University of Texas Bulletin

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GEOLOGY AND MINERAL RESOURCES OF MCLENNAN COUNTY

BY

W. S. ADKINS

BUREAU OF ECONOMIC GEOLOGY AND TECHNOLOGY
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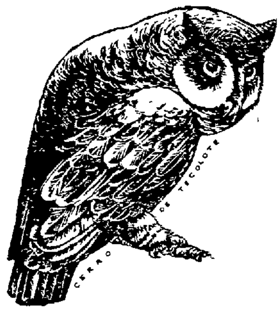
PUBLISHED BY
THE UNIVERSITY OF TEXAS
AUSTIN



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PUBLISHED BY THE UNIVERSITY FOUR TIMES A MONTH AND ENTERED AS SECOND-CLASS MATTER AT THE POSTOFFICE AT AUSTIN, TEXAS, UNDER THE ACT OF AUGUST 24, 1912

The benefits of education and of useful knowledge, generally diffused through a community, are essential to the preservation of a free government.

Sam Houston.

Cultivated mind is the guardian genius of democracy. . . It is the only dictator that freemen acknowledge and the only security that freemen desire.

Mirabeau B. Lamar.

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THE GEOLOGY AND MINERAL RESOURCES OF McLENNAN COUNTY[1]

BY

W. S. ADKINS

INTRODUCTION

McLennan County is situated in Central Texas somewhat east of the geographic center of the State. The county is practically rectangular with its greatest length running N. 60 E., following the original Spanish league lines, and has an area of about 1041 square miles. It is in the zone of densest population of the State, having a population of 82.921 (1920 census). The county is located far enough south to escape the severity of the northers, and on the whole has an equable climate; the mean annual temperature is 67°, the mean annual rainfall is 22.77 inches. The elevations of the surface range from about 950 feet in the west corner to about 350 feet where the Brazos River leaves the county. The magnetic declination in December 1921 was 9° 04′ East, and is increasing at the rate of 3 minutes per year.

The county seat of McLennan County is Waco (elevation 414 feet[2]; population, official estimate, March, 1923, 41,626; 1920 census, 38,500). The city of Waco occupies the site of two Indian villages, El Quiscat and Flechazos, which in the latter part of the eighteenth century were occupied by the agricultural Waco (Tawakoni) Indians. The main village in 1824 had a population of about 100 men, according to Stephen F. Austin. Numerous remains from these villages have been

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[1]Manuscript submitted July, 1923, published January, 1924. The writer studied the Bosqueville area in March, 1919; the geologic county map was made during October—December, 1921. I am greatly indebted to Dr. J. A. Udden for valuable suggestions and for information on the subsurface geology; and to Dr. R. T. Hill and Dr. Lula Pace for their kind assistance on various questions. Many persons have generously supplied well data and samples. Mr. Baker Hoskins assisted in some of the later field work.

[2]See table of precise levels in McLennan County.

found, and earthworks were extant until recently. (See: F. W. Hodge, Handbook of North American Indians north of Mexico, Bur. Am. Eth., Bull. 30, pt. 2, p. 888, 1910).

A white settlement was early established at Waco Springs on the Brazos. In 1850 McLennan County was formed from parts of Navarro, Limestone and Falls Counties. Some communities, as Bosqueville, antedate considerably the Civil War,

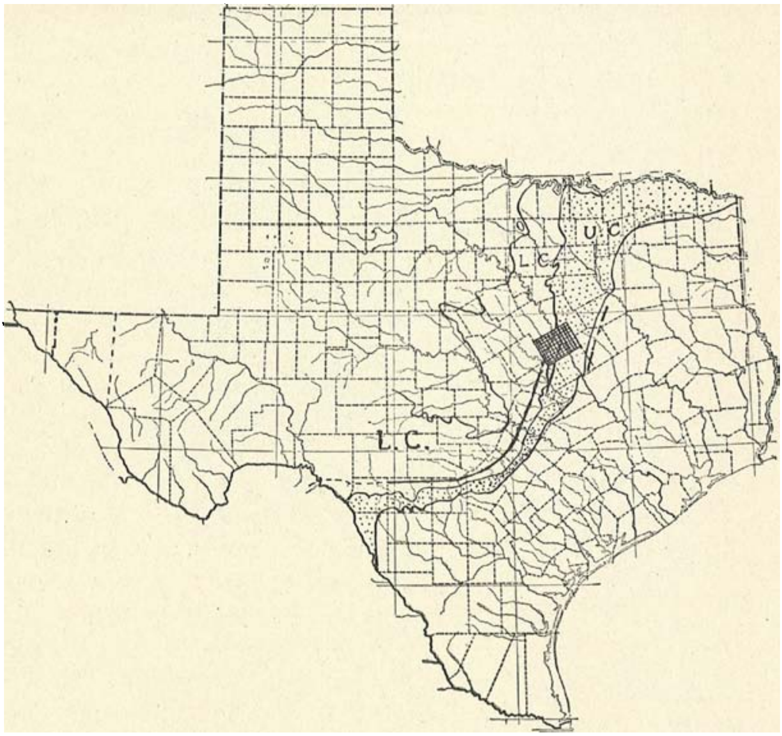

Fig. 1. Map of Texas, showing location of McLennan County and of Lower Cretaceous and Upper Cretaceous outcrops.

but in the readjustment following the building of railroads, Waco was favored by topographic advantage, and became the most important town in the county. Waco is the center of a rich farming country, and lies on the main line of automobile and rail travel from north to south Texas, so that its radius of economical transportation is sufficiently large to assure it of a trade territory covering much of Central Texas.

PHYSIOGRAPHY AND TOPOGRAPHY

McLennan County lies in an eastward sloping coastal plain country underlain by eastward dipping Lower and Upper Cretaceous rocks.

The entire county is drained directly or indirectly by the Brazos River, which cuts across the county from northwest to southeast. The Brazos winds through a broad flat alluvial covered valley which varies from one to four miles in width, and in the west part of the county lies as much as 250 feet below the adjacent uplands. In the northwest part of the county where the formations cut through by the river consist largely of hard beds, mainly limestone, the valley is narrow and is bordered by cliffs, but in the southeast part of the county, where the softer Upper Cretaceous beds occur, fresh exposures are rarer and the valley floor is largely mantled by flood plain deposits.

The largest lateral of the Brazos is the Bosque River. This flows east of north and empties into the Brazos about 3 miles above Waco. The Bosque follows very closely the boundary between the Lower and Upper Cretaceous formations and over most of its course skirts the west base of a long line of west facing cliffs, the Bosque Escarpment. This escarpment continues north of the Brazos along the east side of Aquilla Creek, and enters Hill County just north of Tokio; it thus divides the county roughly into halves, the part east of it comprising the Black Prairie (Upper Cretaceous) and the part west of it the Grand Prairie (Lower Cretaceous). The west branches of the Bosque River are the North Bosque, Hog Creek and the Middle Bosque. They arise as long straight laterals from the highlands in Bosque and Coryell Counties which form the divide between the Leon and Bosque Rivers and descend towards the southeast, following very nearly the dip of the underlying formations. As they approach the Bosque River, they cut rather deep valleys so that their lower courses are separated by broad erosional divides.

The county includes three portions of the East Central Province of Texas: (a) the Lampasas Cut-Plain, (b) the Grand Prairie, and (c) the Black Prairie. Of these, the

Lampasas Cut Plain occupies only a small area in the west corner of the county, from Crawford to Valley Mills, which is a continuation of the typical Coryell County topography and forms the extreme eastern edge of the Cut Plains; this region is underlain by rocks of the Fredericksburg division of the Lower Cretaceous. The Grand Prairie includes the dissected uplands west of the Bosque, around McGregor, and a

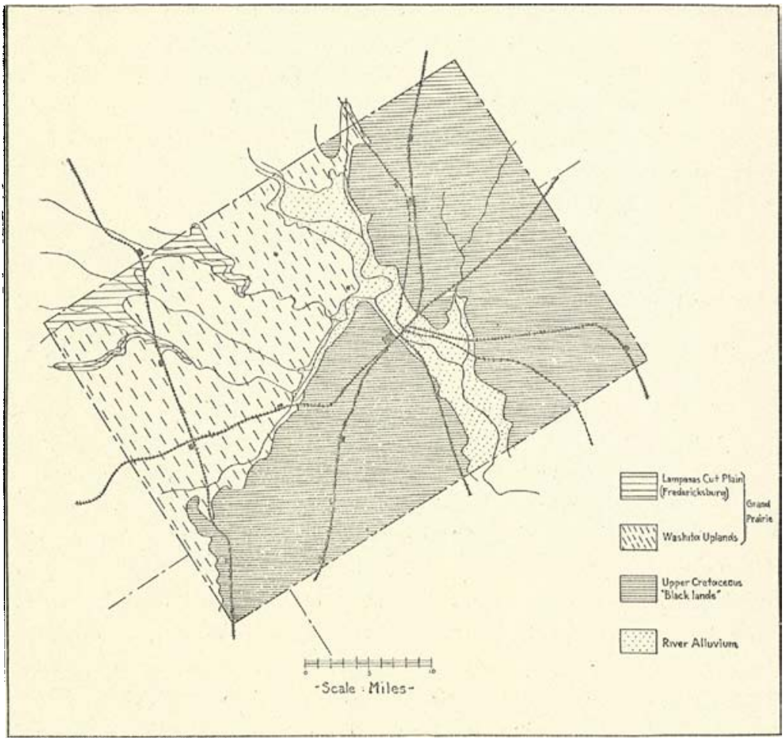

Fig. 2. The physiographic divisions of McLennan County.

small area north of the Brazos, near Gholson, and is underlain by rocks of the Washita division of the Lower Cretaceous. The Black prairie includes the "black land" country, east of the Missouri, Kansas and Texas Railway, and is underlain by Upper Cretaceous formations. Due to the practical absence of Woodbine outcrops of the sandy facies in McLennan County the Eastern Cross Timbers area is not represented in the county.

DRAINAGE

The Brazos Valley

The difference in elevation between the bottom and the crests of the present Brazos River valley, as at high points near China Springs and West, is about 250 feet. The Brazos Valley in northwestern McLennan County, as indicated by the distance between the adjacent drainage divides, is considerably narrower than in the southeastern part of the county; the immediate river valley bottoms are also much narrower to the northwest. In the area of outcrop of the Trinity and Fredericksburg divisions the large stream valleys have tortuous, often precipitous sides, and the small streams are in places deeply intrenched in limestone canyons. On the other hand, in the softer Upper Cretaceous formations of the Black Prairie, the valleys are wider and flatter, and their sides lower. The Brazos valley increases in width from less than a mile on the northwest border of the county to about four miles at the southeast border; the extent of its various terraces is described later.

The Bosque River and its Tributaries—The South Bosque arises in the Washita uplands west of McGregor and flows northeastward to the Brazos about 3 miles above Waco. The Bosque thus flows diagonally across the strike of the formations, ascending in the geologic column to the Austin Chalk. Since over most of its course the Bosque Escarpment skirts the east bank, the escarpment contains progressively higher formations as it approaches the point where the Brazos cuts through it. At this point it is composed entirely of Austin Chalk. On passing southwards the bulk of the escarpment consists of successively lower formations. At the Brazos therefore, the Eagleford lies in the valley floor, and its apparently reduced thickness is due mainly to concealment, not to faulting. The Middle Bosque and Hog Creek arise in the Washita uplands of eastern Coryell County, and the North Bosque arises near the northwestern corner of Bosque County.

