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OIL AND GAS IN OKLAHOMA

LOVE AND MARSHALL COUNTIES

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and
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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.

This report on the oil and gas geology of Love and Marshall counties was written by Dr. Fred M. Bullard of the department of geology of the University of Texas and Mr. John S. Redfield, geologist of the Oklahoma Geological Survey. Dr. Bullard has had wide field experience in these two counties, the results of which were published by the Survey as Bulletins 33 and 39. This report was largely written by Mr. Redfield with the help and direction of Dr. Bullard.

Norman, Oklahoma
March, 1930

CHAS. N. GOULD,
Director.

OIL AND GAS IN OKLAHOMA

LOVE AND MARSHALL COUNTIES

By

Fred M. Bullard[1] and John S. Redfield

INTRODUCTION

Location

Love and Marshall counties are located in the extreme south-central part of Oklahoma. They are bounded on the south by Red River, on the west by Jefferson County, on the north by Carter and Johnston counties, and on the east by Bryan County. The total area is approximately 965 square miles, Love comprising 523 square miles and Marshall 442.

Literature

For a list of the principal publications relating to the geology of the area discussed in the present report, see pp. 9-10, Bulletin 39,[2] Oklahoma Geological Survey. Bulletins 33[3] and 39 of the Oklahoma Geological Survey served as the source for practically all of the data and maps used in this report; up-to-date production and development data were added.

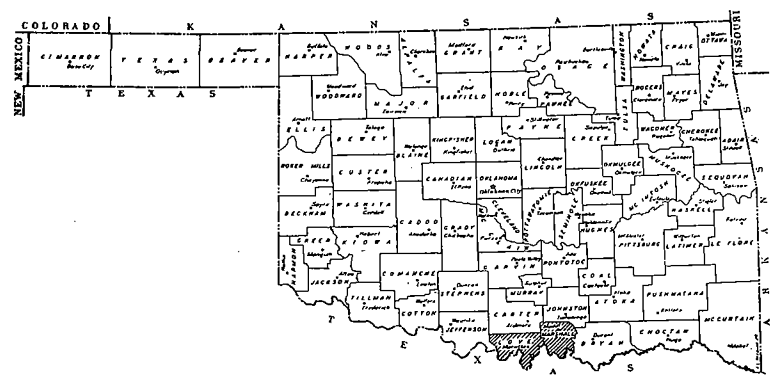


Figure 1.—Index map of Oklahoma showing location of Love and Marshall counties.

1. Department of Geology, University of Texas.
2. Fred M. Bullard, 1926.
3. Fred M. Bullard, 1925.

Physiography

Love and Marshall counties lie in the Red River Plain, which is the northern border of the larger physiographic province of North America known as the Gulf Coastal Plain. The Gulf Coastal Plain extends almost entirely around the Gulf of Mexico as a broad belt of sands, clays, and limestones having a gentle slope toward the sea.

Drainage and Topography

Red River and its tributaries drain the entire area of Love and Marshall counties. The principal tributaries, from east to west, are Washita River, Buncombe Creek, Hickory Creek, Walnut Bayou, and Mud Creek. The drainage which is generally to the south and east, conforms to the normal dip of the surface rocks. As a rule the streams have narrow channels with broad flood plains. Red River has a very slight gradient, averaging less than one foot six inches per mile for its extent along the southern boundary of the area.

The topography of this region is rolling to hilly. In the Criner Hills of northern Love County elevations of 150 to 300 feet above the surrounding country are not uncommon. In the Cretaceous area the maximum relief is less than 150 feet except along Red River where bluffs 200 feet above the water level are found.

The main topographic feature, other than the Criner Hills, is the Goodland limestone escarpment (see Goodland outcrop, Plate I). Underlying the massive, hard Goodland limestone is Trinity sand which is a loose, unconsolidated pack sand. The difference in hardness of these two formations gives rise to a pronounced escarpment where they outcrop together, the ridge being continuous and regular, usually from 75 to 100 feet high.

Another noticeable feature is the line of symmetrical hills southeast of Marietta which rise 150 to 200 feet above the valleys at their base, capped by the Main Street limestone.[4]

The wide, meandering bends which Red River makes are conspicuous physiographic features of the southern parts of Love and Marshall counties.

The Criner Hills of northern Love County are made up essentially of the same formations as are exposed in the Arbuckle Mountains. The limestones as a rule form the hills and the shales the valleys.

General Geologic Features

The surface rocks of Love and Marshall counties are mainly Lower Cretaceous in age, although Upper Cretaceous and Paleozoic rocks are represented in small exposures. Just to the north of this area the old

4. The name Main Street limestone is adopted because of its priority over Bennington limestone.

Paleozoic rocks and pre-Paleozoic granites come to the surface in the Arbuckle Mountain uplift. The upper surface of the Paleozoic rocks is believed to have been worn down to a peneplain prior to the deposition of the Comanchean sediments upon it, and subsequently tilted seaward. The Comanchean rocks, lapping unconformably upon the Paleozoic rocks and the pre-Paleozoic granites, represent the ancient shore line of the Comanchean sea in which practically all the rocks exposed at the surface in Love and Marshall counties were deposited as a result of the wasting and erosion of the Arbuckle Mountains and other land areas to the north.

Only the basal part of the Upper Cretaceous deposits are represented in this area, and that is in southeastern Marshall County where the Woodbine sand occupies an area of approximately three square miles. No doubt the major part of the Upper Cretaceous section was present in this area at one time since it is well developed in the area adjoining to the east and south, but erosion has removed all except the basal portion of the lowest formation.

In the Criner Hills of Love County there is a considerable area of Pennsylvanian rocks, and near Overbrook a small *V*-shaped area of Paleozoic rocks older than Pennsylvanian.[5] In the western part of the county the Permian underlies the Comanchean but does not extend very far to the east. Well records in the eastern part of Love County show that the Comanchean lies directly upon the Pennsylvanian. If the Permian ever covered the eastern part of the county it evidently was removed by pre-Comanchean erosion.

The Lower Cretaceous rocks consist of sands, shaly clays, marls, and limestones. They form a total thickness averaging about 1,000 feet in this area. Overlying the Comanche series, and separated from it by a probable unconformity, is found the basal part of the Woodbine sand, the oldest of the Upper Cretaceous formations.

Recent alluvium, river sand, and terrace deposits along Red River represent the youngest formations found on the surface in this area.

STRATIGRAPHY

Paleozoic

On the geologic map (Plate I) the Paleozoic area is outlined as being undifferentiated and completely surrounded by rocks of Trinity age. These regions have subsequently been worked by Dr. C. W. Tomlinson and J. A. Stone (referred to above). Some changes of areal outcrop and nomenclature have been made which will not be discussed in this report since their findings will be presented in future reports of the Oklahoma Geological Survey.

5. A detailed report on the geology of the Criner Hills is now being prepared by J. A. Stone, former Assistant Geologist of the Oklahoma Geological Survey.

