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BULLETIN No 39

GEOLOGY OF MARSHALL COUNTY OKLAHOMA

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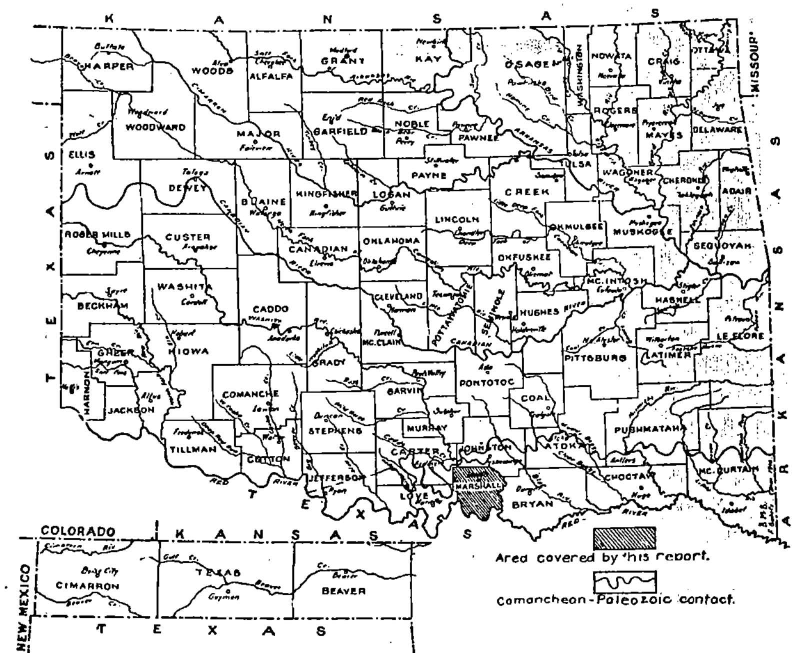
GEOLOGY OF MARSHALL COUNTY, OKLAHOMA

INTRODUCTION

LOCATION

Marshall County is located in the extreme south-central part of Oklahoma. It is one of the border counties of Oklahoma, Red River forming its southern boundary. It is bounded on the west by Love and Carter counties, on the north by Johnson county, and on the east by Bryan County. Marshall County includes townships 5 to 8 south and ranges 4 to 7 east. It has an area of approximately 442 square miles.

FIGURE 1



INDEX MAP OF OKLAHOMA, SHOWING LOCATION OF MARSHALL COUNTY

FIELD WORK

The geology of this region has been mapped and published in a number of publications by the United States Geological Survey.

The northern part of Marshall County is included in the Tishomingo folio[1], and the southern part is covered in Professional Paper No. 120[2]. These publications are now out of print and since the geologic mapping was chiefly of a general nature, the writer was assigned the task of revising these maps previously published and adding such new material as was necessary to bring them up to date in preparing a report covering Marshall County. The writer spent approximately one month in the field during the summer of 1925, but made numerous trips to the area during the course of the field work on Love County, adjoining Marshall County to the west, during the summers of 1920 to 1924.

ACKNOWLEDGMENTS

The writer wishes to state that the publications above refered to, and also the work of R. T. Hill[3], on this region are excellent, and that the changes which have been made are in no way a criticism but merely represent more detailed work than previous investigations. The area north of the 34° parallel, which passes through Kingston, and includes approximately the northern half of Marshall County, was mapped by J. A. Taff in 1900, and published in the Tishomingo folio[4]. Taff's work was found to be correct without exception and in the geologic map accompanying this report the mapping, as given on the Tishomingo folio, is used for that part of Marshall County included in the Tishomingo quadrangle. The only changes made in Taff's mapping were the separation of the Caddo formation into the Duck Creek formation and the Fort Worth limestone, and the division of the Bokchito formation into three members. Beginning with the oldest they are: the Denton clay member, the Weno clay member, and the Pawpaw sandy member.

In the portion of Marshall County lying to the south of the 34th parallel, the main geological groups, the Trinity, Fredericksburg and Washita, were mapped by Stephenson[5]. Stephenson's mapping was, however, of a general nature, but with a few minor changes the contacts of these main groups have been taken from Stephenson's map. These groups were then subdivided into the various formations and members as given on the columnar section, Figure No. 4, page 19.

No attempt was made to do any structural work in Marshall County as this has been covered in a very satisfactory manner in

1. Taff, J. A., U. S. Geol. Survey Geol. Atlas, Tishomingo folio (No. 98), 1903.
2. Stephenson, L. W., A contribution to the geology of northeastern Texas and southern Oklahoma: U. S. Geol. Survey Prof. Paper 120, pp. 129-163, 1918.
3. Hill, R. T., Geography and geology of the Black and Grand prairies, Tex.: U. S. Geol. Survey Twenty-first Ann. Rept., pt. 7, 1901.
4. Op. cit.
5. Op. cit.

Bulletin No. 736 of the United States Geological Survey[6]. The structural map and details regarding the structure given in this report are quoted direct from the above mentioned bulletin, with a few additions by the writer.

In preparing this report, the writer is in one sense merely compiling the information already published on Marshall County from various sources, many of which are now out of print. Many of the sections and descriptions given in this report have been taken from the various published reports on this region, due credit being given in each case. The additional information secured by the writer is inserted in the proper place and the report presented as a unit.

The writer wishes to express his appreciation for suggestions and advise to Dr. Chas. N. Gould, Director of the Oklahoma Geological Survey, under whose supervision the work was done. Assistance was rendered in the field by Mr. C. L. Cooper. The drafting on all the maps, charts and sections included in this report, was done by Mrs. Bess Mills-Bullard.

LITERATURE

The principal publications relating to the geology of the area discussed in the present report are given below in chronological order.

Shumard, B. F., Notes upon the Cretaceous strata of Texas; St. Louis Acad. Sci. Trans., Vol. 1, pp. 582-610, 1860.

Taff, J. A., and Leverett, S., Report on the Cretaceous area north of the Colorado River: Texas Geol. Survey Fourth Ann. Rept., pp. 239-354, 2 maps, 1 plate, 1893.

Hill, R. T., On the occurrence of artesian and other underground waters in Texas, eastern New Mexico, and Indian Territory west of 97th meridian; 52d Congress, 1st sess. S. Ex. Doc. 41, pt. 3, pp. 41-166, 19 pls., 1893.

Hill, R. T., Geology of parts of Texas, Indian Territory, and Arkansas adjacent to Red River: Geol. Soc. America Bull., vol. 5, pp. 297-338, pls. 12, 13, 1894.

Hill, R. T., and Vaughn, T. W. The lower Cretaceous Grypheas of the Texas region: U. S. Geol. Survey Bull. 181, 139 pp., 35 pls., 1898.

Hill, R. T., Physical geography of the Texas region; U. S. Geol. Survey Top. Atlas, folio 3, 12 pp., 11 pls., 1900.

Hill, R. T., Geography and geology of the Black and Grand prairies, Tex.: U. S. Geol. Survey Twenty-first Ann. Rept., pt. 7, 666 pp., 71 pls. 1901.

Taff, J. A., Chalk of Southwestern Arkansas: U. S. Geol. Survey Twenty-second Ann. Rept. pt. 3, pp. 687-742, pls. 47-53, 1902.

Taff, J. A., U. S. Geol. Survey Geol. Atlas, Atoka folio (No. 79), 8 pp., 4 maps, 2 columnar-section sheets, 1902.

Taff, J. A., U. S. Geol. Survey Geol. Atlas Tishomingo folio (No. 98), 8 pp., 3 maps, 1 columnar-section sheet, 1903.

6. 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.

Veatch, A. C., Geology and underground water resources of northern Louisiana and southern Arkansas: U. S. Geol. Survey Prof. Paper 46, 422 pp., 51 pls., 1906.

Gordon, C. H., The chalk formations of northern Texas: Am. Jour. Sci., 4th ser. vol. 27, pp. 369-373, 1909.

Taff, J. A., and Reed, W. J., The Madill oil pool, Oklahoma U. S. Geol. Survey Bull. 381, pp. 504-513, 1910.

Gordon, C. H., Geology and underground waters of northeastern Texas: U. S. Geol. Survey Water-Supply Paper 276, 78 pp., 2 pls., 1911.

Hutchison, L. L., Preliminary report on Rock Asphalt, Asphaltite, Petroleum and Natural Gas in Oklahoma, Oklahoma Geol. Survey Bull. No. 2, 1911.

Buttram, Frank, The Glass sands of Oklahoma, Oklahoma Geol. Survey Bull. No. 10, 1913.

Shannon, C. W., and others, Petroleum and natural gas in Oklahoma, Oklahoma Geol. Survey Bull. 19, pt. 2, pp. 316-321, 1917.

Stephenson, L. W., A contribution to the geology of northeastern Texas and southern Oklahoma: U. S. Geol. Survey, Prof. Paper 120, pp. 129-163, 1919.

Hopkins, O. B., Powers, Sidney, and Robinson, H. M., The Structure of the Madill-Davison area, Oklahoma and Texas, with notes on oil and gas development: U. S. Geol. Survey, Bull. 736, pp. 1-34, 1922.

Bullard, Fred M., Geology of Love County, Oklahoma, Oklahoma Geol. Survey Bull. 33, 1925.

PHYSIOGRAPHY

The entire area of Marshall County lies in the Red River Plain, which is a part 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. The belt covers a large area in Mexico, the southeastern half of Texas, the southeastern counties of Oklahoma, all of Louisiana and Mississippi, the southern part of Alabama, and Georgia, all of Florida, and merges into the Atlantic Coastal Plain province which borders the Atlantic ocean from Florida to New Jersey.

The Red River Plain province of Oklahoma is a minor division of the Gulf Coastal Plain differing in no way from it either in structure or with regard to the surface features.

The strata bordering the Gulf of Mexico all dip gently toward the gulf. The youngest, or those most recently deposited, occur at the waters edge; the oldest, namely the Trinity sand, is found outcroping farthest north, and all intermediate formations from the youngest to the oldest may be found in their proper place farther and farther from the waters edge outcroping as concentric belts around the gulf.

DRAINAGE AND TOPOGRAPHY

Marshall County lies at the northern border of the Gulf Coastal Plain and may be described as a dissected Coastal Plain upland. The elevation ranges from 550 feet above sea level in the south-

eastern corner of the county to 850 feet in the central part of the county. Red River, which forms the southern boundary and the drainage basin of the county, flows with a sinuous course in a southeasterly direction; it has cut a broad valley some 200 to 300 feet below the general level of the surrounding country. The gradient of Red River is very slight, averaging less than one foot six inches per mile for its extent along Marshall County. The entire area of Marshall County is drained into Red River, although a portion of the drainage flows first into the Washita River and then into Red River. The Washita River is one of the chief tributaries of Red River and forms the eastern boundary of Marshall County. It flows in a general southeasternly direction until it reaches a point about the northeastern corner of Marshall County where it takes a more southernly direction emptying into Red River at the southeastern corner of Marshall County. The drainage of the northern part of the county is northward into the Washita River through a number of small creeks of which Turkey Creek and Oil Creek are the most important.

Beginning at the western edge of Marshall County the principal creeks, in the order of their occurrence are Brier Creek, Buncombe Creek, Sand Creek, Rock Creek, Caney Creek and Glasses Creek. The last named creek and its tributaries drain the eastern part of Marshall County into the Washita River.

The topography of a region is determined chiefly by the character of the underlying formations. On this basis the north central part of Texas, which is made up of rocks similar to those underlying Marshall County, is separated into a number of distinct physiographic provinces of which the following are represented in Marshall County: (1) The Western Cross Timbers, or the area covered by the outcrop of the Trinity sand. (2) The Grand Prairie, or the area underlain by the limestone and shaly clays and marls lying above the Trinity sand. (3) The Eastern Cross Timbers, which is the area covered by the outcrop of the Woodbine sand.

The Western Cross Timbers is represented in Marshall County by a rather broad area extending along the northern part of the county and a long narrow belt extending in a northwesternly direction through the central portion of the county representing the crest of the Preston anticlinal uplift. It is characterized by a rolling to hilly topography covered with a growth of black jack and scrub oak.

Above the Trinity sand are several hundred feet of limestones and clays which form a rolling upland prairie called the Grand Prairie. The eastern half of Marshall County falls in the above division. It has a rolling to hilly topography, upon which the indurated layers tend to produce small escarpments and benches.

The most prominent of these escarpment-forming ledges are in ascending order the following: (1) Goodland limestone, (2) lower Duck Creek limestone, (3) Fort Worth limestone, (4) Quarry limestone and (5) Bennington limestone.

The Eastern Cross Timbers, or the area covered by the outcrops of Woodbine sand, is represented by an isolated occurrence in the east-central portion of the county, where an outlier of Woodbine sand some four or five square miles in area occurs. The topography of the Eastern Cross Timbers is very similar to that of the Western Cross Timbers being more or less hilly and rugged, covered by a dense growth of black jack and scrub oak.

GENERAL GEOLOGIC FEATURES

Marshall County is underlain throughout its entire area by rocks of the Comanchean and Cretaceous series, which rest upon a buried, moderately smooth basement composed of ancient Paleozoic rocks. Just to the north of Marshall County, in Johnson and Murray counties these old Paleozoic rocks and pre-Paleozoic granites come to the surface in the Arbuckle Mountain Uplift. The upper surface of the Paleozoics 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 northern boundary or contact of the Comanchean rocks lies a few miles to the north of the northern boundary of Marshall County. Here the Comanchean laps unconformably upon the Paleozoic rocks and the pre-Paleozoic granites, representing the ancient shore line of the Comanchean sea in which practically all the rocks exposed at the surface in Marshall County were deposited as a result of the wasting and erosion of the Arbuckle Mountains and other land areas to the north.

The Paleozoic rocks have been brought within a few hundred feet of the surface in a part of Marshall County by the Preston anticlinal uplift, which is described under the heading of Structure. However in one place along the northern line of Marshall County, Turkey Creek has cut its bed down through the surface rocks and exposed the Paleozoics for about one half mile along the creek bed.

The Paleozoic rocks are separated from the overlying Comanchean sediments by a marked angular unconformity representing a long interval of geologic time, including at least, the Jurassic and Triassic periods and probably a portion of the basal Comanchean.

The character and nature of the Paleozoic rocks, as well as the Comanchean will be discussed in some detail under Stratigraphy.

The Comanchean is divided into three main subdivisions beginning with the oldest: (1) Trinity group, (2) Fredericksburg group and (3) the Washita group. These in turn are divided into various formations and some of the formations have been separated into several members. The relation of each of these can be seen by refering to the columnar section, Figure No. 4, page 19.

Only the basal part of the Cretaceous deposits are represented in Marshall County. No doubt the major part of the Cretaceous section was present in Marshall County at one time as it is well developed in the county adjoining to the east, but erosion has removed all except the basal portion of the lowest formation, namely the Woodbine sand.

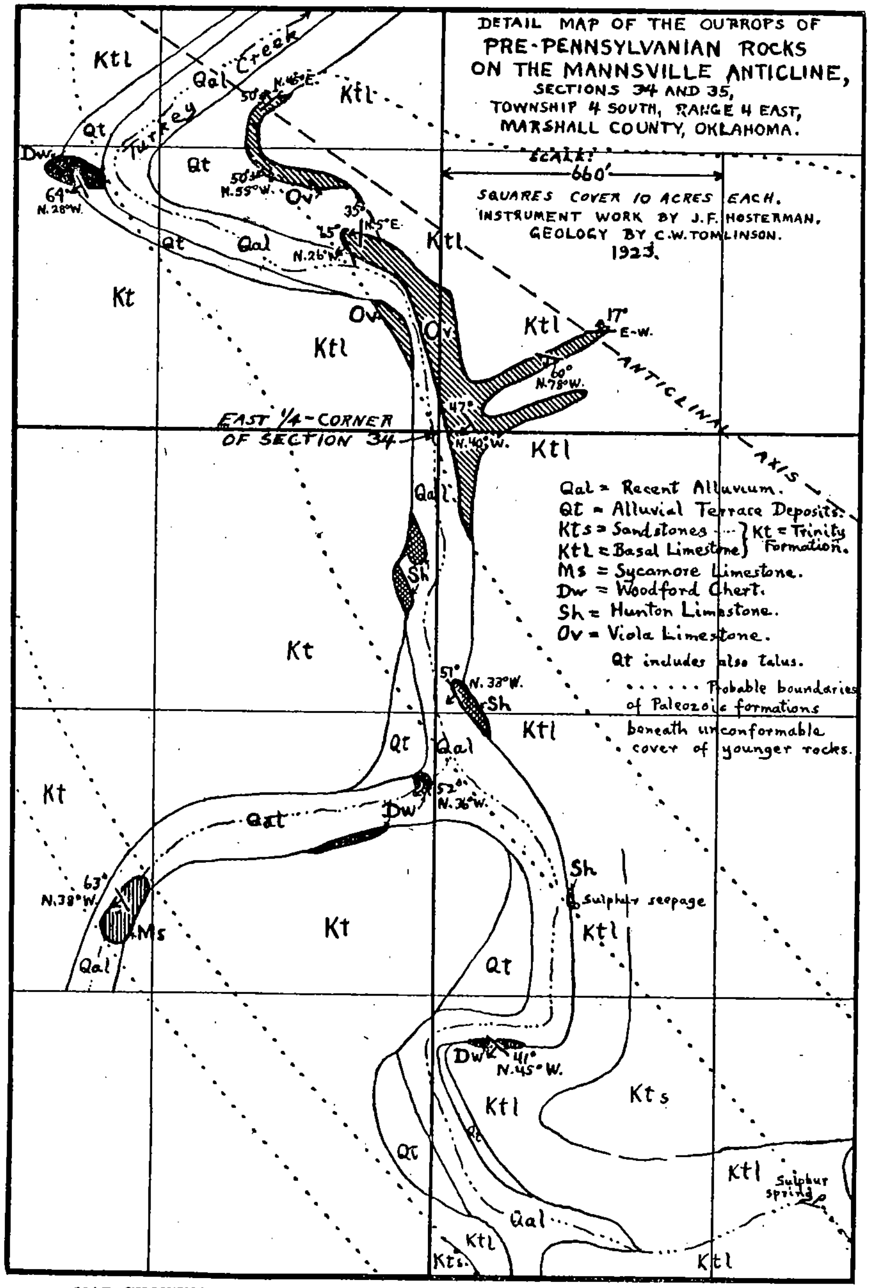
STRATIGRAPHY

PALEOZOIC ROCKS

The Paleozoic rocks are entirely concealed in Marshall County, except one isolated exposure 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 consists of an outcrop of Sycamore limestone, four outcrops of Woodford chert, four of the Hunton formation, and three of the Viola limestone. The Viola outcrops are the most extensive, covering an irregular area totalling about two acres. All of these outcrops occur in the bed and along the sides of Turkey Creek and its tributaries and may be found for a distance of about one-half mile beginning at the south line of the above named sections. No attempt was made to separate these formations on the geologic map due to the small scale of the map, and all of them are grouped under one symbol as Paleozoic. The exposure of Sycamore limestone is found on one of the principal tributaries of Turkey Creek, which enters from the west and joins Turkey Creek near the southwest corner sec. 35, T. 4 S., R. 4 E. The outcrop is about one fourth mile west of the point where the tributary enters Turkey Creek. At the point where the two creeks come together two outcrops of Woodford chert and one of Hunton limestone are present. About 100 yards down stream on Turkey Creek, along the west bank, is another exposure of the Hunton. The main outcrop of the Viola limestone begins at this point on the east bank of the Creek and continues in a general northwesternly direction for about one fourth mile. On the west bank, where the creek makes a sharp bend to the northeast, another exposure of Woodford chert occurs. All of these outcrops strike northwest and dip to the southwest at an angle ranging from 40° to 65°. The Paleozoic exposure in Marshall County was discovered and described by Tomlinson[7]. See Figure No. 2, page 14.

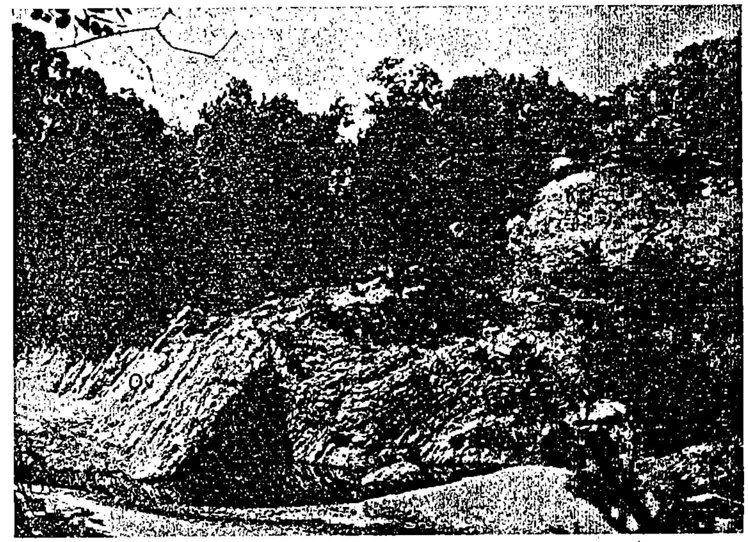
7. Tomlinson, C. W., Buried hills near Mannsville, Oklahoma: Am. Assoc. Petroleum Geologists Bull., vol. 10, pp. 138-143, 1926.

FIGURE 2



MAP SHOWING PRE-PENNSYLVANIAN OUTCROPS IN MARSHALL COUNTY. (COURTESY AMER. ASSOC. PET. GEOLOGISTS, GEOLOGY BY C. W. TOMLINSON.)

PLATE I



VIOLA LIMESTONE ON TURKEY CREEK SE¼ SEC. 34, T. 4 S., R. 4 E., OVERLAIN BY TRINITY SAND. (COURTESY OF AMER. ASSOC. PET. GEOLOGISTS, PHOTO BY C. W. TOMLINSON).

His description is given as follows:

"Sycamore limestone:

45 feet dense drab massive blocky limestone, very finely crystalline, in beds 2 inches to 1 inch thick. No fossils found.

35 feet concealed interval.

9 feet limestone like that above.

3 feet concealed interval.

10 feet dense drab blocky limestone, very finely crystaline. No fossils found.

2 greenish calcareous shale.

1 foot white calcareous sandstone, medium coarse grained.

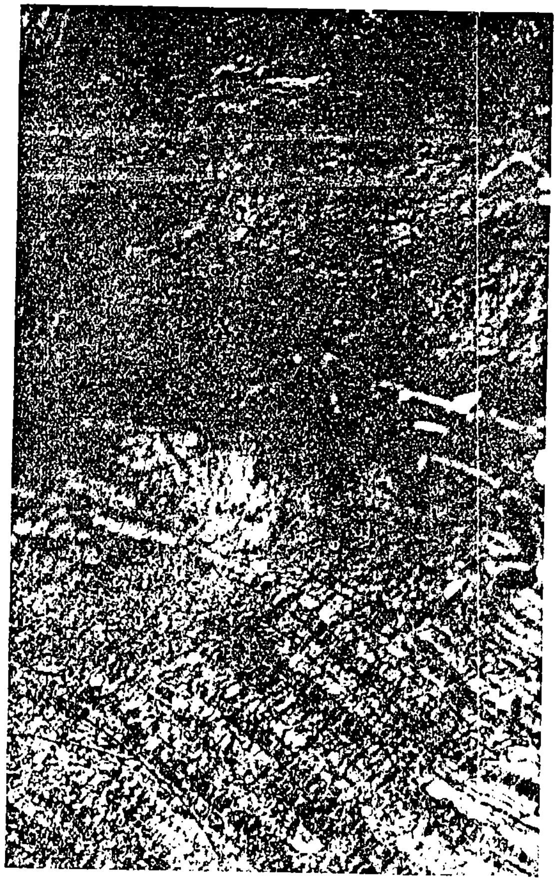
Woodford chert:

Southernmost outcrop: striped black and white chert, pretty well rotted and much iron stained; overlain by a 10 foot bluff of massive chalky limestone of the Trinity formation containing many angular fragments of chert. The basal 2 feet of the limestone grades into recemented sub-soil on the Devonian rocks, which still show interrupted steeply dipping bedding planes corresponding to those in the solid Woodford chert below. This subsoil layer is marked off from the solid chert by a black marcasite strip one fourth inch to 2 inches wide, which varies 2 feet from the horizontal in the length of this outcrop (about 100 feet).

Middle outcrop: interbedded black chert and green shale more or less iron stained on the weathered surface.

Northernmost outcrops: 40 feet of black chert and white siliceous clay or clayey chert, banded in layers from a fraction of a millimeter up to 7 inches thick. The lowest 9 feet is all black, the

PLATE II



WOODFORD CHERT, OVELAIN BY THE TRINITY SAND ON TURKEY CREEK, SEC. 34, T. 4 S., R. 4 E. (PHOTO BY C. W. TOMLINSON).

next 9 feet all white chert, and the next 7 feet banded, white, brown and gray.

"**Hunton formation:**

18 feet very fine grained, white to drab, blocky to platy, non-crystalline limestone.

6 feet coarsely crystalline, white, medium massive limestone in beds 3 inches to 2 feet thick, crammed with crinoid rings; grading at base into dense drab glauconitic limestone carrying many fossils, including brachiopods and gastropods. A collection from this horizon was identified by Mr. D. K. Gregor of the Roxana Petroleum Corporation as belonging to the Henryhouse shale division of the Hunton formation.

9 feet dense white thin-bedded limestone, platy to blocky; more or less chalky.

15 feet concealed interval.

13 feet massive, drab, finely crystalline limestone.

10 feet medium coarsely crystalline drab limestone, massive to irregularly blocky.

9 feet finely crystalline drab limestone, massive to irregularly blocky, with many seams and lenses of drab chert.

6 feet concealed interval above Viola linmestone (Sylvan shale?)

"**Viola limestone:**

Solid bluish gray to drab minutely crystalline limestone, very solid and hard. In part massive and rather poorly bedded, but mostly in well defined beds 6 inches to 2 feet thick. Occasional layers of cream colored chert of irregular thickness (up to 3 inches) and extent. About 10 feet below the top of the Viola exposure occurs 4 or 5 feet of a hard dense black bituminous shale, weathering gray. A total of about 250 feet of Viola is exposed. No well defined fossils were observed in it."

Both above and below these exposures the Trinity sand extends to a topographic level lower than the surface of the Paleozoic outcrops. This is not due to folding, but to a thinning of the sediments over the Paleozoic outcrops. It is believed that these exposures represent the top of a buried hill which existed on the pre-Comanchean erosinal surface and which were covered by the Comanchean sediments. The course of Turkey Creek happened to pass over the top of this buried hill and on the top of the hill, where the sediments were thinner, the creek has cut through the mantle of Trinity sand exposing the Paleozoics. The Criner Hills[8], located a few miles to the northwest of Marshall County represent a similar condition, except there the hills have been uncovered to a very large extent by erosion.