Other Tributaries of the Brazos—The short west laterals of the Brazos within McLennan County include Childress, Eagle and Rock Creeks, all contained in the Washita area; the main north lateral is Aquilla Creek. In the Upper Cretaceous, east of the Bosque Escarpment, are Whiterock Creek and Waco Creek in the Austin Chalk area. In the Taylor area the main lateral east of the Brazos is Tehuacana Creek, and west of the Brazos a series of long dip-slope creeks draining the Austin and Taylor uplands, Cottonwood Creek, Flat Creek, Castleman Creek, Dry Creek, Bullhide Creek and Cow Bayou.

THE BOSQUE ESCARPMENT

The Bosque escarpment, which marks the border between the Black and the Grand Prairies, forms a prominent topographic feature running nearly in the strike of the formations across McLennan County from near West to below Moody. It is continuous with the "White Rock" (Austin Chalk) escarpment which passes southwards across Texas from Grayson County and near Dallas to the Colorado River, near Austin.

This west-facing erosional escarpment averages about 150 feet in height and runs in a direction about N 30 E. being parallel to and about 5 to 7 miles west of the axis of the Balcones fault zone. In McLennan County it is not properly an Austin Chalk escarpment since only in the central part of the county does the Austin Chalk approach its edge; elsewhere the chalk recedes considerably eastward from the escarpment, which is then protected from erosion by the hard middle Eagleford Flags. It runs successively along the east bank of Aquilla Creek, the Bosque, and the South Bosque Rivers. North of the Brazos it consists of Eagleford shales and flags. North of South Bosque station, it is capped by Austin Chalk, and is precipitous and timbered. South of South Bosque the chalk retreats eastward and the Eagleford scarp is broader and more rolling, with numerous rounded knolls and long ridges, and is untimbered. This Eagleford ridge, capped by Eagleford Flags, makes south of McGregor a very prominent line of hills, which is visible for a great distance.

The escarpment throughout the county is a conspicuous drainage divide. The streams running west from it are short laterals of the Bosque River. Those running east, heading at a greater elevation, are long nearly parallel dip-slope streams which empty into the Brazos; they rise stratigraphically low in the Upper Cretaceous beds and gradually ascend the series, since the beds dip eastward somewhat faster than the streams fall. South of the Brazos the South Bosque River cuts diagonally across the strike, flowing down the dip and ascending the geologic column.

The Lampasas Cut Plain—The Lampasas Cut Plain barely touches the west corner of McLennan County. The border of the Cut Plain is seen at Valley Mills, and the Comanche Peak and Edwards formations comprising it appear in the county for only a short distance in the beds of the North and Middle Bosque, between Washita uplands.

The Grand Prairie—The part of the county west of Aquilla Creek and the Bosque River consists of uplands and valleys underlain by Washita (Lower Cretaceous) formations, chiefly limestones, and forms the Grand Prairie as it is developed in this county.

The Black Prairie—East of the Grand Prairie the county is underlain by Upper Cretaceous formations, Eagleford, Austin Chalk and Taylor, which together with the Navarro formation lying to the east of McLennan County and reaching to the Tehuacana scarp, weather into soils collectively called "Black Land." This rich agricultural territory, devoted mainly to cotton raising, is the southern continuation of the Upper Cretaceous black land belt of north-central Texas.

BASE MAP

The base for geologic mapping (Plate 1) was constructed on a polyconic projection, scale 1: 63360, using the astronomically located points tabulated on the following pages, which were kindly furnished by the Director of the United States Coast and Geodetic Survey; the roads were filled in by compass and speedometer traverse and in part by the use of the road map made by Mr Manton Hannah, County Engineer. In areas of narrow or isolated outcrops, especially along the Bosque Escarpment, plane table traverses were made. The resulting map, reduced to the scale of 1: 190080, unavoidably contains various small errors which could not be corrected in the time available; in such places the geology is mapped with reference to the road net.

The following maps include a part or all of McLennan County (geologic maps indicated by an asterisk):

Board of Highway Engineers: Road map of McLennan County. Scale 1:126720.

Corps of Engineers, U. S. Army: Progressive military map, advance sheets and controlled reconnaissance sheets, 1918.

488 N I and III: Meridian sheet

488 N II and IV: Waco sheet.

488 S I and III: Gatesville sheet. Scale 1:125000.

488 S II and IV: Temple sheet. Contour: 50 ft.

512 N III, W/2 (1919) Mart sheet. Scale 1:62500. Contour interval: 20 ft.

Craddock's Map of McLennan County, 1919. A property map; scale 1:109167.

*Deussen, Alexander: Geology of the Coastal Plain region of Texas west of Brazos River. U. S. G. S., Prof. Paper 126, 1923. Scale 1:500000.

*Dumble, E. T.: Areal Map of Central Texas, in the Geology of East Texas, Univ. Texas Bull. 1869, 1919. Scale 1:760320.

472nd Engineers, U. S. Army, 1918: Topographic map of rifle range and danger zone, Camp MacArthur, Texas. Contour interval 5 feet; scale 1:4800.

Hannah, Manton: Road Map of McLennan County, Texas. Scale 1:62865 (blue print).

*Hill, R. T.: Geology of the Black and Grand Prairies of Texas, including the Eastern and Western Cross Timbers. 1899. U. S. G. S., 21 st Ann. Rept. pt. 7, 1901, pl. LXVI. Scale 1:633600.

Map of Waco, Texas, and suburbs. McCall–Moore Engineering Company, August 1, 1923. Scale 1:14765.

Mangum and Carr: Soil Map of the Waco Area, Texas. U. S. Bureau of Soils, 1906. Scale 1:63360.

*Pace, Lula: Gelogical Map of McLennan County, 1921. Scale 1:126720.

Map of Waco, McLennan County, Texas, and vicinity showing rural delivery routes. Post Office Department, 1906. Scale 1:63360.

Potts and Arneson: Map of Drainage District No. 1, McLennan County, showing topographic features, land ownership and proposed drainage system. Waco, May, 1915. Two sheets. Contour interval, 2 feet. Scale 1:6000.

State Land Office: Map of McLennan County. Scale 1:66000. May, 1896.

[4]Taff and Leverett: The Cretaceous area north of the Colorado River. Geol. Surv. Texas, 4th Ann. Rept., 1893. Scale 1:570,240.

[5]Udden, Baker and Bose: Review of the Geology of Texas. Univ. Texas Bull. 44, 1919 (Third edition). Scale 1:1,500,000.

United States Geological Survey: Topographic Sheets. Contour interval 50 ft. Scale 1:125000.

Waco Quadrangle (surveyed 1890, issued 1892, reissued with red overprint, 1918).

Temple Quadrangle.

Meridian Quadrangle.

Gatesville Quadrangle.

UNITED STATES COAST AND GEODETIC SURVEY MAGNETIC STATION

Waco, McLennan County—The station is located on the grounds of the Fifth Ward public school in East Waco. The station is near the north corner of the grounds, 35.5 feet from the northeast fence and 60.3 feet from the northwest fence, and about 114 feet from the nearest corner of the school building. The station is marked by a limestone post, 36 by 6 by 8 inches, set nearly flush with the ground and marked on the top U. S. C. & G. S. 1902. The spire on the chapel of the negro college, about 3 blocks to the east, was used as mark, and bears 78° 17′.4 east of true north. The spire of the old cotton mill bears 69° 24′.5 east of true south.

Magnetic data for this station:

Declination (Dec. 1921)	9° 04′ East.
Dip	61° 30′
Horizontal Intensity	0.2610 c.g.s.

The declination is increasing at the rate of 3 minutes per year.

Astronomic Locations

(Data from United States Coast and Geodetic Survey.)

Waco, Amicable Building, flagpole, 1919:
Lat. 31° 33′ 24.284″; Long. 97° 07′ 54.327″

Waco, Amicable Building, center of elevator shaft, 1919:
Lat. 31° 33′ 24.691″; Long. 97° 07′ 54.559″

Waco, Power Plant, tall brick stack, 1919:
Lat. 31° 33′ 34.800″; Long. 97° 07′ 15.570″

Waco, Power Plant, tall steel tank, white top, 1919:
Lat. 31° 32′ 57.59″; Long. 97° 10′ 30.91″

Waco, Raleigh Hotel flagstaff, 1919:
Lat. 31° 33′ 14.57″; Long. 97° 08′ 05.69″

North Waco, steel tank, 1919:

Lat. 31° 31′ 48.25″; Long. 97° 08′ 59.91″
Harrington well, near Lakeview, 1919:
Lat. 31° 38′ 21.345″; Long 97° 07′ 16.961″
Lakeview, standpipe, 1919:
Lat. 31° 38′ 17.624″; Long. 97° 06′ 28.157″
West, tall red church spire, 1919:
Lat. 31° 48′ 01.122″; Long. 97° 05′ 53.201″
West, church, low white spire, 1919:
Lat. 31° 48′ 25.36″; Long. 97° 05′ 40.59″
West, standpipe, 1919:
Lat. 31° 48′ 04.296″; Long. 97° 05′ 38.300″
West, tank on brick cotton mill, 1919:
Lat 31° 48′ 02.715″ Long. 97° 05′ 26.069″
WEST, 1919:
Lat. 31° 47′ 12.217″; Long. 97° 06′ 07.764″
Axtell, low smokestack No. 1, 1919:
Lat. 31° 37′ 05.129″; Long. 96° 56′ 02.610″
Axtell, smokestack No. 2, 1919:
Lat. 31° 39′ 25.260″; Long. 96° 58′ 03.453″
Axtell, smokestack No. 3, 1919:
Lat. 31° 39′ 35.719″; Long. 96° 58′ 03.382″
BATTLE, 1919:
Lat. 31° 33′ 52.987″; Long. 96° 53′ 35.667″
Mart, standpipe, 1919:
Lat. 31° 32′ 22.646″; Long. 96° 50′ 13.526″
Hewett, steel smokestack, 1919:
Lat. 31° 27′ 45.79″; Long. 97° 11′ 48.98″
Tall steel tank near Camp MacArthur, 1919:
Lat. 31° 32′ 34.465″; Long. 97° 10′ 59.638″
Tall wooden tank near Camp MacArtur, 1919:
Lat. 31° 33′ 32.236″; Long. 97° 10′ 36.112″
BARCUS, 1919:
Lat. 31° 27′ 58.829″; Long. 97° 14′ 45.544″
Moody, steel tank, 1919:
Lat. 31° 18′ 27.63″; Long. 97° 21′ 27.27″
Moody, schoolhouse cupola, 1919:
Lat. 31° 18′ 52.05″; Long. 97° 21′ 30.72″
Church east of BARCUS, 1919:
Lat. 31° 28′ 16.953″; Long. 97° 14′ 06.022″
Old Fairgrounds pavilion, 1919:
Lat. 31° 28′ 08.313″; Long. 97° 24′ 50.168″
McGregor, tank near old artesian well, 1919:
Lat. 31° 26′ 08.971″; Long. 97° 24′ 36.055″
McGregor, tank in group of stacks, 1919:
Lat. 31° 26′ 21.517″; Long. 97° 24′ 12.009″
SIMPSON, 1919:

Lat. 31° 36′ 03.369″; Long. 97° 29′ 33.269″

PAYNE, 1919:

Lat. 31° 39′ 52.649″; Long. 97° 19′ 36.897″

China Springs, church, 1919:

Lat. 31° 39′ 00.33″; Long. 97° 18′ 38.26″

China Springs, steel smokestack, 1919:

Lat. 31° 39′ 05.94″; Long. 97° 17′ 56.99″

Dalmore ranch, tall white silo, 1919:

Lat. 31° 37′ 47.21″; Long. 97° 23′ 34.76″

Dalmore ranch, low silo, 1919:

Lat. 31° 37′ 47.50″; Long. 97° 23′ 34.93″

PRECISE LEVELS IN McLENNAN COUNTY AND NEARBY POINTS

Bowie and Avers, U. S. Coast and Geodetic Survey, Special Publ. 18, 1914, p. 108.