*Formations exposed in Love and Marshall counties, Oklahoma**

AGE			FORMATION	THICKNESS IN FEET	CHARACTER
CRETACEOUS	GULF SERIES		WOODBINE SAND	50	Soft yellow to brown sandstone with large quantities of ferruginous segregations. Cross-bedding is present.
			PROBABLE UNCONFORMITY		
CRETACEOUS	Comanche Series	WASHITA DIVISION	GRAYSON MARL	30	Yellow to gray calcareous marl; lime nodules present.
CRETACEOUS	Comanche Series	WASHITA DIVISION	MAIN ST. LIMESTONE	10-20	Massive brown-yellow limestone, massive and fossiliferous.
CRETACEOUS	Comanche Series	WASHITA DIVISION	PAWPAW SAND (BOKCHITO FORMATION)	50	Yellow to gray sandstone with calcareous shales and numerous ferruginous layers.
CRETACEOUS	Comanche Series	WASHITA DIVISION	WENO CLAY (BOKCHITO FORMATION)	100	Dark gray shaly clay with thin lenses and layers of soft yellow sand.
CRETACEOUS	Comanche Series	WASHITA DIVISION	DENTON CLAY (BOKCHITO FORMATION)	45-60	Brownish yellow clay. Thinly laminated brown sandstone with ripple marks conspicuous.
CRETACEOUS	Comanche Series	WASHITA DIVISION	FT. WORTH LIMESTONE	40-45	Alternating beds of white limestone and bluish gray shale.
CRETACEOUS	Comanche Series	WASHITA DIVISION	DUCK CREEK FORMATION	100	Blue-gray calcareous shale, and alternating beds of blue-gray shale and limestone.
CRETACEOUS	Comanche Series	WASHITA DIVISION	KIAMICHI CLAY	30-40	Greenish yellow clay containing indurated shell breccia composed of *Gryphea navia*, called "edge rock."
CRETACEOUS	Comanche Series	FREDERICKSBURG	GOODLAND LIMESTONE	15-25	Massive white limestone, sometimes nodular.
CRETACEOUS	Comanche Series	TRINITY DIVISION	TRINITY SAND	400-700	Fine white to yellow pack sand with occasional lentils of red and blue shale; basal conglomerate of quartz and chert pebbles with some intraformational conglomerates.
			UNCONFORMITY		
PENN. AND OLDER			PALEOZOIC ROCKS		

* In part after Bullard, Fred M., Geology of Love County: Oklahoma Geol. Survey Bull. 33, 1925; and Geology of Marshall County: idem. Bull. 39, 1926.

The Paleozoic rocks are entirely concealed in Marshall County except in one isolated inlier along the bed of Turkey Creek, between secs. 34 and 35, T. 4 S., R. 4 E., about 7 miles northwest of Madill. This exposure, consisting of an outcrop of Sycamore limestone, four outcrops of Woodford chert, four of the Hunton formation, and three of the Viola limestone, was discovered and described by Tomlinson.[6]

Pennsylvanian and Permian (?)

The Permian-Lower Cretaceous contact is difficult of delineation because the basal member of the Trinity sand contains beds of red shale and sandstone very similar to the Permian red beds. The contact has been mapped on a quartzose conglomerate, supposedly at the base of the Comanche series, but there are several conglomerates in the lower part of the Trinity formation. It is extremely difficult to determine whether the particular conglomerate in question is a basal conglomerate or an intraformational conglomerate.

It is probable that in the southwestern portion of Love County, along Red River and Mud Creek, the Pennsylvanian or Permian, or both, are represented. Much of this area is covered by alluvial material from Red River and exposures are very meager. However, investigations on the Texas side, especially at Rock Bluff crossing, indicate that a considerable thickness, 50 to 75 feet, of Pennsylvanian (upper Cisco) sandstones and conglomerates are present between the water level of Red River and the overlying Trinity sand. This establishes the fact, almost without doubt, that a considerable area in southwestern Love County must contain rocks of Pennsylvanian age. However, as above stated, much of this area is covered by alluvium, and for that reason no attempt has been made to draw any contacts.

Cretaceous

COMANCHE SERIES

TRINITY DIVISION

The Trinity sand, which represents the Trinity division in this area, is the beach or near-shore deposit of the Comanchean sea which encroached upon the land from the southeast. Due to a slow transgression of the sea, the Paleozoic rocks which underlie the Comanchean sediments were worn smooth and upon this weathered surface the Trinity sand was deposited in about the same position that it is now found.

The Trinity sand is composed of fine incoherent, white to yellow pack sands, local coarse conglomerates, and occasional lentils of clay and shale. However, the Trinity sand is extremely variable and it is not unusual to find beds of red or blue shale, or thin calcareous sand-

6. Tomlinson, C. W., Buried hills near Mannsville, Oklahoma: Am. Assoc. Pet. Geol. Bull., vol. 10, pp. 138-143, 1926.

stones. Silicified (or carbonized?) wood is abundant in this sand. The basal conglomerate has quartz pebbles varying from a size of a pea to three inches in diameter.

The Trinity weathers, forming a flat to gentle rolling plain. Small ravines in the Trinity are characterized by almost perpendicular sides. The Trinity sand is a water horizon, most of the water wells in this region deriving their supply from this formation.

FREDERICKSBURG DIVISION

GOODLAND LIMESTONE

The Trinity sand is overlain by the Fredericksburg division which is represented in this area by the Goodland limestone. This limestone is pure, semi-crystalline, massive, and white, and is approximately 25 feet in thickness. The Goodland outcrops in a narrow sinuous band, distributed over a large portion of the area. The Preston anticlinal uplift has brought the Goodland limestone and other formations in the lower part of the section to the surface in areas where otherwise they would be deeply buried by later sediments. The outcrop is usually in the form of an escarpment, capped by the Goodland limestone, overlooking the outcrop of the Trinity sand.

WASHITA DIVISION

The Washita division, which lies conformably upon the Fredericksburg division, is the highest member of the Comanche series. It is composed of marine shaly clays, marls, sandstones, and subordinate limestones, having a total thickness of approximately 415 feet. The limestone beds, although less in amount than the shaly clays, form several definite horizons that are readily traceable throughout the area, and are valuable key beds in determining the structure.

The Washita division has been mapped and differentiated as follows:

WASHITA DIVISION	Grayson marl	
	Main Street limestone	
	Pawpaw sand	BOKCHITO FORMATION
	Weno clay	BOKCHITO FORMATION
	Denton clay	BOKCHITO FORMATION
	Fort Worth limestone	
	Duck Creek formation	
	Kiamichi clay	

KIAMICHI CLAY

Lying immediately above the Goodland limestone is a zone of about 35 feet of yellowish green clay known as the Kiamichi. The top of the formation is marked by two or three thin ledges of a hard yellowish limestone made up principally of oyster shells, *Gryphea navia* Hall and *Gryphea corrugata* Say, being the most common species. The weathering of the soft clay underlying the hard shell breccia permits it to slump, breaking into large slabs which are found standing at every angle.

DUCK CREEK FORMATION

The Duck Creek formation, which is typically exposed on Duck Creek north of Denison, in Grayson County, Texas, consists of approximately 100 feet of limestone and gray to bluish shaly calcareous clay which intervenes between the Kiamichi clay below and the Fort Worth limestone above. In the lower 30 to 40 feet of the formation the limestone and shaly clay layers alternate in beds averaging from six to twelve inches in thickness in about equal proportion; in the upper 50 to 60 feet of the formation the clay greatly predominates, the limestone layers become thinner and are separated by a greater thickness of clay.

A complete section of the Duck Creek is exposed in an almost verticle cliff along the west bank of Red River in sec. 22, T. 8 S., R. 2 E., Love County. A detailed description of this section is given on page 35, Bulletin 33, Oklahoma Geological Survey.