Some 4 or 5 miles north of the above described Paleozoic outcrops the Glenn formation, which is Pennsylvanian in age, outcrops, and north of this exposure a more or less complete section of the Paleozoic rocks are exposed, beginning with the granite below and extending upward through the section. For convenience a generalized section of the Paleozoic rocks exposed in the Arbuckle Mountains is given in Figure 3, page 18.

The Paleozoic rocks encountered in wells are discussed under the heading of Oil and Gas Possibilities, page 57.

8. Bullard, Fred M., Geology of Love County, Oklahoma: Oklahoma Geol. Surrey Bull. 33, p. 48, 1925.

FIGURE 3

System	Series	Formation	Thickness in Feet	Character of Formations
CARBONIFEROUS	PENNSYLVANIAN	Franks conglomerate	300-500+	Limestone and chert conglomerates, gritty sandstone, limestone and shale. Probably represents the upper portion of the Glenn formation and lies unconformably on all the other Paleozoic formations.
		—UNCONFORMITY—		
		Glenn formation	1000 to 3000	Blue shale, with thin brown sandstone and occasional thin limestone.
	MISSISSIPPIAN	Caney shale	1500	Blue shale, with sandy lentils and small ironstone concretions. Black fissile shale, with dark blue fossiliferous limestone concretions.
		Sycamore limestone	0-160	Bluish to yellow limestone
—?—	—?—			
DEVONIAN		Woodford chert	600	Thin-bedded chert and fissile black shale; local blue flint lentils at the base.
SILURIAN		Hunton limestone	0-200	White-yellowish limestone, with flint & chert concretions.
ORDOVICIAN		Sylvan shale	50-300	Blue clay shale.
		Viola limestone	750	White and bluish limestones, with flint concretions in the middle.
		Simpson formation	1600	Bituminous sandstone, calcareous sandstone, and shale. Thin fossiliferous limestone and shale. Bituminous sandstone, calcareous sandstone, and shale. Fossiliferous limestone and shale. Sandstone and shaly beds.
		—SLIGHT UNCONFORMITY—		
		Arbuckle limestone	4000 to 6000	Massive and thin-bedded white and light-blue limestones with cherty concretions.
—?—	—?—			
CAMBRIAN				Dull-blue massive and thin bedded limestones, sandy at the base.
		Reagan sandstone	50 to 150	Coarse dark-brown sandstone.
PRE-CAMBRIAN		Tishomingo granite		Coarse red granite and monzonite, with diabase, granite, porphyry and aplite dikes.

SECTION OF THE PALEOZOIC FORMATIONS EXPOSED IN THE ARBUCKLE MOUNTAINS. FROM J. A. TAFF, U. S. GEOL. SURV., GEOL. ATLAS, TISHOMINGO FOLIO (NO. 98), 1903.

FIGURE 4

System	Series / Group	Formation	Thick'ss in feet	Character of Formations
CRETACEOUS	GULF SERIES	Woodbine sand	50	Soft yellow to brown sandstone with large quantities of ferruginous segregations
		—UNCONFORMITY—		
COMANCHEAN	WASHITA GROUP	Grayson marl	30	Yellow to gray calcareous marl; lime nodules.
		Bennington limestone		Massive brown yellow limestone.
		Bokchito formation — Pawpaw sandy member	50	Yellow to gray sandstone with calcareous shales and numerous ferruginous lenses.
		"Quarry" limestone		
		Bokchito formation — Weno clay member	100	Dark gray shaly clay with thin lenses and layers of soft yellow sand.
		"Ostrea carinata bed"		
		Bokchito formation — Denton clay member	45-60	Brownish yellow clay. Thinly laminated brown sandstone with ripple marks.
		Fort Worth limestone	40-50	Alternating beds of white limestone and bluish gray shale.
		Duck Creek formation	65	Blue-gray calcareous shale.
			35	Large ammonite horizon (Schloenbachia brazoensis). Alternating beds of blue-gray shale & limestone.
	FREDERICKSBURG GROUP			Indurated shell breccia composed of Gryphaea navia.
		Kiamichi clay	30-40	Greenish yellow clay.
		Goodland limestone	15-25	Massive white limestone.
	TRINITY GROUP	Trinity sand	400-700	Fine white to yellow pack sand with occasional lentils of red and blue shale. Basal conglomerate of quartz pebbles.
		—UNCONFORMITY—		
		PALEOZOIC		

SECTION OF ROCKS EXPOSED IN MARSHALL COUNTY, OKLAHOMA.

COMANCHEAN ROCKS

GENERAL STATEMENT

The Comanchean rocks consist of sands, shaly clays, marls and limestones. They form a total thickness averaging about 1,000 feet in Marshall County. Overlying the Comanchean, and separated from it by a slight unconformity, is found the basal part of the Woodbine sand, the lowest Cretaceous formation. The Woodbine sand is the youngest formation outcroping in Marshall County, except recent alluvial and terrace deposits along Red River.

The stratigraphic column for Marshall County

Recent			Alluvial and terrace deposits
Cretaceous (Gulf series)			Woodbine sand
Comanchean	Washita Group		Grayson marl
			Bennington limestone
		Bokchito formation	Pawpaw sandy member
			Weno clay member
			Denton clay member
			Fort Worth limestone
			Duck Creek formation
			Kiamichi clay
	Fredricksburg Group		Goodland limestone
	Trinity Group		Trinity sand
Paleozoic			Sycamore limestone
			Woodford chert
			Hunton formation
			Viola limestone

TRINITY SAND

The Trinity sand was named by Hill[9] from the Trinity River of central Texas where the formation is well exposed. The Trinity sand represents the near shore or beach deposit of the Comanchean sea which transgressed upon the land from the southeast. Taff[10] who studied the formation in the Tishomingo quadrangle, which includes the northern part of Marshall County, described the Trinity sand as a fine, incoherent sand and scattered lentils of sandy clay with a basal conglomerate a few feet to 50 feet thick, which in the western part of the quadrangle is cemented with lime.

In its typical development the Trinity sand is a fine, white to yellow pack sand. The pack sand occurs in massive beds 40 to 50 feet in thickness and scattered throughout the formation are found lentils of clay. The clays are variable in thickness from a few inches to 20 to 30 feet and vary in color from yellow to purple and a mixture of variegated colors. Locally, the Trinity sand has some indurated layers which project as massive ledges and form hills and escarpments. These ledges are more prominent in the lower part of the formation. They are usually composed of a white sand which weathers a dull gray. A good exposure of this

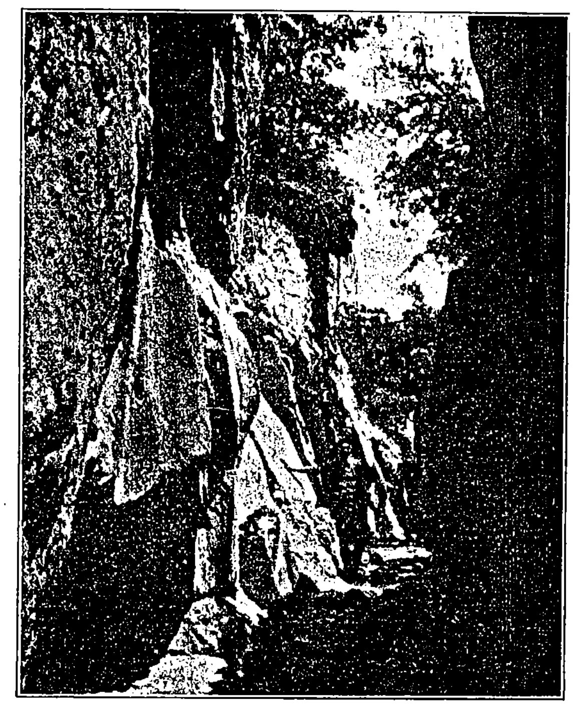
9. Hill, R. T., Ark. Geol. Survey Ann. Rept. for 1888, vol. 2, pp. 116-152, 176-179, 1888.
10. Op. cit.

phase of the Trinity is found along the east line of sec. 34, T. 4 S., R. 4 E., near the southeast corner, along Turkey Creek.

It is very difficult to secure a section of the Trinity as it weathers so easily that the slopes are usually covered by a thick mantle of loose debris. The thickness of the Trinity sand has been determined chiefly from the records of wells which have penetrated it. According to well records its thickness in the vicinity of Red River is from 400 to 600 feet.

Good exposures of the Trinity sand which will permit a detailed section to be measured are not very abundant. There are numerous bluffs of Trinity sand capped by Goodland limestone along Red River. They are from 150 to 250 feet in height but are usually covered by loose material hence detailed sections can rarely be secured.

PLATE III



VIEW OF RAVINE IN THE TRINITY SAND. NOTE VERTICAL WALLS.

Stephenson[11] gives the following section:

11. Op. cit. p. 134.

"At Rock Bluff, Red River, 2½ miles south of Preston, Texas, near the axis of the Preston anticline, the upper 150 feet of the Trinity is well exposed, as described in the following section.

Section at Rock Bluff, Red River, Grayson County, Texas.

(Altitude at top of section estimated to be 690 feet above sea level)

	Feet
Fredericksburg group (Goodland limestone)	
Limestone, hard massive	10
Clay, shaly, poorly exposed	1
Limestone	2
Trinity sand (Antlers of Hill)	
Sand, light gray, mostly fine argillaceous irregularly bedded compact, with subordinate lenses of fine sandy clay and some pebbly lenses; in lower 30 feet are interbedded lenses of purplish clay having a maximum observed thickness of 6 feet	150

The best and most complete section of the Trinity sand in this general region, observed by the writer, is on the south bank of Red River between Love County, Oklahoma and Cooke County, Texas, some 30 miles to the west of Marshall County. This section is approximately north and a little west of Gainesville, Texas.

Section[12] of Trinity sand on south bank of Red River, Sec. 14, T. 8 S., R. 1 W.

This section is found on the bluffs which occur at the point where the river makes a sharp bend to the northeast between Warrens bend and Sivells Bend.

	Ft.	In.
Goodland limestone		
Trinity sand		
Clay, brown, finely stratified and laminated	11	9
Breccis, indurated with oyster shell	1	5
Oyster bed, (Exogyra texana)	0	3
Clay, bituminous, interstratified with yellow sand	1	5
Sandstone, hard bluish	0	6
Sandstone, calcareous hard, with selenite in joints	1	4
Clay, marly, locally carbonaceous, containing an abundance of fossils	4	0
Oyster shells (Ostrea crenulimargo)	0	2
Clay, dark brown marly	0	3
Clay, black carbonaceous	3	6
Pack sand, massive white	21	6
Shale, greenish blue, appearing to be a lens	1	6
Pack sand, white	23	0
Sand, hard, pure white	2	0
Sand, yellowish white to gray clay	14	6
Sand, white, pink, red to yellow	32	6
Sandstone, hard indurated masses of brown	1	0
Clay, sandy, red, purple, yellow and white	48	0
Pack sand, white	12	0
Water level—Red River		
	181	7

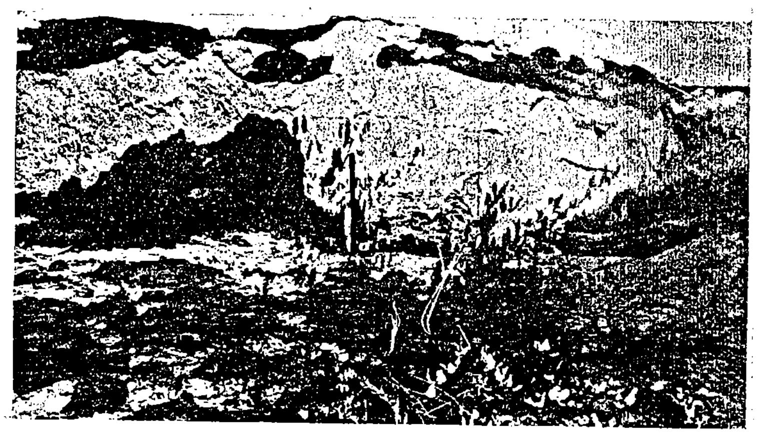
12. Bullard, Fred M., op. cit. p. 21.

The Trinity sand outcrops in the northwestern and western parts of Marshall County and in a narrow belt extending southeastward across the southern part of the county where it is exposed along the crest of the Preston anticlinal unlift.

South of Red River, in Texas, the middle portion of the Trinity sand becomes calcareous, and south of the Brazos River of Texas, is separable, according to Hill[13], in ascending order into the basement sands, 127 feet; the Glen Rose formation, chiefly limestone, 315 feet; and the Paluxy sand, 190 feet. Still farther south, at Austin, Texas, the Paluxy sand is apparently represented by limestone in the upper part of the Glen Rose so that the Trinity is divided into two formations; namely, the Travis Peak formation consisting of conglomerate, grit, sand, clay and calcareous beds having a thickness of about 100 feet; and the Glen Rose formation consisting chiefly of limestone having a thickness of about 450 feet. Marshall County was throughout Trinity time a near shore, shallow zone, so that sand was being deposited throughout Trinity time, but to the south in central Texas limestone deposits were being formed.

Good exposures of the Trinity sand may be found in the northwestern corner of the county near Simpson, in the south-central part of the county on Buncombe Creek, along the headwaters of Sand Creek about 5 miles south of Kingston, and as before stated in the bluffs along Red River.

PLATE IV



VIEW SHOWING THE GOODLAND-TRINITY CONTACT NEAR THE CENTER OF SEC. 3, T. 7 S., R. 5 E., ON A SMALL TRIBUTARY TO BUNCOMBE CREEK. NOTE IRREGULAR CONTACT.

13. Hill, R. T., Geography and geology of the Black and Grand prairies, Tex.: U. S. Geol. Survey Twenty-first Ann. Rept., pt. 7, 1901.

The Trinity sand weathers to form a rolling topography usually covered by a thick growth of scrub oak and black jack. Where it outcrops with the Goodland limestone overlying, steep escarpments and a very rugged topography is developed. Small ravines in the Trinity sand develop very narrow channels having nearly vertical sides.

FREDERICKSBURG GROUP

GENERAL STATEMENT

The Trinity sand is overlain by the Fredericksburg group which is represented in this area by the Goodland limestone. The Goodland limestone was named by Hill from the town of Goodland, Choctaw County, Oklahoma, where it is well exposed.

The basal 2 to 4 feet of the Goodland limestone consists of presistent hard thin bedded nodular limestone containing thin marly layers of shale. These beds were not recognized by Hill[14] in the type section at Goodland, in Choctaw County. He says:

> "Proceeding westward along the ancient Ouachita shortline from Arkansas into Texas, the **Exogyra texana** beds (the Walnut clay and **Gryphea** breccia) are missing until the escarpment is reached north of Marietta, in Chickasha Nation (Love County, Okla.) where they first appear, thinly represented beneath the Goodland limestone."

In 1894[15] and again in 1901[16] Hill restricted the term Goodland to the massive limestone between the underlying Walnut clay, which he regarded as forming the upper part of the "Antlers" (Trinity) sand, and the overlying Kiamichi clay. In the Atoka folio[17] and again in the Tishomingo folio[18], Taff included the Walnut clay in the Goodland, and this usage has since been adopted and followed by other writers, including the United States Geological Survey. Stephenson[19] in 1918, although following the usage of Taff advocates that the original definition of the Goodland, as given by Hill, be followed and that the Walnut clay or as it is sometimes called, the Walnut shaly member, be separated from the massive limestone in accordance with Hill's original usage.

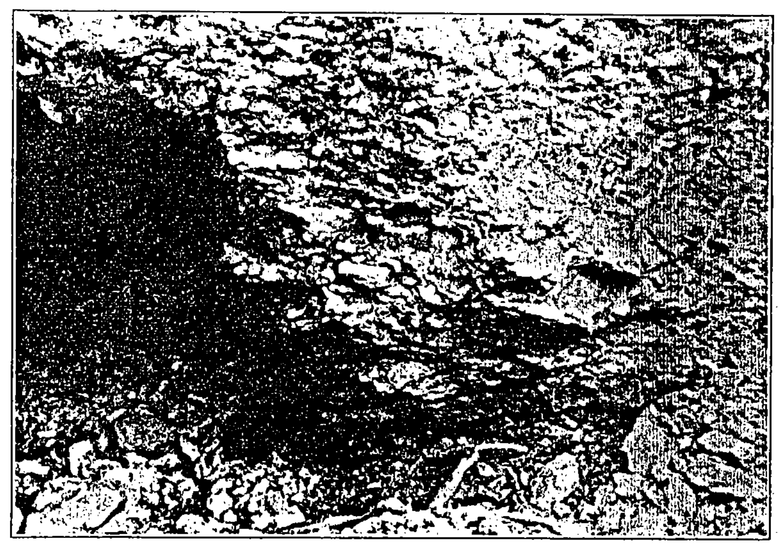
South of Red River, in Texas, the Walnut clay becomes thicker and assumes the importance of a formation rather than a member. Its maximum thickness is attained in the vicinity of Dallas where it is approximately 150 feet in thickness. It then begins to thin out, and at Austin is only about 15 feet thick. Following is the description of the Walnut clay as given in the Austin folio[20].

14. Hill, R. T., Geol. Soc. America Bull., vol. 2, pp. 502-514, 1891.
15. Hill, R. T., Geol. Soc. America Bull., vol. 5, pp. 303-304, 1894.
16. Hill, R. T., U. S. Geol. Survey Twenty-first Ann. Rept., pt. 7, pp. 216-222, 1901.
17. Taff, J. A., U. S. Geol. Survey Geol. Atlas, Atoka folio (No. 79), 1902.
18. Idem, Tishomingo folio (No. 98), 1903.
19. Stephenson, L. W., A contribution to the geology of northeastern Texas and southern Oklahoma: U. S. Geol. Survey Prof. Paper 120, p. 135.
20. Hill, R. T., and Vaughn, T. W., U. S. Geol. Survey Geol. Atlas, Austin folio (No. 76), p. 3, 1902.

> "Walnut clay.—At the top of the Glen Rose formation a bed of yellow calcareous clay always occurs, which is extremely rich in two species of oysters: **Exogyra texana** Roëmer and **Gryphea marcoui** Hill and Vaughn. Its thickness is from 10 to 15 feet. This is an extremely presitent bed both in its lithologic and its palontologic characters. To it the name of Walnut clay has been given. Above these clays is a soft chalky limestone, the Comanche Peak limestone."

The writer believes that the Walnut clay is not represented by this lower bed of the Goodland limestone as previously stated, but that the equivalent of the Walnut clay is another horizon still lower in the section. In the section of the Trinity sand and overlying Goodland limestone, measured along the south bank of Red River north of Gainesville, a yellowish marly clay carrying an abundance of fossils, including *Exogra texana* and *Gryphea marcoui* was found about 20 feet below the base of the Goodland limestone, previously described as the Walnut shaly member. (See section of Trinity sand given on page 22, and the section of the Goodland limestone, which overlies the Trinity in practically a vertical cliff at the same locatiton, on this page. This horizon was not observed in Marshall County although few clear cut sections of the upper part of the Trinity were found. The lower bed of the Goodland limestone, which has been described as a marly nodular, shaly limestone, the equivalent of the Walnut clay, is

PLATE V



CLOSE VIEW OF THE GOODLAND SHOWING THE GOODLAND-TRINITY CONTACT present in Marshall County, having a thickness of approximately three feet. The writer does not think that there is any justification for separating this bed from the massive limestone above for the lower bed grades into the typical massive Goodland limestone and is essentially a part of that formation. The Walnut clay equivalent, in the opinion of the writer, is represented by this marly clay zone approximately 4 feet in thickness on Red River north of Gainesville. About 30 miles south of Red River on the southern boundary of Cooke County, Texas, the Walnut clay has attained a thickness of approximately 25 feet, and occupies a position immediately beneath the Goodland limestone.

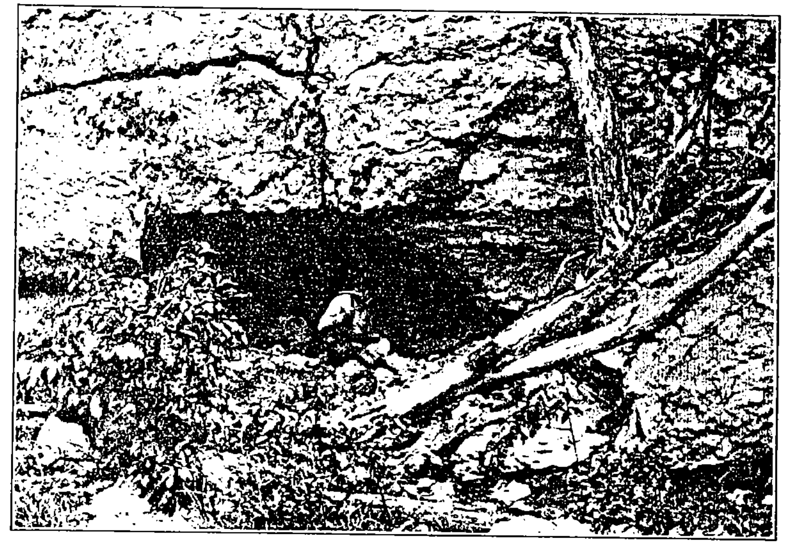
PLATE VI

VIEW SHOWING THE TOTAL THICKNESS OF THE GOODLAND LIMESTONE

GOODLAND LIMESTONE

The Goodland limestone consists of from 15 to 20 feet of hard, white semi-crystalline limestone, which weathers almost

PLATE VII



VIEW SHOWING LOWER PART OF THE GOODLAND LIMESTONE

pure white. It is massively bedded, there being as a rule about four beds ranging in thickness from 4 to 6 feet. The lower part of the Goodland limestone is slightly chalky, while the upper part is a very hard, pure, white limestone. A peculiar characteristic of the upper part of the Goodland is that of breaking or scaling off in thin plates. This gives an exposure of the limestone a more or less shattered appearance.

The Goodland limestone overlies the Trinity sand. The contact between the two is more or less a sharp contact, as the upper part of the Trinity sand is a typical white to yellow pack sand and passes by a sharp line into a very nodular, marly limestone. At one locality, near the center of sec. 3, T. 7 S., R. 5 E., on a small tributary to Buncombe Creek, this contact was more or less irregular suggesting a slight unconformity, although, in as much as it was observed at one locality it is considered an irregularity in deposition rather than an unconformity.

Section of the Goodland limestone on an east tributary of Buncombe Creek in the SE¼ of the NW¼ sec. 3, T. 7 S., R. 5 E., Marshall County, Oklahoma.

	Ft.	In.
Kiamichi clay		
Goodland limestone		
Limestone, massive white	15	0
Limestone, white	0	7
limestone, impure nodular	1	6

	Ft.	In.
Marl, impure, arenaceous yellowish white contains numerous lenses and nodules of limestone, irregular and wavy laminations	2	0
Pack sand, massive gray, (Trinity)		
	19	1

Stephenson[21] gives the following section of the Goodland limestone which was measured on the Texas side of Red River, approximately two miles east of Henderson Ferry.

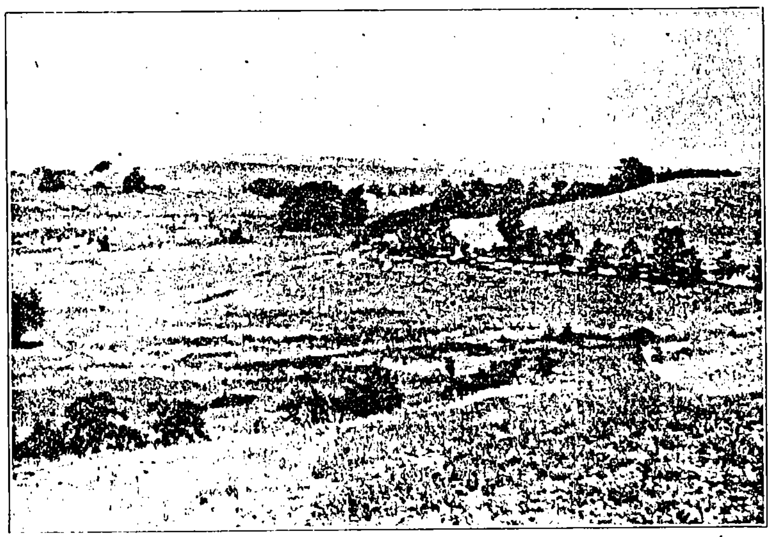
Section on Little Mineral Creek four and one half miles north of Potosboro, Grayson County, Texas.

(Altitude at top of section estimated to be 615 feet)

	Ft.	In.
Soil	2	0
Fredericksburg group (Goodland limestone)		
Limestone, massive	13	0
Walnut shaly member: Hard, thin bedded, coquina-like limestone containing **Ostrea subovata** Shumard, **Gryphea marcoui** Hill and Vaughn, **Trigonia** sp. and **Anomia** sp., with interbedded thin layers of dark marly shale	6	0
	21	0

The Goodland limestone outcrops in a narrow sinuous band. Its outcrop is distributed over a large portion of the county, due to the Preston anticlinal uplift which has brought the Goodland limestone and other formations in the lower part of the section to the

PLATE VIII



VIEW SHOWING THE ESCARPMENT FORMED BY THE OUTCROP OF THE GOODLAND LIMESTONE.

21. Op. cit. p. 136.

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. The escarpment formed by the Goodland limestone, where it outcrops in contact with the Trinity sand is one of the most prominent topographic features in the region.

South of Red River the Goodland limestone gradually increases in thickness. It is regarded as the time equivalent of the Walnut clay, Comanche Peak limestone and the Edwards limestone of central Texas, which in the vicinity of Austin have a combined thickness of approximately 300 feet.

WASHITA GROUP

GENERAL STATEMENT

The Washita group is the highest division of the Comanchean. It lies conformably upon the Fredericksburg group, and was named by Hill[22] from Fort Washita, Oklahoma, which is located a few miles east of the eastern boundary of Marshall County in Bryan County. Fort Washita has been abandoned since about 1860 and only a few ruins now mark the location of this old fort. The locality of Fort Washita is one of the important historic places in regard to Cretaceous stratigraphy, as it was from this place that Dr. G. G. Shumard collected the fossils that were later described by Dr. B. F. Shumard and Prof. Jules Marcou which led to a controversy which lasted for many years.