Hayford, U. S. Coast and Geodetic Survey, Appendix No. 3, 1917, pp. 789–790.

HILL COUNTY:				
Hillsboro	B_4	193.171	633.762	In white stone in NW cor. of Hill County Court House in cornice about 5′ above ground, and 1½′ north of water spout.
Near Abbott	C_4	211.635	694.339	1½ m. N of Sta., 5th pole S of bridge No. 672, 6′ NW of pole. 35′ E of track, near 1st cut.
McLENNAN COUNTY:				
West	D_4	199.807	655.534	Brick bldg. east side of Main St. 2 doors N of West Natl. Bank.
Elm Mott	E_4	156.910	514.796	2′ W of 2nd pole S of depot, opposite cattle pen.
Waco	F_4	125.909	413.087	Brick bldg. SE cor. S 3d & Jackson Sts., bolt 3′ 9″ above ground.
Waco	Hydr 1	122.805	402.902	SE cor. S 1st & Jackson Sts. Top of hydrant.
Waco	Hydr 2	130.029	426.603	NE cor. 13th & Jackson Sts. Top of hydrant.
Waco	G_4	126.304	414.382	NW cor. 5th & Jackson Sts., brick bldg., bottling works. 10″ below 3rd window from front of bldg. on side towards MKT main track.
Hewitt	H_4	199.685	655.134	Betw. 2 poles, 100 yds. N of Sta. 70″ W of MKT track.
Lorena	I_4	179.600	589.237	100′ E of MKT track in rocky ground about 2 poles S of water tank, and near road, across track from gin.

Eddy	J_4	204.513	670.973	45′ W of track, 300 yds. N of depot. Rocky ground.
BELL COUNTY:				
Troy	K_4	206.686	678.102	5′ S of 2d pole S of depot; 50′ E of MKT track.
Temple	L_1	205.254	673.404	At MKT & GCSF crossing between a telephone pole and its guy pole 60′ W of Katy & 40′ N of GCSF.

ELEVATIONS

Waco, S. A. & A. P. Ry.	400	
Crossing, S. A. & A. P. and St. L. S. W. Ry.	400	
M., K. & T. Ry.	414	
Crossing M., K. & T. and St. L. S. W.	412	
Top of hydrant at South First and Jackson Sts.	403	—U. S. C. & G. S.
BMon building at 5th and Jackson Sts., occupied by bottling works	414	—U. S. C. & G. S.
Top of hydrant, 13th and Jackson Sts.	427	—U. S. C. & G. S.
Abbott, M., K. & T. Ry. U. S. C. G. & G. S.	713	
Aquilla, T. C. R. R.	525	
Axtell, St. L. S. W.	524	
Battle	568	
Bruceville, M., K. & T. Ry. U. S. C. & G. S.	592	
Burdette, siding	458	
Crawford, G. C. & S. F.	687	
Elm Mott, M., K. & T. Ry. U. S. C. & G. S.	518	
B. M., south of sta. U. S. C. & G. S.	515	
Hallsburg	500	
Hewitt B. M., north of M., K. & T. station. U. S. C. & G. S.	656	
Harrison	460	
Hewitt (weather bureau)	664	
Lorena, M., K. & T. U. S. C. & G. S.	593	
Lorena B. M. in rocky ground S. of water tank U. S. C. & G. S.	589	
Mart	510.5	
McGregor, G., C. & S. F.	713	
G., C. & S. F. and St. L. S. W.	712	
Moody, G., C. & S. F.	783	
Norwood, S. A. & A. P.	388	
Ross, T. C.	575	
South Bosque station platform	480	
West, M., K. & T. Ry. (U. S. C. & G. S.)	648	

West, B. M. building, two doors north of National Bank (U. S. C. & G. S.) 655
Eddy, M., K. & T. (U. S. C. & G. S.) 671
Waco, M., K. & T. track at 5th St. (south rail of middle track) 410.266
Amicable Building, 5th and Austin (sidewalk at corner of building) 412.6
Bridge of Crawford (Fish Pond) road over South Bosque River at Rifle Range. Northeast corner of concrete block on northeast pier 447.03

The Amicable Life Insurance Building is visible from many places near Waco and can be used for stadia work. The upper stories are each 11 feet tall except the 3rd and the 20th, which are 13 1/2 feet each. Sidewalk at corner of 5th and Austin streets 412.6 feet; elevation roof of building 658.6; top of flagpole 715.6; elevation of tower 694.6 feet.

THE GEOLOGIC SECTION

The marine formations found at the surface in McLennan County are all of Lower Cretaceous (Comanchean) and Upper Cretaceous age. The Comanchean rocks are underlain by a considerable thickness of shales and other sediments of Pennsylvanian age. These in turn are underlain by a little investigated group of diverse metamorphosed ancient sedimentary or other rocks of questionable age, generally considered Pre-Cambrian. The following table gives the succession of the rocks that have been recognized at the surface or in drilling in McLennan County, and their supposed correlation, with the sections of north-central Texas and south-central Texas.

GEOLOGIC SECTION IN McLENNAN COUNTY AND APPROXIMATE EQUIVALENTS IN NORTH AND SOUTH CENTRAL TEXAS

		Waco	Austin	Fort Worth-Dallas
Recent		Soil, gravel, sand, etc.		
Pleistocene		Low terrace Middle terrace High terrace	river terraces	river terraces
		Unconformity		
Upper Cretaceous		Taylor Austin Eagleford { shale, flags, shale } Woodbine	Taylor Austin Eagleford { shale, flags, shale } ------------	Taylor Austin Eagleford Woodbine
		Disconformity		
Comanchean (Lower Cretaceous)	Washita Division	Buda Del Rio Georgetown (7 members) { Mainstreet (in part), Pawpaw, Weno, Denton, Fort Worth, Duck Creek, Kiamitia }	Buda Del Rio Georgetown	------------ Grayson (Upper three fourths of the Del Rio) Mainstreet* Pawpaw Weno Denton Fort Worth Duck Creek Kiamitia
	Fredericksburg Division	Edwards Comanche Peak Walnut	Edwards Comanche Peak Walnut	Goodland Walnut
	Trinity Division	------------ Glenrose Basal sand	------------ Glenrose Travis Peak	Paluxy Glenrose Basement sand
		Unconformity		
Pennsylvanian		Bend series	------------	------------
		Unconformity		
Pre-Cambrian		Slates, schists, etc. (formations unnamed)	------------	------------

*The Mainstreet includes the lower about one-fourth of the Del Rio.

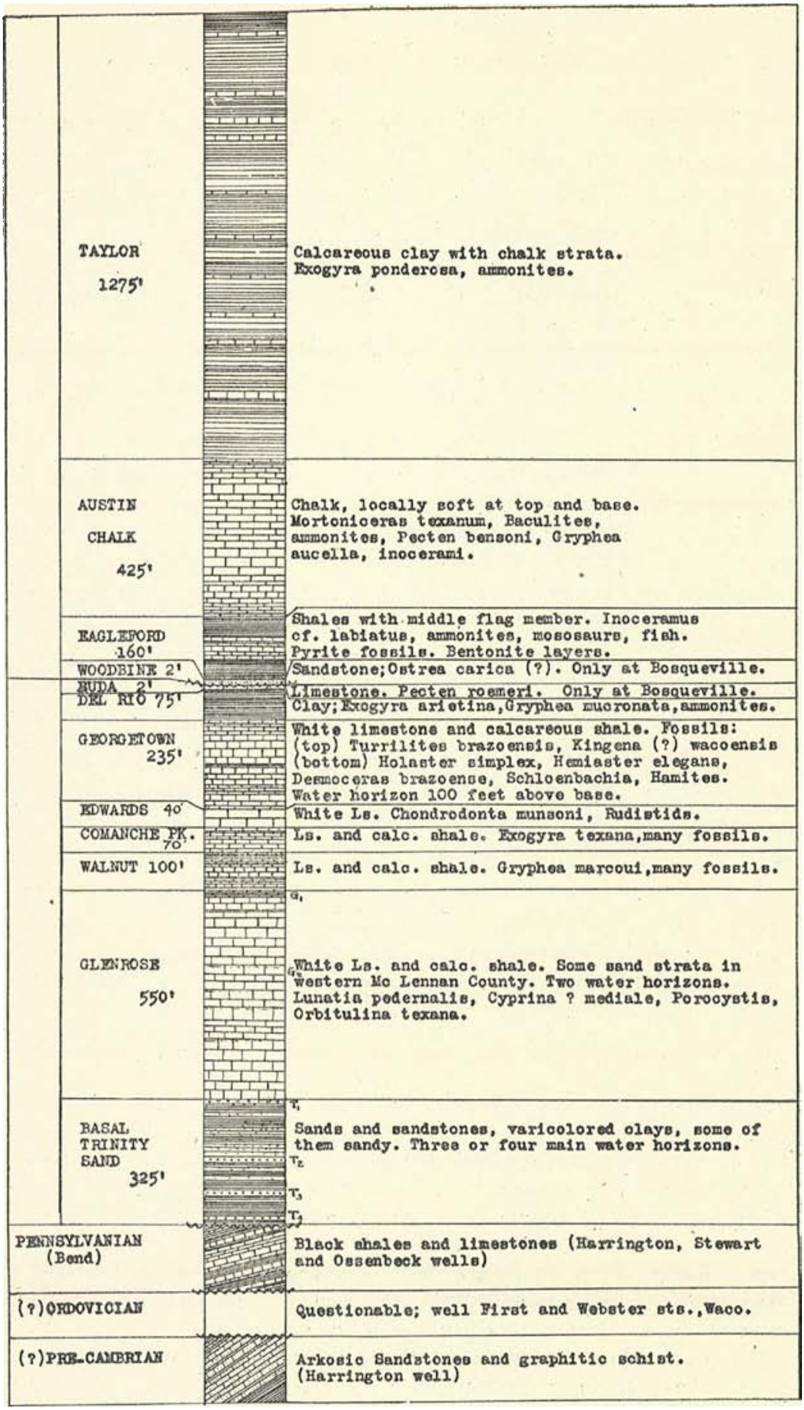

Fig. 3. The geologic column in McLennan County.

The classes of material beneath the surface, reached in wells but not exposed areally in McLennan County, are described under the Geologic Section. The materials which occur at the surface are of three classes:

(1) There are land derived deposits which have never undergone marine water action. Such materials are caliche, and detrital rock and soil which has been degraded in nearly its present position from marine deposits. These materials have been produced by land and subaerial erosion and other forces.

(2) There are fresh water stream deposits, as gravel, sand, soil and certain clays, which have been washed by streams from their original position and deposited where they now occur. These materials have usually in the past and at present been deposited in terraces, whose age can be determined by the fossil remains, elephants, mastodons, snails, etc. which they contain. The highest terrace is the oldest, Pliocene or Pleistocene, and the three main river terraces are Pleistocene.