The lower portion of the Duck Creek contains an abundance of characteristic fossils, the most prominent being a large ammonite, *Desmoceras brazoense*(?) Shumard, which occurs in a narrow zone about thirty feet above the base of the Duck Creek. This "large ammonite" horizon is a good key bed for structural work.

FORT WORTH LIMESTONE

The Fort Worth limestone consists of 40 to 50 feet of alternating beds of white limestone and bluish gray shale. In the lower 10 to 15 feet of the formation beds of yellowish limestone alternate with grayish to blue shaly clay in about equal proportions. The middle portion of the formation is made up chiefly of shale while the upper part is predominately of limestone.

The Duck Creek formation and Fort Worth limestone outcrop in two areas in Marshall County, one in the northeastern part of the county near Cumberland, and the other in the southeastern part, near Kingston. Both of these areas are synclinal in structure.

The Duck Creek and the Fort Worth outcrop in Love County in an oblong area surrounding the town of Marietta and lying in the trough of the Marietta syncline.

BOKCHITO FORMATION

The Bokchito formation is composed of clay and sandy clay, with beds of friable brown sandstone, siliceous shell limestone, and ferruginous concretions of sand and clay totaling 140 feet in thickness. The

Bokchito formation is the equivalent of the Denton, Weno, and Pawpaw formations of north-central Texas, which attain a total thickness of 210 feet. This rapid thinning of the sediments to the north during Bokchito time marks the beginning of the retreat of the Comanchean sea. It is interesting to note that this thinning did not begin until about the middle of Bokchito time, for the lower 70 feet of the Bokchito, the Denton clay, has the same thickness in this region as farther south.

On a basis of lithology and paleontology, the Bokchito formation is divided as follows, from older to younger: Denton clay, 55 feet thick; Weno clay, 100 feet thick; and Pawpaw sand, 45 feet thick. These are well established formation names in Texas and replace the term Bokchito in Oklahoma.

DENTON CLAY

The Denton is a brownish yellow clay, with thinly laminated layers of brown, ripple-marked sandstone, and sandstone lenses. The top is marked by a hard, brownish-yellow sandy limestone containing an abundance of fossils (*Ostrea carinata* and *Gryphea washitaensis* especially) and averaging one foot in thickness. Its outcrop in Love County is in a roughly circular area, lying in the trough of the Marietta syncline to the southeast of Marietta. In Marshall County it outcrops in two isolated areas, one extending southeast from Kingston and the other north and west from Aylesworth; both of these areas occupy the troughs of synclines.

WENO CLAY

The Weno is a yellowish-brown clay with thin lenses and layers of soft yellow sand. In mapping, the "Quarry" limestone, very sandy and averaging one to two feet in thickness, was considered the top of the Weno. The Weno is characterized by an abundance of clay ironstone concretions. Because the Weno weathers very easily and forms a rolling upland, it is very poorly exposed and sections suitable for detailed study are difficult to find.

The Weno like the Denton, outcrops in the troughs of the Marietta, Kingston, and Cumberland synclines.

PAWPAW SAND

The Pawpaw sand is restricted to those sediments lying between the "Quarry" limestone (uppermost Weno) at the base and the Main Street limestone at the top. The Pawpaw contains several thin lenses of highly fossiliferous, ferruginous, oxidized, soft sandstones which resemble the beds in the Weno, but the beds in the Pawpaw, while carrying many of the fossils found in the Weno, do not usually contain *Turritella,* while those in the Weno are composed chiefly of this

gastropod. The Pawpaw weathers forming a very sandy, ferruginous soil, the iron concretions often covering the surface.

The Pawpaw outcrops are confined to a small area southeast of Marietta and two areas in Marshall County, one southeast of Kingston and the other near Cumberland—all occupying synclines.

MAIN STREET LIMESTONE

In Love County the Main Street limestone, (formerly called Bennington), brownish white, massive, and containing an abundance of fossils, is represented by two small outliers covering only a few hundred feet, capping the hills southeast of Marietta in secs. 27 and 34, T. 7 S., R. 2 E. The limestone is only a few feet thick, the remainder having been removed by erosion. The Main Street is the uppermost formation of the Comanche series in this county.

The Main Street limestone is well exposed in Marshall County in the area northeast of Woodville, along the road between secs. 7 and 8; 17 and 18; and 19 and 20, T. 7 S., R. 7 E. In the Cumberland area there are only two small outliers, capping the tops of the hills in the W.½ sec. 6, T. 5 S., R. 6 E. The Main Street outcrops in a narrow band, 10 to 20 feet in thickness, lying directly above the Pawpaw sand and below the Woodbine sand, so that it is frequently covered by debris from the Woodbine and the Main Street is then only exposed where erosion has removed this material.

GRAYSON MARL

The Grayson marl is the uppermost formation of the Comanche series in this region. It consists of light colored, fossiliferous clays or marls with many small lumps of lime and limestone nodules, and has a total thickness of approximately 25 feet in Marshall County.

The Grayson marl is well exposed in the area north of Woodville, at the same locations as given for the Main Street limestone in Marshall County. The Grayson marl outcrops as a narrow bench or gentle slope lying directly above the Main Street limestone and is usually capped by the Woodbine sand.

GULF SERIES

WOODBINE SAND

The Woodbine sand is the basal member of the Gulf series of the Cretaceous in this region. It immediately overlies the Grayson marl and is apparently unconformable on it. The Woodbine sand is cross-bedded and is approximately 300-500 feet thick. In Marshall County only the basal portion of the Woodbine sand is present in one isolated outlier located northeast of Woodville, lying in the trough of the Kingston syncline. It is estimated that the lower 50 feet of the formation is present capping the tops of the hills, the remainder having been removed by erosion. The Woodbine sand has been correlated with at least a portion of the Dakota formation of the Rocky Mountain region.

Pleistocene (?) Deposits

GRAVEL, TERRACE SAND, AND RIVER SAND

Covering the tops of many of the hills and resting unconformably on all of the Cretaceous sediments alike is a very thin mantle of gravel. This gravel consists chiefly of quartz pebbles, well-rounded, and ranging from small gravel size up to pebbles several inches in diameter. This material has been questionably referred to as "Tertiary gravels". It seems probable that these gravels are related to a former course of some stream.

Terrace sands, gravels, and river sand occur in the valleys of the drainage systems of this area. These deposits are found in thinly scattered remnants resting unconformably upon the eroded surfaces of Paleozoic and Cretaceous rocks.

STRUCTURE

The structure of Love and Marshall counties is of two types: pre-Cretaceous, and post-Cretaceous. The pre-Cretaceous or in this case, Paleozoic, structures are those that were developed prior to the deposition of the Cretaceous sediments and are concealed by them. The post-Cretaceous structure is that developed in the Cretaceous sediments after their deposition.

The structure of the surface formations is that of a gently dipping monocline sloping to the south and southeast, toward the Gulf of Mexico, with the rate of dip varying from 30 to 80 feet per mile. This gentle monoclinal dip is interrupted in several places by local folds which will be discussed in detail.

