22 | 302 |
| Soft red sand | 217 | 519 |
| Soft red rock | 23 | 542 |
| Water sand | 10 | 552 |
| Red rock | 15 | 567 |
| Red clay | 20 | 587 |
| Red rock | 98 | 685 |
| Lime | 37 | 722 |
| Red rock | 92 | 914 |
| Shale | 3 | 917 |
| Lime | 3 | 920 |
| Red rock | 63 | 983 |
| Red clay and gravel | 3 | 986 |
| Red clay and gravel | 5 | 991 |
| Red clay | 42 | 1033 |
| Red clay and gyp | 5 | 1038 |
| Red clay | 20 | 1058 |
| Red clay and gyp | 42 | 1100 |
| Gypsum | 30 | 1130 |
| Sand and gyp | 20 | 1150 |
| Gypsum | 20 | 1170 |
| Clay, gravel and gyp | 20 | 1190 |
| Clay, gravel and gyp | 40 | 1230 |
| Fine sand and shale | 45 | 1275 |
| Sand and shale | 30 | 1305 |
| Sand shale and gyp | 30 | 1335 |
| Sand | 9 | 1344 |
| Fine sand | 15 | 1359 |
| Sand | 15 | 1374 |
| Fine sand | 26 | 1400 |
| Sand and clay | 15 | 1415 |
| Sand | 10 | 1425 |
| Clay, sand and gravel | 15 | 1440 |
| Sand and gyp | 20 | 1460 |
| Sand | 30 | 1490 |
| Sand and clay | 15 | 1505 |
| Sand | 70 | 1575 |
| Sand and clay | 8 | 1583 |

Fossils are rare or totally absent in the surface exposure of these rocks, thus making exact age difficult to determine. Seventy miles west near Folsom, New Mexico Stanton mentions red beds containing Triassic dinosaur bones. From the structural relations of this area it is is quite evident that these two outcrops are the same age. Gould believes that these outcrops are more likely Permian Cloud Chief gypsum.

## COMANCHEAN

Rocks of this age found in Cimarron County consists of a series of red beds resting unconformably upon those of Triassic age. Some geologists do not differentiate between the Comanchean and the older red beds. Above these beds is a series of variegated shales which are as yet unnamed. They are below the angular conformity at the base of the Exter sandstone. They are not present everywhere below the unconformity. Good exposures are found in T. 6 N., R. 1 E., C. M. These are mapped by Rothrock as Morrison. The angular unconformity is much more angular westward in New Mexico.

### EXTER SANDSTONE

This lies above the previously mentioned unconformity and can be well observed in T. 6 N., R. 1 E., C. M. Rothrock included this in the Purgatoire formation.

### MORRISON

The Morrison lies conformably upon the Exter sandstone and is separated from the overlying Purgatoire by a disconformity.

### CRETACEOUS

The lower part of the Cretaceous is Dakota sandstone and the upper is Benton shales and limestones. There are about ten square miles of excellent exposures of the Benton shales around the NW. cor. T. 4 N., R. 2 E., C. M. Rothrock mapped this area as Dakota and Purgatoire.

### TERTIARY

Pliocene and Miocene limestones, clays, and gravels lie unconformably upon Cretaceous Dakota sandstone. Lying unconformably upon these is the basalt of Black Mesa which is a lava flow from craters at Bar Seven L Buttes or Piney Mountain. This lies ten miles east of the west end of the Mesa de Maya (Black Msea) of which it forms the cap rock.

### QUATERNARY

The Quaternary is represented by alluvium along the major drainage lines, gravels on the highlands in the southern part of the county along Beaver Creek, and some eolian deposits. Rothrock' gives a more complete description of these formations in his report on Cimarron County.

#### Subsurface Geology

The subsurface rocks of this area are Pennsylvanian (?) to Recent in age. The following three logs of deep wells drilled in the County describe the character of these rocks.