The Washita group is composed of marine shaly clays, marls and subordinate limestones, having a total thickness of approximately 415 feet in Marshall County. Toward the top there is a sandy member, the Pawpaw, which is the only exception to the non-sandy character of this group. The limestones, although subordinate to the clays in thickness, form several definite horizons, that contain characteristic fossils which are readily traceable throughout the area, and for this reason are of the utmost importance in determining the stratigraphic sequence and structure of the region.

The Washita group has been subdivided by Hill[23] and also by Taff[24]. The classification used in this report is essentially that given by Hill, except that several of the apparently unnecessary group terms have been omitted, and the term Bokchito, used by Taff, is applied to a portion of Hill's Denison formation. The relation of the various classifications is given on the Correlation Chart, Figure 5, page 46.

The Washita group represents the beginning of the withdrawal of the Comanchean sea which reached its maximum devel-

22. Hill, R. T., Annotated check list of the Cretaceous invertebrate fossils of Texas: Bull. 4, Geological Survey of Texas, p. 21, 1889.
23. Hill, R. T., U. S. Geol. Survey Twenty-first Ann. Rept., pt. 7, pp. 240, 1901.
24. Taff, J. A., U. S. Geol. Survey Geol. Atlas, Atoka folio (No. 79), 1902; Tishomingo folio (No. 98), 1903.

opment during the preceding epoch, the Fredericksburg, when wide spread deposition of limestone took place. This shallowing of the sea during Washita time is recorded in the increase of shaly material toward the top of the group and finally in the deposition of sand. The numerous sand layers found throughout the Washita group bear evidence of shallow water deposition in the form of ripple marks, cross bedding, etc. Finally at the end of Washita time the sea retreated entirely from this region, and a short erosional interval, indicated by a slight disconformity, intervened between the Comanchean and the succeeding Cretaceous deposits.

The following subdivisions of the Washita group have been mapped in Marshall County:

- Washita Group
  - Grayson marl
  - Bennington limestone
  - Bokchito formation
    - Pawpaw sandy member
    - Weno clay member
    - Denton clay member
  - Fort Worth limestone
  - Duck Creek formation
  - Kiamichi clay

KIAMICHI CLAY

The Kiamichi clay was named for the Kiamichi River in Choctaw County, Oklahoma where the formation is typically exposed. The Kiamichi includes the sediments lying between the Goodland limestone below and the Duck Creek formation above, the lower part of which is chiefly limestone. It consists of about 35 feet of dark yellowish to green shaly clay with thin platy layers of yellow siliceous limestone lenses in the lower portion, and at the top the formation is marked by two or three thin ledges of a hard, yellowish limestone made up principally of oyster shells, *Gryphea navia* Hall, being the most abundant species. This *Gryphea*-bearing limestone occurs at the top of the Kiamichi clay. It makes a small, but recognizable bench, below which large slabs of this indurated oyster shell conglomerate or breccia stand at every angle and are commonly referred to as "edge rock." The weathering of the soft underlying clay caused the beds to slump, and as a result they break off in large slabs which stand at every angle covering the outcrop of the Kiamichi clay.

The contact between the Goodland limestone and the Kiamichi clay is usually marked by a rather presistent bench, caused by the erosion of the soft clay overlying the hard limestone. This contact is not a gradation, but more of a sharp break from the pure limestone to the typical clay of the Kiamichi. Usually a few inches of a brown siliceous limestone can be noticed at the base of the Kiamichi which represent the transition from the Goodland limestone to the Kiamichi clay.

PLATE IX

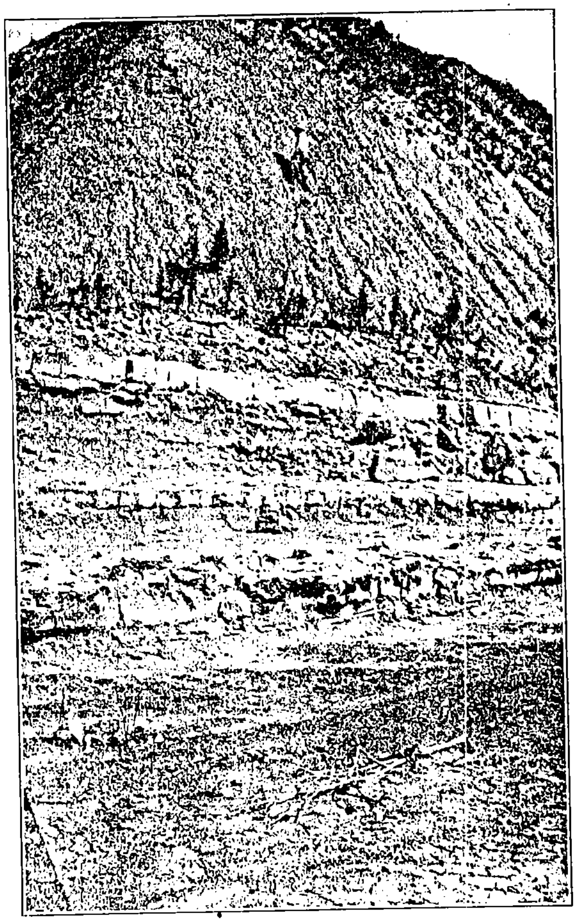
VIEW SHOWING THE GOODLAND-KIAMICHI CONTACT.

The Kiamichi outcrops usually on the slopes above the Goodland escarpment, or on the sides of hills capped by the lower Duck Creek limestone. Since the Kiamichi lies between two relatively hard escarpment-forming limestones its outcrop is rather narrow and tortuous. Good exposures of the Kiamichi may be seen along Rock Creek, south of Kingston, where a section of the Kiamichi was measured having a thickness of 36 feet, also along Brier Creek due west of Kingston, and in many places in the area around Madill.

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 gray 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 6 to 12 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.

PLATE X



VIEW SHOWING COMPLETE SECTION OF THE DUCK CREEK FORMATION

The following section by Stephenson[25] is typical of the formation.

25. Op. cit. p. 138.

Section on Duck Creek and in a cut of the St. Louis and San Francisco Railroad two and three-quarter miles north of Denison, Grayson County, Texas.

	Ft.	In.
Fort Worth limestone		
Limestone, nodular, impure, argillaceous and fossiliferous, in four or five layers, interbedded with gray shaly clay	8	0
Duck Creek formation:		
Clay, gray shaly calcareous, with interbedded layers of impure non ledge-forming limestone at intervals of 2 to 3 feet	22	0
Concealed	20	0
Clay, greenish-gray calcareous from which weather numerous specimens of Plicatula cf P. incongrua Conrad and small rusty ammonites, probably young Pachydiscus and Schloenbachia, also a few specimens of Gryphea washitaensis Hill	15	0
Limestone, ledges with interbedded layers of gray shaly clay, poorly exposed; the limestone, especially one layer near the top, contains numerous keeled and non-keeled ammonites, many of which are of large size (maximum, 2 feet in diameter)	20	0
Limestone and gray shaly clay, in alternate beds, ammonite-bearing, well exposed in bluff along the creek	20	0
	97	0

The lower part of the Duck Creek contains an abundance of well preserved fossils. The large ammonite (*Desmoceras brazoense*) occurs at the top of the series of alternating limestone and shaly clay layers in the lower part of the Duck Creek formation. About 30 feet above the *Gryphea* bearing limestone at the top of the Kiamichi clay there is a massive, white limestone bed, which averages about two feet in thickness. It is a very persistent bed and is the most prominent ledge in the lower Duck Creek. In its unweathered appearance this bed resembles the Goodland limestone. The large ammonites above referred to occur in this limestone ledge and also in the shaly clay directly above and below it. They are limited in vertical range to a zone probably not more than 4 or 5 feet in thickness. For this reason this "large ammonite" horizon is an excellent key bed for the determination of structure. Below the "large ammonite" horizon there is an abundance of fossils including *Inoceramus comancheansis, Hamites fremonti, Hemiaster whitei, Schloenbachia trinodosa* and many others which will be found listed under the Duck Creek formation in the chapter on Paleontology.

The upper part of the Duck Creek is practically barren of fossils.

FORT WORTH LIMESTONE

Overlying the Duck Creek formation is the Fort Worth limestone, named from the city of Fort Worth, Texas, where it may be seen typically exposed along the streets. The Fort Worth limestone is readily separated into three parts. The lower division consists of from 10 to 15 feet of alternating beds of a yellowish white limestone and grayish to blue shaly clay. The middle division is chiefly shale and also ranges from 10 to 15 feet in thickness. The upper division is predominately limestone, separated by thin layers of shaly clay. The limestone is a hard, cream colored limestone, very similar to the more massive beds in the lower Duck Creek formation. The resemblence in lithologic character, between the lower Duck Creek and the Fort Worth makes it difficult to distinguish the two formations except by the fossils contained therein. However, the fossils are so abundant in both of these formations that a few minutes search will usually reveal some fossils characteristic of one of the formations. The fauna of the Fort Worth and lower Duck Creek is quite different, there being a number of fossils characteristic of each formation and also of certain horizons in the formations. The fossils relied upon particularly to determine the Fort Worth are: *Holaster simplex, Hemiaster elegans Scholenbachia leonensis,* and a large oyster, *Exogyra americana.* Further details regarding the fossils will be found under Paleontology.

The following section of the Forth Worth is taken from Bulletin No. 736 of the United States Geological Survey[26].

Section of the Fort Worth limestone in east bank of Red River half a mile south of the mouth of Washita River, Bryan County, Oklahoma.

Fort Worth limestone	Feet
Limestone. hard, thin to massive bedded, nodular	12
Shale, with one or more thin limestone layers	12
Limestone and shale interbedded, half and half	10
	34

The thickness of the Fort Worth averages about 40 feet. In the above section the base of the formation is not exposed.

Following is Hill's[27] description of the Fort Worth at the type locality:

"The Fort Worth formation, as exposed in the railway cuts north of the Union Station at Fort Worth, and underlying all the business portion of that city, consists of a group of impure white limestones, very slightly arenaceous, regularly banded in persistent layers averaging nearly a foot in thickness, and alternating very regularly with similar layers of marly clay. The limestones and marls occur in strata 4 or 5 inches to 2 or more feet in thickness. The marly layers alternate with the hard limestone bands ranging from thin laminae to beds 6 inches or more thick. The gradation from hard marly bands to firm limestone is apparently sharp, but on close examination it is found to be very gradual, so that well-defined lines cannot always be clearly drawn between them. Upon weathering in vertical bluffs the hard ledges become projecting shelves and the marls form recessions between them. Before exposure the rocks are dull blue, but when weathered they are glaring white, sometimes with a slightly yellowish tinge."

26. Hopkins, O. B., Powers, Sidney and Robinson, H. M., op. cit. p. 4.
27. Hill, R. T., U. S. Geol. Survey Twenty-first Ann. Rept., pt. 7, p. 259, 1901.

The Fort Worth limestone and the Duck Creek formation are equivalent to Taff's Caddo formation. The Fort Worth outcrops 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.

BOKCHITO FORMATION

GENERAL STATEMENT

The Fort Worth limestone passes upward into a group of sediments of various aspects laid down in shallower water and characterized by certain well marked paleontological zones. Taff[28] applied the name Bokchito, from the town of the same name in Bryan County, Oklahoma, to this group of sediments lying between the Fort Worth limestone below and the Bennington limestone above. They are for the most part near shore, littoral deposits, some of which have no traceable representative farther south than north-central Texas, so that arenaceous and argillaceous formations in Marshall County become limestones and marls in central Texas. This gradation may be illustrated by comparing the thickness of the Washita group in Marshall County and in central Texas, as given by Hill in the Austin folio. In Marshall County the Washita group, as previously stated, is composed chiefly of shaly clays, marls and a subordinate amount of thin limestones with an average thickness of approximately 450 feet, while in the vicinity of Austin, Texas, the Washita group is represented by a single limestone formation, the Georgetown, having a thickness of 80 feet.

Hill's[29] description of the beds which make up the Bokchito formation, as given for the Denison area, which he states may be considered the type locality for north Texas and Indian Territory, is as follows:

"In this region it consists of laminated ferruginous clays, sandy clays, impure limestone (littoral breccia) and sand. These beds are all characterized by strong ferruginous colors peculiar to near shore deposits, which appear only faintly, if at all, in the lower lying Comanche series, or the extension of the Denison beds south of the Brazos, while the white chalky element is entirely absent.

28. Op. cit.
29. Idem. p. 266.

"In the Denison section the beds consist of about 300 feet of ferruginous dark colored clays and sands, free from the lighter colored calcareous (chalky) element of the underlying beds, with occasional conspicuous indurated layers of impure limestone, ferruginous sandstone, iron ore, and clays, which lie between the top of the Fort Worth limestone and the Grayson marl."

The Bokchito formation, as used by Taff, and also in this report, is equivalent to Hill's Denison formation as defined in the Twenty-first Annual Report of the United States Geological Survey. Stephenson[30] modified Hill's classification and included all the sediments of the Comanchean lying above the Fort Worth including the Bennington limestone and the Grayson marl in the Denison. The Denison section, above referred to and described by Hill lies just a few miles south of Marshall County.

SUBDIVISIONS OF THE BOKCHITO FORMATION

The Bokchito formation may be divided into three rather distinct members. The basis for the separation of this series of sediments is chiefly on paleontological grounds, although each member has certain well marked lithological characteristics which can be recognized. The division as made by Hill is adopted in this report and is as follows:

Bokchito formation	Feet
Pawpaw sandy member	45
Weno clay member	100
Denton clay member	55
	200

As above stated the basis for the separation of these beds is chiefly on the basis of paleontology, although the upper member is quite distinct in that it is chiefly sand while the lower two are principally clay. The writer is inclined to favor a discarding of the term Bokchito, and the advancing of the three members above listed to the rank of formations. It is the tendency at the present time to eliminate all unnecessary terms and simplify as much as possible the nomenclature of beds, which at best will need be rather complicated.

DENTON CLAY MEMBER

The Denton clay member is the lowest or basal division of the Bokchito formation. It is named for the city of Denton, Denton County, Texas. In Marshall County the Denton consists of from 45 to 55 feet of brownish yellow clay with numerous sandstone beds and lenses terminating at the top with a hard, brownish yellow arenaceous limestone containing an abundance of fossils. This fossiliferous limestone rarely exceeds one foot in thickness.

30. Op. cit.

Hill[31] makes the following statement in regard to the Denton:

"The lower part of the Denton subgroup consists of blue marly clays, terminating above by conspicuous indurations of oyster breccia made up largely of **Gryphea washitaensis** accompanied by **Ostrea carinata.**"

The Denton clay immediately overlies the Fort Worth limestone. The lower 5 to 10 feet is decidedly a calcareous clay. The first horizon that can be definitely recognized in the Denton clay is a sandstone bed, ranging from one to two feet in thickness. This sandstone is thinly laminated, a yellowish brown on weathered surfaces and usually contains well developed ripple marks on its surface. This "ripple mark" sandstone lies near the middle of the Denton, varying from 30 to 35 feet above the top of the Fort Worth. It is practically the only indurated bed in the Denton, and can usually be used to an advantage in mapping since it is very easy to locate as large slabs of this sandstone frequently cover the slope of a small escarpment or bench which it forms. The top of the Denton, as above stated, is marked by an impure, fossiliferous limestone containing an abundance of fossils. This bed is the "*Ostrea carinata*" horizon of Hill, but in Marshall County only a few scattered specimens of *Ostrea carinata* were observed, the most abundant fossils being *Gryphea washitaensis*, *Ostrea quadruplicata*, spines and plates of an echinoid, probably *Leiocidaris hemigranosus*.

Section of the Denton clay as exposed on the east bank of Red River, ½ mile south of the mouth of Washita River, Bryan County, Oklahoma.

Weno clay members exposed on slope of hill.

Denton clay member:	Feet
Limestone, shaly argillaceous, containing an abundance of **Gryphea washitaensis**	1
Limestone, hard brownish yellow, containing numerous **Gryphea washitaensis**, plates and spines of large echinoids, probably **Leiocidaris hemigranosus,** and a few specimens of **Ostrea carinata**	1
Clay, brownish yellow to greenish	17
Sandstone, hard, thinly laminated, brownish yellow, containing an abundance of well preserved ripple marks	1
Clay, brown to green, calcareous at base and with numerous thin beds and lenses of soft yellow sandstone in upper part	26
Top of Fort Worth limestone:—(for section of Fort Worth see page 34.)	
	46

Section of the Denton clay exposed in the SW¼ Sec. 27, T. 6 S., R. 6 E., about 3 miles east of Kingston, Marshall County, Oklahoma.

(This section was measured on the north slope of the hill.)

Weno clay member: (for section see page 40).

31. Op. cit. p. 268.

Denton clay member:	Feet
Limestone, hard, brownish yellow, impure, fossiliferous, containing **Ostrea quadruplicata, Gryphea washitaensis**, a few fragments of **Ostrea carinata**, and numerous echinoid spines (probably **Leiocidaris hemigranosus**)	1
Clay, yellow, brownish	11
Sandstone, hard, thinly laminated, brownish yellow, containing ripple marks	2
Clay, yellowish green to brownish, containing numerous lenses of soft yellow sandstone	42
Top of Forth Worth limestone:	
	56

It is desired to call the readers attention to the difference in thickness of the Denton in the two sections just given. The first section was measured on the south limb of the Preston anticline, while the second section was measured on the north limb of that fold, the thicker section being on the landward side of thte anticline. It is merely desired at this time to call attention to this fact, and in so far as possible sections will be given on each side of the Preston anticline for the succeeding formations in order to bring out this variation in thickness of sediments.

WENO CLAY MEMBER

The Denton clay member is overlain by a dark gray to yellow clay varying in thickness from 90 feet in the southwest portion of Marshall County to 135 feet in the northern part. The name Weno was given by Hill[32] from the village of Weno, on Red River, 5 miles northeast of Denison, Grayson County, Texas. Weno does not appear on recent maps and apparently has been abandoned.

Following is Hill's[33] description of this member:

"This subgroup attains its maximum development in the Denison section, where it includes all the beds between the top of the **G. washitaensis** agglomerate and the top of the Quarry limestone. It is well developed in the Red River region, where its several beds are important stratigraphic units, but those lose individuality southward across the State.

The Weno formation is characterized by a littoral fauna of many small species occurring in great quantities in certain horizons, notably **O. quadruplicata** and certain ammonitic forms of the **Engonoceras** type; which are now being studied by paleontologists.

"Character of beds at Denison:—In the Denison section these beds embrace several well defined members, consisting of very ferruginous brownish marls, with occasional presistent harder beds, such as large lens-shaped segregations, beds of ferruginous sandstone, impure limestone, etc., all of which are locally presistent and some very conspicuous. The indurated beds of the Denison are interesting. One of these indurated layers, 80 feet below the summit, is especially noticeable, in as much as it consists of large lenticular indurations of a clay ironstone which are thinly laminated and break into sheets along the line of laminae. These concretions are blue interiorly and brown exteriorly, and are often 4 or 5 feet in diameter. About 22 feet below the indurations, or 104 feet below the Quarry limestone, there is another indurated bed consisting of sandstone, as exposed near the cemetary gate north Denison. Below this, extending down to the **O. carinata** beds there are brown clay, marls to a depth of about 22 feet. In the Denison section the strata of the Weno subgroup are clearly defined and easily recognizable. Southward toward Fort Worth they lose their individuality, after the disappearance of the Quarry limestone in Denton County, which to the northward separates the Weno from the Pawpaw formation. * * * Furthermore the limestone element increases proportionately until the lithologic character so changes that along the banks of the Trinity the beds somewhat resemble the underlying Fort Worth beds."

32. Hill, R. T., U. S. Geol. Survey Twenty-first Ann. Rept., pt. 7, pp. 121, 274, 1901.
33. Idem. p. 274.

The Weno is very similar to the Denton in lithologic characteristics, the principal differences being that the Weno contains more thin soft sandy layers and also many clay ironstone concretions. The following sections give a detailed description of the upper part of the Weno:

Section of the Weno clay member exposed on the east bank of the Washita River, just below the St. Louis & San Francisco Railroad bridge west of Woodville, Oklahoma.

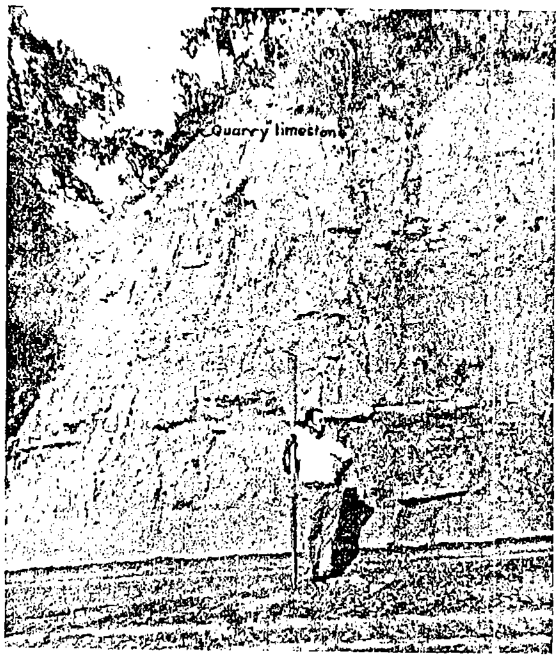
Pawpaw beds: exposed on top of bluff.

Weno clay member:	Ft.	in.
"Quarry" limestone.		
Ostrea quadruplicata agglomerate, also contains **Protocardia** sp., **Trigonia** sp. a large **Exogyra**; dark brown sandstone usually has a stain or a coating of red iron oxide on upper surface	1	0
Sandstone, hard, light yellow to bluish gray, containing numerous fossils, chiefly **O. quadruplicata**	2	0
Clay, yellow, sandy	0	8
Clay, bluish gray	12	0
Sand, soft, yellowish white	0	8
Clay, bluish gray, shaly	2	0
Sand, soft yellowish white, containing clay ironstone concretions and marcasite nodules in lower portion	4	0
Sand, yellowish white and clay, bluish gray shaly, in alternating beds	1	10
Sand, soft yellowish white	0	6
Clay, bluish gray, with clay ironstone concretions marcasite nodules and numerous well preserved specimens of **Turritella** sp.	0	8
Sand, yellowish, soft, lenticular bed	0	8
Clay with iron concretions	1	8
Sand, soft yellowish white	0	2
Clay, blue gray shaly	0	6
Pack sand, yellowish white	0	2
Clay, sandy bluish gray	0	3

Clay, lense, friable, ferruginous, containing an abundance of fossils, **Protocardia** sp., etc.	0	2
Clay, bluish gray shaly, containing thin layers of sandstone and numerous clay ironstone concretions and marcasite nodules	8	6
Pack sand, yellowish white, containing marcasite nodules	0	8
Clay, bluish gray	0	4
Pack sand, soft white	0	2
Clay, bluish gray	0	6
Pack sand, yellowish white	0	2
Shale, bluish gray, numerous small iron concretions in upper part	11	10
	54	1

A fairly good exposure of the upper part of the Weno occurs on the west bank of the Washita River, on the road due east of Woodville. At this place the following section was measured.

PLATE XI



UPPER PART OF THE WENO CLAY AS EXPOSED ON THE EAST BANK OF THE WASHITA RIVER, JUST BELOW THE ST. LOUIS & SAN FRANCISCO RAILROAD BRIDGE, WEST OF WOODVILLE.

Section of the Weno clay on the west bank of the Washita River, due east of Woodville, Marshall County, Oklahoma.

Pawpaw clay member and the Bennington limestone occur on the bluff.

Weno clay member:

"Quarry" limestone:

	Ft.	In.
Limestone, sandy bluish gray, weathers a brownish yellow, with a coating of reddish to purple iron oxide on the upper surface; contains **Ostrea quadruplicata** in considerable abundance	3	0
Clay, bluish to brownish yellow, containing numerous iron concretions in lower part and thin beds of soft yellow sandstone, averaging about 2 inches in thickness	57	0
Alluvial material		
	60	0

A complete section of the Weno as well as the other members of the Bokchito formation, occurs on the bluff on the south side of Red River, along sec. 26, T. 8 S., R. 5 E., near Bounds Ferry. At this point the Weno has a total thickness of 90 feet. The slope is covered with loose material and soil so that it is impossible to measure a detailed section, but the indurated layers and contacts between the various members can be clearly located. The Fort Worth limestone outcrops at the foot of the bluff and the Bennington limestone caps the bluff. This section is on the south limb of the Preston anticline.

A complete section of the Weno is exposed on the north limb of the Preston anticline in the SW¼ sec. 27, T. 6 S., R. 6 E., 3 miles east of Kingston. At this location there is a small rounded knob capped by the "Quarry" limestone and in the creek to the north the Fort Worth limestone outcrops, so that a complete section of the Denton and Weno may be obtained at this place. The total thickness of the Weno as measured at the above location is 135 feet. Due to the gentle slope it was impossible to measure a detailed section, but along the public road, just east of the knob, fairly good exposures of the upper part of the Weno were observed. A considerable thickness of soft yellow sand occurs in the upper part of the Weno, so that at this place it resembles the overlying Pawpaw more closely than typical Weno. However, the "Quarry" limestone above definitely places the beds in the Weno. This increase in thickness from 90 feet on the south side of the Preston anticline to 135 feet on the north, is apparently due to the increase in the thickness of the sandy layers, which here are several feet in thickness, while the typical Weno contains sandy layers averaging only about 2 inches in thickness.

There is a slight variation in the thickness of other members of the Bokchito formation, but none that compare to the variations of the Weno. The fact that this difference in thickness is noted on opposite sides of the Preston anticlinal uplift, and also that the Weno contains more sand on the north side, seems significant. The

Preston anticline, as will be noted on Plate XXIV, is the surface reflection, or is superimposed over the Criner Hills. The Criner Hills consist of intensely folded and faulted Paleozoic rocks which no doubt formed hills of considerable prominence which for a time were islands in the Comanchean sea but were finally covered by Comanchean sediments. The Bokchito formation is composed of the sediments deposited while the sea was retreating hence this ridge of buried islands, if they existed, may have influenced the currents or in some way the deposition of material, so that a greater thickness accumulated on the landward side than the seaward side.