There is no marked structural unconformity between the various subdivisions of the Cretaceous in this area; for this reason a fold in the beds at the surface is substantially duplicated in all of the underlying Cretaceous formations, although it may not be present in the underlying Paleozoic rocks. It seems reasonably safe to assume that the major structural features of the Cretaceous, such as the Preston anticline and Marietta syncline, are present in the underlying Paleozoic rocks. It is also likely that the smaller folds have occurred along lines of previous folding in the Paleozoic rocks, since all of these folds are parallel to one another and the lines of folding can be traced in the old rocks where they are exposed in the Criner Hills and along Turkey Creek. (See figure 4, map of the principal folds in Love and Marshall counties, page 20.)

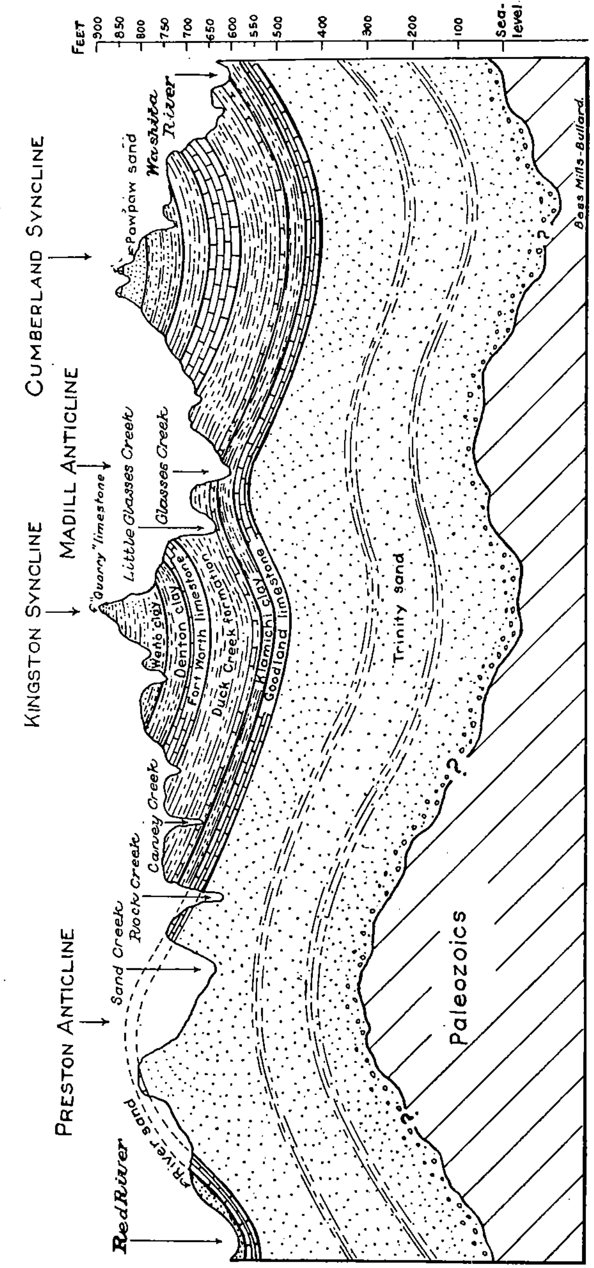


Figure 2.—Cross-section of Marshall County, structure section (BB′) southeast of Kingston, showing relation of Cretaceous sediments to the underlying Paleozoics.

Marietta Syncline

The outstanding structural feature of Love County is the Marietta syncline, asymmetrical in shape, with the steep side to the northeast. The axis of the syncline trends approximately due northwest. The hills southeast of Marietta, the highest of which is capped by the Main Street limestone, lie approximately in the trough of the syncline. The Sherman syncline in Grayson County, Texas is believed to be a continuation of the Marietta syncline. Figure 2 illustrates the features of the Marietta syncline.

Preliminary work in the vicinity of Horseshoe bend, in the south-central part of T. 8 S., R. 2 E., shows indications of folding at that point. Good southwest and northeast dips were observed on limestone beds in the lower part of the Duck Creek formation near the edge of the water level in Red River. About five miles south of the above described area, and due east of Thackerville, is another bend, known as Walnut bend. It is thought that detailed work in this area might disclose the presence of a structure similar to the one in Horseshoe bend. Subsurface work, according to Decker,[7] indicates the possibility of an anticline with its axis roughly along the line between the villages of Burneyville and Pike.

"The Overbrook anticline[8] extends from central Carter County in a southeasterly direction to Red River. Tomlinson says in part that the Overbrook anticline is '***an overturned fold with a structural height of at least 10,000 feet, which can be traced continuously for 15 miles through the belt of Pennsylvanian rocks which lies between Ardmore and the Criner Hills.' "

On the geologic map the structure of the surface formations is shown by structural contours, (lines, in this case printed in red, which connect points of equal elevation above sea level on a particular bed), representing the top of the Goodland limestone. From a study of this map some additional structural features are to be found.

Preston Anticline

One of the major structural features of southern Oklahoma and north-central Texas is the Preston anticline. It is a large arch, 30 to 50 miles in length, beginning near Ardmore, Oklahoma, and extending southeastward to a point a few miles east of Denison, Texas. It is a plunging anticline with the crest of the structure near Shay and Enos, Marshall County, where a number of gas wells have been drilled. The Criner Hills are believed to represent a portion of the Preston anticline where the Cretaceous cover has been removed exposing the ancient Paleozoic core.

7. Decker, La Verne, Structural trends in southern Oklahoma: Oklahoma Geol. Survey Bull. 40-P, p. 12, 1927.
8. Op. cit. p. 10.

Oakland Anticline

The Oakland anticline is a long plunging anticlinal nose which occurs mostly in the southwest part of T. 5 S., R. 5 E., Marshall County, Oklahoma. The crest of this anticline is along Glasses Creek valley which is rimmed on both sides by the Goodland limestone forming the sides of the eroded arch.

Madill Anticline[9]

> The Madill anticline, so named from the small oil pool on its northwest end, extends in a southeasterly direction from sec. 36, T. 5 S., R. 5 E., passing 1 mile northeast of Cliff and 1½ miles south of Aylesworth. Its extreme southeast end is not outlined on Plate IV,[10] but the part shown is 12 miles long. The axis of this fold dips gently to the southeast through its entire length at a rate of 20 to 40 feet to the mile. The dip on the flanks of the anticline amounts to as much as 90 feet to the mile. The trend of the Madill anticline is parallel to that of the Preston anticline, from which it is separated by a broad, shallow syncline.
>
> The Madill anticline may be a direct continuation of the Oakland anticline which has been offset by a cross fault in the underlying rocks. This hypothesis would account for the abrupt southeast termination of the Oakland anticline and also for the presence of the very small Madill oil pool, as the cross fault would form an avenue of escape for oil from the petroliferous Paleozoic rocks into the Trinity sand, where it is found.