*Log of Ramsey State School Land No. 1-D well in cen. N.½ N.½ S.½ SE.¼ sec. 34, T. 4 N., R. 1 E., C. M.*

| Formation | Top | Bottom |
|---|---|---|
| Top soil | 0 | 1 |
| White sand stone | 1 | 12 |
| Blue shale | 12 | 17 |
| Sand stone—yellow | 17 | 40 |
| Sand rock | 40 | 100 |
| Blue shale | 100 | 120 |
| White sand soft | 120 | 175 |
| Water sand white | 175 | 205 |
| Shale | 205 | 215 |
| Red rock | 215 | 280 |
| Lime | 280 | 285 |
| Sandy lime | 285 | 290 |
| Sand rock | 290 | 340 |
| Red rock | 340 | 350 |

(Continued on page 485)



| Formation | Top | Bottom |
|---|---|---|
| Sand rock red | 350 | 380 |
| White slate | 380 | 397 |
| Hard sand rock | 397 | 400 |
| Sand rock—red | 400 | 420 |
| Red rock hard | 420 | 423 |
| Sand rock | 423 | 470 |
| White mud | 470 | 480 |
| White sandy shale | 480 | 545 |
| Hard sand rock | 545 | 550 |
| Sand stone hard | 550 | 553 |
| Blue slate | 553 | 568 |
| Blue mud | 568 | 640 |
| Sandy shale | 640 | 665 |
| Gray sandy shale | 665 | 675 |
| Red rock | 675 | 693 |
| Red sandy lime | 693 | 698 |
| Red rock | 698 | 739 |
| Sand red rock | 739 | 747 |
| Lime | 747 | 752 |
| Red sand rock | 752 | 754 |
| Lime | 754 | 756 |
| Red rock | 756 | 775 |
| Sand water | 775 | 788 |
| Red sand | 788 | 794 |
| Red rock | 794 | 808 |
| Red sand rock | 808 | 855 |
| Sandy lime | 855 | 862 |
| Lime—some sand | 862 | 870 |
| Red rock | 870 | 923 |
| Sandy lime | 923 | 935 |
| Red rock | 935 | 1008 |
| Sand lime | 1008 | 1025 |
| Red bed | 1025 | 1045 |
| Red mud | 1045 | 1075 |
| Red rock—muddy | 1075 | 1150 |
| Sandy red rock | 1150 | 1275 |
| Lime hard | 1275 | 1283 |
| Red mud | 1283 | 1290 |
| Lime | 1290 | 1333 |
| Red rock | 1333 | 1415 |
| Lime | 1415 | 1425 |
| Red rock | 1425 | 1440 |
| Red sand rock | 1440 | 1520 |
| Sandy rock hard | 1520 | 1535 |
| Red rock | 1535 | 1585 |
| Hard sand rock | 1585 | 1615 |
| Hard lime | 1615 | 1645 |
| Rock salt | 1645 | 1720 |
| Hard white sand | 1720 | 1740 |
| White sandy lime | 1740 | 1750 |
| Rock salt | 1750 | 1815 |
| Lime hard & sandy | 1815 | 1852 |
| Red rock | 1852 | 1880 |
| Sandy lime hard | 1880 | 1896 |
| Hard lime | 1896 | 1916 |
| Fine brown sand | 1916 | 1946 |
| Sandy lime | 1946 | 1965 |
| Brown sand | 1965 | 2015 |
| Red rock | 2015 | 2021 |
| Sandy red rock | 2021 | 2136 |
| Sandy red rock | 2136 | 2187 |
| Quick sand red | 2187 | 2201 |
| Sand | 2201 | 2225 |
| Sand red rock | 2225 | 2240 |
| Sand | 2240 | 2245 |
| Red rock | 2245 | 2253 |
| Hard sand | 2253 | 2268 |
| Red shale | 2268 | 2272 |
| Sand | 2272 | 2295 |
| Sandy red rock | 2295 | 2320 |
| Hard red sand | 2320 | 2327 |
| Hard sand | 2327 | 2341 |
| Sand | 2341 | 2350 |
| Red rock | 2350 | 2360 |
| Sand | 2360 | 2366 |
| Red sand | 2366 | 2374 |
| Red rock | 2374 | 2380 |
| Hard sand | 2380 | 2410 |
| Hard lime | 2410 | 2420 |
| Hard sand | 2420 | 2488 |
| Red mud | 2488 | 2493 |
| Lime | 2493 | 2500 |
| Red rock | 2500 | 2508 |
| Hard lime | 2508 | 2520 |
| Hard red sand | 2520 | 2584 |
| Hard sand | 2584 | 2608 |
| Soft red sand | 2608 | 2616 |
| Red sand | 2616 | 2652 |
| Red rock | 2652 | 2664 |
| Red sand | 2664 | 2707 |
| Red sand rock hard | 2707 | 2745 |
| Sand hard | 2745 | 2765 |
| Red rock | 2765 | 2780 |
| Sand | 2780 | 2785 |
| Red rock | 2785 | 2808 |
| Hard sand | 2808 | 2820 |
| Sand | 2820 | 2840 |
| Red rock | 2840 | 2870 |
| Sand | 2870 | 2890 |
| Red rock | 2890 | 2898 |
| Red rock | 2898 | 2904 |
| Hard sand | 2904 | 2912 |
| Red rock | 2912 | 2940 |
| Sandy red rock | 2940 | 3000 |
| Red rock | 3000 | 3010 |
| Sand | 3010 | 3020 |
| Red sand | 3020 | 3038 |
| Hard rock | 3038 | 3050 |
| Red rock | 3050 | 3068 |
| Sandy red rock | 3068 | 3095 |
| Red clay cave | 3095 | 3110 |
| Red rock & lime | 3110 | 3130 |
| Red sandy lime | 3130 | 3135 |
| Red rock cave | 3135 | 3180 |