The Weno is easily recognized by the larger amount of iron concretions which it contains. The top of the Weno is mapped on the "Quarry" limestone. The "Quarry" limestone is so named because it is commonly quarried for use as local building stone. The name limestone is somewhat of a misnomer, for the typical "Quarry" is probably more of a sandstone than a limestone. Detailed descriptions of the "Quarry" have been given under various sections. It maintains its thickness throughout the area, although some confusion results in the area north of Kingston, as there are several indurated layers in the lower part of the Pawpaw which resemble the "Quarry". One of the methods used to determine the "Quarry" is the presence of ferruginous masses of very fossiliferous material consisting chiefly of *Turritella* sp., and *Protocardia* sp. casts. These beds are usually lenticular, but are in such abundance that scattered fragments can usually be found on any slope of the upper Weno. It is notable that these ferruginous beds containing *Turritella* in abundance occur some 20 to 30 feet below the "Quarry" limestone. Beds of a similar nature occur in the overlying Pawpaw but carry chiefly a small pelecypod with only an occassional *Turritella*. A more or less complete list of fossils found in these beds will be given under Paleontology.

A rather persistent horizon in the Weno is formed by a sandy limestone which is rarely more than one foot in thickness. It is a very hard limestone which weathers a yellowish white. It occurs about 30 to 40 feet below the "Quarry" limestone. It is well exposed along the head of the small ravine near the public road at the location of the Weno section east of Kingston.

The Weno weathers very easily forming a rolling upland. For this reason it is very poorly exposed and sections suitable for detailed study are very difficult to find.

The Weno outcrops in Marshall County in two isolated areas, one extending southeast from Kingston and the other north and west from Aylesworth. Both of these areas occupy the trough of synclines which are described later.

PAWPAW SANDY MEMBER

The Weno clay member is overlain by 50 feet of more or less irregularly bedded sandy clays and sands extending from the "Quarry" limestone at the base, to the Bennington limestone at the top. The Pawpaw here is restricted to those sediments lying between the two limestones above named. Stephenson[34] included the "Quarry" limestone with the Pawpaw, but in this report Hill's original usage, that is, considering the "Quarry" as the top of the Weno is followed.

Following is Hill's[35] description of these beds in the Denison area:

"Pawpaw beds:—These include the strata between the "Quarry" and the Main Street limestones. In the Denison section these are very impure laminated sandy clays and sands, dark blue and bituminous in places, oxidizing surficially into brown ferruginous colors, very much like the Woodbine (Dakota) formation. They are very sandy in the upper 5 feet at the crossing of Pawpaw Creek and the Texas Central Railway. This aspect is local however. There are also small fragments of lignite in the sands and the character of the sediments seem to be favorable to the preservation of leaf impressions, but careful search up to date has failed to discover these.

"The Pawpaw is the most impure of all the Denison beds, and was apparently laid down near the shore, being accompanied by beds of ferruginous sand, which are not elsewhere found in the Washita division. The total thickness at Denison is 45 feet.

"At the base of the Pawpaw, just above the "Quarry" limestone, are lead colored shales with sandy alterations containing innumerable well preserved calcareous shells, which in some places are replaced by pseudomorphs of iron ore. One band, just above the "Quarry" limestone, consists of one foot or more of impure, friable ferruginous material, containing beautifully preserved fossils. These fossils are especially abundant in the lower 12 feet and consist of littoral Mollusca of many species.

"In certain clay layers the calcareous shells are preserved with all their pearly luster. In sandy layers where ferruginous percolation has taken place the shell substance is dissolved and they are preserved as casts and mounds in an arenaceous matrix of limonitic ironstone."

Section of the Pawpaw sandy member on west bluff of Washita River due east of Woodville, Oklahoma.

Bennington limestone—caps bluff.
Pawpaw sandy member:

	Ft.	in.
Sandstone, soft yellowish to brown, containing numerous veins of limonite, which weather out and cover the surface. This sandstone grades downward into a yellowish clay	38	0
Clay, blue to yellow, containing ironstone concretions, similar to the lower part of Weno member. Thin beds of yellow sandstone	22	0
Weno clay member—for section see page 39.		
	60	0

34. Op. cit. p. 142.
35. Hill, R. T., U. S. Geol. Survey Twenty-first Ann. Rept., pt. 7, p. 276, 1901.

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. There are several indurated ledges in the Pawpaw which may be confused with the "Quarry" limestone. These beds seem to be more prominent in the northern exposures in Marshall County than farther south. Messrs. Hopkins, Powers and Robinson[36], state that the "Quarry" limestone is not recognizable north of the latitude of Kingston, but it is represented by several beds resembling it. The writer has mapped a bed, which is typically exposed on top of the hill at the north edge of Cumberland, occupying the stratigraphic position of the "Quarry", as the Weno-Pawpaw contact. This bed is well developed and is typical of the "Quarry" as seen farther south.

The Pawpaw weathers forming a very sandy, ferruginous soil, the iron concretions and segregations often covering the surface. Frequently small hills are capped by a mass of limonite which has accumulated by the weathering of the Pawpaw. The Pawpaw produces a topography very similar to the Woodbine, and may be confused with it. It is usually covered by a growth of timber which stands out in marked contrast to the prairie upland of the other members of the Washita group.

The Pawpaw, like the Weno, outcrops in two isolated areas in Marshall County, one near Cumberland and the other southeast of Kingston.

BENNINGTON LIMESTONE

The Bennington limestone, named by Taff[37] from the town of Bennington in Choctaw County, Oklahoma, consists of from 10 to 20 feet of heavy bedded, brown, hard, semi-crystalline limestone with subordinate interbedded layers of calcareous marl. As a rule, the limestone is more massive near the base, but becomes thinner bedded toward the top with a corresponding increase in the amount and thickness of the marly beds. The Bennington is characterized by the presence of a peculiar ram's horn shaped fossil, *Exogyra arietina* Roemer, which occurs particularly in the upper part; the only brachiopod of common occurrence in the Comanchean, *Kingena wacoensis* Roemer occurs in the lower part.

Hill[38] gives the following section of the Bennington (called Main Street in Texas) on Rock Creek in the northwestern portion of Grayson County, Texas.

36. According to Stephenson, L. W., U. S. Geol. Survey Prof. Paper 120, p. 142, 1918.
37. Op. cit.
38. Hill, R. T., U. S. Geol. Survey Twenty-first Ann. Rept., pt. 7, p. 281, 1901.

Section of Bennington limestone on Rock Creek, Northwestern Grayson County, Texas.

	Feet
Grayson marl:	
Marl light yellow, with bands of limestone and great numbers of Gryphea mucronata, the upper portion concealed	15
Main Street limestone:	
Limestone beginning at the base with compact yellow shell, and grading upward into friable marl. Kingena wacoensis occurs in the lower portion, while Exogyra arietina ranges throughout	18
Limestone, arenaceous shell, with Ostrea quadruplicata and O. subovata at the base, and Exogyra arietina and Kingena wacoensis succeeding	5
Pawpaw formation	
	38

Following is Hill's[39] description of the Main Street limestone in the Denison area:

> Main Street limestone: In the Red River section the Main Street limestone constitutes a very conspicuous formation, not only on account of the hardness of the strata, but because of its effect as a topographic factor. It consists of a coarsely crystalline, bedded, brecciated, white limestone, which, on oxidation, turns a deep yellow, showing much more ferruginous coloring than any of the other limestones of the Comanche series. It occurs in strata of various thicknesses. Usually there are more massive beds at the base and thinner strata at the top, with occasional sandy marl layers. The formation nowhere aggregates more than 25 feet. Taff notes a thickness of 23 feet at Rock Creek, Grayson County. At Denison 15 feet have been noted.

The Bennington limestone is well exposed in Marshall County in the area north of Woodville, along the public 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 W½ of sec. 6; T. 5 S., R. 6 E.

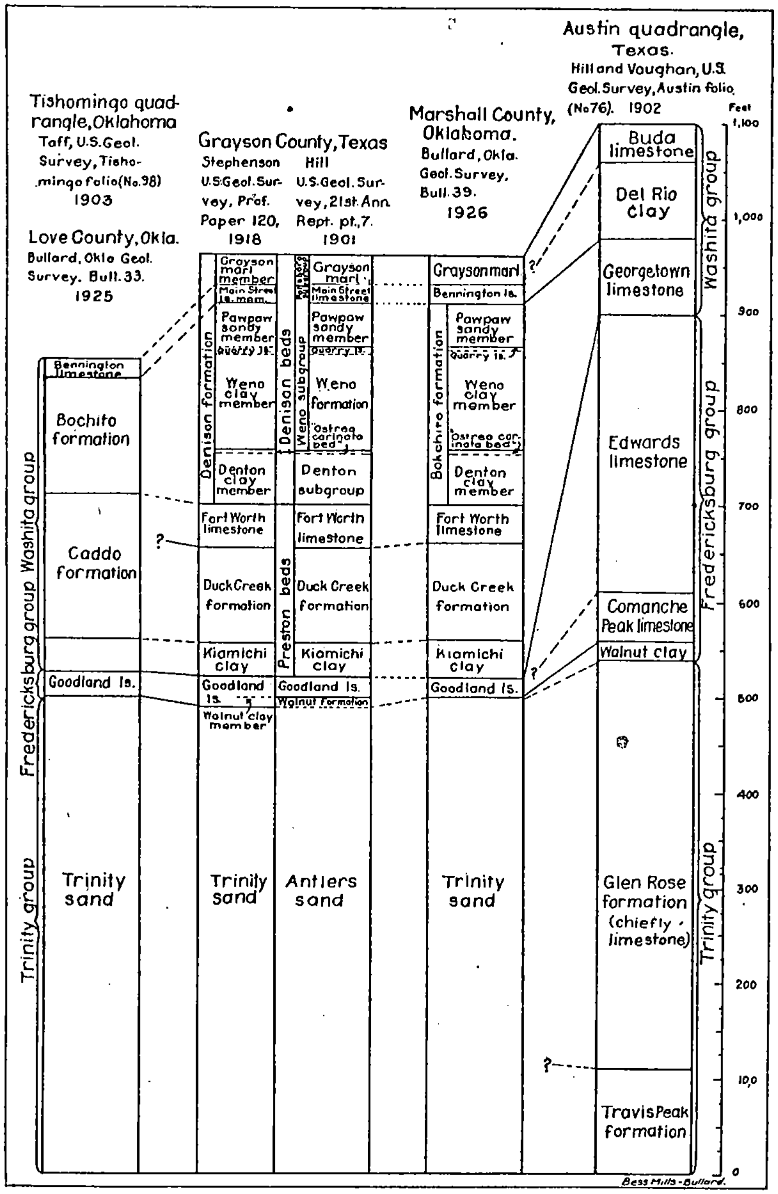
The Bennington limestone outcrops in a narrow band, lying directly above the Pawpaw sandy member. Its outcrop, due to the fact that it lies between two sand formations, the Pawpaw below and the Woodbine above, is frequently covered by debris from the Woodbine, and the Bennington is then only exposed where erosion has removed this material.

GRAYSON MARL

The Grayson marl is the uppermost formation of the Comanchean in this region. The type exposure of the Grayson is in an abandoned cut of a old unused railroad grade in the southeast portion of Denison, Grayson County, Texas, discovered by Prof. Cragin[40], who first named the formation. The Grayson marl con-

39. Idem. p. 280.
40. Cragin, F. W., Colorado College Studies, Colorado Springs, Colorado, p. 43, 1894.

FIGURE 5



CORRELATION TABLE SHOWING THE RELATION OF THE SUBDIVISIONS OF THE COMANCHEAN IN MARSHALL COUNTY TO THOSE IN OTHER PARTS OF OKLAHOMA AND TEXAS.

sists of light colored fossiliferous clays or marls with many small lumps of lime and limestone nodules, having a total thickness of approximately 25 feet in Marshall County.

The lower contact of the Grayson, or its contact with the Bennington limestone, is rather difficult to determine, as it is more or less a gradation from the typical limestone into the marl. The upper contact of the Grayson is usually covered by ferruginous sandstone and other debris from the overlying Woodbine sand. In fact in many places the marl is entirely concealed by this debris from the Woodbine sand so that it outcrops only in a few disconnected places.

The lower part of the Grayson contains an abundance of *Exogyra arietina.* Two other fossils, which are characteristic of the Grayson are also found very abundantly, they are: *Gryphea muceronata* and *Turrilites brazoensis.*

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

CRETACEOUS ROCKS

GULF SERIES

WOODBINE SAND

The Woodbine sand, named by Hill[41] from the town of Woodbine in eastern Cooke County, Texas, is the basal member of the Gulf series of the Cretaceous in this region. The Woodbine sand immediately overlies the Grayson marl and is apparently unconformable on it. In this connection Stephenson[42] says:

> "The nature of the contact separating the Gulf series from the underlying Comanche series has not been satisfactorily determined in northeastern Texas. Probably it is that of an unconformity, the basal member of the upper series, the Woodbine sand, having been deposited in shallow waters of the transgressing sea, in the deeper waters of which the succeeding truly marine sediments of the series were laid down."

Hill's[43] description of the Woodbine sand is as follows:

> "The rocks of the Woodbine formation are largely made up of ferruginous, argillaceous sands, characterized by intense brownish discoloration in places, which are accompanied by bituminous laminated clays. These sands like those of the Trinity division (Western Cross Timbers), are consolidated in places, but differ from them by containing a greater proportion of iron and other mineral salts,

41. Op. cit. p. 294.
42. Op. cit. p. 144.
43. Idem. p. 294-295.

which materially influence the character of the waters derived from them. The sands, which in unoxidized substructure are usually white and friable, contain particles of iron occurring as glauconite and pyrite. These minerals oxidize toward the superfacies, and their solutions consolidate the more porous beds into dark-brown siliceous iron ore, occurring in immense quantities in certain localities. Other beds of sand break down into deep, loose soil. These support a vigorous timber growth and are especially adapted to fruit culture. The clays are usually sandy and sometimes bituminous, although in some places, as near Denton, of sufficient purity for making stoneware. They occur either as extensive beds or as laminae and thin strata interbedded in the sands.

The presence of fossil vegetation, such as leaf impressions and lignite, distinguishes the beds of this division from the other formations of the Upper Cretaceous and attest its shallow water littoral origin."

The Woodbine sand is cross bedded to a large extent, so that it is extremely difficult to determine the thickness from surface exposures. Stephenson states that it is not less than 300 to 400 feet thick in Grayson County, Texas, and may reach a thickness of 500 feet. In Marshall County only the basal portion of the Woodbine sand is present in one isolated outlier located north 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 weathers into a loose, sandy soil, mostly covered with a dense growth of post oak and black jack timber. It forms a rather hilly topography, the tops of the hills being covered by a mass of ferruginous material, which is so characteristic of the basal portion of the Woodbine. These segregations and veins of iron ore concentrate on the hill tops and other places due to the removal of the soft friable sand.

The Woodbine sand has been correlated with at least a portion of the Dakota formation of the Rocky Mountain region. It is the equivalent of the Silo sand, used by Taff, although the term Woodbine has now replaced Silo.

PLEISTOCENE DEPOSITS

Red River has cut a broad deep valley along the southern boundary of Marshall County. In this cutting process it developed a number of alluvial terrace plains of which Stephenson[44] says:

"The belt of alluvial terrace plains bordering Red River includes plains at several levels:

(1) The present flood plain of Red River narrows along that part of the river bordering Grayson County, Texas, but broadens out to 3 or 4 miles in places along the northern border of Fannin and Lamar counties, Texas, and Bryan County, Oklahoma. (2) A well defined river terrace 45 to 75 feet above low water level of Red

44. Op. cit. p. 128

River is moderately extensive in places along the river valley; the village of Preston, in Preston Bend, in the northern part of Grayson County, is situated in an exceedingly flat portion of this plain, 4 or 5 square miles in extent, and Woodville, about 2½ miles north of Preston in Marshall County, Oklahoma, stands on a somewhat larger portion of the plain. (3) A terrace plain 140 to 160 feet above water level is represented here and there in that part of the valley above the mouth of the Washita River but occupies extensive areas in the valley below that river; in the southwestern portion of Bryan County, Oklahoma, the alluvial deposits of this terrace form a flat sandy plain 8 miles or more in width from north to south, and large areas of the plain occur in the northern parts of Fannin and Lamar counties, Texas. (4) Remnants of surficial deposits were observed at still higher altitudes at several places in the area and may represent one or more additional terraces. The alluvial deposits on these terrace plains effectually obscure the Cretaceous formations over many square miles in the Red River Valley, rendering it difficult to determine the areal extent and structure of the formations."

The terraces described above by Stephenson are plainly visible at Woodville and also at Willis. The alluvial deposits of the river consist chiefly of sand, although in a few localities mud and clay are deposited. It is practically impossible to distinguish between the alluvial material along the river and the weathered Trinity sand, as both consist chiefly of more or less loose sand.

In regard to the alluvial deposits along Washita River, the following is quoted from the Tishomingo folio[45]:

"**Terrace Sand and Gravel:** Along the valley of the Washita River are deposits of gravel and sand resting in nearly horizontal positions at an average elevation of about 100 feet above the river bottom plain. These deposits were found in thinly scattered remnants or mantles of considerable thickness and occur on both sides of the valley. The highest levels reached by these deposits are farthest from the river. The materials of these deposits are quartz, quartzite, jasper and other hard siliceous gravels, besides sand and silt, and they are found upon the eroded surfaces of both the Paleozoic and Cretaceous rocks. These rocks usually occur at the base of the surficial deposits and are succeeded by sands of finer texture, which are succeeded in turn by fine sands and silts. The coarser gravels are not found at all places at the base of these deposits, however. The finer sediments cannot be distinguished from the weathered surface sands of the Trinity formation, both being a fine, yellow quartz sand. Where these surficial deposits come in contact with the Trinity sand it is not possible to accurately draw the division line. Abundant gravels occur as a thin mantle spread over the surface in the vicinity of Tishomingo. These gravels are also found upon high land west of Earl and at many other places where the Trinity formation approaches the immediate valley of Washita River. The north and south limits of the areas occurring between Linn and Emet are separated by about 6 miles, the deposits extending gradually downward toward the river valley.

"In view of the fact that these deposits occur along the borders of the river valley, and are related to a certain degree to the more recent deposits of the same river, it is considered that they represent

45. Taff, J. A., op. cit. p. 6.

deposits of this river when it flowed at elevations of 100 feet and less above its present plane at some time probably early in the Pleistocene. In the Coalgate quadrangle surficial deposits of practically the same kind occur as remnants in a wide, shallow and elevated channel contiguous to the valley of the Canadian River.

"**River Sand:**—Washita River in its course across the Tishomingo quadrangle has a grade approximately 2 feet per mile and at no place observed does it cut bed rock, except laterally, where in a few places its meanders approach the outer limit of its sand and silt deposits. In the past its load of sand and silt has been more than it could carry and conditions have not changed materially up to the present time. The excess of sand and silt brought down and deposited along its course has caused the river to meander from side to side until it has built up of these surficial deposits a graded plain in places 4 miles in width. There are some indistinct or limited terraces near the outer border of these deposits, but as a rule the sand plain grades down to the present river flood plain. This flood plain is approximately 20 feet below the general level of the sand plain. In places, however, the sand at the border of the plain reaches 50 feet above the river level.

STRUCTURE

GENERAL STATEMENT

The structure of the surface formations in Marshall County is that of a gently dipping monocline sloping to the south and southeast, toward the Gulf of Mexico. The rate of dip varies from 30 to 80 feet per mile, according to Stephenson. This general dip is interrupted in Marshall County by a large anticlinal fold, the Preston anticline, and in addition to this major structural feature a number of smaller folds, such as the Madill and Oakland anticlines with intervening synclines, all of which will be described in some detail.

The Comanchean rocks are underlain by Paleozoic rocks which come to the surface in the Arbuckle Mountains, and also in one small exposure in the bed of Turkey Creek in the northern part of Marshall County.

There is no marked structural unconformity between the various subdivisions of the Comanchean in this area; for this reason a fold in the beds at the surface is substantially duplicated in all the underlying Comanchean formations, although it may not be present in the underlying Paleozoics. The force which caused the folds in the Comanchean rocks no doubt also folded the underlying Paleozoics, although this movement may have followed a new line of folding. It seems more reasonable to assume that it occurred along a line of previous folding where a zone of weakness had already been formed. For this reason it is not only impossible to forecast what formations underlie the Comanchean, but also impossible to forecast the structure of these underlying formations. It seems reasonably safe, however, to assume that the major structural features of the Comanchean, as the Preston anticline, are

present in the underlying Paleozoics. It is also likely that the smaller folds, such as the Madill and Oakland anticlines and the synclines separating these 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 to the northwest.

The structure of Marshall County has been mapped in a very satisfactory manner by Messrs. Hopkins, Powers, and Robinson[46] and published by the United States Geological Survey. The portion of their report that applies to Marshall is given herewith in full:

"The structure of the surface formations in this area is outlined on Plate XXIII, by structural contours, or lines connecting points of equal elevation on a particular bed. In the Madill-Preston area the contours represent the top of the Goodland limestone and show its elevation above sea level. The elevations were determined with aneroid barometers, and readings, taken in duplicate, were carefully adjusted by comparison with a barograph. Most of the elevations are believed to be correct within 10 feet.

PRESTON ANTICLINE

"The Preston anticline, as outlined by the contours on Plate XXIII is a large plunging arch that extends southeastward from a point near the northwest corner of T. 7 S., R. 5 E., passing south of Bonham through Ector and dying out in the vicinity of Gober. It represents a maximum upthrust of 700 to 800 feet. It is bordered on the north by a broad, shallow syncline, which extends from the vicinity of Platter northwestward just north of Kingston to a point 3 miles west-southwest of Oakland. On the south it is bordered by the even broader and shallower Sherman syncline. The highest part of the axis of the Preston anticline, shown on Fig. 6, extends from the southeast corner of that township, to a point 5 miles north-northeast of Pottsboro. From this point it plunges to the southeast. The crest of the anticline is represented by the closed 800 foot contour near Shay and Enos, where a number of gas wells have been drilled. It is probable that the fold is higher than is indicated by the 800 foot contour, but as the Goodland limestone is absent within the area inclosed by the contour, it is not possible to determine the highest point of the fold. As outlined, however, this anticline has a reversal of dip to the northwest amounting to at least 60 feet. The mapping of the crest of the anticline in the vicinity of Red River may be only approximately correct, because of the absence of significant exposures there.

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

46. Op. cit.

OAKLAND ANTICLINE

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

"There are no significant exposures along the crest of the anticline, so that the mapping of the crest may be only approximately correct. As shown, it passes from a point near the center of NE¼ sec. 3, T. 6 S., R. 5 E., past the northwest corners of secs. 34 and 28, T. 5 S., R. 5 E., to the northwest corner of sec. 19 of the same township. Over this distance the axis dips only gently to the southeast. Northwest of sec. 19 the anticline is not mapped because of the absence of key beds. There is probably no reversal dip, however, in that direction. The dip on the southwest side of the anticline is fairly steep, ranging from 110 to 130 feet to the mile, on the northeast side it ranges from 25 to 80 feet to the mile.

MADILL ANTICLINE

"The Madill anticline, so named from the small oil pool on its northwest end, extends in a southeasternly 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 23, 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 a cross fault would form an avenue of escape for oil from the petroliferous Paleozoic rocks into the Trinity sand, where it is found."

KINGSTON SYNCLINE

The broad shallow syncline separating the Preston anticline and the Madill anticline has been called the Kingston syncline, from the town of Kingston which is located on the southern edge of the structure. The Kingston syncline is represented on the surface by a row of prominent hills which trend in a southeasternly direction extending from Kingston on the north to near Woodville. These hills represent approximately the trough of the syncline and are composed of the youngest sediments in the area. The trough of the syncline protected these rocks from the process of erosion, so that here we find the remnants of the Comanchean and Cretaceous formations which once covered this area. It is worth while to note that in this area the **structural low is represented on the surface by a topographic high.** This fact seems to apply to all the region of southern Oklahoma and north Texas covered by rocks of Comanchean and Cretaceous age. It has been noted in Cooke County, Texas, and also in Love County, Oklahoma.

CUMBERLAND SYNCLINE

The Cumberland syncline lies to the northeast of the Madill anticline and is parallel to it. It was named for the town of Cumberland which is located in the eastern part of Marshall County. Cumberland is situated in the trough of this syncline. The Cumberland syncline, like the Kingston syncline, is marked by a row of prominent hills which occupy the trough of the syncline extending in a northwesternly direction from Aylesworth.

KEY HORIZONS IN MARSHALL COUNTY

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 recognized. In the portion of Marshall County covered by the formations lying above the Trinity sand there are a number of excellent "key horizons." The first of these, and also probably the one best suited for structural work, is the Goodland limestone. It is a most persistent horizon and is easily recognized. The next horizon is the oyster shell conglomerate occurring at the top of the Kiamichi formation. This horizon is easily recognized and widely distributed but care must be used as it very frequently slumps and it is more or less difficult to be sure that the bed is in place. There are several horizons in the lower Duck Creek formation which may be used as key beds, the most prominent being the "large ammonite" horizon occurring near the top of the lower Duck Creek limestone. There are no easily recognized horizons in the Fort Worth limestone, although if the top of the formation is exposed, the contact of the Fort Worth with the overlying Denton clay can be used as a key bed. The thinly laminated "ripple marked" sandstone, occurring near the middle of the Denton clay is well suited for a key horizon. The next bed which can be used in structural work is the "Quarry" limestone. It marks the top of the Weno clay member and can usually be recognized without difficulty. Occurring near the top of the Comanchean is the Bennington limestone, which is well adapted for use as a key horizon. Ordinarily elevations are taken on any of these beds and the data reduced to a common plane for the entire area. In this county all elevations were reduced to the top of the Goodland limestone, which is taken as the "key horizon" for the mapping of the structure.

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.

ECONOMIC GEOLOGY

OIL AND GAS

Marshall County has been classed as an oil and gas producing county for the past 15 years. The production of oil is chiefly from the area east of Madill known as the Madill pool[47]. However, recently production has been secured about one mile north of the original production by Bilbo et al, and this area is commonly called the Bilbo pool, although it is no doubt located on the same structural feature as the Madill pool. The gas production in Marshall County is concentrated chiefly in the south-central part of the county near the store of Enos and is called the Enos gas field. A great deal of oil activity has centered around Marshall County during the past five years, due to the presence of the large Preston anticline, and many of the larger oil companies have drilled deep tests on various parts of this structure in search of production without success. Each of the above mentioned areas will be discussed in some detail.

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[48]. 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.

47. Taff, J. A., and Reed, W. J., The Madill oil pool, Okla.: U. S. Geol. Survey Bull. 381, pp. 504-513, 1910.
48. Op. cit. p. 10.

"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[49], 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 XXIII). 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."