(3) The great bulk of the material visible at the surface in McLennan County is marine sedimentary material deposited beneath the Comanchean and Cretaceous seas which covered this area. These strata are minutely classified, and consist of diverse materials, corresponding to the various marine formations (limestone, marl, clay, sand, etc.) which prevailed in the area at the time of deposition. These lithologic variations are discussed in the Section on the geologic column.

Stratigraphically the area included in McLennan and adjoining counties is one of the most interesting and significant in the whole Comanchean. The region displays particularly the following stratigraphic features:

(1) The Georgetown limestone problem: In the area northwest of Waco, the North Texas formations composing the Georgetown limestone of Central Texas consolidate to produce this formation.

(2) The Woodbine-Buda problem: The Woodbine sand in passing southward thins, and in the vicinity of Waco disappears at its outcrop by overlap of the Eagleford shales onto the top of the Comanchean, there being locally at least, a disconformity at this stratigraphic level south of Waco. Almost coincidently the Buda formation becomes a distinct limestone member thickening rapidly towards the south.

(3) The Del Rio formation south of Waco is represented north of

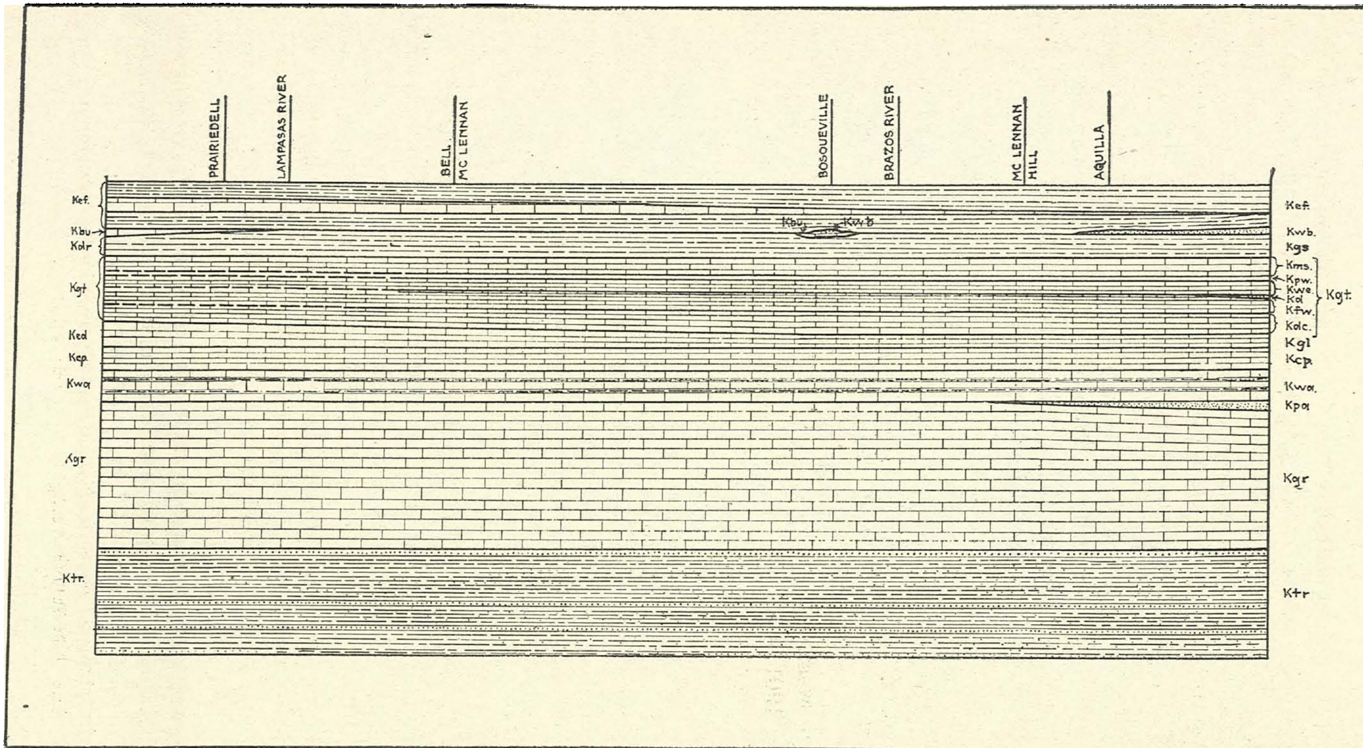

Fig. 4. North-south changes in the Comanchean forma tions near McLennan County.

Waco by two formations. The upper three-fourths of the Del Rio is equivalent to the Grayson marl and the lower one-fourth is equivalent to the upper part of the Mainstreet limestone.

(4) The Paluxy sand facies of the north disappear in the region of Waco and is represented to the south by a thinned off-shore facies.

(5) The basement sand of North Texas changes south of Waco to an off-shore marly-limy facies.

(6) A Pre-Cambrian structurally high area underlying this region accounts for certain of the depositional features just enumerated.

(7) The Balcones faulting system in crossing this structurally high area, changes its composition and relations.

The county thus lies in a region of considerable changes of facies and thickness in various Cretaceous formations. If these surface formations, especially the relations and extent of the Woodbine, had been properly understood before the time of extensive drilling for oil east of McLennan County, much wasted effort and money would have been saved.

In 1901 R. T. Hill wrote, concerning the need for a geological survey of the county:

"It is to be regretted that no minute geological survey of McLennan County has been made, as it is one of the most important areas in the State. The writer has had opportunity to make a few brief reconnaissances, sufficient to determine the sequence of the formations, but more accurate details are needed concerning the exact thickness of these formations and their areal distribution, and the course of the Balcones fault line across the county."

McLennan and Hill Counties are typically transitional between the north and south Texas sections; the limestones are calcareous argillaceous and the formation thicknesses are intermediate; they lie at the junction of the Woodbine and Buda, of the flag and shale facies of the Eagleford, and at the point of southward disappearance of the Paluxy sand; they have a softer Fredericksburg like north Texas with, however, the rudistid-coral fauna of south Texas; the various Georgetown members are recognizable, though due to the virtual disappearance of the soft members do not have the topographic distinctness ("terraces" etc.) of north Texas.

Bell County on the other hand is markedly southern in aspect; the Fredericksburg has hard, thinner bedded strata like the southern section, with chert (lacking in McLennan County), and the typical rudistid fauna is well developed; the topography and vegetation have a south Texas aspect; and the Balcones fault with its associated large fissure springs is present. Needless to say the changes across Texas within each formation are very gradual.

PRE-CAMBRIAN (?)

One well in the county, the Harrington well about 5 miles north of Waco, reached strata which have been doubtfully assigned to the Pre-Cambrian. As can be seen from the sample descriptions, these consist of arkosic quartzite, graphitic schist and other ancient looking rocks. Dr. Udden has noted precambrian rocks from wells at Georgetown and Leon Springs and has presented evidence indicating an old line of structural disturbance in this Comanchean basement complex along the Balcones Fault zone. It is evident that the floor upon which the Comanchean rests consists of different materials at different places; in the Harrington well the sediments described are reached almost immediately underneath the Comanchean; in the Waco City Well (First and Webster Sts.) strata suspected of being early Paleozoic were reached; and in the Stewart and Ossenbeck wells the Comanchean was underlain by shales and limes generally considered to be of Pennsylvanian age. It is probable also that this floor was irregular since the Harrington well, judging by the thickness of Trinity beneath the water sands, apparently contained a thicker basal Trinity than either the Ossenbeck or the Stewart well, indicating its location in a depositional trough.

PALEOZOIC

Ordovician or Earlier (?)—Of the four wells in McLennan County which reached rocks older than the Trinity, the Waco City well is apparently the one in which it has been surmised that Lower Paleozoic, possibly Ordovician was reached at about 2400 (?) feet. This sample was stated to be fossiliferous, but neither its exact depth nor its lithologic character is known to the writer.

With regard to the possible existence of Lower Paleozoic at Waco, Mr. E. G. Woodruff says:

" . . . Late in the fall of 1914, while passing through Waco, I visited a well, which was being drilled near the center of the town. I cannot give you the street name at present, but it was really in the business part of the city. I procured a sample from the well, which was two or three inches long, approximately two inches wide and an inch thick. The specimen came from about 2400 feet. Lithologically this appeared to be older than the Upper Paleozoics. As I remember the specimen, there were some fragmentary fossils in it. I took it with me on one of my trips to Washington, and showed it to some of the men of the United States Geological Survey, who expressed the opinion that it was probably as old as Ordovician. I do not recall just who expressed this opinion, or whether or not it was based on the fragmentary fossil evidence. At any rate, I considered the evidence too imperfect to form a basis for scientific conclusion. Therefore, I neither published on it, nor presented it to others, who were working on the problem. Personally I am inclined to think that the specimen came from Lower Paleozic. . . . "[3]

Pennsylvanian—The Ossenbeck, Harrington and Stewart wells reached pre-Comanchean black shale, slate and limestone, probably belonging to the Bend Series. These were reached in the Ossenbeck well at 1540 feet, in the Harrington well at about 2215 feet, and in the Stewart well at 1235 feet. Writers have generally regarded the Pennsylvanian formations of the Central Mineral Region as passing gulfwards under this region. Plummer[4] says: "Regarding the Bend at Waco, I am quite positive that the Bend group is present east of the Llano Mountains as far as the Balcones Fault at depths that can be reached. Probably it will contain more shale and less limestone than on the outcrop. East of the Balcones Fault I am not sure what has happened It may be that the Bend is present but very deep, and it may be that it plays out against an old shoreline."

Paleozoic-Mesozoic Contact

Throughout Texas so far as known, except in the Malone (Torcer) and Quitman Mountains area, the marine Cretaceous

[3]Extract from letter to Dr. J. A. Udden, Oct. 7, 1919.

[4]Letter, October 7, 1920.

sediments lying below the Travis Peak are absent, the interval being represented by a large unconformity at the base of the existing earliest Comanchean, of whatever age this may locally be. The earliest Comanchean is of younger age in north Texas than in south or southern Trans-Pecos Texas; in McLennan County it is of Trinity age. In the wells of this county, after the usual three or four Trinity waters are penetrated, the basal Trinity may be recognized by its varicolored sands and clays.

CRETACEOUS

The Texas Cretaceous is divided into two series: the Lower (Comanchean), and the Upper (Gulf). The two series in some places, including McLennan County, are separated by a considerable non-conformity, the amount of which is unknown, due to lack of detailed stratigraphic and faunal data. The Woodbine, which in north central Texas lies at the base of the Upper Cretaceous between the Eagleford and Grayson formations, is here largely absent, in part at least due to subsequent erosion. The total thickness of the Lower and Upper Cretaceous in the county is about 3259 feet, divided as follows (average thicknesses):

		Feet.	
	Taylor	1275+	
	Austin	425	
	Eagleford	160	
	Woodbine	2	
Total Upper Cretaceous			1862
	Buda	2	
	Del Rio	75	
	Georgetown	235	
	Edwards	40	
	Comanche Peak	70	
	Walnut	100	
	Glenrose	550	
	Basal Sands	325 (max. 490?)	
Total Lower Cretaceous			1397
Total Cretaceous			3259

COMANCHEAN (LOWER CRETACEOUS)

The Comanchean Series in this county consists of three divisions: Trinity, Fredericksburg and Washita, in ascending order. The total thickness of the series is about 1397 feet.