(Continued on page 486)

| Formation | Top | Bottom |
|---|---|---|
| Sandy lime | 1887 | 1915 |
| Sandy r. r. & shale | 1917 | 2009 |
| Sand | 2009 | 2014 |
| Sandy red rock | 2014 | 2114 |
| Red rock & shale | 2114 | 2144 |
| Sandy red rock | 2144 | 2159 |
| Shale | 2159 | 2171 |
| Sandy r. rock | 2171 | 2406 |
| Sand | 2406 | 2424 |
| Red rock | 2424 | 2456 |
| Sand | 2456 | 2462 |
| Red rock | 2462 | 2498 |
| Shale | 2498 | 2502 |
| Red rock & sand | 2502 | 2673 |
| Shale | 2673 | 2683 |
| Sandy red rock | 2683 | 2783 |
| Shale | 2783 | 2818 |
| Shale & red rock | 2818 | 2859 |
| Sand | 2859 | 2866 |
| Shale | 2866 | 2900 |
| Broken lime | 2900 | 2912 |
| Broken lime & sand | 2912 | 2973 |
| Broken lime & shale | 2973 | 2993 |
| Shale | 2993 | 3001 |
| Red rock | 3001 | 3025 |
| Red sand | 3025 | 3035 |
| Blue shale | 3035 | 3080 |
| Black shale | 3080 | 3085 |
| Blue shale | 3085 | 3100 |
| Black shale | 3100 | 3108 |
| Sand | 3108 | 3128 |
| Brown shale | 3128 | 3140 |
| Sand | 3140 | 3182 |
| Red rock | 3182 | 3200 |
| Sandy red rock | 3200 | 3220 |
| Sand | 3200 | 3230 |
| Sandy lime | 3230 | 3242 |
| Red rock | 3242 | 3275 |
| Lime | 3275 | 3280 |
| Red rock | 3280 | 3300 |
| Sand | 3300 | 3310 |
| Brown shale | 3310 | 3335 |
| Black shale | 3335 | 3355 |
| Lime | 3355 | 3365 |
| Blue shale | 3365 | 3390 |
| Brown shale | 3390 | 3405 |
| Lime | 3405 | 3425 |
| Brown shale | 3425 | 3435 |
| Red rock | 3435 | 3450 |
| Lime | 3450 | 3475 |
| Blue shale | 3475 | 3485 |
| Red rock | 3485 | 3510 |
| Sand | 3510 | 3520 |
| Brown shale | 3520 | 3530 |
| Red rock | 3530 | 3565 |
| Brown shale | 3565 | 3580 |
| Brown lime | 3580 | 3600 |
| Brown shale | 3600 | 3610 |
| Red rock | 3610 | 3625 |
| Red rock | 3625 | 3640 |
| Brown shale | 3640 | 3645 |
| Hard lime | 3645 | 3650 |
| Hard sand | 3650 | 3660 |
| Broken lime & sand | 3660 | 3665 |
| Sand | 3665 | 3705 |
| Red rock | 3705 | 3730 |
| Sand | 3730 | 3755 |
| Red rock | 3755 | 3770 |
| Sandy lime | 3770 | 3785 |
| Hard lime | 3785 | 3800 |
| Sandy red rock | 3800 | 3820 |
| Red sand | 3820 | 3840 |
| Red rock | 3840 | 3890 |
| Sand | 3890 | 3905 |
| Pink shale | 3905 | 3935 |
| Blue shale | 3935 | 3950 |
| Shale & shell | 3950 | 3970 |
| Brown lime | 3970 | 4005 |
| Sand | 4005 | 4050 |
| Red shale | 4050 | 4060 |
| Broken sand & lime | 4060 | 4085 |
| Brown shale | 4085 | 4095 |
| Bkn. shale & lime | 4095 | 4150 |