At the present time one well in the Madill pool is being pumped and it produces about eight barrels per day. This is one of the first wells drilled in the Madill pool and its initial production was listed as only 15 barrels per day. The new area, discovered in the fall of 1925 by Geo. W. Bilbo, is located in the southeast corner of sec. 24, T. 5 S., R. 5 E. This well is reported to have averaged 208 barrels per day during the first fifty days by official pipe line gauge. An offset to the well drilled also by Bilbo is reported to be making 20 to 30 barrels per day. Lane and Wasson drilled an offset to the south in the NE. ¼ NE. ¼ sec. 25, T. 5 S., R. 5 E., but failed to pick up the producing horizon of the Bilbo well and the well was reported dry at a depth of 712 feet. The production in the Bilbo well is obtained from a sand at a depth of 571 feet, which is a little more than 100 feet deeper than the producing horizon in the Madill pool less than one mile to the south. A number of wells have been started around the Bilbo producer, including one by the Humble Oil and Refining Co. No information is available regarding the character of the sand in these new wells, but it is assumed that it is a lenticular sand, similar to the Madill pool horizon, which would account for the failure of offsets to secure production. The area is located on the northwest side of the Madill anticline, somewhat lower down on the structure than the Madill pool; this would explain the difference in depth of the wells in the two areas, assuming that the production is obtained in both cases from lenticular sands in the base of the Trinity sand.

ENOS GAS FIELD

The following summary of the Enos Gas field is quoted from the United States Geological Survey[50] 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,

49. Petroleum and natural gas in Oklahoma: Oklahoma Geol. Survey Bull. 19, pt. II, p. 319, 1917.
50. Hopkins, O. B., Powers, Sidney and Robinson, H. M., op. cit. pp. 10-12.

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.

Drillers log of Smith-Colcman well No. 2, Kingston, Okla., in the SW. ¼ sec. 35, T. 7 S., R. 5 E.

Formation	Feet Thickness	Feet 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 sand	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	1,03[illegible]
Shale, hard, sandrock	506	1,536
Rock, hard sand	3	1,539
Shale, blue	36	1,575
Lime shells	1	1,57[illegible]
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 NW. ¼ SW. ¼ sec. 35 of the same township, was drilled to a depth of 515 feet and is reported to have yielded showings of oil at 220 and 420 feet and a volume of gas estimated at 1,500,000 cubic feet. In the southwest corner of SE. ¼ SW. ¼ sec. 25 the Roy Milliken well was drilled to a depth of 760 feet and reported a showing of about 1,000,000 cubic feet of gas and a trace of oil. In the northeast corner of the NE. ¼ sec. 2, T. 8 S., R. 5 E., the Deeren well was drilled to a reported depth of 620 feet. Gas was found below 507 feet with an estimated volume of 4,000,000 cubic feet. Another well was drilled by 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. 23), at its northwest end, which is its highest part. The gas wells obtain their gas from sandy lenses in the lower part of the Trinity sand. The largest gas wells have been drilled in secs. 25, 35, and 36, T. 7 S., R. 5 E. Oil has been found in sand lenses near the base of the Trinity and also in sandy beds in black shale of the Caney (?) formation. The best oil showings have been found in sec. 23, T. 7 S., R. 5 E., in the Trinity sand."

At the present time no commercial production of either oil or gas is obtained from the Enos gas field.

OIL AND GAS POSSIBILITIES

In regard to the oil and gas possibilities of Marshall County, Messrs. Hopkins, Powers and Robinson[51] have summarized it in a very satisfactory manner. The following is quoted from their report:

"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

51. Op. cit. pp. 28-32.

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

"The Trinity has yielded prominent showings of oil and gas in 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 disposition 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."

PALEOZOIC ROCKS

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. The generalized section of the Paleozoic rocks in the Arbuckle Mountain region to the northwest is given in Figure 3. In regard to the oil and gas possibilities of the Paleozoic rocks, Messrs. Hopkins, Powers and Robinson[52] 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, sec. 5, T. 7 S., R. 4 E., Oklahoma; in the C. V. Westover well in the northwest corner of Grayson County, Texas; and in the Indian Chief well, in sec. 19, T. 7 S., R. 4 E., Oklahoma. 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 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, northwest of Berwyn, at the outcrop of vertical Caney shale and the Sycamore limestone. The 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

52. Op. cit. p. 30.

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 involve great hazards because of the unknown but probably complex structure of the Paleozoic rocks, because of the succession of beds below the Caney is not known, and because of the high degree of metamorphism which the rocks have probably undergone."

Log of Texas Drilling Syndicate Co.'s well on Chaff Farm, SE. NW. NW., Sec. 27, T. 5 S., R 4 E., Marshall County

Formation	Top	Bottom
Clay	0	7
Lime	7	14
Sand	14	50
Lime and gumbo	50	59
Sand	59	105
Shale	105	120
Sand and shale	120	180
Hard sand	180	195
Hard shale and sand	195	272
Shale	272	282
Sand	282	354
Lime	354	360
Sand	360	390
Shale	390	440
Lime	440	445

Formation	Top	Bottom
Shale	445	485
Gumbo	485	505
Red beds	505	538
Shale	538	558
Sand	558	564
Shale	564	640
Lime and sand	640	643
Shale	643	665
Lime	665	672
Shale	672	720
Lime	720	723
Red sticky shale	723	750
Shale	750	817
Lime	817	819
Shale	819	890
Sandy lime cased	890	892
Shale	892	908
Lime	908	912
Shale	912	930
Broken lime and shale	930	950
Sandy lime	950	953
Broken lime and shale	953	970
Shale	970	1,040
Lime	1,040	1,043
Shale	1,043	1,075
Gumbo	1,075	1,090
Sandy shale	1,090	1,098
Gumbo	1,098	1,110
Shale	1,110	1,263
Sand and boe	1,263	1,265
Hard sand	1,265	1,267
Gumbo	1,267	1,297
Sand	1,297	1,311
Shale and boe	1,311	1,368
Shale	1,368	1,460
Lime	1,460	1,462
Shale and boe	1,462	1,510
Shale	1,510	1,540
Sandy lime	1,540	1,558
Hard sand	1,558	1,560
Sandy lime	1,560	1,562
Shale	1,562	1,580
Sandy shale	1,580	1,623
Water sand	1,623	1,628
Gumbo	1,628	1,632
Lime and sand	1,632	1,667
Gumbo and shale	1,667	1,706
Gumbo	1,706	1,720
Shale	1,720	1,742
Broken lime	1,742	1,757
Gumbo	1,757	1,765
Gumbo and shale	1,765	1,810
Sand and lime	1,810	1,837
Shale, sand and boe	1,837	1,860
Sand, shale and lime	1,860	1,906
Shale and sand	1,906	1,951
Shale and sand	1,951	2,032
Shale	2,032	2,070
Hard shale and sand	2,070	2,096
Shale	2,096	2,140
Lime	2,140	2,151
Lime	2,151	2,166
Shale	2,166	2,178
Lime	2,178	2,183
Shale	2,183	2,331
Gumbo	2,331	2,346
Shale	2,346	2,380
Clay	2,380	2,390
Broken lime shale and sand	2,390	2,420
Shale	2,420	2,486
Sandy lime	2,486	2,495
Shale	2,495	2,508
Sand	2,508	2,512
Broken sand and shale	2,512	2,522

Formation	Top	Bottom
Sticky shale	2,522	2,530
Shale	2,530	2,544
Shale and sand	2,544	2,566
Broken lime	2,566	2,570
Sand	2,570	2,572
Hard shale and boe	2,572	2,589
Sandy shale	2,589	2,621
Sand and shale	2,621	2,633
Broken lime	2,633	2,640
Shale	2,640	2,650
Broken lime	2,650	2,655
Hard shale	2,655	2,675
Lime	2,675	2,676
Sand	2,676	2,680
Sand shale and boe	2,680	2,704
Hard sand	2,704	2,716
Sand lime	2,716	2,732
Hard shale and sand	2,732	2,750
Gumbo	2,750	2,775
Broken shale and sand	2,775	2,791
Brown shale	2,791	2,818
Hard sandy shale	2,818	2,828
Gumbo	2,828	2,837
Shale	2,837	2,845
Shale and sand	2,845	2,854
Sandy lime	2,854	2,863
Gyp and sandy shale	2,863	2,875
Hard sand	2,875	2,878
Hard sand shale	2,878	2,888
Hard sand	2,888	2,893
Sandy lime	2,893	2,895
Brown shale and sand	2,895	2,914
Blue shale and sand	2,914	2,933
Shale	2,933	2,940
Hard sand (cased)	2,940	2,943
Hard sand	2,943	2,945
Shale	2,945	2,975
Gumbo and gyp	2,975	2,985
Shale	2,985	3,002
Gumbo	3,002	3,012
Sticky shale	3,012	3,022
Shale and slate	3,022	3,089
Hard lime	3,089	3,096
Hard sandy lime	3,096	3,097
Hard lime	3,097	3,101
Shale	3,101	3,104
Sandy lime	3,104	3,107
Hard shale	3,107	3,126
Hard sand	3,126	3,129
Shale	3,129	3,132
Hard sand cased	3,132	3,136
Shale and hard sand	3,136	3,140
Shale	3,140	3,171
Sandy shale	3,171	3,180
Sticky shale	3,180	3,203
Hard sandy shale	3,203	3,208
Hard brown shale	3,208	3,220
Sandy shale	3,220	3,245
Sandy shale and lime	3,245	3,257
Sandy lime (cased)	3,257	3,263
Hard sand (cased)	3,263	3,269
Shale	3,269	3,285
Broken lime	3,285	3,297
Sandy lime	3,297	3,303
Sand, shale and lime	3,303	3,312
Lime and gyp	3,312	3,315
Sand, shale and lime	3,315	3,319
Shale	3,319	3,329
Lime and shale and sand	3,329	3,338
Shale	3,338	3,355
Shale sand and lime	3,355	3,366
Shale sand gyp	3,366	3,390
Lime and gyp	3,390	3,392
Brown shale	3,392	3,420
Shale and gyp	3,420	3,461

Broken shale	3,461	3,471
Shale sand and gyp	3,471	3,480
Sand and shale	3,480	3,492
Shale	3,492	3,505

Log of Humble Oil & Refining Co.'s well on the Bowman lease, SE. NE. SW. Sec. 22, T. 6 S., R. 4 E., Marshall County

Formation	Top	Bottom
Sand	0	30
Blue shale	30	40
Sand	40	66
Blue shale	66	99
Sand	99	104
Blue shale	104	120
Lime	120	122
Sand	122	125
Blue shale	125	158
Red bed	158	161
Blue shale	161	173
Sand	173	181
Blue shale	181	202
Lime	202	207
Blue shale	207	244
Sand	244	248
Lime	248	252
Blue shale	252	262
Sandy lime	262	277
Blue shale	277	282
Sandy lime	282	333
Blue shale	333	465
Lime	465	505
Sandy shale	505	600
Lime shell	600	637
Sand lime	637	670
Lime shell	670	679
Blue shale	679	695
Gravel	695	697
Blue shale	697	775
Red beds	775	781
Sandy lime	781	797
Blue shale	797	800
Brown shale	800	1,083
Gray shale	1,083	1,135
Blue shale	1,135	1,150
Hard sandy shale	1,150	1,196
Black shale	1,196	1,203
Gray shale	1,203	1,340
Blue shale	1,340	1,460
Gray sand	1,460	1,470
Blue shale	1,470	1,560
White shale—shells	1,560	1,600
Hard sandy shale	1,600	1,660
Gray shale	1,660	1,675
Sandy shale	1,675	1,720
Sand	1,720	1,751
Lime	1,751	1,759
Blue shale	1,759	1,850
Sand	1,850	1,855
Blue shale	1,855	1,980
Sand (see top)	1,980	1,985
Brown shale	1,985	2,015
Red rock	2,015	2,030

Log of Magnolia Petroleum Co.'s well on the Bruce May lease, NE. NE. NE., Sec. 12, T. 8 S., R. 5 E., Marshall County

Formation	Top	Bottom
Quick sand	0	120
Red rock	120	130
Blue gumbo	130	295
Gray sand	295	320
Blue gumbo	320	444

Formation	Top	Bottom
W. lime bd.	444	465
White mud	465	475
Soft sand	475	500
Blue mud	500	535
Hd. sand-gas	535	580
Blue mud	580	600
Red rock	600	665
Blue mud	665	675
Hd. lime	675	680
Brn. slate	680	690
Soft lime	690	700
Soft sand-gas	700	740
Black slate	740	760
Lime-sand	760	817
Blue shale	817	870
Soft sand	870	885
Black slate	885	910
Gray sand	910	950
Brn. slate	950	1,000
Hd. sand	1,000	1,150
Hd. lime	1,150	1,220
White slate	1,220	1,310
Soft lime	1,310	1,410
Black slate	1,410	1,495
Hd. lime	1,495	1,510
White slate	1,510	1,840
Hd. lime	1,840	1,845
Brn. slate	1,845	1,895
Black lime	1,895	1,915
White slate	1,915	2,055
White lime	2,055	2,110
Soft slate	2,110	2,750
Black sand	2,750	2,760
Black lime	2,760	2,790
Wh. soft slate	2,790	3,000

Log of Magnolia Petroleum Co.'s well on the Everett farm, NE. NE. SW., Sec. 36, T. 7 S., R. 5 E., Marshall County

Formation	Top	Bottom
Quick sand	0	60
White slate	60	85
Red rock	85	100
White mud	100	145
White sand	145	155
White mud	155	315
Sand	315	320
Mud	320	446
Soft sand	446	456
White mud	456	500
Sand	500	535
Red mud	535	600
Yellow sand	600	675
Black sand	675	765
White sand	765	820
Black lime	820	880
Black slate	880	900
White slate	900	1,000
Black shale	1,000	1,240
Sand	1,240	1,300
Black shale	1,300	1,520
Hard sand	1,520	1,560
White lime	1,560	1,700
White sand	1,700	1,720
White slate	1,720	2,230
White sand	2,230	2,280
White slate	2,280	2,300
Hard sand	2,300	2,320
White slate	2,320	2,380
White lime	2,380	2,510
Black slate	2,510	2,630
Hard sand	2,630	2,650

Formation	Top	Bottom
Slate-shells	2,650	2,880
Hard sand	2,880	2,890
Black shale	2,890	3,280
White slate	3,280	3,402
White lime	3,402	3,408
Black shale	3,408	3,680
Black lime	3,680	3,690
Black slate	3,690	3,810
Brown lime	3,810	3,816
Black slate	3,816	4,194
White sand	4,194	4,232
Black sand	4,232	4,240
Black shale	4,240	4,245
Brown lime	4,245	4,265

Log of Moore Bros. well No. 1 on the Creer Lease, NW. SW. SW. Sec. 25, T. 5 S., R 5 E., Marshall County

Formation	Top	Bottom
Lime	0	26
Wtr. sand	26	115
Blue shale	115	210
White shale	210	260
Wtr. sand	260	275
White shale	275	320
Wtr. sand	320	375
Blue shale	375	400
Red mud	400	418
Arbuckle sand	418	425
Red rock	425	432
Arbuckle sand	432	440
Red rock	440	455
Yellow mud	455	470
Red rock	470	505
Blue-yellow shale	505	545
Black shale	545	575

Log of Lane & Wasson Co.'s well No. 1 on the Sacra farm, C. of SE. NE., Sec. 18, T. 5 S., R. 5 E., Marshall County

Formation	Top	Bottom
Yellow surface clay	0	34
Rock	34	40
White sand and b'drs	40	80
Sand and gravel blue (showing of oil)	80	100
Sand gray	100	103
Blue shale and bldrs.	103	177
Hard sand	177	197
Sand shale and bldrs	197	220
Lime	220	223
Shale	223	243
Lime	243	245
Shale and bldrs	245	315
Shell	315	317
Sandy shale and bldrs	317	348
Sticky shale	348	368
Sandy shale	368	388
Broken lime	388	396
Lime shell	396	416
Arbuckle sand (oil sand)	416	425
Shale and gravel	425	464
Sticky shale blue	464	482
Shale black	482	676
Brkn and sml. show oil	676	682
Gumbo	682	718
Shale black	718	813
Shale and bldrs	813	836
Shale black	836	936
Shale and bldrs.	936	956
Gumbo	956	995

Formation	Top	Bottom
Brkn lime (1st showing of gas)	995	1,000
Shale black (small show oil and gas)	1,000	1,180
Broken lime	1,180	1,200
Shale and bldrs black	1,200	1,266
Shell	1,266	1,268
Shale	1,268	1,328
Brkn lime	1,328	1,333
Shale black	1,333	1,360
Brkn lime (pyrites of iron)	1,360	1,380
Shale and Bo. Black	1,380	1,433
Broken lime—hard	1,433	1,452
Shale black	1,452	1,495
Broken lime	1,495	1,500
Shale black	1,500	1,700
Shell	1,700	1,730
Shale and bldrs.	1,730	1,779
Shell	1,779	1,780
Gumbo and bldrs.	1,780	1,800
Shell—show of oil	1,800	1,814
Shale and bldrs. black	1,814	1,854
Brkn. sand and shale (showing of oil)	1,854	1,884
Shale Bo. and shell	1,884	1,980
Gumbo	1,980	1,990
Shale and shell	1,990	2,001
Shale and bldrs.	2,001	2,089
Bldrs.	2,089	2,092
Shale and bldrs.	2,092	2,211
Broken formation	2,211	2,212
Shale black	2,212	2,249
Shell—show oil	2,249	2,250
Shale and bldrs.	2,250	2,328
Water sand	2,328	2,330
Gumbo and bldrs.	2,330	2,353
Shell	2,353	2,355
Shale black	2,355	2,540
Sand and shale	2,540	2,547
Shell	2,547	2,550
Gumbo	2,550	2,563
Shale and bldrs.	2,563	2,565
Gumbo and bldrs.	2,765	2,854
Gumbo and bldrs.	2,754	2,851
Shale black	2,854	2,903
Shale and bldrs. black	2,903	3,004

SUMMARY OF OIL AND GAS DEVELOPMENT

No attempt has been made to include all of the wells drilled in the county, but only the more important ones. The date of completion or the date of drilling, when known, is given. The location of all wells, where the exact description is known is given on Plate 23. The data regarding most of these wells have been received from various sources. In many instances this data was fragmentary and impossible to check, often times not entirely trustworthy.

T. 5 S., R. 4 E.

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

On the H. F. Chaff farm, in the center of the NW. ¼ NW. ¼ sec. 27, and a well was started by the Texas drilling syndicate in July, 1923. The well was later taken over by the Hudson and Jones Co. of Ardmore and drilled to a depth of 3,505 feet. Drilling was stopped in April, 1924. No important shows of either oil or gas were reported.

The Van Vleck Oil Co., drilled a dry hole in the SE. ¼ NW ¼ sec. 27. The well was drilled to a depth of 3,500 feet and completed in 1923.

A well was drilled in the SE. ½ SE. ¼ SW. ¼ sec. 7, to a depth of 3,180 feet. The well was abandoned due to the loss of the tools in the hole.

T. 5 S., R. 5 E.

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

The Ardmil Oil and Gas Co.'s Sacra No. 2, in the center of the SE. ¼ SW. ¼ SW. ¼ sec. 17, was drilled to a depth of 2,004 feet. This well started near the top of the Goodland limestone and penetrated the Trinity sand and shales to a depth of 402 feet. Black shale, probably a part of the Caney shale, was penetrated at 500 to 1,450 feet and black shale with thin layers of oil bearing sand at 1,724 to 2,004 feet. Some barrels of oil having a gravity of 66.2° Baume were obtained near 2,000 feet. The high grade oil is comparable to that found in Ordovician beds in the Healdton oil field and is probably the highest grade oil found in Oklahoma.

In 1919 a well was drilled near No. 2 above described, in the SE. ¼ NW. ¼ SW. ¼ sec. 17, by the Sacra Driling Co., to a depth of 1,860 feet. The "Arbuckle" sand was reported at 419 feet, and a showing of high grade oil at 1,750 feet.

Lane and Wasson Co., Sacra No. 1, center of the SE. ¼ NE. ¼ sec. 18, was completed in 1924 to a depth of 3,004 feet as a dry hole and plugged. The "Arbuckle" sand was reported at 416 and 425 feet as dry. Shows of oil were reported at 682, 1,884, and 2,250 feet.

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

A well was drilled during 1915 on the C. N. Love place, in the center of the SW. ¼ sec. 19, to a depth of 898 feet. Oil sand was reported in this well at 420 feet and dry sand at 800 feet.

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

In the NW. ¼ NW. ¼ NW. ¼ sec. 24, on the John Null farm, a well was drilled by Carpenter, Stiles and Dees to a depth of 963 feet. Drilling was completed in January, 1925. Oil shows were reported from 765 to 804 feet. Salt water was reported from 804 and 816 feet.

In sec. 27, in the town of Madill, a number of shallow water wells and deep tests have been drilled. Two water wells were drilled near the electric light plant, in the NW. ¼ SW. ¼ sec. 27, to a depth of 200 and 207 feet. These wells furnished the city of Madill with water in 1918 from a depth of 165 to 207 feet. The water is sulphurous but potable. A well 1½ blocks southwest of the station at Madill, in the NW. ¼ SE. ¼ sec. 27, was drilled to a depth of 150 feet and yielded sulphur water and enough gas to burn with a flame 5 feet long. In a well drilled by Mr. Davidson, of Ardmore, in the yard of the County jail, near the center of the north line of the

SW. ¼ sec. 27, to a depth of 1,100 feet, a show of gas was found at a depth of 800 to 1,100 feet. Another well was drilled in the SW. ¼ NE. ¼ sec. 27, across the railroad from the cotton mill, to a reported depth of 1,750 feet. A well near the railroad coal chute, near the center of the NW. ¼ SE. ¼ sec. 27, was drilled to a depth of 325 feet and said to yield fresh water.

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

In 1918 a well was drilled on the Tallifero farm, in the NE. ¼ SW ¼ SW. ¼ sec. 28, by K. J. Schumaker to a depth of 690 feet. The "Arbuckle" sand was reported at 422 feet as dry. Drilling was stopped at 690 feet after having penetrated black slate for 150 feet.

In 1922 a well, located in the SE. ¼ SE. ¼ SW. ¼ sec. 25, on the Tallifero farm, was drilled by Cole-Marshall of Ardmore to a depth of 512 feet. A sand 5 feet thick at the depth of 484 feet was reported as the "Arbuckle" sand and another sand at 4 feet thick at a depth of 502 feet was reported as the "Arbuckle 2nd pay sand." No production was obtained.

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

In 1924 Carpenter and Stiles drilled a well in the NE. ¼ NW. ¼ NW. ¼ sec. 36, Rice No. 2, to a depth of 635 feet. A sand 7 feet in thickness was reported at 433 feet as dry. The well was cased back to 400 feet and is now a water well producing from that horizon.

In 1922 Cole-Marshall of Ardmore drilled a well in the NE. ¼ NW. ¼ NW. ¼ sec. 36, on the F. D. Herron farm to a depth of 485 feet. The "Arbuckle" sand was reported as 3 feet thick at 463 feet. The well was dry.

No attempt will be made to list all of the wells drilled in sec. 25, but the following are some of those completed in recent years:

K. J. Schumaker drilled a dry hole on the Arbuckle farm in the NW. ¼ SE. ¼ SE. ¼ SW. ¼ sec. 25, to a depth of 455 feet. The "Arbuckle" sand was reported from 420 to 422 feet and carried a small show of oil and gas. The well was completed in January, 1919.

F. W. Merrick drilled a dry hole on the Rice farm in the NW. ¼ SE. ¼ SE. ¼ sec. 25, to a depth of 508 feet. The "Arbuckle" sand was reported absent in this well. The well was completed in February, 1925.

Moore Brothers drilled a well on the Arbuckle farm in the SW. ¼ SW. ¼ SE. ¼ sec. 25, to a depth of 112 feet and reported 2,000,000 cubic feet of gas. The well was capped and the gas is not being used. The well was completed in 1923.

Moore Brothers drilled a well on the Greer farm in the NW. ¼ SW. ¼ SW. ¼ sec. 25, to a depth of 575 feet. The "Arbuckle" sand was reported from 418 feet to 425 feet and the second "Arbuckle' sand from 432 to 440 feet. Drilling was stopped in black shale. No production was obtained. The well was completed in 1922.

Davidson and Alworth driled a well on the Hattie Palmour farm in the NE. ¼ SE. ¼ NE. ¼ sec. 25, to a depth of 522 feet. An oil sand was reported at 490 to 504 feet. It showed about 3 barrels of oil but was too small to produce. The well was completed in 1924.

T. 5 S., R. 6 E.

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

A well drilled in the NW. ¼ SE. ¼ sec. 28, to a depth of 800 feet, and another drilled the SW. ¼ SW. ¼ sec. 30, to a depth of 500 feet, were both reported as dry.

Geo. W. Bilbo, Trustee, drilled a dry hole in the NW. ¼ NW. ¼ sec. 36, in 1923 and 1924. The well was drilled to a depth of 2,300 feet.

A well is being drilled in the center of the SE. ¼ sec. 31. It is shut down at 1,000. September, 1925.

T. 6 S., R. 5 E.

The approximate location of a well on the Willis Williams farm in the NE. ¼ of sec. 7, is reported to have been drilled to a depth of from 500 to 600 feet.

T. 6 S., R. 4 E.

The Humble Oil and Refining Co., drilled a dry hole on the Bowman farm in the SE. ¼ NE. ¼ SW. ¼ sec. 22. The well was drilled to a depth of 2,986 feet. No important shows of either oil or gas were reported. The well was completed in December, 1923.

T. 6 S., R. 6 E.

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

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

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

The Greenwich Co., drilled a well on the Simmons farm, in the SW. ¼ NE. ¼ NE. ¼ sec. 14, to a depth of 725 feet. A pocket of gas was encountered at 664 feet, which exhausted itself in approximately one day. The well was completed in 1923 with no production.

The Moore Oil and Gas Co., drilled a well on the Matilda Simmons farm, in the NE. ¼ NE. ¼ NE. ¼ NE. ¼ sec. 14, to a depth of 686 feet. A sand 9 feet in thickness was reported at 657 feet which made ½ million cubic feet of gas and from 15 to 20 barrels of heavy oil, together with a like amount of salt water. The well was completed in 1920.

The H. T. Wolfe Oil and Gas Co., drilled a well in the NE. ¼ NE. ¼ SW. ¼ SE. ¼ sec. 8, on the Little farm, to a depth of 620 feet. The "Arbuckle" sand was reported at 593 feet to 602 feet, as carrying a small showing of oil. The well was completed in 1921.

The United Eight Oil Trust, G. W. Bilbo, Trustee, drilled a well on the Setliff farm in the NW. ¼ NW. ¼ NW. ¼ NE. ¼ sec. 1, to a depth of 1,568 feet. The well was completed in 1923 with no production.

