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OIL AND GAS IN OKLAHOMA

WOODS, ALFALFA, HARPER, MAJOR, WOODWARD, AND ELLIS COUNTIES

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FOREWORD

In 1917 the Oklahoma Geological Survey issued Bulletin 19, Part II, entitled "Petroleum and Natural Gas in Oklahoma." This volume was so popular that the supply was soon exhausted, and for several years copies have not been obtainable.

The present Director has seen the need of a revision of this bulletin. On account of the lack of appropriations he has not been able to employ sufficient help to compile the data, and has called on some twenty representative geologists throughout the state to aid in the preparation of reports on separate counties. These gentlemen, all busy men, have contributed freely of their time and information in the preparation of these reports.

It will be understood that the facts as set forth in the various reports represent the observation and opinion of the different men. The Oklahoma Geological Survey has every confidence in the judgment of the various authors, but at the same time the Survey does not stand sponsor for all statements made or for all conclusions drawn. Reports of this kind, are at best, progress reports, representing the best information obtainable as of the date issued, and doubtless new data will cause many changes in our present ideas.

The present paper, the first of the series to be printed has been prepared by Mr. R. L. Clifton, geologist for the Champlin Refining Company, of Enid, Oklahoma. It includes six counties in the northwestern part of the State. namely, Woods, Alfalfa, Major, Woodward, Harper, and Ellis. Mr. Clifton is particularly fitted to write on these counties, having lived the greater part of his life in this part of Oklahoma. He is probably better acquainted with the geology of the region, both surface and subsurface, than any other man.

CHAS. N. GOULD,

June 1st, 1926. Director.

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.

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 western 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.

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

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

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 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.

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.
8. Clifton, R. L.; Bull. Oklahoma Acad. Sci., vol. 5, pp. 128-132, 1925.

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 Kay 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).

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 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

9. Gould, C. N.; A New Classification of the Permian Redbeds: Bull. Am. Assn. Petroleum Geologists, vol. 8, pp. 322-341, 1924.

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 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.

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 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	745
Red sand, soft	745	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
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

	Top	Bottom
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 400 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