| Sand | 4150 | 4165 |
| Shale | 4165 | 4200 |
| Shale | 4200 | 4210 |
| Black shale | 4210 | 4235 |
| Bkn. shale & lime | 4235 | 4295 |
| Lime | 4295 | 4305 |
| Sticky shale | 4305 | 4340 |
| Shale & lime | 4340 | 4390 |
| Shale & sand | 4390 | 4400 |
| Shale & lime | 4400 | 4435 |
| Sticky shale | 4435 | 4450 |
| Shale & lime | 4450 | 4470 |
| Red shale | 4470 | 4500 |
| Red shale | 4500 | 4530 |
| Blue shale & lime shells | 4530 | 4550 |
| Blue lime | 4550 | 4565 |
| Gray sand | 4565 | 4570 |
| Slate & lime | 4570 | 4580 |
| Sand | 4580 | 4590 |
| Lime | 4590 | 4615 |
| Lime | 4615 | 4625 |
| Shale | 4625 | 4640 |
| Sand | 4640 | 4660 |
| Gray sand | 4660 | 4665 |
| Sandy lime | 4665 | 4690 |
| Hard sand | 4690 | 4705 |
| Blue slate | 4705 | 4735 |
| Sand lime | 4735 | 4740 |
| Black slate | 4740 | 4765 |

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| Formation | Top | Bottom |
|---|---|---|
| Red sand | 3180 | 3206 |
| Sand | 3206 | 3223 |
| Red sand | 3223 | 3247 |
| Sandy red rock | 3247 | 3250 |
| Slate blue & gray | 3250 | 3255 |
| Lime | 3255 | 3264 |
| Red rock | 3264 | 3297 |
| Sandy red rock | 3297 | 3312 |
| Sand—H.F.W. | 3312 | 3371 |
| Sand red | 3371 | 3378 |
| Slate blue | 3378 | 3383 |
| Sandy lime | 3383 | 3393 |
| Blue slate | 3393 | 3399 |
| Red rock | 3399 | 3423 |
| Lime | 3423 | 3433 |
| Red rock cave | 3433 | 3496 |
| Lime shell | 3496 | 3500 |
| Red rock & shells | 3500 | 3550 |
| Lime | 3550 | 3573 |
| Sandy lime | 3573 | 3608 |
| Sand | 3608 | 3635 |
| Sandy gray | 3635 | 3642 |
| Sand—hole full water | 3642 | 3665 |
| Blue shale | 3665 | 3670 |
| Sandy lime | 3670 | 3725 |
| Red rock | 3725 | 3732 |
| Sand | 3732 | 3767 |
| Sand | 3767 | 3800 |
| Red sandy shale | 3800 | 3818 |
| Red rock | 3818 | 3855 |
| Lime shell | 3855 | 3858 |
| Gray lime | 3858 | 3865 |
| Red rock | 3865 | 3870 |
| Lime | 3870 | 3880 |
| Sandy lime | 3880 | 3915 |
| Blue shale | 3915 | 3923 |
| Sandy lime | 3923 | 3960 |
| Blue shale | 3960 | 3985 |
| Sandy lime | 3985 | 4010 |
| Sandy lime | 4010 | 4050 |
| Sand | 4050 | 4056 |
| Sandy lime | 4056 | 4090 |
| Water sand | 4090 | 4100 |
| Sandy lime | 4100 | 4190 |
| Sand | 4190 | 4205 |
| Sandy shale | 4205 | 4220 |
| Sandy lime | 4220 | 4235 |
| Sandy brown shale | 4235 | 4250 |
| Sandy lime | 4250 | 4289 |
| Brown shale | 4289 | 4295 |
| Sand | 4295 | 4306 |
| Total depth | | 4306 |