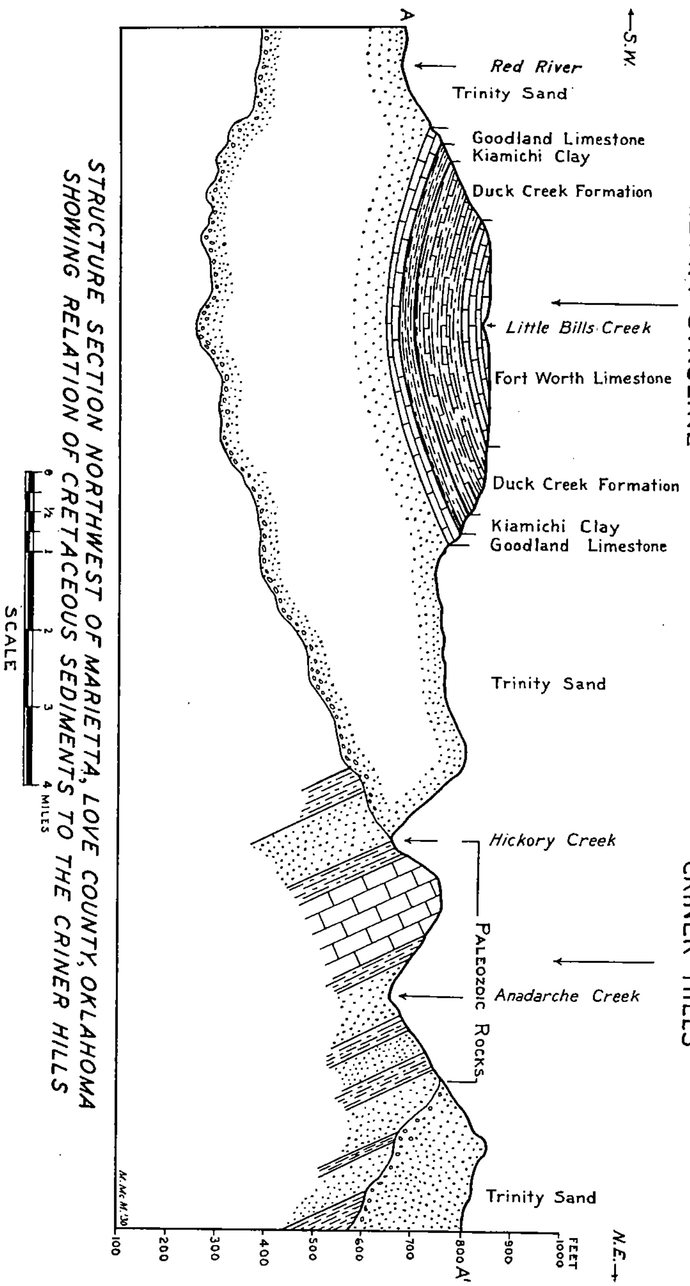
The Turkey Creek exposure of Paleozoic rocks in northwestern Marshall County is located along the northwestern extension of the Madill anticline. This part of the anticline and its northwestern continuation are frequently referred to as the Mannsville-Madill anticline.

The Kingston syncline, a broad, shallow basin, separates the Preston and Madill anticlines. It is represented on the surface by a row of prominent hills which trend in a southeasterly direction extending from Kingston on the north to near Woodville. These hills occupy approximately the trough of the syncline and are composed of the youngest sediments in the area.

The Cumberland syncline lies to the northeast of the Madill anticline and is parallel to it. A row of prominent hills marks the axis of this downfold. Notably in this instance, and that of the Kingston syncline and other basins of southern Oklahoma and north Texas covered by rocks of Cretaceous age, the structural low is represented on the surface by a topographic high. Figure 3 illustrates the structural features of Marshall County.

All of the folds of Love and Marshall counties are aligned in a parallel sequence, in a northwest-southeast direction, conforming in general to the trend of the Arbuckle Mountains and Criner Hills. This fact is illustrated in figure 4, p. 20.

9. Hopkins, O. B., Powers, Sidney, and Robinson, H. M., The structure of the Madill-Denison area, Oklahoma and Texas, with notes on oil and gas development: U. S. Geol. Survey Bull. 736, p. 9, 1922.
10. Structure contours shown in Plate I of this report were in part derived from Plate IV, U. S. G. S. Bulletin 736.



STRUCTURE SECTION NORTHWEST OF MARIETTA, LOVE COUNTY, OKLAHOMA SHOWING RELATION OF CRETACEOUS SEDIMENTS TO THE CRINER HILLS

Figure 3.

KEY HORIZONS IN LOVE AND MARSHALL COUNTIES

In working the structure of a region it is necessary to have some bed or horizon which extends over the area, and which can be easily recognized. In the portion of Love and Marshall counties covered by the formations lying above the Trinity sand, there are a number of excellent "key horizons". These key horizons, beginning with the oldest, are described in the following paragraphs.

Goodland limestone.—This is probably the horizon best suited for structural work. It is a most persistent horizon, outcrops over a broad area, maintains a fairly uniform thickness, and forms a sharp, easily recognized contact with the overlying Kiamichi clay. As a rule a flat terrace varying in width up to several hundred feet is found at the top of the Goodland, formed by the removal of the soft clay above.

"Oyster shell conglomerate."—This bed occurs at the top of the Kiamichi clay. It is a very easily recognized bed, but care must be used in working structure on this horizon as it frequently slumps and is found covering the entire slope below.

Duck Creek formation.—There are several horizons in the lower Duck Creek which may be used as key beds, the most prominent being the "large ammonite" horizon occurring about 33 feet above the base of the Duck Creek. It is a zone about 6 to 10 feet in thickness, in which the "large ammonite" *Desmoceras brazoense* is abundant. A massive white limestone bed about two feet in thickness, occurs in the same zone as the "large ammonite". This bed is the most prominent bed in the lower Duck Creek.

Fort Worth limestone.—There are no easily recognized horizons in the Fort Worth limestone, although the top of the formation, the contact of the Fort Worth with the overlying Denton clay, may be used as a key bed.

Denton clay.—The thinly laminated "ripple-marked" sandstone occurring near the middle of the Denton clay may be used as a key bed. It is easily located, as it frequently forms a distinct bench or terrace, due to the fact that it is harder than the remainder of the formation.

Denton-Weno contact.—The contact of the Denton and Weno is marked by a shell conglomerate composed of countless specimens of *Gryphea washitaensis* and *Ostrea carinata*. This horizon is easily recognized and well suited for structural work.

"Quarry" limestone.—This bed, which marks the top of the Weno, may be used as a key horizon, although care must be taken to prevent confusing it with similar beds in the Pawpaw.

Main Street limestone.—Occurring near the top of the Lower Cretaceous is a yellowish-brown, semi-crystalline limestone which is