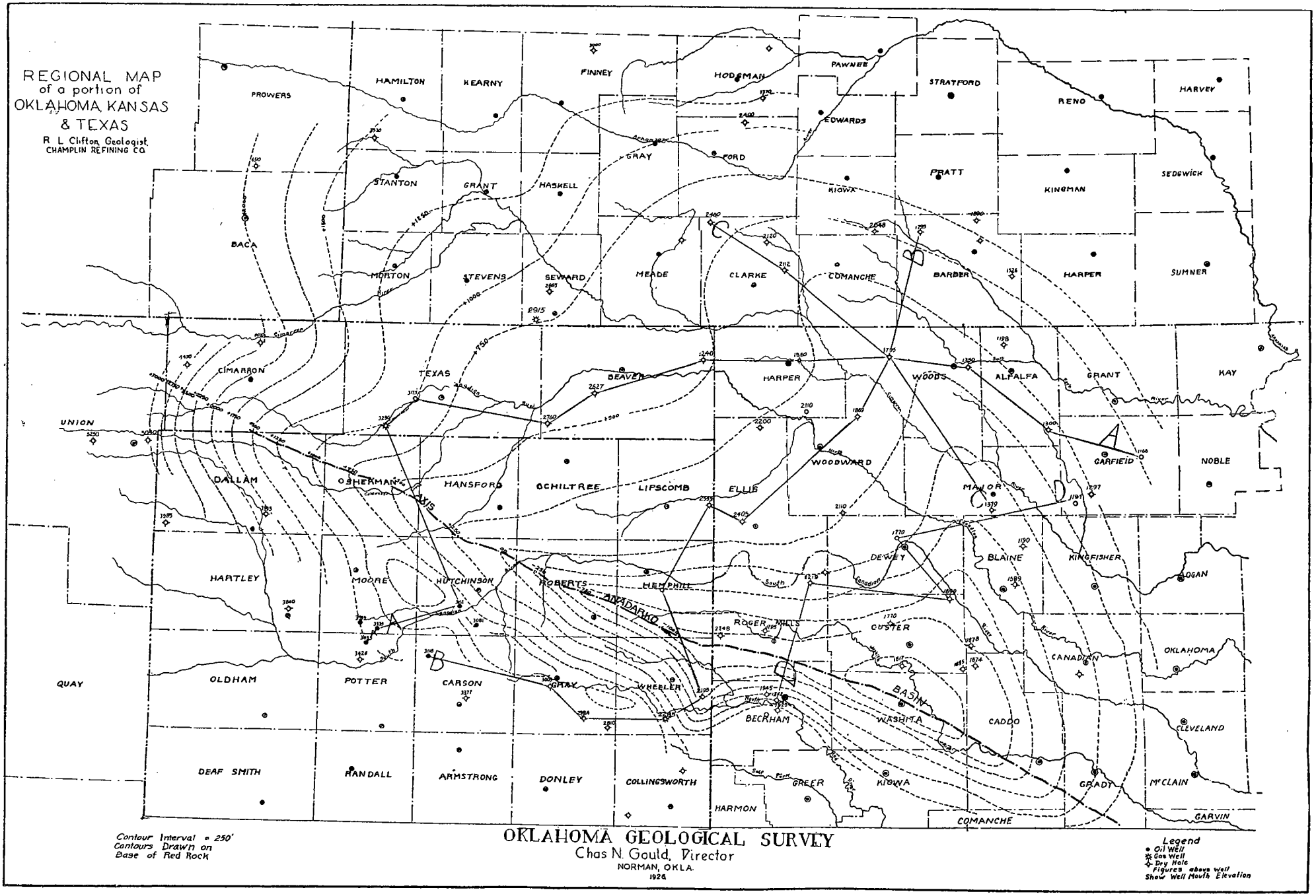
Ellis County is located in the northwestern part of the State. Its western boundary is a part of the Oklahoma-Texas boundary. The county extends from Tps. 16-24 N., inclusive, and from Rs. 21-26 W., inclusive. This includes 25 entire townships and parts of 16 others. The total area is approximately 1,188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