Trinity Division

The Trinity division in McLennan County consists of two rather heterogeneous formations: the Basal Sands (equivalent in part to the Travis Peak formation farther south), and above, the Glenrose Limestone. The Paluxy Sand as such is supposed to be absent under McLennan County, its southernmost outcrops being mapped on the Leon River in southern Hamilton County; its reduced limy equivalents are probably present beneath the county. In McLennan County no formation of the Trinity division appears at the surface, the only available data regarding its thickness and distribution being derived from well logs and samples. The Trinity division is about 875 feet thick under McLennan County.

Basal Sands of Trinity Division

This formation in wells is easily recognized as a varicolored, water-bearing sand series below the Glenrose limestone. There are three well-defined water horizons, and logs of a few deeper wells indicate a fourth. The average spacing of these water sands seems to be:

T_1 to T_2 about 150 feet.
T_2 to T_3 about 100 feet.
T_3 to T_4 about 60 feet.

In the Harrington and Ossenbeck wells a hot water stratum is intercalated about midway between T_1 and T_2. Some wells, like the Harrington well have irregularities in the spacing of the water horizons, possibly due to the fracturing of the strata by faulting. The Harrington well seems to contain more Basal Trinity than the other deep wells; the Stewart well has thin Basal Trinity.

Thickness of Basal Sands: Stewart well, 260 feet; Ossenbeck well, 310 feet; Filtration Plant No. 2, 359 feet; Harrington well, 490 feet. Further information on these sands is presented in the discussion of artesian waters.

Glenrose Formation

The Glenrose Limestone is one of the most easily recognized formations in McLennan County wells. It consists of medium hard limestones, softer argillaceous limestones and some shales; the sands are of small amount, except that in several wells in the west part of the county sand strata are recorded; the water occurs in porous limestones. Two Glenrose waters are widespread, one near the top and the other near the middle of the formation. The Harrington well showed in the Glenrose, as in the Basal Sands, irregular water relations, including a stratum of hot water at 1330-1350, apparently in the upper third of the Glenrose. The highly mineralized (magnesium sulfate, etc.) water reported by Hill from 1180 feet in the Padgett well, and occuring in the mixed water flowing from the Harrington well (see analysis), appears to be in the top of the Glenrose.

Approximate thickness of Glenrose:

	Feet
Texas L. & P. Co.	460
Ossenbeck well	510
Stewart well	510
Harrington well	530
Padgett well	554
Belrose test	555
Filtr. Plant No. 2	567
Threet test	576
1st & Webster	593

Some of this variation is undoubtedly due to defective well records and interpretation.

Fossils: Among the fossils of this formation are the following: *Orbitolina texana*, rudistids, *Chondrodonta*, *Lunatia pedernalis*, *Nerinea*, large gastropods, *Cardium mediale*

Equivalents of the Paluxy Formation

The Paluxy sand thins and becomes calcareous on passing down the valley of the North Bosque, and from McLennan County southwards into south-central Texas may be considered absent as a water and oil bearing horizon. The difference of a few feet between top Glenrose and Paluxy cannot be detected in well logs but since the waters near this level occur in the top part of the thick limestone series, they are assigned to the Glenrose formation. This interpretation is borne out by a study of the nearest outcrops. Under these conditions it is impossible to state from well data what thickness of limestone under McLennan County if any, should be considered the age equivalent of the Paluxy sand of north-central Texas.

Fredericksburg Division

The Fredericksburg division in McLennan County consists of three formations, as follows, in ascending order: Walnut, Comanche Peak, and Edwards. The Edwards is a thin formation of massive limestone and over wide areas resists erosion so that it forms the caps of hilltops, while the other two formations are softer and generally form more receding exposures in cliffs, or steep slopes in hillsides. These formations taken together, weather in this region into a topography characteristic of the edge of Lampasas Cut Plain. The Edwards and Comanche Peak are equivalent to the Goodland limestone of North Texas.

The Fredericksburg division is about 210 feet thick in this county; of its formations, the Comanche Peak is the lowest which outcrops at the surface.

Walnut Formation

The Walnut formation is not exposed at the surface in McLennan County, and is inconspicuous in well samples. It consists of shelly limestone and calcareous clay layers lying beneath the Comanche Peak limestone and is the basal formation of the Fredericksburg division. Its nearest outcrop is in the valley of the Leon River in Coryell County, where it underlies the massive Edwards and Comanche Peak bluffs bordering the Leon River and Coryell creek valleys and forms the floor of the valley upstream nearly to Gatesville. West of Gatesville it occupies the stream divides. Its outcrop thus covers nearly half the area of Coryell County. In the valley of the North Bosque River Hill[4] gives the following section:

Section No. 20. Bosque River Valley.

	Feet.
Comanche Peak Formation:	
6. Calcareous and argillaceous, chalky, white and light blue limestone, which contains in its upper portion *Exogyra texana*, in their greatest development in point of size, *Enallaster texanus*, *Epiaster elegans*, *Holectypus planatus*, *Sphenodiscus pedernalis*, *Gryphea marcoui* and casts of gastropodos	15
Walnut Clays:	
5. Uppermost *Gryphea marcoui* zone; compact thin layers of limestone. The fossils are small and are cemented in the hard limestone	3
4. Marly white to buff limestone bearing but few fossils..... Fragments of oyster shells and fossil casts occur. On weathering, the marly lime breaks up into soft marl and angular balls of marly lime.	25
3. Middle *Gryphea marcoui* zone; composed of layers of hard and semi-crystalline lime, bearing numerous individuals of small *Gryphea marcoui* fossils.....................	3
2. Marly limestone beds .... The limestone layers composing this bed are of varying thicknesses. Occasional hard bands project from the surface and leave fragments of limestone on the sloping hillsides.	30
1. Soft marly and compact semi-crystalline limestone in alternating layers, varying in thickness from very thin bands to beds 3 to 4 feet thick	35
Paluxy Sand.	

In the Threet test at South Bosque station, strata assigned to the Walnut aggregate about 96 feet in thickness; in the nearby Belrose test they are about 105 feet thick. In the McLennan County wells, the Walnut seems to average about 100 feet. It thickens somewhat on passing east from its out-

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[4]R. T. Hill, U. S. G. S., 21st Ann. Rept. pt. 7, p. 206.

crop. The horizon of the South Bosque oil is a thin sand near the base of the Walnut.

Fossils: The Walnut in this region is often recognizable by the presence of indurated limestone strata which contain great numbers of *Gryphea marcoui* in shell banks, and *Exogyra texana*.

Comanche Peak Formation

The Comanche Peak limestone underlies the Edwards and outcrops in a restricted area in western McLennan County in the sides of the dissected hills which form the east edge of the Lampasas Cut Plain. The outcrop occupies a narrow valley strip along the Middle Bosque River as far downstream as the mouth of Bluff Creek west of Crawford. The floor of the intrenched gorge of Bluff Creek is this formation. It skirts the base of the hills around Valley Mills and follows the North Bosque downstream for about two miles below the Bosque-McLennan County line. East of these points throughout the county the formation is buried beneath Edwards and later formations.

In this region the Edwards limestone forms the massive cap of the uplands, and the top of the Comanche Peak limestone is lithologically transitional to the Edwards. The middle and base of the Comanche Peak formation contain alternating layers of limestone and calcareous clay, which are highly fossiliferous. On the Meridian Highway about 1.5 miles east of Valley Mills the hillsides show good exposures of fossiliferous Comanche Peak limestone and marl, containing *Hemiaster whitei* Clark, *Enallaster texanus* (Roemer), *Engonoceras piedernale* v. Buch, *Schloenbachia* spp., *Schloenbachia acuto-carinata* (Shumard), *Cerithium bosquense* Shumard, *Turritella* cf. *seriatim-granulosa* Roemer, *Tylostoma chihuahuense* Böse, *Tylostoma tumidum* ( ) (Shumard), *Lunatia pedernalis* Roemer, *Rostellaria* sp., *Exegyra texana* Roemer, *Protocardia texana* (Conrad), *Isocardia* sp. corals, serpuloids and many other fossils. Similar very fossiliferous exposures occur west of Valley Mills along the Coryell City road, northwards along the Meridian road, and in the Santa Fe cuts near the station.

Farther south in the county, at Bluff Creek, the limestone is more pure and carries a special fauna, as noted in the discussion of the Edwards limestone.

Thickness—Hill considers the Comanche Peak to be about 65 to 70 feet thick in this region. It probably thickens towards the east. In wells it is difficult to separate from adjacent formations.

Edwards Formation

The Edwards formation in McLennan County is a massive limestone about 40 feet thick. It outcrops in two connected areas: (a) along the Middle Bosque River from a point two miles west of Windsor northwest to the Bosque County line, including the area east of Crawford and along Bluff Creek; and (b) along the North Bosque River, near Valley Mills.

The limestone, although thin, is relatively resistant to erosion and caps the hills and divides in its outcrop. When exposed along streams, it usually forms vertical or overhanging bluffs with smooth faces and obscure bedding planes. The marlier Comanche Peak limestone beneath erodes more rapidly and leaves the Edwards projecting in long straight corniced massive ledges. Along Bluff Creek and elsewhere, the stream is deeply intrenched in a canyon with vertical walls, cut through a flat Edwards plain, and the topography has every aspect of the intrenched streams in the Edwards canyon region near Del Rio and in Trans-Pecos Texas, which produce some of the most rugged and picturesque scenery in Texas.

Near Valley Mills, the northernmost exposure of this formation in the county, the Edwards follows the hilltops on both sides of the North Bosque, and the slopes and valleys contain fine exposures of the highly fossiliferous Comanche Peak limestone, as far down as the zone of abundance of *Exogyra texana* Roemer. The Santa Fe cuts south of the town, the slopes just north of the river northwest of the town, and various exposures about a mile west of the town on the south side of the track furnish practically a complete section of these strata.

At Patton, the bed of Hog Creek at the wagon road bridge exposes the *Schloenbachia trinodosa* zone, the *Desmoceras brazoense* zone, and the *Hamites-Kingena* zone of the basal Duck Creek limestone, which overlies about three feet of Kiamitia marly limestone with typical fossils. Beneath this is the Edwards. On the North Bosque River 3.3 miles southwest of China Springs is a long cliff which exposes the basal members of the Georgetown (Kiamitia to Weno), and below them a few feet of indurated extremely fossiliferous Edwards limestone. The limestone is almost pure calcium carbonate and consists of a twisted mass of *Ichthyosarcolites*, *Requienia*, *Chondrodonta munsoni* (Hill), and numerous other fossils. Locally it contains pyrite concretions. These fossils occur in vast numbers and make up the bulk of the upper strata of Edwards. This horizon in this region can be traced over the entire Edwards outcrop.

The easternmost exposure of the Edwards on the Middle Bosque is two miles west of Windsor. Thence the formation follows the river up to Crawford, and passes just east of the town. The *Desmoceras* zone and other basal Duck Creek zones may be seen on the Waco road between Crawford and the iron bridge over Tonk Creek. The new Crawford-Patton road exposes the Edwards-Kiamitia contact just east of the Middle Bosque bridge. Bluff Creek has cut its valley through the Edwards limestone and its bed lies on the underlying Comanche Peak limestone. The Edwards area follows this creek from its mouth west to the Coryell County line; the surrounding uplands are Washita, rising as high as the Fort Worth limestone. The best sections of Edwards on Bluff Creek are on the crossing of the Crawford-Coryell city road, 3.5 miles north of west of Crawford.

The Edwards outcrop turns south from the Middle Bosque valley just west of Osage and turns southeast along the east bank of the Leon River valley keeping within Coryell County to a point below Whitson.