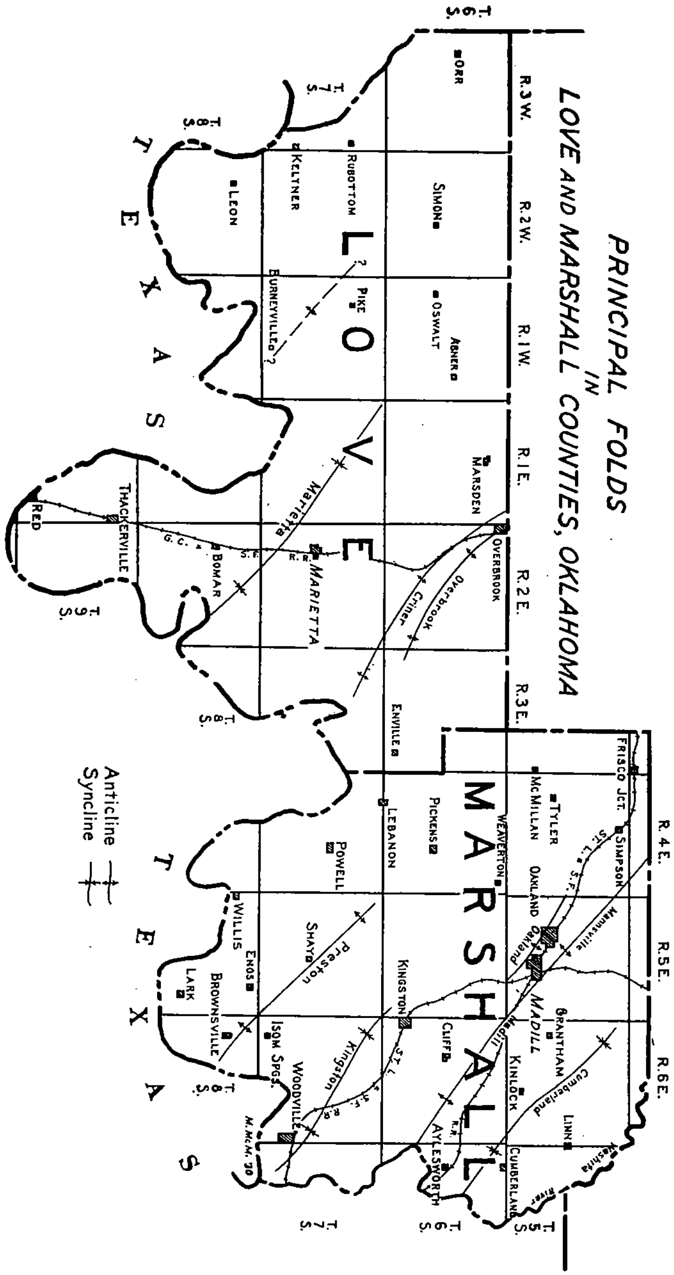


Figure 4.

practically the only exception to a clay-sand series of several hundred feet. The Main Street (Bennington) is an excellent marker and is well adapted for use as a key horizon.

The intervals between these various horizons having been determined, elevations may of course be taken on any of them and then reduced to a common plane of "Datum".

In that portion of the county covered by the outcrop of the Trinity sand, it has been impossible to do any structural work, as thus far no beds which can be traced or recognized at other localities have been found. The variable character of the Trinity sand and also the cross-bedding and the rapid change in lithologic character tend to make structural work very uncertain.

In these counties all elevations were reduced to the top of the Goodland limestone, which is taken as the "key horizon" for the mapping of the structure.

OIL AND GAS DEVELOPMENT

So far as is known, no oil or gas occurs indigenously to the Cretaceous sediments in this general region. Some oil production has been obtained in the basal beds of the Trinity sand in Marshall County but this oil evidently migrated from the underlying Pennsylvanian rocks.

Love County

No commercial production has been obtained in Love County although it has been tested rather extensively. The eastern part of the county near the Criner Hills would not be considered favorable territory for the production of oil or gas due to the intense folding that the rocks have undergone. Oil that was present in the Pennsylvanian of this area would have escaped in the form of gas, except the heavier portions which would remain in the form of asphalt. Field investigations tend to bear out this relation, for deposits of asphalt occur in the Trinity sand adjacent to the Criner Hills.

In the Brock structure, which borders the Criner Hills to the north of Love County, oil is found in a faulted anticline. It is probable, however, that the fault sealed the reservoir rocks below and has been the most important factor in the accumulation of oil. Conditions similar to those found at Brock, while unusual, might be expected along the southwest flank of the Criner Hills in north-central Love County.

The presence of the Marietta syncline should not necessarily prevent the production of oil from the underlying Pennsylvanian rocks. The unconformity between these two systems makes it very difficult to tell anything regarding the structure of the Pennsylvanian from the surface, and it is possible that structures favorable for the accumulation of oil are buried by the Lower Cretaceous sediments.

In the western part of the county the surface is covered by the Trinity sand, and due to the unconsolidated and extremely variable character of this formation it is nearly impossible to tell anything regarding the subsurface structure from surface outcrops. However, it is thought that there are good chances for the discovery of oil and gas in this portion of the county. An extension of the line of folding of the Hewitt, Bayou, and Healdton fields, parallel to the general trend of folding in this part of the state, extends through this western part of Love County. While any prospecting in this area must be considered strictly "wildcat" drilling it is believed that this portion of the county is favorably located with reference to oil and gas production. It is altogether probable that folds similar to the fields to the northwest are buried by the mantle of Cretaceous which covers this portion of the county.

The absence of reliable outcrops in western Love County makes it necessary to rely upon well records for information on this area. So few wells have been drilled in this portion of the county that a definite statement regarding subsurface conditions can not be made.

The collection and identification of samples would be of much value in future exploration.

See Plate I, red overprint, for location of the various tests for oil and gas which have been drilled. These data were obtained from the files of the Well Log Division, Corporation Commission, Oklahoma City, and from the Schermerhorn-Ardmore Oil Company.

Marshall County

Marshall County has been classed as an oil and gas producing county for the past 21 years. The production of oil is chiefly from the area 1½ miles east of Madill, located in secs. 13, 14, 24 and 25, T. 5 S., R. 5 E., and the NW.¼ of sec. 30, T. 5 S., R. 6 E., usually called the Madill or Bilbo pool, and from the SW.¼ of sec. 25, T. 5 S., R. 5 E., the old Madill or Arbuckle pool. Although these two areas are about a mile apart, they are no doubt located on the same structure. Figure 5 is a recent oil and gas production map of the Madill (Bilbo) and the old Madill (Arbuckle) pools. The gas production in Marshall County is concentrated chiefly in the south-central part near the store of Enos and is called the Enos gas field. This area is located on the Preston fold.

MADILL POOL

A very good summary of the early development and history of the Madill oil pool and also of the Enos gas field is given in Bulletin 736 of the United States Geological Survey.[11] This description is given herewith in full:

> The presence of oil seeps in the region near Madill led to prospecting with the drill and finally in March, 1909, to the discovery of a small pool of oil 1½ miles east of town. Oil was discovered by the Mal-Millan Oil Co., on the Arbuckle farm, in the SW.¼ sec. 25, T. 5 S., R. 5 E., and this pool is sometimes called the Arbuckle pool. Active drilling was begun immediately after the discovery, but the pool has not been extended beyond the limits of the quarter section although showings of oil were found in widely scattered parts of the surrounding area. By April 20, 1909, eight wells had been drilled in this pool, four of which were productive. The largest well in the pool was completed March 22, 1909, and had an estimated initial daily production of 400 barrels. During January, 1918, only one well was producing at the rate of eight barrels a day. One well was drilled through 18 inches of sand at 420 feet and abandoned dry at 460 feet during that month. The Kanoky Oil Co. is reported to have completed a five barrel well at 430 feet in the northwest corner of the SW.¼ SW.¼ sec. 25, T. 5 S., R. 5 E., in July, 1918.
>
> The wells here start near the top of the Goodland limestone and find the oil sand at a depth of 420 to 460 feet, presumably near the base of the Trinity sand. The oil-bearing sand is lenticular and ranges in thickness from 1½ to 20 feet. It is considered of Trinity age because the rocks above it are soft, and no fragments of shale or sandstone that might be of Paleozoic age could be found in the cuttings. In a report of the Oklahoma Geological Survey,[12] however, it is suggested that the oil-bearing sand (which Oklahoma geologists call the "Arbuckle sand") may be of Pennsylvanian age. Structurally the oil is found here near the northwest end of the Madill anticline. (See Plate 1). This oil pool is on what, if viewed locally, may be considered a terrace.
>
> The oil from the Madill pool is of high grade. It has a specific gravity of 0.7887 (47.5° Baume′) at 60° F. and yields 60 per cent of gasoline and kerosene, about 7 per cent of paraffin, and little or no asphalt. It is 13° Baume′ lighter than the average Mid-Continent crude oil.