J. P. Jackson drilled a dry hole in the SW. ¼ NE. ¼ SW. ¼ sec. 30, on the Fred Mutz farm to a depth of 935 feet. The well is reported to have stopped in the Goodland limestone. It was abandoned in 1923.

In the SE. ¼ SE. ¼ sec. 22, two wells were drilled to depths of 350 and 700 feet respectively with a reported showing of gas in one of them.

M. I. Larrick drilled a well on the State Prison farm in the NE. ¼ SE. ¼ NW. ¼ sec. 25, to a depth of 139 feet. A sand carrying a showing of oil and gas was reported from 131 to 133 feet. Two more wells were drilled on the State Prison farm by Larrick, one in the NE. ¼ SE. ¼ NW. ¼ sec. 25, to a depth of 592 feet which gave a show of gas at 93 feet and a show of oil at 131 feet. The other, located in NW. ¼ SE. ¼ NW. ¼ was drilled to a depth of 590 feet and reported no showings of gas or oil. These wells were all drilled in 1919 and 1920.

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

H. S. Shaw and Co. drilled a dry hole on the State Prison farm in the NW. ¼ SW. ¼ NE. ¼ sec. 25, to a depth of 508 feet. A show of gas was reported at 372 feet. The well was completed in 1923. No production was obtained.

T. 6 S., R. 7 E.

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

Geo. W. Bilbo, Trustee, drilled a well in the NE. ¼ SE. ¼ NE. ¼ sec. 18, to a depth of 765 feet. No oil or gas shows were reported and the well was plugged in June, 1924.

T. 7 S., R. 4 E.

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

T. 7 S., R. 5 E.

The Indian Chief Oil and Gas. Co., drilled a test well on the Willis farm, in the NE. ¼ NE. ¼ SW. ¼ sec. 19, to a depth of 2,548 feet. This well started 30 feet above the top of the Goodland limestone, reached the base of the Trinity sand at 616 feet, and penetrated red and brown shales and sand-

stones to 2,548 feet. The well was abandoned in 1917.

Five wells were drilled in sec. 23 by the Kingston Dome Oil Co., from 1917 to 1919. They are as follows: In the NW. ¼ SW. ¼ NE. ¼, a well was drilled to a depth of 420 feet and reported a thin gas sand with a production of 100,000 cubic feet. The well was cased and capped, but not used; in the SE. ¼ SE. ¼ SE. ¼ NW. ¼, a well was drilled to a depth of 1,812 feet, with a show of heavy oil at 230 feet, a good show of gas at 365 feet, and a show of light oil at 420 feet. In the NE. ¼ SW. ¼ SE. ¼ NW. ¼, a well was drilled to a depth of 220 feet without any showings. In the NE. ¼ SW. ¼ SE. ¼ NW. ¼ a well was drilled to a depth of 450 feet without any showing of oil or gas. In the SE. ¼ NE. ¼ SE. ¼ NW. ¼, a well was drilled to a depth of 420 feet and gave a show of light oil with an estimated initial production of 5 to 10 barrels.

The Wolfe Oil Corporation drilled a dry hole on the Thomas farm in the SW. ¼ SW. ¼ SW. ¼ sec. 36, to a depth of 835 feet. A gas sand was reported at 554 to 574 feet and a good oil show at 747 to 760 feet. The well was completed in 1922. No production was obtained.

The Magnolia Petroleum Co., drilled a dry hole on the J. V. Everett farm, in the NE. ¼ NE. ¼ SW. ¼ sec. 36, to a depth of 4,265 feet. This is the deepest well in the county. No oil or gas shows of importance were reported. The well was completed in May of 1924.

T. 7 S., R. 7 E.

Three wells have been drilled on the Owens farm, in the southern part of sec. 17. Well No. 1 reached the top of the Goodland limestone at 410 feet and the base (?) of the Trinity sand at 1,023 feet, below which it penetrated red, yellow and black shale, probably belonging to the Glenn formation, to a depth of 1,215 feet, where it was abandoned. Showings of oil and gas were found in this well at about 1,000 feet. No information is available regarding well No. 2. Well No. 3 reached the top of the Goodland at 362 feet and was abandoned at 1,200 feet.

T. 8 S., R. 5 E.

The Magnolia Petroleum Co., drilled a dry hole on the Bruce May farm, in the NE. ¼ NE. ¼ NE. ¼ sec. 12, to a depth of 3,000 feet. A gas sand was reported at a depth of 700 feet, a gas and oil sand at 795 to 805 feet, estimated one barrel production. Also a small show of oil at 495 feet. This well was completed in 1923.

T. 8 S., R. 7 E.

In the southeast corner of section 14, two miles south of Colbert, Bryan County, a well was drilled in 1918 by the United Oil and Refining Co., of Denver and Oklahoma City. No information is available on the results of this test.

ASPHALT DEPOSITS

The asphalt deposits of Marshall County have not been studied in detail, although extensive deposits are known to occur. The following descriptions are quoted from Bulletin No. 2 of the Oklahoma Geological Survey[53], which is practically the only information available on the asphalts of Oklahoma.

53. Hutchison, L. L., Rock asphalt, asphaltite, petroleum and natural gas in Okla.: Oklahoma Geol. Survey Bull. 2, pp. 64-67, 1911.

"The existence of asphaltic material in what is now Marshall County, Oklahoma, has been known ever since the early settlement of northern Texas. The first occurrence which attracted attention was the oil spring near the source of what is known as Oil Creek, a few miles north of Madill. The Indians frequently camped around this spring and drank the crude oil as a medicine, while the settlers in northern Texas made long pilgrimages to this point to collect the crude petroleum, which was then known as "Seneca Oil" and was considered a panacea for rheumatism, burns, indigestion and in fact nearly all human ailments. The deposits of rock asphalt in the county did not attract attention until later.

"Rock asphalt is found in various parts of Marshall County from the breaks along the Washita River almost to Red River. The various occurrences studied will be described under the respective field numbers and such details of stratigraphy and structure given as were noted in a hurried study. No tests of the percent of asphaltic saturation have been made of the samples collected; the statements, therefore, as to amount of bituminous matter are based on comparative studies.

"**Location number one:**—This occurrence is found in the SE. ¼ sec. 34, T. 4 S., R. 5 E., and is what is known as the oil spring mentioned above. Heavy asphaltic petroleum seeps from a lentil shaped sandstone near the top of the Trinity formation. This does not seem to differ materially in character from the Trinity sandstone in which it is imbedded, other than it contains more cementing material and is thterefore harder. The flow of petroleum is very slight; in fact, it consists of only a few drops per minute, which are washed from the rocks by sulphur water (the sulphur being due to the generation of hydrogen sulphide by the decomposition of pyrite) that really forms the spring. The oil seeps from the formation about ten feet below the base of the Goodland limestone that lies conformably above the Trinity sandstone. The lentil from which the oil comes is approximately fifteen feet in thickness and is exposed for a distance of about fifty yards along the bank of the ravine. The petroleum seems to come from the lower portion of this member, the productive zone varying from three to five feet in thickness along the exposure. What seems very peculiar is the fact that though the oil seems to come from the sandstone, yet the outcrop of the rock is not saturated with petroleum. In times past three small pits, into which the water and oil collect, have been dug at the foot of the bluff.

"The flow of petroleum is scant and is not likely that the pits will ever produce an economic yield. The structure of the region is monoclinal, with a dip of about 1° S., 40° E.

"**Location number two:**—Location number two is found in the SW. ¼ sec. 32. T. 4 S., R. 5 E. The stratigraphic position of this occurence is approximately the same as that of number one, but the material is a low grade sand asphalt, instead of heavy petroleum. The asphaltic material impregates a lentil, less friable than the surrounding rock near the top of the Trinity sandstone. It appears to contain a greater per cent of bituminous matter near the top than at the base, though a few seepages of heavy oil occur near the bottom of the lentil. The asphaltic sandstone rests upon a friable sandy shale which grades downward into an unconsolidated, thin bedded sandstone. The exposure examined is about 300 feet long and could be easily drained by gravity if quarrying should be undertaken. The material, which may be found of value, has an overburden of about twenty-five feet of Goodland limestone. From what was seen it is not believed that it could be economically worked under present conditions. The asphaltic content is not believed to exceed two per cent and this is not always uniform.

"**Location number three:**—This occurrence is found in the SW. ¼ sec. 26, T. 5 S., R. 5 E. The material is rock asphalt which outcrops along the east bank of Glasses Creek about a half mile north of the northeast corner of the Madill townsite. The deposit has never been worked, though some prospecting has been done. The outcrop shows a thickness of about four feet of sand asphalt, which is exposed for several hundred feet along a small ravine. At some places where it was examined the sandstone carries sufficient asphatic material to make it plastic when slightly warmed.

"Like the other occurrences it is found in a hard lentil near the top of the Trinity sandstone. The overburden is therefore the Goodland limestone, where it is present. That formation however, has been worn down very thin near the outcrop so that a large quantity of material could be removed with the handling of but little overlying detritus. The quarries could be drained by gravity. The shipping point is only about one and one-half miles distant and the haul would be over good country roads. It is therefore believed that the rock asphalt could be economically quarried at this place.

"The structure is monoclinal, the dip being southeastward at low angles.

"**Location number four:**—Location number four is in the NE. ¼ sec. 29, T. 5 S., R. 5 E. or to be more exact, in the head of a small ravine in the southwest block of the Oakland townsite. The occurrence consists of a small sand asphalt lentil in the Trinity formation. At its greatest development, the lentil has a thickness of eight or ten feet, but pinches rapidly both east and west from that point. The principal part of the asphaltic material seems to have lost its viscosity so that it is in the main, what the citizens of that vicinity call "dead asphalt." There are places, generally quite local, which contain four or five per cent of viscuous asphaltic bitumen. It is not likely that this occurrence will repay working unless the per cent increases rapidly upon opening a quarry.

"The structure is monoclinal with low dips to the southeastward. The bituminous matter occurs along the bedding plane of the sandstone.

"**Location number five:**—This occurrence is in the NW. ¼, sec. 17, T. 5 S., R. 5 E. Like other occurrences this one consists of a lenticular mass of sandstone, which is slightly harder than the surrounding rock in the Trinity formation, and contains asphaltic bitumen along the bedding plane. At its greatest development the lentil, which is impregnated at two different horizons, is about twelve feet thick. The deposit is exposed for nearly 400 yards along the south side of a small creek, but thins rapidly in both directions, so that nearly its entire east and west extent is exposed.

"'The deposit has never been prospected so that it is not known how far the zone of impregnation extends southward. The sandstone appears to carry from one to five per cent of asphaltic material at the outcrop. The rich places are usually localized. Often there is nothing left of the bituminous matter except a dark stain and a very slight odor.

"From a study of the exposure it seems that there are only a few places where the sandstone carries enough viscous material to make it valuable as an adulterant for richer rock asphalt, unless the bituminous content increases under the overburden. The deposit, however, appears to be so large that the writer believes it to be worthy of further investigation. Quarries could be drained by gravity. The occurrence is only about two miles from the railroad station at Oakland, and the haul would be down grade the greater part of the distance and over good roads.

Location number six:—The writer did not examine this occurrence, but he saw some of the material which came from the place. It consists of an unconsolidated sandstone, in the upper portion of the Trinity, which is so thoroughly saturated with asphaltic bitumen that it clogged the bit while drilling the well at the Madill cotton seed oil mill. The deposit occurs near the surface, but it has never been examined further than the note that was made during the drilling of the well. Its desirability and availability are unknown. Since it is so near the railroad it is thought worthy of investigation by operators.

"**Location number seven:**—This occurrence is found in the NW. ¼ sec. 26, T. 7 S., R. 5 E. It consists of two small lenticular deposits at different levels in a sandstone bluff on the south side of Sand Creek. The zones of impregnation, which occur about 100 feet below the top of the Trinity formation that has been brought up at this place by the Red River fault, are only about five feet thick. The enriched portions pinch rapidly in both directions so it appears that the deposits are probably small."

SOURCE OF ASPHALT

The asphalt found in Marshall County represents the residue of accumulations of petroleum. The source of the petroleum, which gave rise to the asphalt deposits, is discussed at some length under oil and gas. It will be sufficient to repeat here that the petroleum probably originated in the underlying Paleozoic formations, and migrated into the overlying Trinity sand, accumulating in lenticular masses of sand. Upon exposure of these masses to the atmosphere, due to erosian, the lighter gases escaped leaving a tarry, viscous residue or asphalt. The absence of organic matter in the Trinity sand precludes the possibility of the petroleum being indigenous to that formation.

GLASS SAND

The Trinity sand which outcrops in the northern half of Marshall County, as outlined on the Geologic map, Plate XXIII, is remarkably pure in certain localities and suitable for use as a glass sand. No attempt is made to list all of the localities at which sand

sufficiently pure to be used as glass sand, occur. The following descriptions and analysis of glass sand occurrences in and near Marshall County are taken from Bulletin 10[54] of the Oklahoma Geological Survey.

"Durwood.—There is a large quantity of sand near the village of Durwood on the St. Louis and San Francisco Railroad, and the Chicago, Rock Island, and Pacific Railroad east of Ardmore. The surface of the land is rolling or even rough, and the soil sandy, the whole being typical of a sand hill country. There is a 17 foot bank of sand exposed on the south bank of a small creek about 1 mile northeast of Durwood, analyses of which are given in sample G3 below. About 20 feet of impure sand and surface soil lies above the 17 foot bed.

The exposure is easily accessible and the railroad is only one half mile distant. A spur could therefore be built to this exposure at a very low cost.

Analysis of sample of sand from near Durwood

No.	Fe_2O_3	Al_2O_3	CaO	MgO	SiO_2	Organic Matter
G3	.322	.75	.105	.025	98.593	.123
G3a	.133	.497	.105	.021	99.077	.085

Sample G3a is the same sand as G3 after being washed by immersion in water one hour.

Size of grains of sample of sand from near Durwood

No. Mesh	40	60	80	100	200	Pan	Total
G3	1.5	6.61	25.31	23.3	40.79	2.5	100.01

"A 20 foot bluff of sand is exposed in a small ravine about 2 miles southeast of Durwood. The upper 15 feet is too impure for glass sand. The 5 feet at the base is represented by sample G4, analysis of which is given below. In this are thin layers of coarse-grained sand containing a large per cent of iron and carbonaceous material. The base of the sand is not exposed. This bluff is not readily accessible on account of the rugged character of the country.

Analysis of sample of sand from 2 miles southeast of Durwood

No.	Fe_2O_3	Al_2O_3	CaO	MgO	SiO_2	Organic Matter
G4	.112	.468	.115	.052	99.123	.04

Size of grains of sample of sand from 2 miles southeast of Durwood

No. Mesh	40	60	80	100	200	Pan	Total
G4	2.68	57.4	27.58	7.03	5.34	.01	100.04

"Russett[55]:—A ledge of sand, 15 feet thick, sample G5, is exposed in a ravine one-half mile south of Russett and one-fourth mile southeast of the Chicago, Rock Island and Pacific Railroad. While the region as a whole is very rugged, a narrow ravine leads from the railroad to the deposit, rendering it accessible. It is underlain by yellow clay and covered by three feet of surface soil.

54. Buttram, Frank, Glass sands of Oklahoma: Oklahoma Geol. Survey Bull. 10, pp. 80-83, 1913.
55. A small village located one mile north of the NE. cor. of sec. 31, T. 4 S., R. 5 E.

Analysis of sample of sand from one half mile south of Russet.

No.	Fe_2O_3	Al_2O_3	CaO	MgO	SiO_2	Organic Matter
G5	.126	.174	.07	.057	99.496	.022

Size of grains of sample of sand from one half mile south of Russet.

No. Mesh	40	60	80	100	200	Pan	Total
G5	.1	3.45	66.11	18.3	12.32	.25	99.98

"The chemical and physical analyses show this to be a good grade of glass sand. The per cent of impurities is small and the grains subangular and transparent.

"Exposures similar to that near Russet are seen just below Randolph near the St. Louis and San Francisco Railroad. Another occurs near Teller and still others are reported near Tishomingo, Milburn, and Filmore on the Chicago, Rock Island, and Pacific Railroad.

"Madill:—One-half mile northwest of the public square in Madill is a sand bluff 75 yards long and 25 feet high. It is capped by from 5 to 10 feet of surface soil. The 10 feet of sand at the top of the exposure is reddish brown and contains too many impurities for glass. The next 10 feet is represented by sample G6. Cross bedding and irregular deposition are seen in the whole bluff. Portions of the 10 feet are made up of lenticular pockets of almost pure white sand. Around these pockets are little seams of impure yellowish sandstone. At the base of the bluff occurs a greenish blue sandy clay. The bluff is only a short distance from either branch of the St. Louis and San Francisco Railroad and could be reached easily. From this bluff the sand extends south and underlies almost the entire town of Madill. The following analysis shows the character of the sand."

Analysis of sample of sand from near Madill

No.	Fe_2O_3	Al_2O_3	CaO	MgO	SiO_2	Organic Matter
G6	.154	.636	.1	.061	98.89	.08

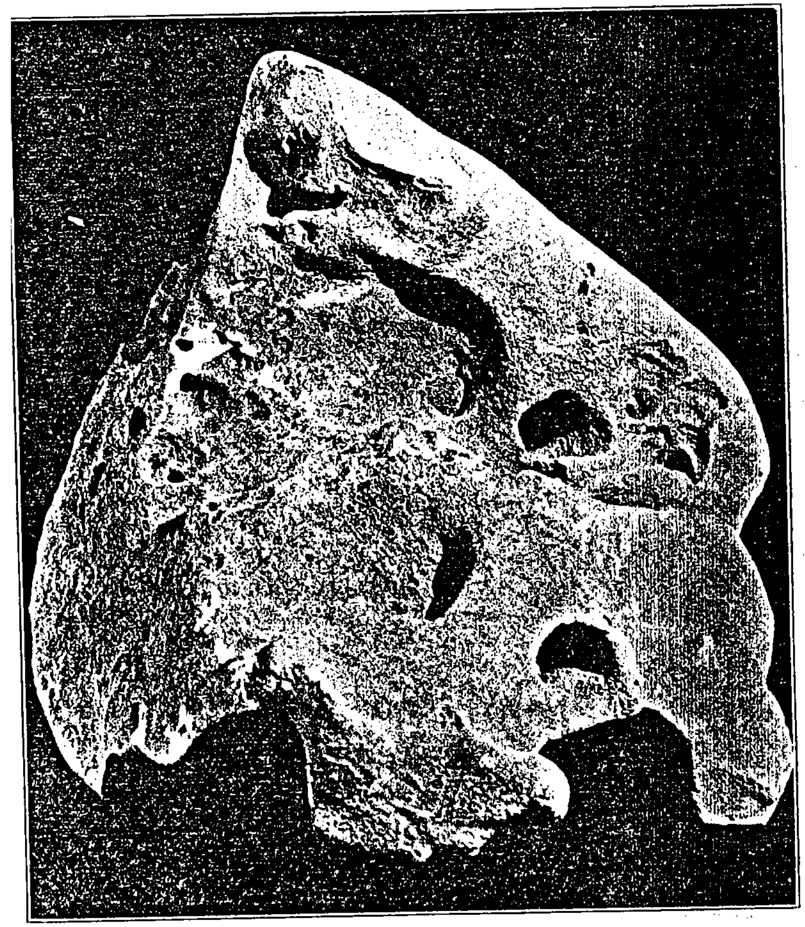
Size of grains of sample of sand from near Madill

No. Mesh	40	60	80	100	200	Pan	Total
G6	.95	1.85	27.35	27.45	40.29	2.12	100.01

BUILDING STONE

No building stone of commercial value is found in Marshall County, although an abundance of native stone is used locally. One of the chief stones used is the Goodland limestone, but due to the fact that it is not evenly bedded it is difficult to secure material of a uniform size. Several of the other formations contain beds which find a rather wide spread local use. Some of those commonly used are the indurated shell conglomerate at the top of the Kiamichi and the "Quarry" limestone at the top of the Weno. The "Quarry" limestone, as has been previously stated, was so named due to the fact that it was extensively quarried for building stone. It is not strictly a limestone and especially in Marshall County would more properly be classed as a sandstone. It is yellowish brown in color and ranges from one to three feet in thickness. It finds a rather wide spread local use for buildings, curbstones, foundations, chimneys and etc.

PLATE XII



A WEATHERED MASS OF THE GOODLAND LIMESTONE SHOWING CHARACTERISTIC APPEARANCE.

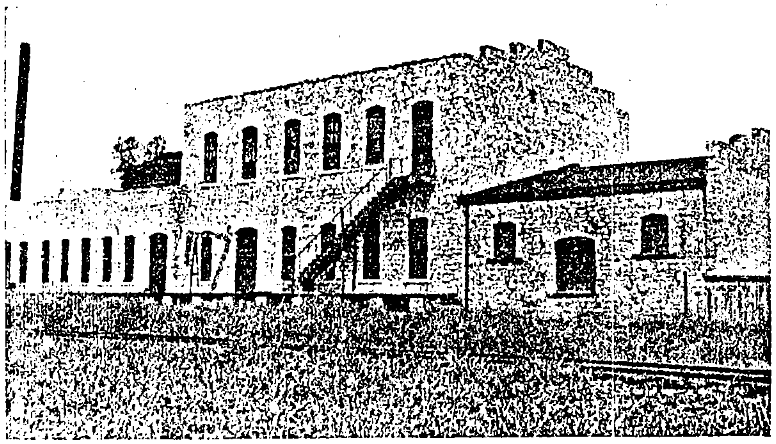
OTHER NATURAL RESOURCES

The upper part of the Goodland limestone is remarkably pure and could be utilized as a source of lime.

The Kiamichi clay and the clays in the Denton and Weno are excellent brick clays. Many plants in north Texas are using these same clays as brick clays.

The essential constituents in Portland cement are limestone and clay or shale. The Goodland limestone and the Kiamichi clay im-

PLATE XIII



VIEW SHOWING BUILDINGS CONSTRUCTED OF NATIVE (GOODLAND) STONE, COTTONSEED OIL MILL AT MADILL, OKLAHOMA.

mediately overlying it furnishes an almost inexhaustible supply of these two materials and the only remaining feature to consider is a cheap fuel supply.

Gravel, used as a road metal, on the principal highways in Marshall County has been obtained from gravel beds along some of the larger creeks. Recently a rather extensive gravel pit has been opened at Cliff on Little Glasses Creek and the gravel used on the main highway south from Madill.

AGRICULTURE

(From data prepared by Judge David Russell of Madill, Oklahoma.)

TYPES OF SOIL

The soils of Marshall County may be divided into three principle types, (1) upland prairie, (2) river bottom and (3) sand hills. The upland prairie covers about one-half the area of the county, located in the east and south-central sections of the county. It consists mainly of the black waxy variety of soil characteristic of the north Texas counties. This type of soil is very fertile and lends itself easily to cultivation. Wheat, corn, oats, cotton and all sorghum grains and grasses grow to perfection on this soil. The river bottom soils are largely alluvium. This type of land constitutes about one-fourth of the land area of the county. It is exceedingly fertile, strong in organic content and rich in all the elements necessary to plant life. A heavy growth of hardwoods, consisting chiefly of oak, walnut, ash and pecan, cover these bottom lands. After the removal of the timber the soil responds abundantly to the touch of

the plow. It seems as though its fertility is inexhaustible. Cotton, corn, alfalfa and potatoes are chief among the staple crops grown on these bottom lands, but they are adaptable to all plant life indigenous to the temperate zone. The remaining one-fourth of the area of Marshall County consists of sandy loam and breaks. The sandy loam type is characteristic of the northwest portion of the county. It has a reddish clay subsoil. The top soil ranges from one to two feet in thickness, and while not as fertile as either the black prairie or alluvium bottom it is rich in organic matter and responds abundantly to intelligent care and cultivation. Cotton, corn and vegetables are the chief crops produced on this type of soil. Broken, rugged and rocky soil characterize the breaks on the river bottoms. These lands are covered with natural grasses such as mesquite, gramma, and prairie, and afford an excellent pasture for live stock.

RELATION OF SOILS TO THE GEOLOGY

The type of soil found in any region is usually dependent on the character of the underlying formations, as the soil merely represents a weathered portion of the formation. The Trinity sand weathers to a loose sandy soil, which has been described above as a sandy loam. The other dominately sandy formation, the Woodbine sand, resembles the Trinity sand, but contains a great deal more iron. The Woodbine sand is well suited to the growing of fruits and vegetables. Most of the water wells in the county obtain their water from the Trinity sand. The limestone formations usually weather to form a black soil, but as a rule it is too thin to be of much value for farming, and is used chiefly as pasture land. The principle farming land in Marshall County is found where the shale and clay formations outcrop. They weather to form a black waxy gumbo soil which has been described above under the upland prairie type. These shale or clay formations are rather wide spread in Marshall County. The lowest formation of importance is the upper Duck Creek formation which produces an excellent soil. The other clay formations are the Denton and Weno clay members of the Bokchito formation. As a rule the soil produced by the Denton and Weno is darker and more waxy than the Duck Creek soil.

CLIMATE

The extremes of temperature range from 15 degrees above zero in January to 100 degrees in July. The mean average for January being 37 degrees and for July 82 degrees. The average daily range of temperature for the winter season is about 10 degrees and for the summer season is about 20 degrees. An average annual rainfall of 35 inches provides an ample supply of moisture for plant growth. The winter and early spring months receive the bulk of the rainfall. Showers are frequent during the summer, but the early autumn months are generally dry. The prevailing winds in the winter are from the northwest changing occasionally to the north and northeast bringing rain and snow. During the summer the winds are chiefly from the south and southwest. The winds are moderate in velocity and refreshingly cool at night. Rarely do hot winds invade this region. Taken as a whole the climate is very delightful with no extremes of heat or cold, a low humidity and an abundance of sunshine.

TRANSPORTATION

The main line of the St. Louis and San Francisco Railway traverses the county from north to south; while its subsidiary, the Arkansas and Choctaw Railway runs east and west the entire width of the county. The Ardmore-Haileyville branch of the Rock Island Railway serves a portion of the northwestern section of the county. These railroads afford every facility for transportation and give direct connection with the principle markets, both north and south. In addition to its railroads Marshall County has an excellent system of hard surfaced highways covering a distance of 42 miles. This system of highways begins at the north approach of the Preston bridge, which spans Red River, and extends in a northwesternly direction for a distance of 28 miles to the northern boundary of the county, where it connects with the State's hard surface highway system in Johnston County. Another State hard surface highway begins at Madill, the county seat, and extends in a southeasternly direction 14 miles to the bridge over the Washita River where it connects with the State hard surface highway system through Bryan County. Motor truck and motor bus service operate southward over these highways to Denison, Sherman, Dallas and Ft. Worth, Texas; and northward to Ardmore and Oklahoma City. The famous Lee Highway, which begins in Washington and ends in San Francisco passes east and west through Marshall County on a hard surface highway. This highway gives access to Memphis and the whole southeast. A system of county hard surface roads already built and under construction at the present time rounds out the transportation system. When completed every part of the county will be easily and readily accessible to either railway or motor bus transportation.