Section of Edwards and Comanche Peak Formations on Meridian Highway, 2 miles east of Valley Mills.

	Feet.
Edwards:	
Massive limestone, rather pure, slightly iron-stained, grayish on weathering. Fossils: *Ichthyosarcolites anguis*, *Chondrodonta munsoni*, *Requienia texana*..................	12
Soft limestone, chert; *Exogyra texana*	10
Nodular whitish limestone, projecting ledge	5

	Feet.
Soft nodular, whitish, slightly argillaceous limestone, receding ledge; *Lima wacoensis*	3
Harder white limestone, nodular, projecting	2
Comanche Peak:	
White, soft, fossiliferous limestone, projecting exposure; *Enallaster texanus*, *Hemiaster whitei*; *Tylostoma* sp., *Cerithium bosquense*, *Natica* sp.; *Exogyra texana*; *Schloenbachia* spp.	20
Soft white argillaceous fossiliferous limestone	15

Section of Edwards Limestone, 2 miles west of Windsor, in Middle Bosque River.

	Feet.
Kiamitia:	
Yellowish calcareous clay	5
Edwards:	
Shell breccia, white crystalline nearly pure limestone, at places iron-stained	3.5
Nodular white limestone	2
Gray limestone	3
Massive gray limestone	15

Dr. Pace has collected above the railroad bridge at Patton *Schloenbachia acutocarinata*, *Ichthyosarcolites anguis*, *Nerinea* sp., *Ostrea* sp., *Trigonia* sp., *Pecten irregularis*, *Tapes* sp., *Cardita* sp., *Gryphea marcoui*, *Tylostoma chihuahuense*, and *Engonoceras* cf. *piedernale*.

Edwards and Comanche Peak Limestones at west crossing of Bluff Creek, 3.5 miles northwest of Crawford.

		Feet
13.	Hard crystalline limestone projecting	1.5
12.	Softer crystalline limestone, receding	1.0
11.	Hard limestone, with small cavities; projecting	4.0
10.	Softer powdery limestone, receding	1.2
9.	Hard limestone, projecting; stalactites	1.9
	The above compose the three rather thin projecting ledges seen near the top of the Edwards at all Bluff Creek localities. They are very fossiliferous and contain the Upper Rudistid Horizon.	
8.	Receding limestone, rounded at top	10.0
7.	Limestone, massive, soft, crystalline, rounded	10.0
6.	Soft limestone, locally cavernous, receding	1.0
5.	Thick limestone, somewhat cavernous; projecting	7.0
4.	Soft fossiliferous limestone, very cavernous; receding	

		Feet.
	Lower Rudistid Horizon; salenids, *Trochus texanus* Roemer	6.0
3.	Massive limestone; projecting	5.0
2.	Massive softer nodular limestone; receding	6.0
1.	Massive limestone, thin-bedded on weathering, forms ledge; projecting	6.5

This section is rather uniform at all Bluff Creek localities examined, and the strata are relatively persistent although they grade into each other. Farther north, in Bosque County, the limestone is more nodular and impure, the strata here enumerated are not distinct and the section more resembles the north Texas (Goodland) section. For fossils see the following tabulation.

The Bluff Creek locality northwest of Crawford has been visited by various geologists; through the kindness of Dr. T. W. Stanton I have been enabled to examine the collection in the United States National Museum, which contains:

cf. Caprina crassifibra Roemer.
Caprinula (Ichthyosarcolites) anguis (Roemer).
Plagioptychus? cordatus Roemer.
Eoradiolites (Agria?) davidsoni (Hill).
Monopleura sp.
Radiolites sp.
Requienia texana Roemer.
Requienia sp.
Caprina sp.
Caprotina sp.
Pecten occidentalis Conrad.
Pecten duplicicosta Roemer.
Chondrodonta munsoni (Hill)
Lima wacoensis Roemer.
Pleuromya (?) sp.
Protocardia texana (Conrad).
Gryphea marcoui Hill and Vaughan.
Lima sp.
Nerinea sp.
Cerithium bosquense Shumard.
Tylostoma tumidum (Shumard).
Turritella seriatim-granulosa Roemer var.
Aporrhais sp.
Parasmilia austinensis Roemer.
Cladophyllia furcifera Roemer.
Terebratula sp.
Enallaster texanus (Roemer)

The limestone at Bluff Creek and elsewhere in central McLennan County is of almost pure calcium carbonate. Analysis follows:[5]:

Fredericksburg Limestone from Crawford:

Silica	trace	
Al_2O_3	0.60	
Fe_2O	trace	
CaO	55.60	
CO_2	43.68	Total 100.08

This is reputed to be the purest limestone in the State

There are scattered areas in the Edwards and Comanche Peak of Central Texas which are composed of nearly pure calcium carbonate and which invariably carry a peculiar rudistid-coral fauna, thus indicating a special facies of deposition in these areas .

Such areas are:

(1) Bluff Creek, McLennan County, and nearby exposures.

(2) Oglesby, Coryell County. There is a considerable thickness of nearly pure limestone on both sides of the railway near Oglesby in three main localities partly outliers. This rock has been extensively quarried, and is too soft for ballast though it has been used on fills, as at South Bosque station, and is valuable for purposes for which a high purity of limestone is required.

(3) Belton, Bell County, Santa Fe quarry, 5 miles west of town. Nearby there are pulverulent layers of nearly pure calcium carbonate interbedded in the Comanche Peak limestone. The quarry contains a rich fauna, especially of corals, rudistids and echinoids, suggesting a rudistid-coral reef facies

This particular facies will probably be found widespread in the Fredericksburg division. It will be noted that many of the fossils were described by Roemer and C. A. White from somewhat similar deposits near Austin. The pulverulent layers in the Fredericksburg are known from widely separated localities The rudistid-coral fauna is also widespread in the area north of San Antonio.

J. K. Prather[6] lists from the Edwards limestone:

Enallaster texanus (Roemer)
Holectypus planatus (Roemer)

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[5]Univ. Texas Bull. 365, p. 174; Univ. Texas Bull. 1814, pp. 44, 177.

[6]Trans. Texas Acad. Sci., 1900

Crinoids
Terebratula sp.
Radiolites rugosa (Giebel)
Radiolites davidsoni Hill
Monopleura marcida White
Monopleura coralliochama (Stanton)
Ostrea munsoni Hill
Hippurites texanus Roemer
Cerithium bosquense Shumard
Tylostoma tumidum Shumard
Schloenbachia wacoensis (Roemer)

Washita Division

Georgetown Formation

The Georgetown formation in McLennan County is composed of seven well differentiated and partially mapable members, as follows from the base upwards: Kiamitia, Duck Creek, Fort Worth, Denton, Weno, Pawpaw and Mainstreet. These members are the stratigraphic and paleontologic equivalents of the formations of the same names in north-central Texas and southern Oklahoma, and their relations with these formations have been accurately traced. Each formation of the Washita group, on passing southwards from Tarrant County gradually becomes thinner, and this is especially true of the softer formations of the north Texas section (Kiamitia, Denton, Pawpaw), which in Hill and McLennan counties are inconspicuous receding ledges of marly limestone, noticeably more calcareous than farther north. The intervening harder formations of the north Texas section (Duck Creek limestone, Fort Worth, Weno, Mainstreet) are conspicuous members in McLennan County, having outcrops over considerable areas and appearing as massive projecting exposures in stream cuts. On account of the inconsecutive nature of the Georgetown exposures, two good sections will be especially detailed, and will serve to describe the lithologic and thickness changes in this region. The more northern of these exposures is in the channel of an east lateral of the Brazos beginning about 1.5 miles west of Aquilla in southern Hill County. The other is on the North Bosque River, 3.5 miles (air line) southwest of China Springs.

Section of Georgetown and higher formations in creek about 2 miles south of west of Aquilla, Hill County, Texas.

	Feet.
Eagleford:	
Blue shale and layers of variously colored indurated shale and sandstone. Fossils: *Inoceramus* sp	20
Brown sandstone, fossiliferous	1
White sandstone	0.8
Blue shale	2
(Possibly part of this section is of Woodbine age.)	
Woodbine:	
Sandstone layers and interbedded blue shale, about	9
Del Rio:	
Yellowish jointed clay, blue on fresh exposure, with thin platy sandy flags near base; pyrite and iron oxids, some gypsum; considerable exposures in a dissected hillside just west of the R. E. Finley well. Extensive Del Rio limonite fauna; fossils: °Turrilites sp., °Flickia (?) bosquensis, °Schloenbachia sp., °Acanthoceras worthense, °Turritella sp., °Nucula sp., °Plicatula sp., Gryphea mucronata, Exogyra arietina, Pecten subalpinus, Pecten texanus	55+
Georgetown:	
Mainstreet member: At base of preceding Del Rio exposures: Argillaceous limestone and calcareous clay, *Turrilites brazoensis* and other typical fossils. In tall cliffs down creek: Vertical cliffs of rather massive white limestone, locally strata one foot or less thick. Fossils: *Kingena wacoensis*, *Exogyra arietina*, *Pecten* spp., *Turrilites brazoensis*, about	35
Pawpaw member: Receding ledges of soft marly limestone..	5
Weno member: Vertical exposure of alternating white chalky nodular limestone and softer argillaceous limestone. Fossils: *Epiaster* sp., *Holaster* sp., *Alectryonia* sp., (zigzag), *Plicatula* sp., *Pecten* spp.	50
Denton member: Soft argillaceous limestone, receding exposure, about	3
Fort Worth member: Vertical exposure of thin bedded argillaceous nodular white limestone. Fossils: *Hemiaster longisulcus*, *Hemiaster elegans*, *Epiaster aguilerae*, *Exogyra americana*, *Schloenbachia leonensis*, *Schloenbachia* spp....	10

(About 20 feet more of Fort Worth limestone is exposed with characteristic fossils near the mouth of this creek, and nearby cliffs down the Brazos expose a similar section.)

The R. E. Finlay No 1 well, 1.5 miles west of Aquilla penetrated 12 feet of surface soil and 4 feet of water gravel; from

16 to 100 feet was Eagleford (?), thinned Woodbine and Grayson, there being possibly 20 feet of Eagleford and about 9 feet of Woodbine

Exposure of the Georgetown formation on the North Bosque River, 3.5 miles (air line) southwest of China Springs.

	Feet.
Weno and Denton Members:	
White argillaceous nodular limestone	20+
Fort Worth Member:	
Alternating compact and argillaceous white limestone. Fossils: *Gryphea washitaensis* (abundant), *Hemiaster elegans* (typical), *Schloenbachia leonensis, Epiaster* aff. *wenoensis, Protocardia* sp.	27
Duck Creek Member:	
Argillaceous white limestone with interbedded calcareous clay; forms receding exposure. Fossils: *Schloenbachia trinodosa* Böse, *Gryphea washitaensis, Gryphea corrugata, Pecten subalpinus*	4
Nodular white limestone; forms projecting exposure. Fossils: *Gryphea washitaensis*	8
White chalky limestone, top part argillaceous and receding. Fossils: *Schloenbachia trinodosa* (2 feet below top), *Exogyra* sp. aff. *columbae, Gryphea washitaensis, Gryphea corrugata, Nautilus texanus, Kingena? wacoensis, Cardita* sp., *Schloenbachia* spp., *Schloenbachia* cf. *belknapi*, (1 foot above base). The basal 3 feet contains *Hamites comanchensis* and *Hamites* spp. The remainder contains *Desmoceras brazoense*	9
Kiamitia Member:	
Nodular chalky argillaceous limestone. Fossils: *Enallaster* sp. aff. *bravoensis, Schloenbachia* cf. *belknapi, Kingena wacoensis, Protocardia texana, Lunatia pedernalis, Gryphea navia, Pecten irregularis, Pholadomya, sanctisabae*	2.5
Calcareous blue clay; *Gryphea navia, Kingena* sp...........	1.5
Gray indurated calcareous clay; *Lunatia pedernalis?*........	1.0
Edwards Limestone:	
Limestone, gray-blue on exposure, yellowish to white interiorly, porous, locally indurated and pyritic, very fossiliferous. Fossils: *Ichthyosarcolites anguis, Chondrodonta munsoni, Requienia* cf. *texana, Nerinea* sp. (large), *Pleurotomaria* sp. Thickness exposed, about.................	3

Section on Meridian Highway 0.4 mile west of McLennan-Bosque County line.