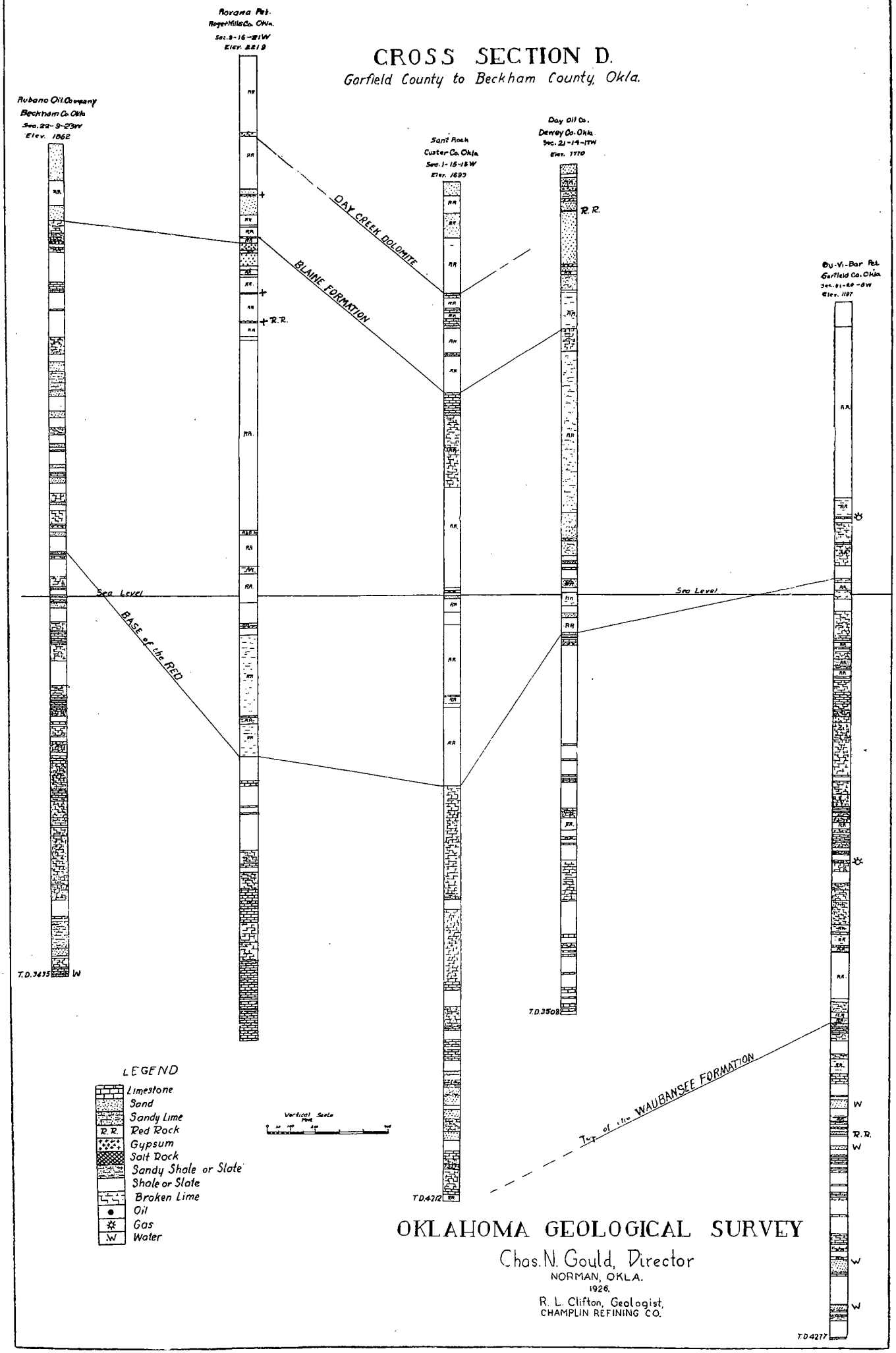
GEOLOGY

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


REGIONAL MAP
of a portion of
OKLAHOMA, KANSAS
& TEXAS
R. L. Clifton, Geologist
CHAMPLIN REFINING CO.
PROWERS
HAMILTON
KEARNY
FINNEY
HODGEMAN
PAWNEE
STRATFORD
RENO
HARVEY
EDWARDS
STANTON
GRANT
HASKELL
GRAY
FORD
KIOWA
PRATT
KINGMAN
SEDGWICK
BACA
MORTON
STEVENS
SEWARD
MEADE
CLARKE
COMANCHE
BARBER
HARPER
SUMNER
CIMARRON
TEXAS
BEAVER
HARPER
WOODS
ALFALFA
GRANT
KAY
UNION
DALLAM
SHERMAN
HANSFORD
OCHILTREE
LIPSCOMB
ELLIS
WOODWARD
MAJOR
GARFIELD
NOBLE
HARTLEY
MOORE
HUTCHINSON
ROBERTS
HEMPHILL
DEWEY
BLAINE
KINGFISHER
LOGAN
ROGER MILLS
CUSTER
CANADIAN
OKLAHOMA
QUAY
OLDHAM
POTTER
CARSON
GRAY
WHEELER
BECKHAM
WASHITA
CADDO
CLEVELAND
DEAF SMITH
RANDALL
ARMSTRONG
DONLEY
COLLINGSWORTH
GREER
KIOWA
GRADY
McCLAIN
HARMON
COMANCHE
GARVIN
+1250
+1000
+750
+500
Contour Interval = 250'
Contours Drawn on
Base of Red Rock
OKLAHOMA GEOLOGICAL SURVEY
Chas N. Gould, Director
NORMAN, OKLA.
1926
Legend
Oil Well
Gas Well
Dry Hole
Figures above well
Show Well Mouth Elevation

CROSS SECTION D.

Garfield County to Beckham County, Okla.



OKLAHOMA GEOLOGICAL SURVEY

Chas. N. Gould, Director

NORMAN, OKLA.

1926.

R. L. Clifton, Geologist,
CHAMPLIN REFINING CO.