FARMING

Farming is the chief industry of the county. There are some 1,600 farms comprising a total of 185,000 acres. The average acreage of farms in Marshall County is 116 acres. Farmers who own their own farms number about 500. The remainder of the farms, 1,100, are operated by tenants. There are practically no large farms, and only a few are operated by managers. Cotton is the premier crop, with an average annual production of 15,000 bales. Corn comes next in importance averaging 800,000 bushels yearly,

ollowed by oats with an average annual production of 1,000,000 bushels. Native hay, alfalfa, wheat and potatoes rank next in the order named in their importance and their value in exchange. Fruits and vegetables are grown in abundance, but not in commercial quantities. Natural growth pecans are plentiful. In the last few years a number of pecan orchards where the paper shell variety of this nut is grown and cultivated have been started.

LIVE STOCK

Draft horses and mules sufficient to meet the local demand are bred and grown. The breeding and growing of beef cattle is an important industry. Dairy cattle are also bred in considerable numbers. Swine constitute a large commercial asset, thousands of head being shipped annually to the Fort Worth market. Poultry is also a growing industry, car load shipments of chickens and eggs to eastern markets being of frequent occurrence. A commercial poultry farm and hatchery are late additions to this industry.

POPULATION

Marshall County has a population of about 16,000. The people are practically all native stock, coming to Marshall County from the older adjoining states, Arkansas and Texas furnishing the greater number. The negroes form a very small part of the population of Marshall County. The majority of the people live in the country, the rural population being listed at 11,000 while the city and town population is listed at 5,000. Madill is the largest town and county seat with a population of 3,400. Kingston and Woodville rank next in the order named, and are thriving market towns.

PUBLIC SCHOOLS

An excellent public school system is maintained in the county. There are 38 rural schools in which instruction through the eighth grade is given, and three rural high schools with courses extending to the eleventh grade. The towns of Kingston and Woodville have independent consolidated schools giving four year high school courses. These two schools employ 23 teachers and serve about 600 pupils. Madill city schools give a four year high school course and employ 25 teachers to serve 800 pupils.

In addition to these educational facilities the county maintains a County Agent and Home Demonstration Agent. These deal exclusively and intensively with the problems of the farm and farm home.

A system of local, long distance and rural telephones covers the county. Rural free delivery mail service extends to a large part of the county. These facilities make communications rapid and easy, and add greatly to the economic and social development of the people.

HISTORY

The first treaty actually ceding land in Oklahoma to Indians from the country east of the Mississippi River was made on October 18, 1820. By this treaty the Choctaw Indians of Mississippi were given a tract of territory that had been relinquished to the United States by the Quapaw Indians. This tract included all of the land between Red River on the south and the Canadian River on the north. It extended east into what is now Arkansas and indefinitely west beyond the present border of Oklahoma.

The Chickasaw Indians were closely related to the Choctaws in both language and customs. Their homes had been in Mississippi, but in 1834 they were forced to give up their tribal government and take lands west of the Mississippi River. However it was not until three years later that the Chickasaws reached a definite agreement in regard to their new home. By a treaty with the Choctaws, concluded January 17, 1837, at Doaksville, the Choctaw capitol, near Ft. Towson, Oklahoma, it was agreed that the Chickasaws should have the privilege of forming a district within the limits of the Choctaw nation. The Chickasaws were to have equal representation in the general council of the Choctaws and were placed on an equal footing, with some minor exceptions. The western portion of the Choctaw nation was set aside for the Chickasaws for which they were to pay five hundred and thirty thousand dollars.

The composite government however was not entirely satisfactory to the Chickasaws, probably because they were greatly outnumbered by the Choctaws and for that reason had little to do with the government of the tribes. Accordingly in June, 1855, the two tribes signed an agreement by which the Chickasaws obtained a division of the territory and their political separation from the Choctaws. The Chickasaws drafted a new constitution and divided their territory into four counties, namely: Panola, Pickens, Pontotoc and Tishomingo. The present city of Tishomingo was the capitol of the Chickasaw Nation. Pickens County embraced the territory west of the Washita River to the western line of the Chickasaw Nation. The area now included in Marshall County was a portion of Pickens County. During the next fifty years no further subdivisions of any importance were made in this great country. However during the latter part of this period the United States extended its judicial jurisdiction over Indian Territory and gradually supplanted the tribal government of the Indians, paving the way for the admission of Indian Territory and Oklahoma Territory as a state into the Union.

The counties of eastern Oklahoma were first designated by the Constitutional Convention which met in 1906. Mr. William H. Murray, President of the Convention, from Tishomingo, Robert L. Williams from Durant, and W. A. Ledbetter from Ardmore, each with important influences drew the boundaries of their counties to please themselves. Mr. George A. Henshaw, delegate from the district in which the present area of Marshall County was included, was able to secure only a comparatively small area for his county, as its boundaries were more or less determined by those of the adjacent counties.

Marshall County was named by Mr. Henshaw for the maiden name of his mother, Ellen Marshall, and not after the great jurist, Thomas R. Marshall, as is sometimes stated. After Marshall County had been established a popular election was called to locate the county seat. By popular vote it was located at Madill, which was named for a noted railroad attorney of St. Louis, Missouri.

The first white settler in Marshall County was a bachelor by the name of Davis, who settled about a mile and one-half east of the present location of Madill. He brought with him a negro man and woman. The white man was later murdered and the negroes taken into custody but were later released.

The first teacher in Marshall County was Dr. Worthington, who taught a subscription school at Willis Ferry about 1852-1853. The first established school was the Orphans Home Manual Training School for Indians at Lebanon.

The first trading post was owned by Mr. R. L. Boyd established about 1869, two miles east of the present location of Madill.

The first railroad entered what is now Marshall County in 1901 when the St. Louis and San Francisco Railroad extended their line to Denison, Texas.

PALEONTOLOGY

The importance of palentology in stratigraphic work needs no emphasis. It was thought advisable therefore to include in this report a few of the fossils, which mark important horizons in the Comanchean of Marshall County. A number of the Comanchean formations of Marshall County are separated chiefly on the basis of their fossil content and a great many of the formations are easily and accurately identified by the fossils they contain. Some of the outstanding facts which the author has found helpful in field work will be noted with the hope that others working in Marshall County or similar areas will also find them helpful. No attempt is made to list all of the fossils of any of the formations, but merely the "index" fossils or those characteristic and valuable from a stratigraphic standpoint.

Trinity sand—The Trinity sand does not, as a rule, contain fossils, except fossil wood, which is found in abundance in certain localities.

Goodland limestone—The lower bed of the Goodland limestone usually carries an abundance of fossils including *Enallaster texanus* Roemer, *Exogyra texana* Roemer. *Cyprimeria texana* Roemer and *Gryphea marcoui* Hill and Vaughn. The upper part of the Goodland is characterized by the peculiar marked ammonite, *Schloenbachia acutocarinata* Shumard. This ammonite is limited in vertical distribution to the upper part of the Goodland limestone, a few individuals ranging into the lower part of the Kiamichi clay.

Kiamichi clay—The top of the Kiamichi is marked by a hard shell conglomerate from one to two feet thick composed almost entirely of *Gryphea navia* Hall. This species also occurs rather abundantly in the clay underlying the shell conglomerate. The ammonite, *Schloenbachia belknapi* (Marcou), which resembles *Schloenbachia acutocarinata*, occurs in the upper part of the Kiamichi, a few forms ranging into the lower part of the Duck Creek.

Duck Creek formation—The lower part of the Duck Creek contains an abundance of well-preserved fossils including *Inoceramus comancheanus* Cragin, *Hamites comancheanus* Winton and Adkins, *Schloenbachia trinodosa* Boese and a very large ammonite, *Desmoceras brazoense* (Shumard). This "large ammonite" horizon occurs about 25 to 35 feet above the base of the Duck Creek and is limited to a vertical zone of about 8 feet. An abundant horizon of *Hemiaster whitei* Clark occurs just above the "large ammonite" horizon in the lower part of the Duck Creek.

The upper part of the Duck Creek, which is made up of marly clay contains practically no fossils.

Fort Worth limestone—The Fort Worth limestone carries a wealth of fossils. Two very important echinoids occur in this section; *Hemiaster elegans* Shumard and *Holaster simplex* Shumard. Other fossils characteristic of the Fort Worth include *Schloenbachia leonensis* Conrad, *Exogyra americana* Marcou which occurs at the top of the Fort Worth. An abundant horizon of *Gryphea washitaensis* Hill usually occurs at the top of the Fort Worth. Fossil "fucoids" are abundant throughout the Fort Worth limestone.

Bokchito formation:

Denton clay member—The top of the Denton clay or the Denton-Weno contact is marked by a very fossiliferous horizon composed chiefly of *Gryphea washitaensis* Hill, with an occassional *Ostrea carinata* Lamarck and frequently plates and spines of a very ornamented echinoid, probably *Leiocidaris hemigranosus* (Shumard). This horizon is very frequently consolidated into a hard brown shell conglomerate.

Weno clay member—The Weno clay contains a number of highly ferruginous sandy clays in its upper part which contain an abundance of fossils; Stephenson lists the following fossils from these ferruginous beds: *Nucula* sp., *Ostrea quadruplicata* Shumard, *Protocardia texana* (Conrad), *Cyprimera* sp., *Corbula* (three species), *Cymbopora* sp., *Turritella* sp., *Auchura mudgeana* White, *Engonoceras serpentinum* Cragin. Some of these beds were noted which were composed almost entirely of *Turritella* sp. This enables one to distinguish these beds from similar beds in the Pawpaw, which resembles these beds, but do not contain *Turritella* sp.

The top of the Weno is marked by the "Quarry" limestone, which usually carries an abundance of *Ostrea quadruplicata* Shumard and frequently *Ostrea subovata* Shumard.

Pawpaw sandy member—The Pawpaw sandy member contains a number of ferruginous layers and concretions very similar to those found in the Weno. Stephenson lists the following fossils: *Nucula* sp., *Protocardia texana* (Conrad), *Cymbopora* sp., *Corbula* sp., *Anchura mudgeana* White and *Engonoceras serpentium* (Cragin). These fossils are practically identical with those listed for the Weno, except the *Turritellas* are absent.

Bennington limestone—The Bennington is characterized by two easily recognized fossils. *Exogyra arietina* Roemer is found particularily in the upper part of the Bennington and *Kingena wacoensis* Roemer in the lower part. The last named fossil is the only brachiopod of common occurrence in the Comanchean of this region.

Grayson marl—*Exogyra arietina* extends into the lower part of the Grayson marl. The fossil most characteristic of the Grayson is *Gryphea mucronata* Gabb which occurs rather abundantly near the middle of the formation. Other fossils common in the Grayson are *Turrilites brazoensis* Roemer, *Pecten, Trigonia* and *Hoplites*.

Woodbine sand—No fossils were obtained from the Woodbine in Marshall County, although fossil leaves have been obtained from the lower member (Hill's Dexter sands) of the Woodbine near Denison, Grayson County, Texas.

PLATE XIV

FIGURE 1. SCHOENBACHIA ACUTOCARINATA (SHUMARD).

HORIZON: Upper Goodland limestone.

SIZE: x 0.7.

FIGURE 2. SCHLOENBACHIA BELKNAPI (MARCOU).

HORIZON: Upper Kiamichi clay a few forms ranging into the the lower Duck Creek formation.

SIZE: x 0.55.5

PLATE XIV

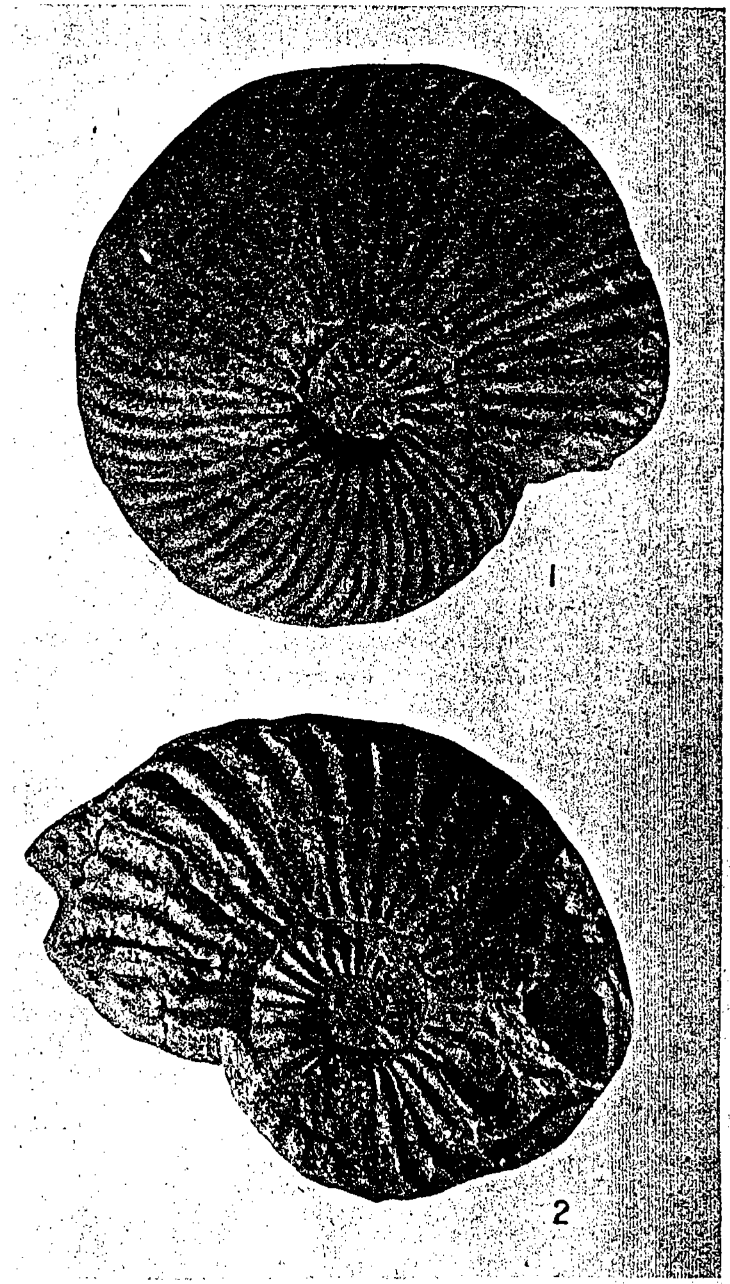


PLATE XV

FIGURES 1-2. GRYPHEA NAVIA HALL.

HORIZON: Kiamichi clay.

SIZE: Natural.

FIGURE 3. SLAB OF SHELL CONGLOMERATE MADE UP CHIEFLY OF GRYPHEA NAVIA HALL.

(*Photograph through courtesy of the United States Geological Survey.*)

HORIZON: Top of the Kiamichi clay.

SIZE: Compare with hammer in picture.

PLATE XV

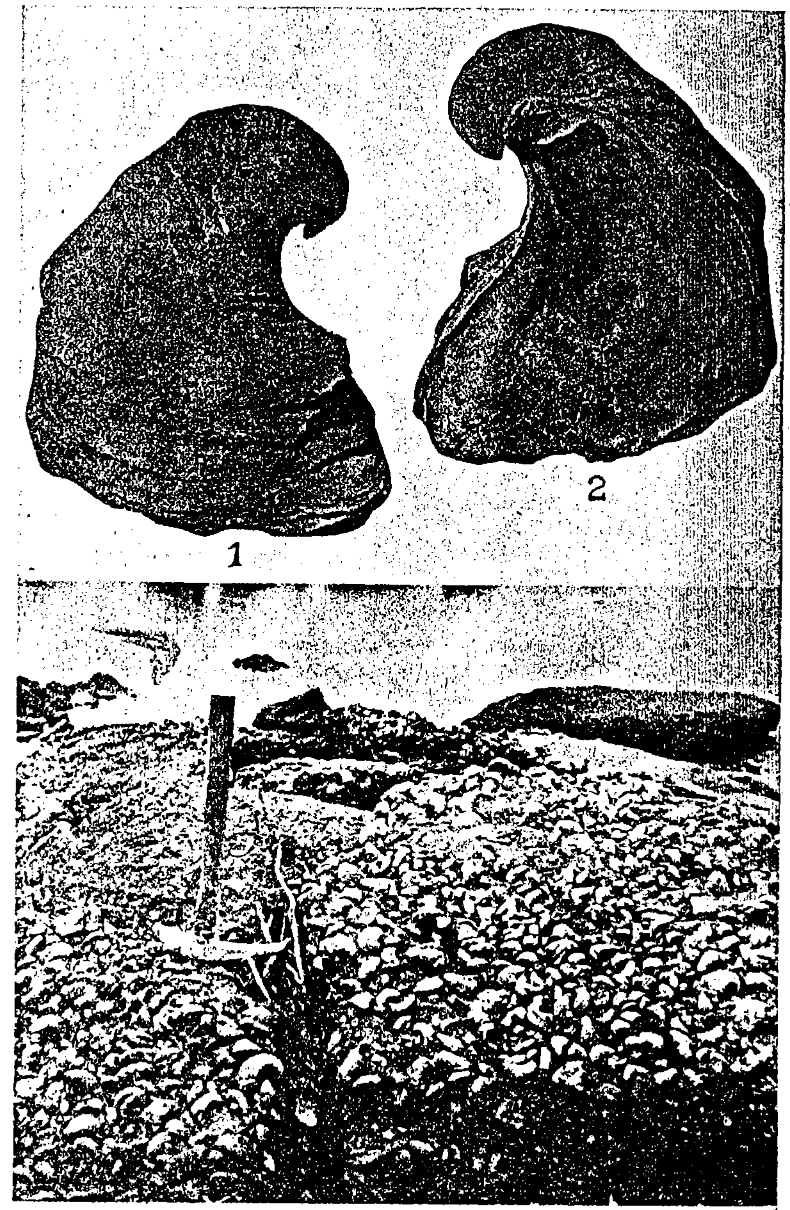


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PLATE XVI

FIGURE 1. DESMOCERAS BRAZOENSE (SHUMARD).

HORIZON: Lower Duck Creek formation, 25 to 35 feet above the top of the Klamichi clay.

SIZE: Compare with 15 inch ruler in picture.

FIGURE 2. INOCERAMUS COMANCHEANUS CRAGIN.

HORIZON: Lower Duck Creek formation, below "large ammonite" horizon.

SIZE: x 0.8.

FIGURE 3. SCHLOENBACHIA TRINODOSA BOESE.

HORIZON: Upper part of lower Duck Creek formation.

SIZE: x 0.6.

PLATE XVI

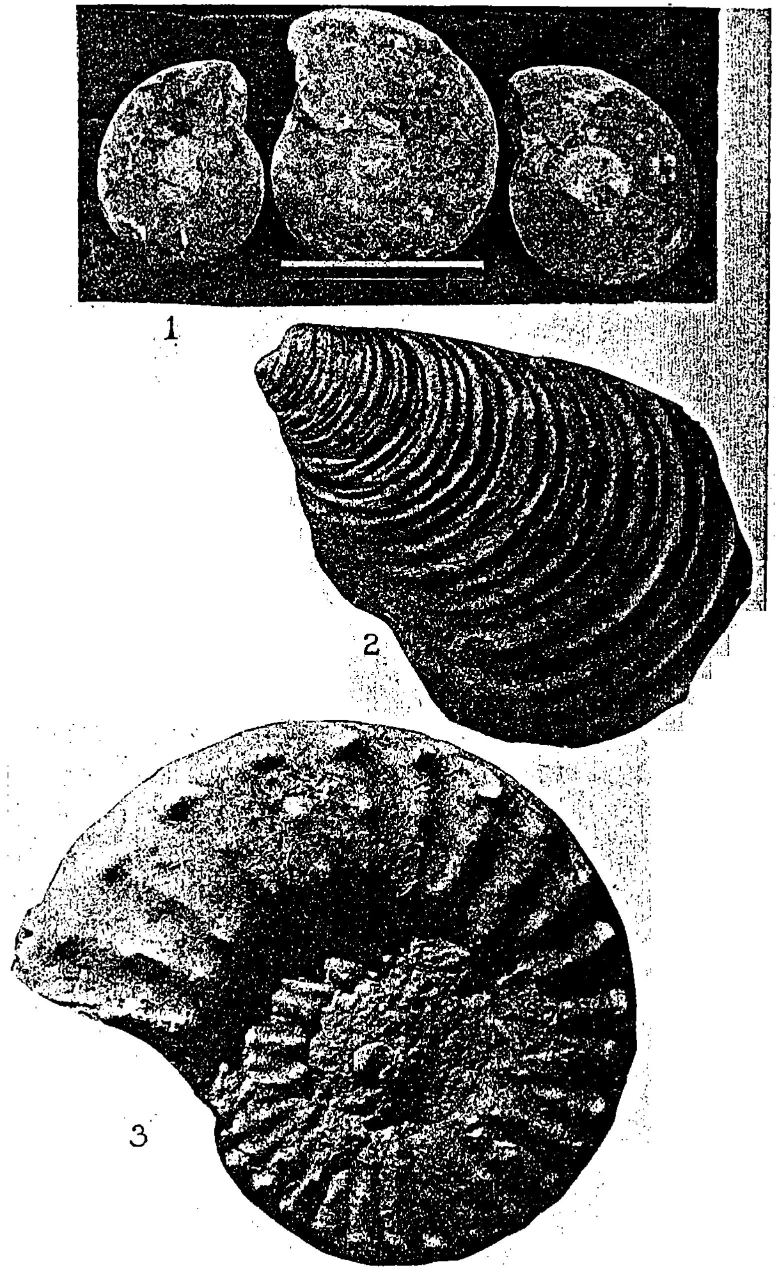

PLATE XVII

FIGURE 1. SCHLOENBACHIA LEONENSIS CONRAD.

HORIZON: Fort Worth limestone.

SIZE: x 0.3.

FIGURES 1-2. HEMIASTER ELEGANS SHUMARD.

HORIZON: Fort Worth limestone.

SIZE: x 0.6.

PLATE XVII

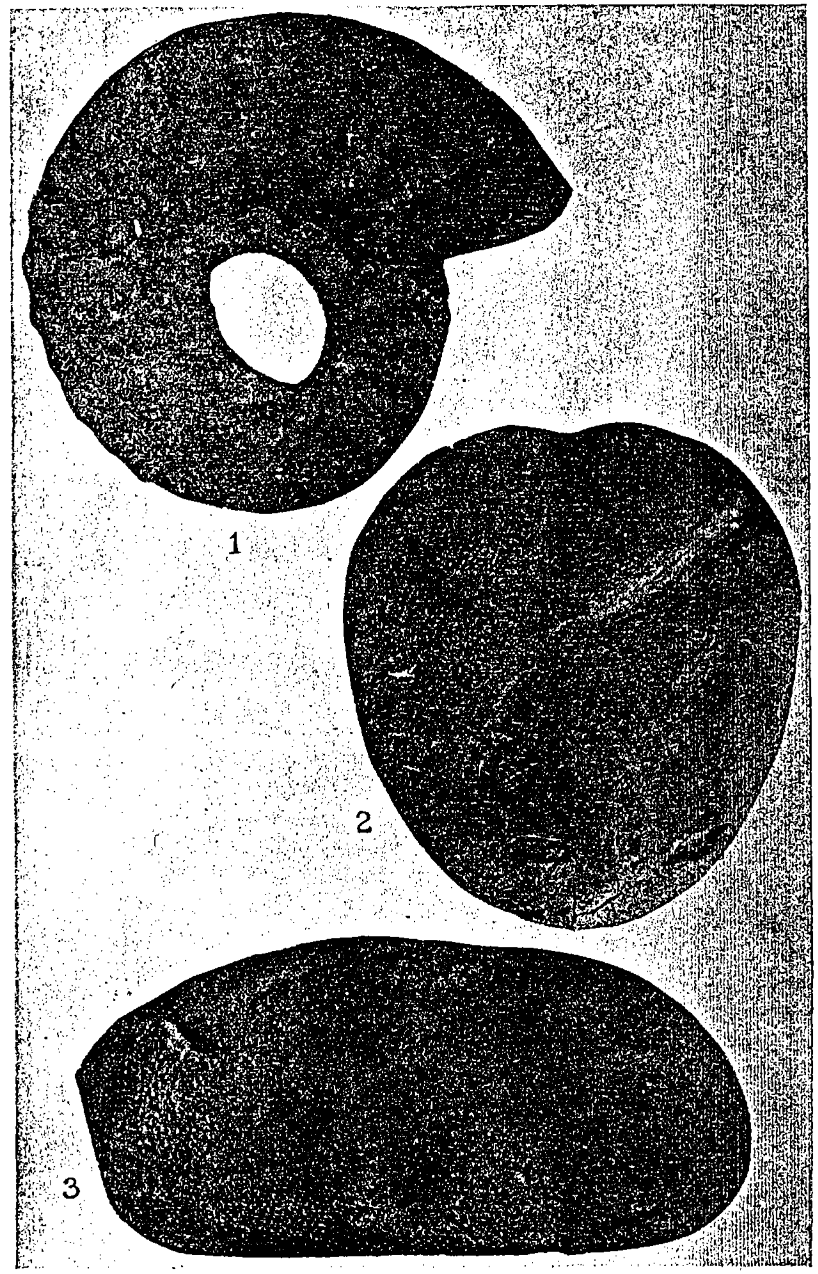

PLATE XVIII

FIGURES 1-2. HOLASTER SIMPLEX SHUMARD.

HORIZON: Fort Worth limestone.

SIZE: Natural.

FIGURE 3. FOSSIL FUCOIDS (?) ON THE UNDER SIDE OF A SLAB OF FORT WORTH LIMESTONE.

(Photograph through courtesy of the United States Geological Survey.)