*Log of Sinclair Oil & Gas Co. School Land No. 48 well in NE.¼ NE.¼ NE.¼ sec. 22, T. 5 N., R. 2 E., C. M.*

| Formation | Top | Bottom |
|---|---|---|
| Lime | 0 | 6 |
| Br. shale | 6 | 20 |
| Shale & lime | 20 | 31 |
| Hard lime | 31 | 41 |
| Sandy shale | 41 | 56 |
| Hard lime | 56 | 64 |
| Red rock | 64 | 71 |
| Sand | 71 | 86 |
| Lime and shell | 86 | 120 |
| Lime and red rock | 120 | 150 |
| Lime and shale | 150 | 342 |
| Red rock | 342 | 432 |
| Lime and shell | 432 | 450 |
| Red rock | 450 | 480 |
| Lime and shell | 480 | 535 |
| Sandy red rock | 535 | 698 |
| Broken shell | 698 | 713 |
| Red shale | 713 | 773 |
| Shell | 773 | 796 |
| Red shale | 796 | 800 |
| Lime | 800 | 806 |
| Red shale | 806 | 816 |
| Broken shell | 816 | 832 |
| Red shale | 832 | 886 |
| Red sh. & shell | 886 | 956 |
| Red rock & shale | 956 | 1118 |
| Br. sand & slate | 1118 | 1157 |
| Red shale | 1157 | 1242 |
| Lime | 1242 | 1246 |
| Red shale | 1246 | 1282 |
| Lime | 1282 | 1290 |
| Broken lime | 1290 | 1340 |
| Shell and lime | 1340 | 1365 |
| Broken shell & L. S. | 1365 | 1385 |
| Broken lime | 1385 | 1440 |
| Sandy red rock | 1440 | 1475 |
| Sandy r. r. sh. & gyp | 1475 | 1527 |
| Gyp & red rock | 1527 | 1540 |
| Red shale | 1540 | 1548 |
| Hard sand & r. r. | 1548 | 1565 |
| Red rock & shale | 1565 | 1587 |
| Shale & lime | 1587 | 1604 |
| Shale & lime | 1604 | 1614 |
| Red r. & shale | 1614 | 1708 |
| Shale | 1708 | 1728 |
| Red r. & shale | 1728 | 1829 |
| Sandy red rock | 1829 | 1853 |
| Broken lime | 1853 | 1885 |
| Shale | 1885 | 1887 |

(Continued on page 488)

| Formation | Top | Bottom |
|---|---|---|
| Blue slate | 4765 | 4780 |
| Slate sandy | 4780 | 4800 |
| Blue shale | 4800 | 4860 |
| Sandy shale | 4860 | 4870 |
| Sand-water | 4870 | 4872 |
| Total depth | | 4872 |