	Feet.
Duck Creek:	
Whitish, medium hard limestone; Hamites spp., Desmoceras brazoense, Plicatula sp., Gryphea corrugata, Gervilliopsis sp. (small), Schloenbachia spp.	1.5
Soft white limestone; Ostrea sp., Gryphea sp.	1.2
Kiamitia:	
Yellowish argillaceous limestone; shell breccia; Gryphea cf., corrugata, Gryphea navia	0.4
Yellowish sandy shale; Exogyra texana, Gryphea corrugata	5.0
Three nodular clayey limestone layers and interbedded yellowish clay; Gryphea corrugata, Ostrea sp., Pecten cf. subalpinus, Plicatula sp., Turritella sp.	1.5
Yellow-brown clay, calcareous; Tylostoma sp.; Exogyra texana, Gryphea navia, Gryphea corrugata; Alectryonia aff. quadriplicata?, Pecten irregularis Pecten subalpinus, Plicatula sp. This layer is rather sandy	2.0
Edwards:	
White, pure soft limestone, weathering gray; massive; Ichthyosarcolites sp.	

Section of Edwards to Duck Creek formations, Meridian Highway 3.5 miles east of Valley Mills.

	Feet.
Duck Creek:	
White limestone, rounded surfaces on weathering; *Hamites* sp., *Gryphea corrugata*	1.0
Kiamitia:	
Thin gray limestone, shell breccia; *Gryphea corrugata*	0.2
Yellow calcareous clay	3.0
Soft gray limestone and interbedded yellow clay; *Exogyra texana*, *Gryphea navia*, *Gryphea corrugata*, *Ostrea* sp., *Pecten subalpinus*, *Pecten* sp., *Schloenbachia* aff. *belknapi*	4.5
Yellow calcareous clay	2.5

Section of lower Georgetown at bridge across Middle Bosque River, 1.8 miles west of Windsor.

	Feet.
Duck Creek Member:	
White limestone in thin strata with interbedded very calcareous white to gray clay. Fossils: *Hamites comanchensis*, *Hamites* sp., *Desmoceras brazoense*, *Inoceramus munsoni*, *Gervilliopsis* sp., *Pecten subalpinus*	10

A short distance upstream there is a gentle anticline in the Duck Creek beds, with axis running about S 10° W.

Edwards-Georgetown contact below bridge at Patton.

	Feet.
Duck Creek Member:	
White limestone. Fossils: *Desmoceras brazoense, Nautilus texanus, Pecten subalpinus*	12
White limestone in two seams; pyrite balls; *Hamites* sp.	2
Massive shelly white limestone; Fossils: *Kingena?* sp., *Schloenbachia* aff. *belknapi, Inoceramus munsoni, Gryphea* sp., *Plicatula* cf. *incongura*	1
Kiamitia Member:	
Bluish clayey limestone; *Exogyra plexa*	3
Edwards: Gray limestone, white interiorly; exposed	1

Weno and Mainstreet members of Georgetown on Middle Bosque River, east of Windsor.

	Feet.
Medium hard white fractured limestone; projecting ledge	15
Argillaceous, gray limestone; receding ledge	2
Medium hard white fractured limestone	12
Blue clay and iron-stained clay with irregular bedding planes	0.5
Gray limestone; projecting ledge	2.2
Soft marly limestone and calcareous clay; receding exposure; *Schloenbachia* sp. M., *Schloenbachia* sp., *Pecten subalpinus, Isocardia* (?) sp.	4.0
Gray limestone	0.8
White limestone and calcareous clay	8.0

In the tall bluffs along Childress Creek to its mouth, 4 miles north of China Springs, Dr. Pace and students have collected the following fossils representing mainly the Fort Worth Limestone:

Schloenbachia trinodosa Bose.
Schloenbachia aff. leonensis (Conrad).
Schloenbachia sp.
Hemiaster elegans Shumard.
Epiaster aguilerae Böse.
Exogyra americana Marcou.
Pecten subalpinus (Böse).
Pecten texanus Roemer.
Pecten bellula (Cragin).
Gryphea washitaensis Hill.
Alectryonia sp. (zigzag).
Pholadomya shattucki Böse.
Trigonia sp.
Nautilus texanus Shumard.

Pleurotomaria austinensis Shumard.
Turritella aff, seriatim-granulosa Roemer.
Large shark vertebra.

In a small creek near the end of the Artillery Range road, 2 miles north of China Springs, Dr. Pace has collected from high Georgetown (probably Mainstreet) limestone the following hematite fossils:

°Kingena (?) sp.
°Plicatula cf. incongrua Conrad.
°Pecten subalpinus (Böse).
°Arca n. sp.
°Nucula (?) sp.
°Cardita (?) sp.
°Turrilites sp.

Along Eagle Creek the following were found (Fort Worth member):

Hemiaster elegans Shumard.
Schloenbachia cf. leonensis.
Schloenbachia sp.
Gryphea washitaensis Hill.

Above railroad bridge at Patton:

Schloenbachia acutocarinata (Shumard).
Caprinula (Ichthyosarcolites) anguis Roemer.
Gryphea marcoui Hill and Vaughan.
Pecten irregularis (Böse).
Ostrea sp.
Trigonia sp.
Tapes sp.
Cardita sp.

KIAMITIA MEMBER

Exposures: Mainly on streams cutting through basal Georgetown to the Edwards: on the North Bosque, southwest of China Springs, and in the Valley Mills region; Hog Creek at Patton; Middle Bosque near Crawford. Concealed by overwash from the uplands.

Thickness: At Blum, Hill County, the Kiamitia is 19 feet think. On the Meridian Highway 3.6 miles east of Valley Mills this member is about 10 feet thick. On this highway at the McLennan-Bosque county line it is about 9 feet thick. There is an exposure about 2 miles east of Crawford on the Valley Mills road, where the Edwards-Kiamitia contact is visible. On the North Bosque River southwest of China Springs it is about 5 feet thick. There are no exposures in the southwest quarter of the county. South of McLennan County it is a thin marly member at the base of the Georgetown. The formation is indistinguishable in wells.

Fossils: In this region the Kiamitia member contains frequent *Gryphea navia* Hall, *Kingena* (?) sp., *Schloenbachia* cf. *belknapi* Marcou, and various Fredericksburg fossils (*Pecten irregularis*, *Exogyra texana*, *Exogyra plexa*, various gastropods.)

DUCK CREEK MEMBER

This is the basal one of the four principal limestone members of the Georgetown formation in McLennan County. It outcrops in a band ½ to 2 miles broad, above and parallel to the top of the Edwards.

Exposures: Valley Mills region; Hog Creek at Patton; Waco road at Middle Bosque bridge 2 miles east of Crawford; Middle Bosque crossing 2 miles west of Windsor, and elsewhere

Thickness: About 30 feet.

Fossils: The base may be recognized by the occurrence of zones of *Hamites* spp. and of *Desmoceras brazoense* (Shumard), with associated fossils (*Gryphea corrugata, Plicatula* sp., *Gervilliopsis*). Above this is a zone of *Schloenbachia* aff. *trinodosa*. *Holaster* and other echinoids are abundant high in this member

FORT WORTH MEMBER

This member in McLennan County is rather harder and more crystalline than other members of the Georgetown, and it is correspondingly poorer in fossils at most places. It contains a small water bearing horizon in wells in the central part of the county.

Exposures: Childress Creek. Rock Creek, Eagle Creek; Brazos bluffs above Patrick, especially on the east bank of the Brazos; Artillery Range road, northwest of China Springs; Middle Bosque below Windsor; Meridian Highway near Bosque-McLennan county line; creeks north of McGregor, and elsewhere

Thickness: This member has a thickness of about 30 feet.

Fossils: The same fossils as in north-central Texas prevail as horizon markers in this county. *Hemiaster elegans, Hemiaster longisulcus, Epiaster aguilerae, Schloenbachia leonensis,* and *Exogyra americana* are fairly diagnostic of the member, and the abundance of *Gryphea washitaensis, Plicatula* sp. cf. *dentonensis* and *Holaster simplex* var. indicates the horizon.

DENTON MEMBER

This member is reduced to a few feet in thickness in this region. It is a soft limestone and calcareous clay, receding in cliffs and overwashed on uplands. Its level can at some places be discovered by the presence of an abundant *Gryphea washitaensis* zone and by associated fossils (echinoids, *Alectryonia carinata*). It is about 5 feet thick.

WENO MEMBER

This is a rather thick argillaceous limestone in McLennan County, and outcrops in a belt of as much as 4 miles in width. In streams it forms projecting ledges.

Exposures: Stream divides on Hog Creek near Ocee; Middle Bosque south of Windsor; Hog Creek near South Bosque Oil Field; uplands south of McGregor, and elsewhere.

Fossils: Various ammonites, especially *Schloenbachia* sp.; a giant species of *Epiaster;* alectryonate oysters and various associated fossils, as in north-central Texas.

MAINSTREET MEMBER

This and the preceding members form wide strips of upland, at places nearly level, in the western part of the county. The Mainstreet member outcrops in streams along the west border of the Del Rio formation, where its top is exposed at numerous localities (for descriptions, see Del Rio formation).

This upper part of the Mainstreet is lithologically transitional to the Del Rio portion of the Mainstreet formation.

Fossils: The top contains numerous *Turrilities brazoensis* Roemer and other Mainstreet horizon markers as in north-central Texas.

Del Rio Formation

The Del Rio formation is at most places on the outcrop in McLennan county the highest formation of the Comanchean, and at such places directly underlies the Eagleford.

It consists mainly of clay, but at its base contains alternating thin layers of soft argillaceous limestone and calcareous clay, and the base is thus lithologically transitional to the underlying Georgetown limestone. The main bulk of the Del Rio is a sticky blue-gray jointed clay, with smaller proportions of limestone in the form of thin layers, or of small concretions; ironstone, in layers or concretions; sand, especially in thin platy layers, locally; pyrite (in well samples, fresh exposures and steep banks) and various iron oxids.

It weathers to a gray loose clay stained with limonite and containing locally a considerable amount of limonite, hematite and ironstone fragments; and may be distinguished from the overlying Eagleford clay by its grayer color, less laminated texture, mode of weathering, its smaller gypsum content, and by its fossils (Pectens are widespread, *Exogyra arietina* and pyrite fossils are locally abundant).