PLATE XVIII

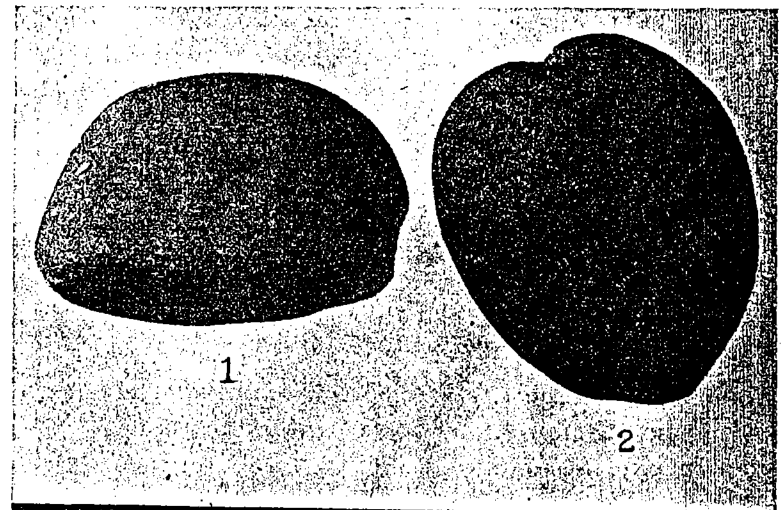

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PLATE XIX

FIGURES 1-6. PLATES AND SPINES OF AN ECHINOID, PROBABLY LEIOCIDARIS HEMIGRANOSUS (SHUMARD).

HORIZON: Denton-Weno contact.

SIZE: Natural.

FIGURE 7. OSTREA CARINATA LAMARCK.

HORIZON: Denton-Weno contact.

SIZE: Natural.

FIGURES 8-9. OSTREA QUADRUPLICATA SHUMARD.

HORIZON: Ranges throughout the upper half of the Washita group especially abundant in the "Quarry" limestone at the top of the Weno clay member.

SIZE: Natural.

FIGURES 10-11. GRYPHEA WASHITAENSIS HILL.

HORIZON: Abundant at the top of the Fort Worth limestone and in the Denton-Weno contact zone.

SIZE: Natural.

PLATE XIX

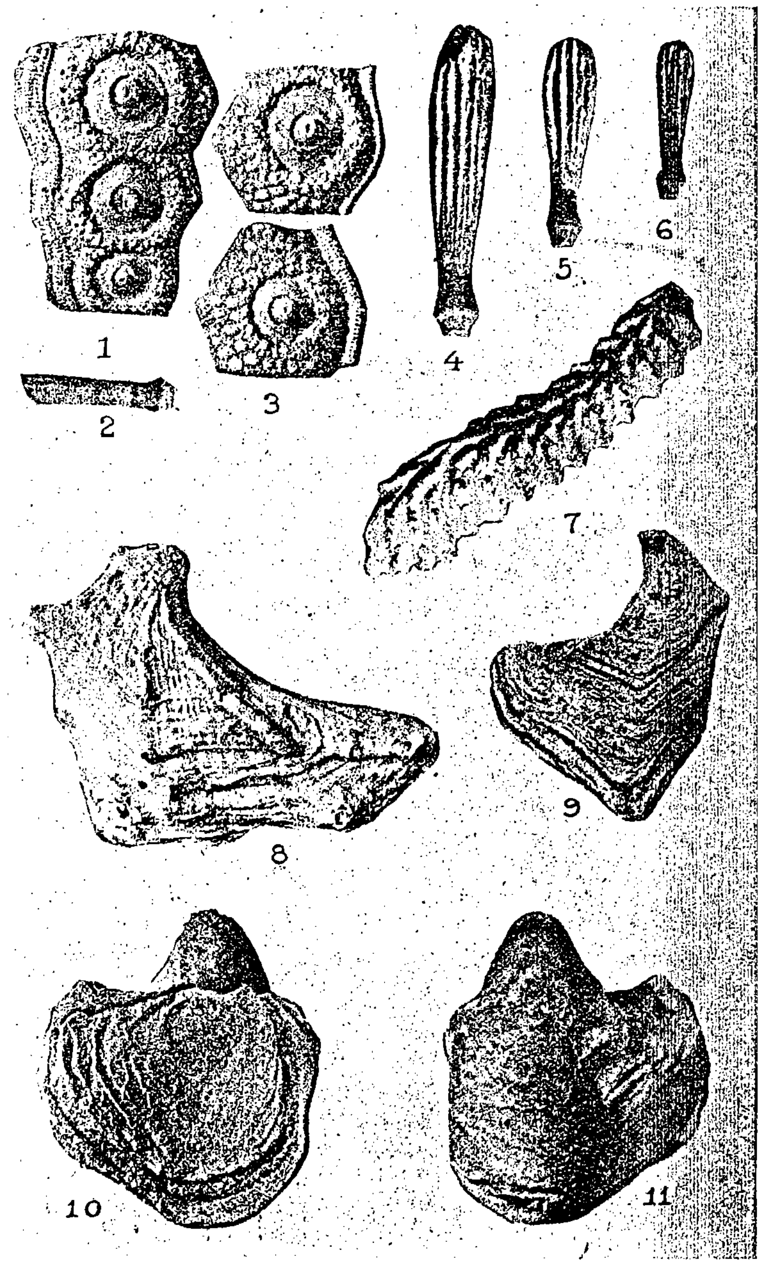


PLATE XX

FIGURES 1-3. EXOGYRA ARIETINA ROEMER.

HORIZON: Abundant, upper Bennington limestone and lower Grayson marl.

SIZE: Natural.

FIGURES 4-5. KINGENA WACOENSIS (ROEMER).

HORIZON: Lower Bennington limestone.

SIZE: Natural.

FIGURES 6-7. GRYPHEA MUCRONATA GABB.

HORIZON: Abundant near the middle of the Grayson marl.

SIZE: Natural.

PLATE XX

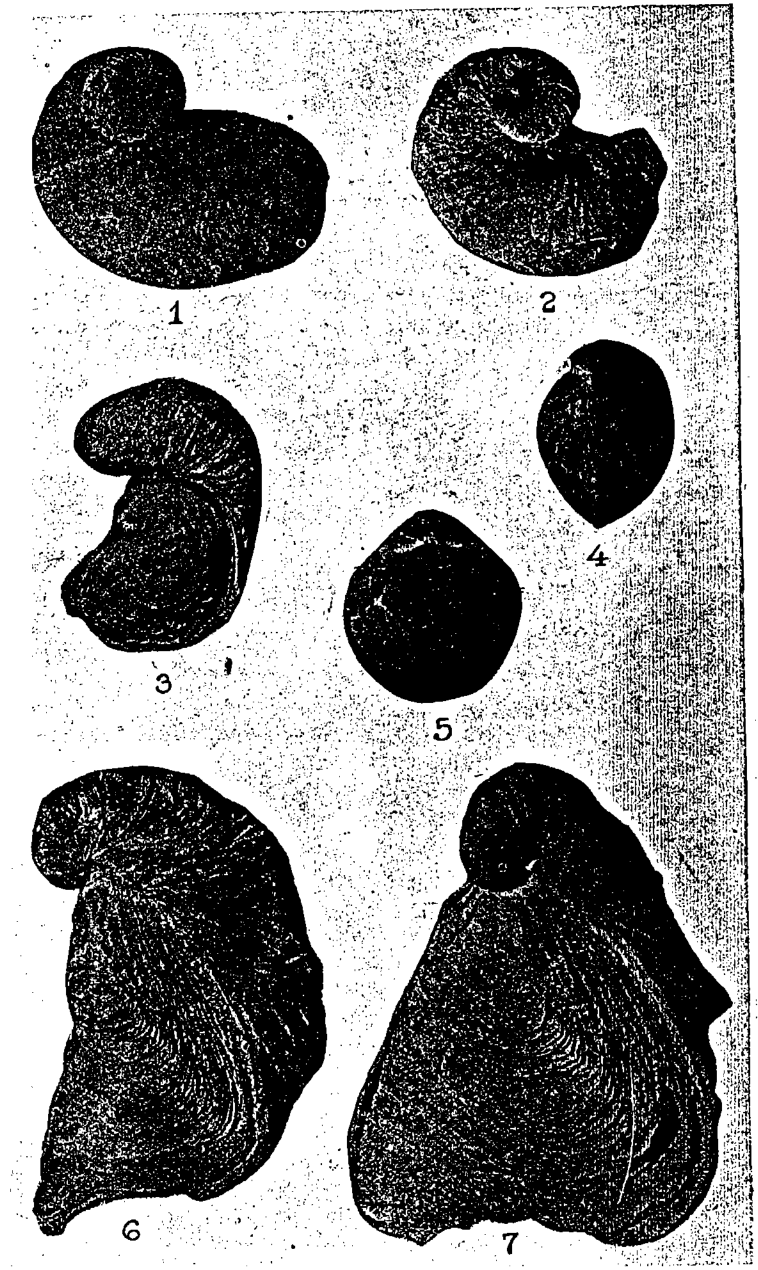


PLATE XXI

FIGURE 1. OSTREA CARINATA LAMARCK.

HORIZON: Denton-Weno contact.

SIZE: Natural.

FIGURE 2. GRYPHEA MUCRONATA GABB.

HORIZON: Grayson marl.

SIZE: Natural.

FIGURE 3. TURRILITES BRAZOENSIS ROEMER.

HORIZON: Grayson marl.

SIZE: x 0.5.

PLATE XXI

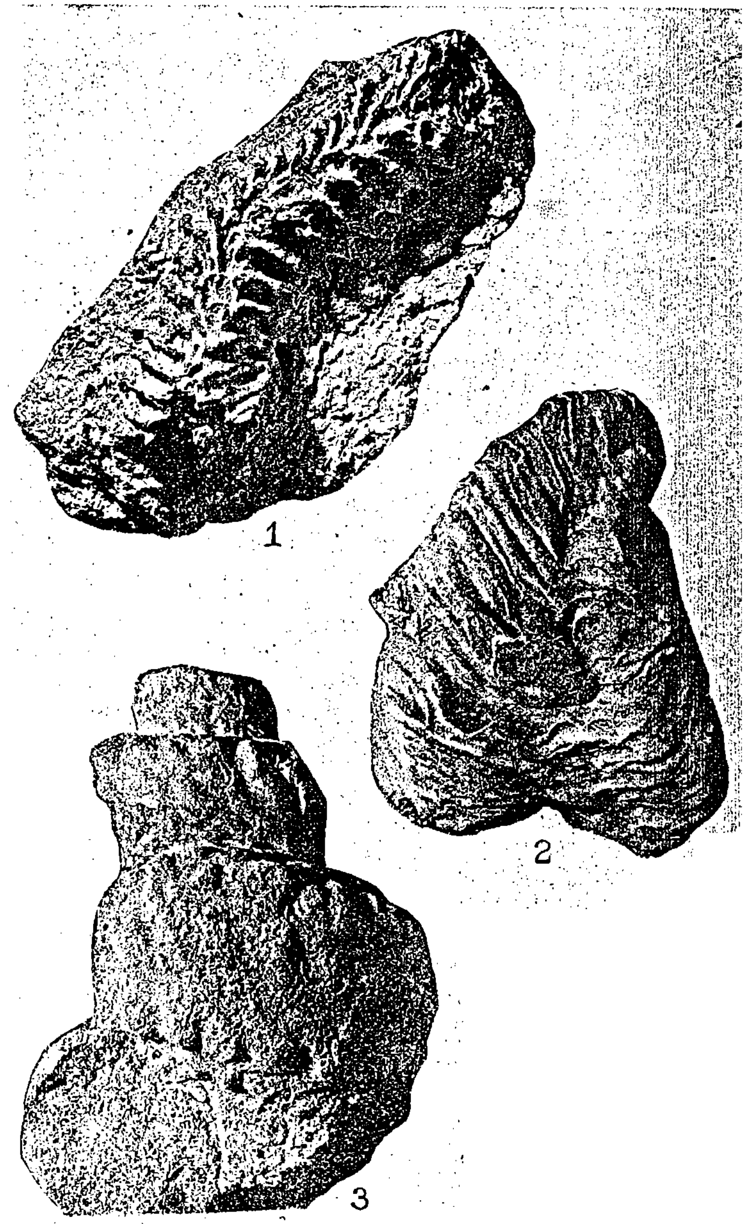
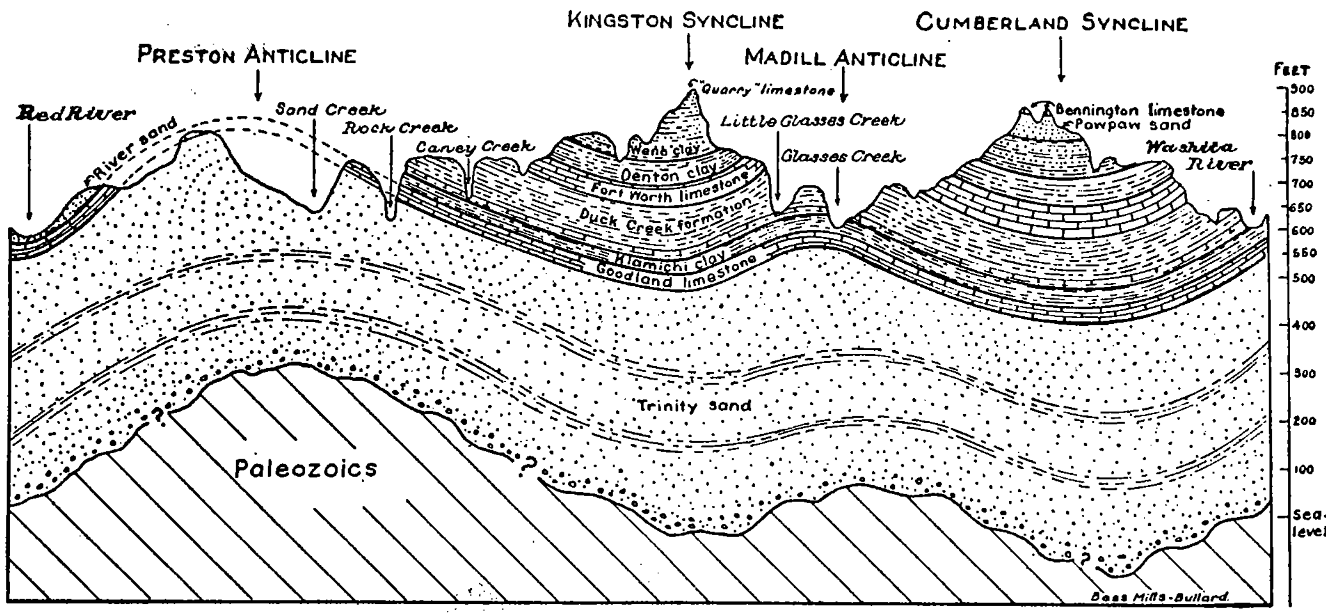


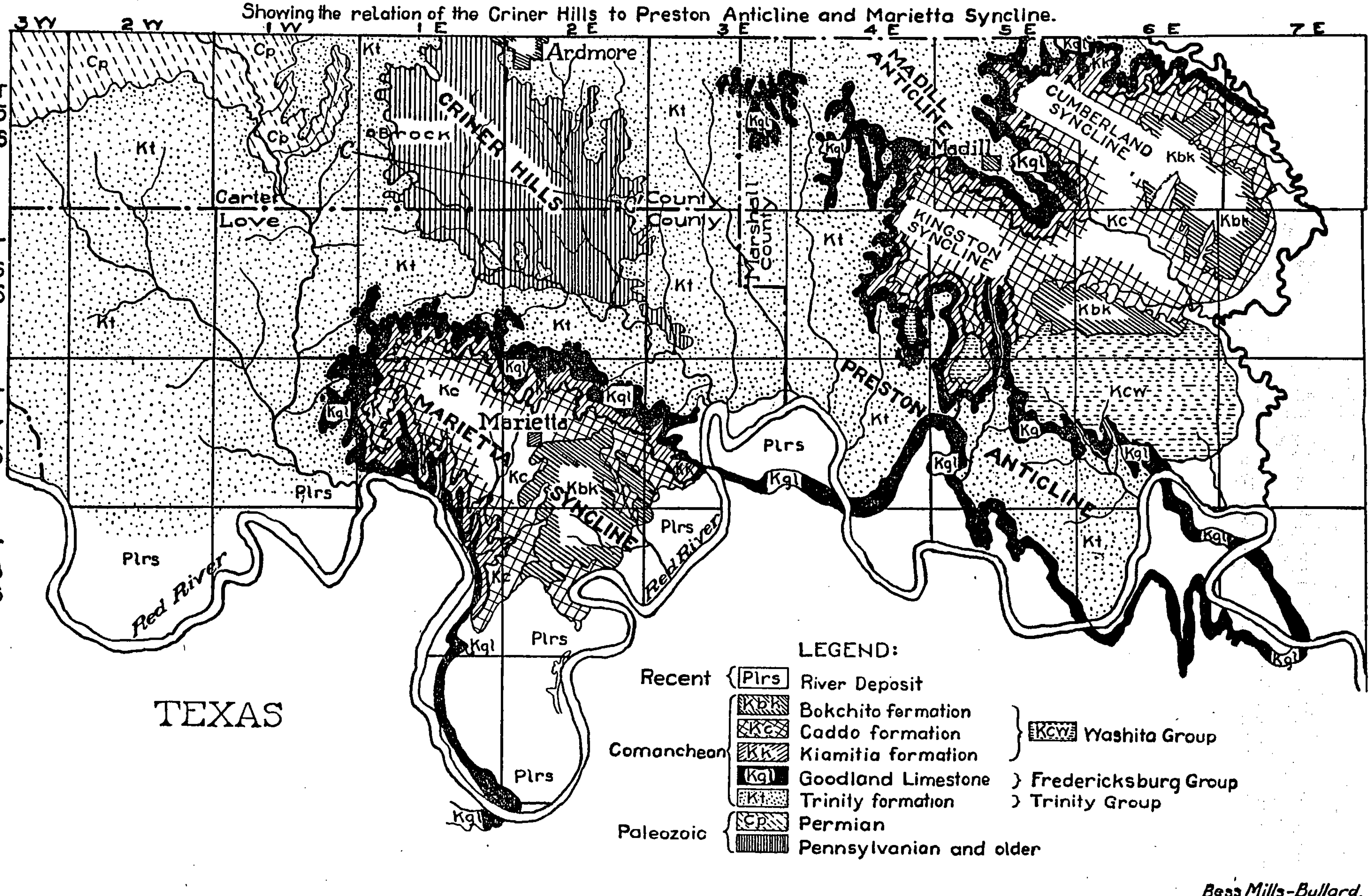
PLATE XXIV

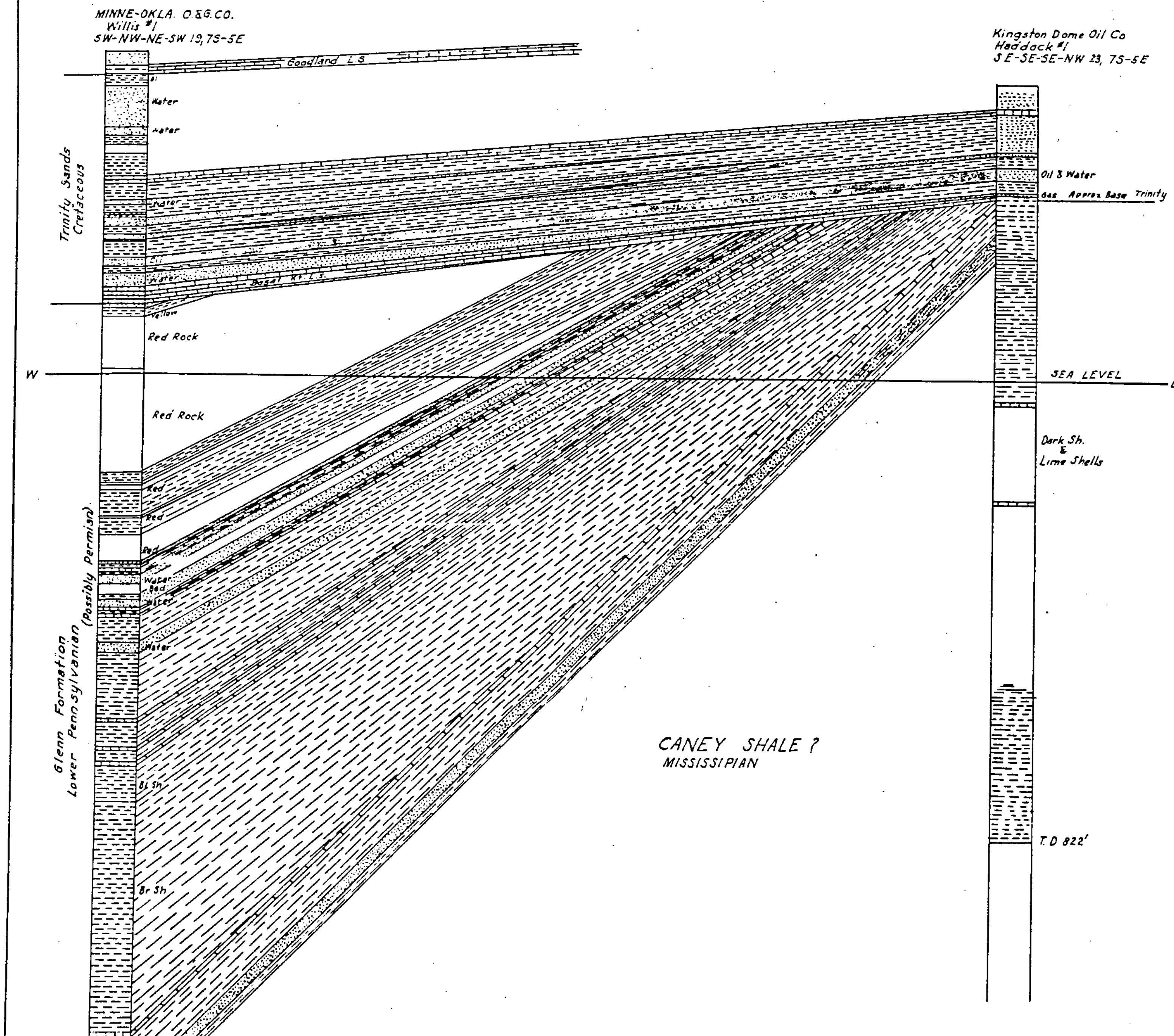


STRUCTURE SECTION ALONG LINE A-A'.

GEOLOGIC MAP OF SOUTH CENTRAL OKLAHOMA

Showing the relation of the Criner Hills to Preston Anticline and Marietta Syncline.





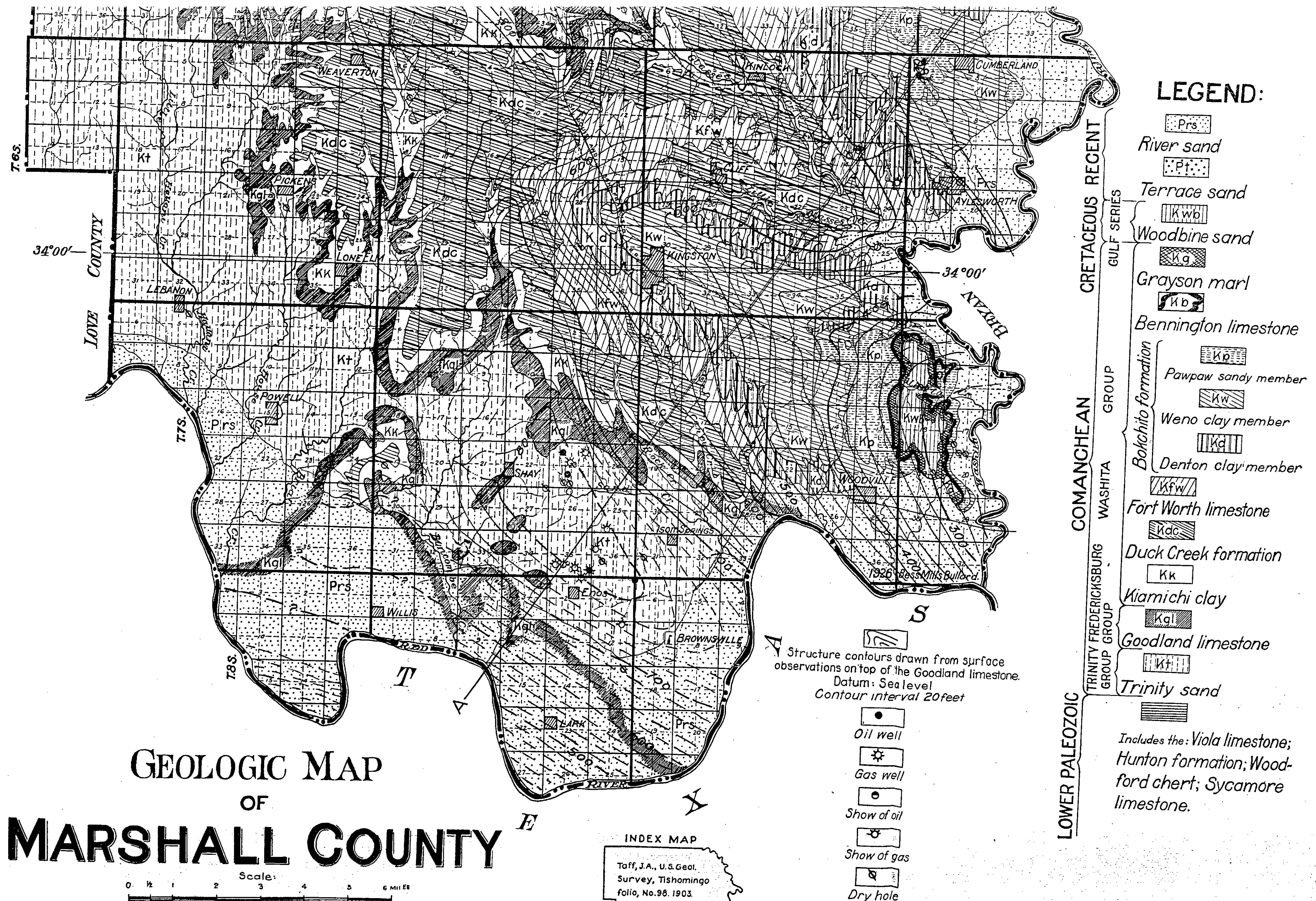
HYPOTHETICAL SUBSURFACE CROSS-SECTION OF
SOUTHWEST FLANK OF PRESTON ANTICLINE, MARSHALL CO., OKLA.

MAY, 1922.

HORIZONTAL SCALE 2½" = 1 MILE
VERTICAL SCALE 1" = 200'

EAST-WEST SECTION

Note – Reported core taken from Kingston Dome well showed Caney shale dipping 45°. This is assumed as fact in this work.



GEOLOGIC MAP OF MARSHALL COUNTY

BY

Fred M. Bullard

Modified from published reports by J.A. Taff and L.W. Stephenson