*Log of J. R. Phillips No. 1 well in SE.¼ SE.¼ NE.¼ sec. 24, T. 6 N., R. 2 E., C. M.*

| Formation | Top | Bottom |
|---|---|---|
| Sand | 0 | 25 |
| Red rock | 25 | 35 |
| Sand | 35 | 45 |
| Red rock | 45 | 55 |
| Sand | 55 | 80 |
| Shale | 80 | 100 |
| Gyp | 100 | 105 |
| Shale | 105 | 120 |
| Gyp | 120 | 125 |
| Shale | 125 | 175 |
| Gyp | 175 | 190 |
| Shale | 190 | 220 |
| Shale | 220 | 265 |
| Gyp | 265 | 275 |
| Sand | 275 | 340 |
| Gyp | 340 | 360 |
| Sand | 360 | 700 |
| Red rock | 700 | 875 |
| Sand | 875 | 885 |
| Gyp | 885 | 930 |
| Red rock | 930 | 1000 |
| Gyp | 1000 | 1025 |
| Sand | 1025 | 1085 |
| Red rock | 1085 | 1110 |
| Sand | 1110 | 1140 |
| Red rock | 1140 | 1180 |
| Sand | 1180 | 1225 |
| Salt | 1225 | 1235 |
| Red rock | 1235 | 1245 |
| Gyp | 1245 | 1275 |
| Salt | 1275 | 1300 |
| Gyp | 1300 | 1330 |
| Salt | 1330 | 1380 |
| Gyp | 1380 | 1430 |
| Red rock | 1430 | 1465 |
| Sand | 1465 | 1675 |
| Gyp | 1675 | 1685 |
| Red rock | 1685 | 1700 |
| Gyp | 1700 | 1705 |
| Red rock | 1705 | 1715 |
| Sand | 1715 | 1730 |
| Sandy shale | 1730 | 1760 |
| Red rock | 1760 | 1785 |
| Gyp | 1785 | 1790 |
| Red rock | 1790 | 1805 |
| Gyp | 1805 | 1815 |
| Red rock | 1815 | 1860 |
| Gyp | 1860 | 1885 |
| Red rock | 1885 | 1955 |
| Sand | 1955 | 1990 |
| Red rock | 1900 | 2150 |
| Sand | 2150 | 2200 |
| Red rock | 2200 | 2240 |
| Sand | 2240 | 2255 |
| Red rock | 2255 | 2290 |
| Sand | 2290 | 2335 |
| Gyp | 2335 | 2350 |
| Sand | 2350 | 2385 |
| Red rock | 2385 | 2395 |
| Sand | 2395 | 2410 |
| Red rock | 2410 | 2455 |
| Sand | 2455 | 2588 |
| Sand | 2588 | 2596 |
| Sand | 2596 | 2610 |
| Sandy shale | 2610 | 2625 |
| Sand | 2625 | 2670 |
| Shale | 2670 | 2710 |
| Sandy shale | 2710 | 2770 |
| Sand | 2770 | 2800 |
| Shale | 2800 | 2890 |
| Sand | 2890 | 2920 |
| Sand shale | 2920 | 2984 |
| Lime | 2984 | 2988 |
| Sand | 2988 | 3000 |
| Broken shale | 3000 | 3160 |
| Sand | 3160 | 3170 |
| Shale | 3170 | 3235 |
| Lime | 3235 | 3238 |
| Shale | 3238 | 3290 |
| Sand | 3290 | 3315 |
| Sand shale | 3315 | 3350 |
| Sand lime | 3350 | 3355 |
| Sandy shale | 3355 | 3400 |
| Sandy lime | 3400 | 3415 |
| Shale | 3415 | 3445 |
| Shale | 3445 | 3462 |
| Lime | 3462 | 3487 |
| Sandy shale | 3487 | 3497 |
| Sandy lime | 3497 | 3515 |
| Shale | 3515 | 3590 |
| Shale | 3590 | 3630 |
| Sandy shale | 3630 | 3670 |
| Sand | 3670 | 3675 |
| Lime | 3675 | 3688 |
| Shale | 3688 | 3734 |
| Sandy lime | 3734 | 3745 |