There are approximately forty oil producers in Marshall County, most of which are in the Madill (Bilbo) field. The newer wells, found northwest of the older area which is in the SE.¼ of sec. 24, T. 5 S., R. 5 E., although producing oil of heavier gravity averaging about 40° Baume′, are on property operated and owned by the United Eight Oil Co., Geo. W. Bilbo, Cox-Hamon, Goddard Company, F. W. Merrick, Westheimer & Daube, and Carter Oil Co. The daily average production during December, 1929, was 540 barrels. In the January 8, 1930 issue of the Krohn Oil Review, the initial 24-hour production of the completions in the Madill area totaled 2,053 barrels.

A well log which represents average conditions in the Madill pool is given on page 25.

11. Hopkins, O. B., Powers, Sidney, and Robinson, H. M., The Structure of the Madill-Denison area, Oklahoma and Texas with notes on oil and gas development: U. S. Geol. Survey Bull. 736, pp. 1-34, 1922.
12. Petroleum and natural gas in Oklahoma: Oklahoma Geol. Survey Bull. 19, pt. II, p. 319, 1917.

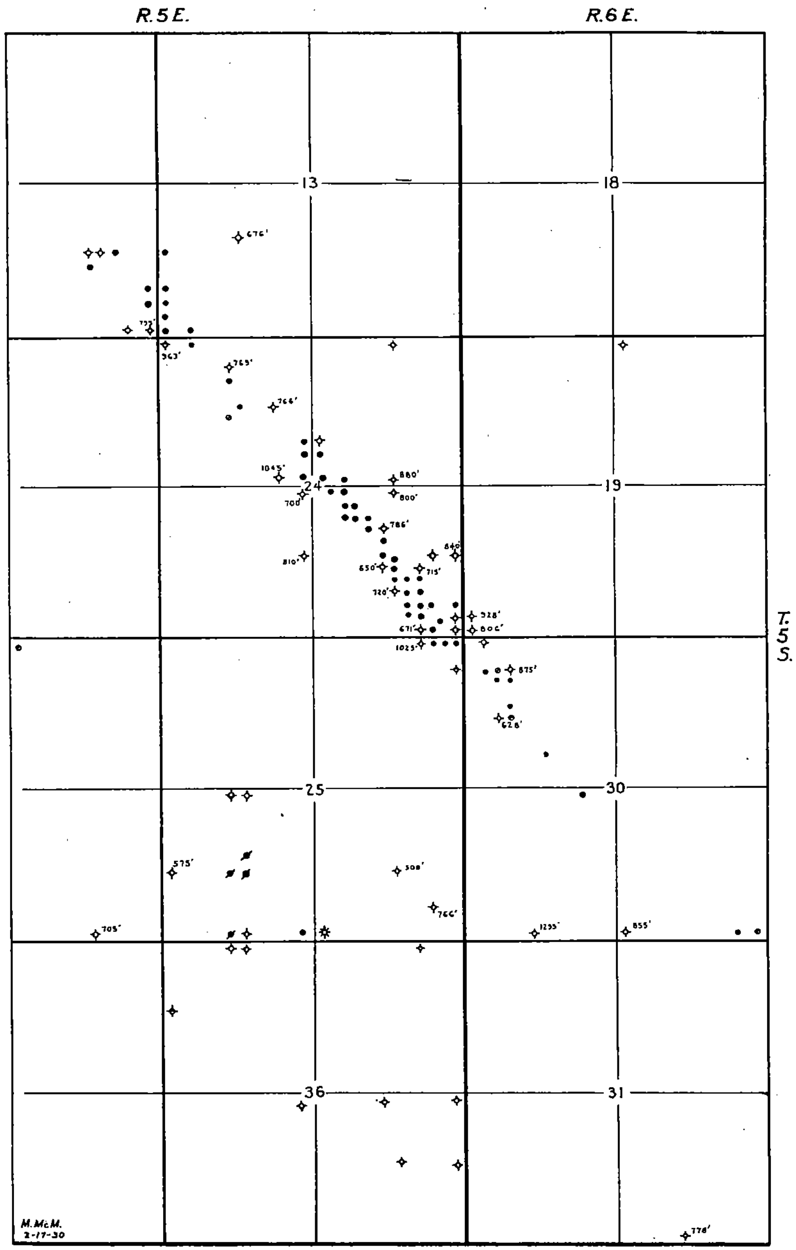


Figure 5.—Production map of the Madill (Bilbo) and the old Madill (Arbuckle) fields.

Log of United Eight Oil Co.'s No. 7 Well on the I. C. Brown lease, SW., SE., SE. Sec. 24, T. 5, S., R. 5 E.

Formation		Top	Bottom
Yellow clay	Duck Creek fm.	0	18
lime shale		18	22
blue shale		22	63
white lime		63	67
black shale	Kiamichi clay	67	95
white lime	Goodland ls.	95	116
blue shale	Trinity sand	116	160
water sand		160	165
white shale		165	192
water sand		192	255
blue sandy shale		255	269
water sand		269	275
blue shale		275	300
water sand		300	336
blue shale		336	365
water sand		365	375
blue shale		375	410
water sand		410	430
blue shale		430	490
water sand		490	530
blue shale		530	555
red rock		555	581
oil sand		581	584

Initial Production: 15 bbls. per day.

ENOS GAS FIELD

The following summary of the Enos Gas field is quoted from the United States Geological Survey[13] Bulletin above referred to:

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

13. Hopkins, O. B., Powers, Sidney and Robinson, H. M., op. cit. pp. 10-12.

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

Formation	Thickness	Depth
Clay, red and blue	10	10
Lime	4	14
Sand, gray	5	19
Lime and boulders	11	30
Sand, yellow	40	70
Soapstone, blue	6	76
Sand and soapstone	34	110
Rock, hard sand	5	115
Sand, water	4	119
Lime boulders	1	120
Gas sand	18	138
Gumbo	16	154
Rock, hard	2	156
Shale, blue	29	185
Lime, shell rock	4	189
Shale, blue	4	193
Gumbo, red	7	200
Shale, red	4	204
Gumbo, blue; set 10-in. casing	5	209
Shale, blue	3	212
Gas sand No. 2	12	224
Oil sand	2	226
Gas sand	4	230
Oil sand	9	239
Oil sand	3	242
Shale, blue	5	247
Rock, hard sand	7	254
Oil sand	10	264
Sand, water	10	274
Shale, blue	73	347
Sand, hard	3	350
Rock, hard	1	351
Shale, blue	29	380
Gumbo, blue	31	411
Rock, shale	10	421
Gumbo	2	423
Rock, hard	14	437
Gumbo, white	6	443
Sand, hard	5	448
Lime, hard	2	450
Gas sand	15	465
Gumbo, blue	32	497
Oil sand	4	501
Gas sand; biggest oil sand in bottom	19	520
Gumbo	10	530
Gas rock; bailed at 532 feet; got dry gas	4	534
Red beds	7	541
Oil sand	26	567
Rock, hard	3	570
Oil sand; good show	20	590
Red beds	4	594
Oil sand	15	609
Red beds	6	615
Oil sands	12	627
Oil sand; brown shale	36	663
Sand, hard, sandrock	49	712
Shale, hard, brown	3	715
Rock, hard	2	717
Shale, black slate	3	720
Shale, black	278	998
Shale, hard, black	10	1,008
Oil sand, dark	3	1,011
Rock, hard sand	19	1,030
Shale, hard, sandrock	506	1,536
Rock, hard sand	3	1,539
Shale, blue	36	1,575
Lime shells	1	1,576
Rock, hard	2	1,578
Sand, fine black; show of gas	17	1,595
Shale, brown	3	1,598
Sand, hard, black	2	1,600
Shale, blue, sandy	2	1,602
Sand, black	23	1,625

The Tobe Greer well, in the SE.¼ NW¼ SW.¼ sec. 35 of the same township, was drilled to a depth of 515 feet and is reported to have yielded showings of oil at 220 and 420 feet and a volume of gas estimated at 1,500,000 cubic feet. In the southwest corner of SW.¼ SW.¼ sec. 25 the Roy Milliken well was drilled to a depth of 760 feet and reported a showing of about 1,000,000 cubic feet of gas and a trace of oil. In the northeast corner of the NE.¼ sec. 2, T. 8 S., R. 5 E., the Deeren well was drilled to a reported depth of 620 feet. Gas was found below 507 feet with an estimated volume of 4,000,000 cubic feet. Another well was drilled by Wascomb Thorne Oil & Gas Co. on the J. A. L. Wolff farm, in the northwest corner of SE.¼ sec. 1, T. 8 S., R. 5 E., to a depth of 550 feet. A volume of gas estimated at 4,000,000 cubic feet was found at 550 feet, but the gas was drowned by water. In the northwest corner of the SW.¼ sec. 6, T. 8 S., R. 6 E., two wells were drilled by the Whitewright Oil Co. The western well was drilled to a depth of 620 feet and at 540 feet encountered 18 feet of sand that made a strong showing of high-grade oil. The other well was abandoned at a depth of 350 feet.

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

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

At the present time no gas from this area is being utilized. Some gas was used for fuel in a nearby cotton gin last fall. Recent development of the gas on the Massenberg lease in sec. 26, T. 7 S., R. 5 E., by Westheimer & Daube of Ardmore will probably lead to commercial production since some of the wells are large enough to justify the laying of a line for serving fuel to Madill and Kingston; but the gas producers are now shut in.

MISCELLANEOUS WELLS

A detailed summary of oil and gas prospecting in Marshall County was published in Bulletin 39 of the Oklahoma Geological Survey, to which reference should be made by interested parties. Since 1926, when that report was published, about the only development has been in the Bilbo district and the results of this are shown by Figure 5. The red overprint on Plate I shows the location of all wells where the exact location is known. It is a general fact that either oil or gas, or both, are found several times as showings in nearly every prospect well drilled on the Madill and Preston anticlines.

FUTURE POSSIBILITIES

In regard to the oil and gas possibilities of Marshall County, Messrs. Hopkins, Powers, and Robinson[14] have summarized the subject in a very satisfactory manner. The following is quoted from their report:

14. Op. cit. pp. 28-32.

The Trinity sand underlies the entire area under consideration and, so far as known, is structurally conformable with all the overlying Cretaceous formations. This being the case, a fold that shows in the surface beds in this area must also be present in the Trinity sand. As oil and gas most commonly occur in anticlines, the folds here outlined from the study of surface formations present favorable structural conditions for oil and gas accumulation in the Trinity sand. Structure is, however, only one of the factors governing the occurrence of oil; there must be a source of oil, favorable sand conditions to permit its migration, and an impervious cap to prevent its dissipation.

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

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

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

The Paleozoic rocks are entirely concealed in Marshall County, except the small exposure which occurs in Turkey Creek, along the

northern boundary of the county, previously described. Information regarding these rocks is obtained chiefly by study of the well records which have penetrated them and from a study of their exposures in the region north and west of Madill where they unconformably underlie the Trinity sand. In regard to the oil and gas possibilities of the Paleozoic rocks, Messrs. Hopkins, Powers, and Robinson[15] are quoted as follows:

> None of these formations have been definitely recognized in well borings in the Madill-Denison area, as no fossils have been obtained from them on the basis of lithologic similarity, however, it is possible to recognize, with more or less certainty, the Glenn and Caney formations. The nearest exposure of the Glenn is two miles northeast of Durwood, or 11 miles northwest of Madill. There it consists of red to pale yellow shales and sandstones that strike northwest and dip 20°-60° SW. Similar rocks are found in the Dulsa Askew well, in sec. 5, T. 7 S., R. 4 E., Okla.; in the C. V. Westover well, in the northwest corner of Grayson County, Tex.; in the Indian Chief well, in sec. 19, T. 7 S., R. 4 E., Okla. It is probable that the Owens well, in the syncline between the Preston and Madill anticlines, encountered the Glenn formation, and that Munson well, north of Denison and south of the Preston anticline, passed through the basal part of that formation and entered the underlying Caney shale.
>
> The Caney shale, characterized by its black color in fresh cuttings and dark gray color in weathered cuttings, was probably found in the Mattie Sacra wells, in sec. 17, T. 5 S., R. 5 E., Okla.; in the Dundee Petroleum Co.'s well, in sec. 9, T. 6 S., R. 6, E., Okla.; in the Waite well in sec. 23, T. 7 S., R. 5 E., Oklahoma; and in the Munson and Campbell wells, in Grayson County, Texas. The Waite well, which encountered below the Trinity more than 1,000 feet of black shale, probably the Caney, is less than 4 miles from the Indian Chief well, which encountered below the Trinity only red and brown shale and sandstone, probably belonging to the Glenn formation, to a depth of 2,540 feet. As the Caney is below the Glenn, the Caney must be more than 1,900 feet lower at the Indian Chief well than at the Waite well, whereas the dip of the Cretaceous between the two places amounts to only about 100 feet. The conclusion seems to be justified that along the Madill, Oakland, and Preston anticlines the dark shales, probably the Caney shale, were folded or faulted up and the overlying formations eroded before the Cretaceous was laid down, and subsequent folding along the old line of uplift has gently arched the Cretaceous formations. The wide area over which the black shale is found and the steep dip determined from well logs and from the exposures in the area to the northwest suggest that the old rocks may be complexly folded and faulted so that there is a repetition of the beds below the gentle arches in the Cretaceous. The structure of the underlying rocks may thus be too complicated to favor commercial accumulation of oil in them.
>
> Indications of petroleum in the Caney shale are rare. There is a seep of light green oil, which is reported to make 1 or 2 barrels of oil daily, on Oil Creek, northeast of Berwyn, at the outcrop of vertical Caney shale and the Sycamore limestone. The

15. Op. cit. p. 30.

oil found in the Caney (?) in the Mattie Sacra well is in part 66° and in part 72° Baume' gravity and is an abnormal oil resulting from natural filtration or distillation. The oil in the Waite wells is also of high gravity. No normal oil has been found in the Caney shale.

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

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

The carbon ratios of the Pennsylvanian coals of north Texas indicate, according to Fuller, the absence of commercial accumulations of oil in the Pennsylvanian and underlying rocks of this area. No determinations of the carbon ratios are available for the Madill-Denison area, but the increase of the carbon ratio to the east probably justifies this conclusion, which is also suggested by the light gravity of the oil found here.

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