(Continued on page 489)



| Formation | Top | Bottom |
|---|---|---|
| Shale | 3745 | 3760 |
| Lime | 3760 | 3800 |
| Shale | 3800 | 3825 |
| Sandy lime | 3825 | 3850 |
| Shale | 3850 | 4005 |
| Sandy shale | 4005 | 4017 |
| Sandy lime | 4017 | 4025 |
| Shale | 4025 | 4045 |
| Broken lime | 4045 | 4105 |
| Shale | 4105 | 4115 |
| Lime | 4115 | 4125 |
| Shale | 4125 | 4130 |
| Lime | 4130 | 4145 |
| Lime | 4145 | 4160 |
| Broken lime | 4160 | 4170 |
| Shale | 4170 | 4187 |
| Lime | 4187 | 4215 |
| Shale | 4215 | 4246 |
| Sandy lime | 4246 | 4268 |
| Broken lime | 4268 | 4315 |
| Conglomerate | 4315 | 4370 |
| Total depth | | 4370 |

### STRUCTURE

Structural relationships in the eastern and southern parts of the county are not very well known due to overlying alluvial and gravel deposits. Mappable horizons are abundant in the northwestern part of the county. Here can be observed a series of folds whose axes parallel the axial trend of the Rocky Mountain flexures farther west in New Mexico. Numerous small anticlinal folds have been mapped in this county and some have been drilled. In no case thus far have wells proved commercially productive of either oil or gas.

### DEVELOPMENT

To date (May 30, 1930) eight wells have been drilled in Cimarron County without production. Further exploration may prove productive.

The table on page 490 gives a list of wells drilled in this county.

## SUMMARY

The foregoing report covers that portion of Oklahoma commonly known as the "Panhandle." It is subdivided into Beaver, Texas and Cimarron counties and embraces some 5,790 square miles of territory.

The surface rocks are Permian, Triassic, Comanchean, Cretaceous, Tertiary and Quaternary in age. Of the subsurface formations little is known because the greater part of the surface is covered by Tertiary sands and gravels. Some data are available from well logs indicating rocks as old as Pennsylvanian.

Structurally the region is a part of the monocline forming the Great Plains and the northern flank of the Anadarko Basin whose axis lies to the south in the Texas Panhandle. The outcrops in the northwestern part of the area along the Cimarron River are easily mapped. Those in other areas are difficult because of the unconsolidated nature of the overlying sediments. Axial trend of the folds is nearly parallel to the southern Rocky Mountain orogenic axes.

CAPULIN, A RECENT VOLCANIC CONE IN NORTHEASTERN NEW MEXICO; A POSSIBLE SOURCE FOR VOLCANIC ASH DEPOSITS OF THE PANHANDLE AND ADJACENT REGIONS.

*Wells drilled in Cimarron County*

| COMPANY | LOCATION | DEPTH Feet | RESULTS |
|---|---|---|---|
| Sinclair Oil and Gas Co. | NW SE NE 22, 5N-2E, CM. | 3,745 | Dry |
| J. R. Phillips | NE 24, 6N-2E, CM. | 3,900 | Dry |
| Ramsey Bros., A1 | NE 27, 5N-5E, CM. | 4,512 | Oil Show |
| Ramsey Bros., C1 | SE SE 4, 5N-6E, CM. | 3,957 | Dry |
| Ramsey Bros., D1 | NW SE 34, 4N-1E, CM. | 320 | |
| Gladys Belle | Cen. 25, 3N-7E, CM. | 4,095 | Dry |
| Smith-Krull | NE 2, 2N-9E, CM. | (?) | Rig down, lease lapsed. |
| Magnolia Pet. Co., School Land No. 1. | Cen. SE NE 22, 5N-5E, CM. | 4,356 | Abandoned |
| Magnolia Pet. Co., School Land No. 1. | Cen. SW NE 27, 5N-5E, CM. | 100 | Drilling |



Thus far three tests for oil and gas have been located in Beaver County, fifteen in Texas County, and eight in Cimarron County. Texas County has the majority because gas was discovered in the Texhoma and Red Point districts, giving impetus to the leasing and royalty business in 1925-26.

Much detailed field work will be necessary to determine the exact stratigraphic relationships in this area. Geophysical and core drilling work in addition to ordinary methods should be used.

A number of corrections in the areal geology as shown on the State geological map have been made in the map accompanying this report. Much data of a confidential nature concerning this region is in the files of major oil companies but is not available for publication.

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