The Grayson formation outcrops as a calcareous to rather pure clay from the Red River district (type locality, Denison, Texas) southwards to McLennan County, Texas. The bulk of the thickness of Del Rio clay in McLennan County is Grayson, containing the typical sequence of Grayson fossil zones, which only a small thickness of impure calcareous basal Del Rio represents the Mainstreet limestone. The Del Rio crosses the Hill-McLennan line near the M. K. and T. Ry. (Rotan Branch) and follows the base of the Eagleford Escarpment down the Aquilla Creek Valley to the Brazos. On the south side of the Brazos its distribution is greatly influenced by the presence of high divides between the east flowing laterals of the Bosque River. Between the Brazos and the North Bosque it caps an irregular upland as far west as a point near the Artillery Range, two and one-half miles northwest of China Springs, as can be ascertained by an investigation of the shallow water wells, which on going west contain progressively thinner Del Rio with its characteristic fossils. This upland is protected from erosion by high terrace "concrete gravel" and by residual Bosqueville limestone At China Springs the Del Rio is about thirty feet thick.

Between the North Bosque and Hog Creek the outcrop is considerably narrower, and south of Hog Creek it is a narrow band which follows southwards along the Eagleford Escarpment. In the north part of the South Bosque oil field there is only a foot or so of Del Rio (with *Exogyra arietina* and other fossils) beneath the surface deposits. Along the upper South Bosque River the Del Rio outcrop lies well up the escarpment, and is correspondingly narrow. It thus follows the escarpment to a point four miles south of McGregor, and passing southward leaves the county southwest of Moody.

The Del Rio is about seventy feet thick in McLennan County. It contains a well defined sequence of fossil zones essentially similar to that observed at Fort Worth and Denison.

The lower part of the formation is distinguished by its thin calcareous and sandy seams and contains *Turrilites* sp., *Kingena? wacoensis* (Roemer), and *Exogyra arietina* Roemer. The middle portion contains a zone of abundance of *Exogyra arietina*, above which this fossil is rare. Above this is a well marked zone of abundance of *Gryphea mucronata*. At this level are hematite layers and abundant pyrite or limonite fossils. *Peltastes* sp. is associated with these. The top part contains few fossils, mainly echinoids, *Pecten texanus*, and a few ammonites. At this level at Georgetown, an Exogyra, probably *E. cartledgei* Böse was found.

The thickness and lithology of the Del Rio are rather constant throughout McLennan County. The top of the formation however in the north part of the county contains one (Loc. 953,956) or two (Loc. 951) thin soft fossiliferous limestone ledges not seen elsewhere. Such limestones in the top of the Grayson are recorded from southern Denton County (Univ. Texas Bull. 1931, p. 73; Univ. Texas Bull. 2229, p. 30).

In the Speegleville region there is a local phase of the basal Del Rio which is noticeably more sandy than usual (see section). Platy sandstone layers near the top of the formation are noticeable from South Bosque station southwards.

Section about one-fourth mile north of North Bosque River and one and one-half miles above its mouth (Locality 956).

	Feet
Buda:	
Yellow shelly sandy limestone	1
Del Rio:	
Yellow fossiliferous clay, blue interiorly. Fossils: *Gryphea mucronata*, **Engonoceras* sp., [1]*Flickia? bosquensis*, [1]*Turrilites* sp., **Hamulina* sp., shark teeth and vertebrae, *Pecten texanus*, *Pecten subalpinus*, *Plicatula* sp., **Goniophorus* sp., *ophiuroid rays, cidarid spines and plates, *Hamulus* sp.	20
Red limonitic gypsiferous clay	0.5
Yellow clay. Fossils: *Gryphea mucronata*, *Pecten texanus*, pyrite fossils	12
Yellow limonitic clay; *Exogyra arietina*	2+

Partial section of the Del Rio Clay at bluff on west bank of South Bosque River, 150 yards upstream from the Speegleville road bridge, 5.5 miles west of Waco, Texas.

This is the type locality of *Turrilites bosquensis* Adkins and *Flickia? bosquensis* Adkins (Univ. Texas Bull. 1856).

	Feet.
Pleistocene:	
Gravel and sand	10
Del Rio:	
Blue clay, *Turrilites bosquensis* on top	8
Indurated blue clay with considerable hematite	0.1
Blue clay, locally red-stained (hematite); *Pecten subalpinus*; pyrite fossils	1.0
Red ironstone	0.1
Blue shale; pyrite fossils abundant. *Exogyra* aff. *columbae*; pyrite fossils, *Pecten subalpinus*, *Flickia? bosquensis*, *Turrilites bosquensis*	1.3
Red ironstone	0.1
Blue shale; *Exogyra arietina*, *Gryphea mucronata*, *Exogyra* aff. *columbae*, *Pinna* sp., *Hemiaster* sp. *Flickia? bosquensis*, *Turrilites bosquensis*	6.8

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[1]Indicates that the fossil is composed of pyrite, limonite or hematite.

Section 100 yards above mouth of Hog Creek.

	Feet.
River gravel	
Blue clay; *Exogyra arietina, Turritella*	10
Bluish thin bedded platy sandy limestone with clay interbedding; *Turrilites brazoensis, Pecten subalpinus, Exogyra arietina.* This layer at the mouth of Hog Creek contains *Exogyra arietina, Turrilites brazoensis Pecten texanus, Pecten subalpinus*	4.5

Lower Del Rio contact, Hog Creek, one-fourth mile below Crawford road bridge.

	Feet.
River gravel	15+
Blue clay	5
Thin platy blue-gray limestone, locally sandy with interbedded blue clay; *Exogyra arietina, Alectryonia* sp. (zig-zag), *Turrilites brazoensis, Pecten subalpinus*	5.2
Blue calcareous clay	0.8
White chalky fossiliferous limestone with abundant small pyrite concretions; *Gryphea* sp. *Pecten texanus, Turrilites brazoensis*	5.0

In blue-gray jointed clay at the first big bend of the South Bosque River below the mouth of Hog Creek, Dr. Pace found the following fossils: *Remondia* sp., *Pecten subalpinus* (Böse), *Cardita* sp., *Gryphea washitaensis* Hill, *Ostrea* sp., *Lima* sp., and *Schloenbachia* sp.

Cliff at Junction of South Bosque and Middle Bosque Rivers.

	Feet.
Pleistocene:	
River gravel and sand	10
Del Rio (Grayson member):	
Blue clay; *Exogyra arietina, Plicatula* sp., *Hemiaster* sp.	5+
Del Rio (Mainstreet member):	
Sandy thin-bedded limestone, with interbedded impure blue clay; *Gryphea* sp	10
Blue clay with thin platy limestone seams	0.6
Sandy shelly limestone; *Exogyra arietina, Gryphea* sp.	0.6
Blue calcareous clay with thin limy seams; *Plicatula* sp., *Exogyra arietina* (abundant) *Gryphea* (flat sp.), *Pecten texanus*	1.7
Marly loosely laminated limestone; *Turrilites brazoensis* (abundant), *Exogyra arietina, Gryphea mucronata, Alectryonia* sp. (small, zig-zag), *Gryphea* sp. (flat), *Pinna* sp., *Pecten subalpinus*	1.9

	Feet.
Nodular chalky limestone; *Turrilites brazoensis, Spondylus hilli* Cragin, *Kingena wacoensis, Pecten texanus, P. subalpinus, Exogyra arietina Gryphea* sp. (flat), *Protocardia texanus, Nautilus* sp. aff. *hilli*	2.1
Blue clay; *Spondylus hilli, Gryphea* sp.	0.7
White limestone; *Nautilus texanus, Turrilites brazoensis, Exogyra arietina* (rare), *Pecten* sp. aff. *georgetownensis, Pholadomya* sp. aff. shattucki	3+

Del Rio bluff at South Bosque Station.

	Feet.
Grayson:	
Blue clay; *Exogyra arietina, Goniophorus* sp., *Cerithium* sp., *Schloenbachia* sp., *Turrilites* sp., *Turritella* sp., *Nerinea* sp., *Lunatia* sp., *Pecten subalpinus, Turrilites brazoensis* Roemer	20
Platy sandy flags; fucoids, reptile? tracks, *Exogyra arietina Pecten subalpinus*	1.5
Blue clay; *Exogyra arietina*	2.0
Mainstreet:	
Thin bedded argillaceous bluish soft fossiliferous limonite stained limestone, locally sandy and platy at top; *Hemiaster* sp., *H. calvini, Kingena wacoensis, Turrilites brazoensis, Alectryonia* sp. (zigzag), *Exogyra arietina, Gryphea mucronata, Gryphea* sp., *Plicatula* sp., *Pecten texanus, Pecten subalpinus*	4.5

Section of Del Rio formation one-half mile west of Speegleville.

	Feet.
Gravel (Pleistocene)	5
Brown sandy shale	2.4
Brown sandstone	0.4
Brown sandy shale	4.8
Shelly limestone; *Exogyra arietina*	0.1
Brown shale	1.0
Hard shelly iron-stained clayey limestone; *Exogyra arietina, Gryphea mucronata, Pecten subalpinus*	0.1
Iron-stained calcareous indurated marl	1.4
Bluish nodular marly limestone; *Exogyra arietina, Gryphea mucronata, Pecten* sp., *Alectryonia* sp. (zig-zag), *Turrilites brazoensis*	1.2

This exposure is near the base of the Del Rio and is noticeably more sandy and indurated than others in the county.

Georgetown-Del Rio exposure on the Middle Bosque River about one mile above Oil Field Road.

Del Rio:	Feet.
Blue clay, weathering yellow-brown, and thin flaggy sandy limestone layers; *Exogyra arietina, Gryphea mucronata, Gryphea* sp.	10
Georgetown (Mainstreet Member):	
White soft limestone and thin interbedded calcareous clay; *Turrilites brazoensis, Gryphea* sp.	15

Del Rio locality 1600 feet west of road running to river from schoolhouse at South Bosque.

Del Rio:	Feet.
Blue clay; *Gryphea mucronata, Gryphea* sp., *Exogyra arietina,* pyrite fossils	16+
Iron-stained compact clay, calcareous	0.1
Blue clay; *Gryphea mucronata, Exogyra arietina*	7.5

There is an exposure of Del Rio clay just downstream from the road leading south from the South Bosque schoolhouse.

Nine miles west of Ross, on the Brazos near the Wortham Bend crossing, Hill reports 60 feet of Del Rio, a calcareous clay with *Exogyra arietina* and ammonites.

For further Del Rio sections, see the descriptions of the Comanchean-Upper Cretaceous contact.

The Del Rio is not distinguished from the Eagleford by drillers in McLennan County, and thus it is difficult to assign to it a thickness based on wells from which no samples are available. The Bickle No. 2 well, lying 36 feet below the Eagleford-Del Rio contact, had 25 feet of Del Rio; this with the dip would give the Del Rio a thickness of about 75 feet, a figure which computation from profile sections confirms.

DEL RIO FOSSILS

The following Del Rio localities are indicated on the geologic map:

955 On Aquilla Creek, first east-west road north of the Tokio-Gholson pike.

956 Keyes Branch, Bosqueville, 0.8 mile north of Bosque River bridge on the Patrick Road.

957 Amphitheatre of Del Rio capped by thin Buda, on Walker Crossing-Erath road about 2 miles south of Bosqueville.

958 150 yards upstream from iron bridge on Speegleville road, at the Bosque; about 5.5 miles west of Waco.

960 Southeast bank of Bosque River 1/2 mile below junction of the South Bosque and the Middle Bosque.

961 Exposure at junction of South Bosque and Middle Bosque Rivers.

962 Exposure on the South Bosque just downstream from railway bridge at South Bosque station.

963 Locality on the South Bosque River 2 miles southwest of South Bosque station, near Mitchell No. 1 well.

964 East bank of South Bosque River, 2 miles south of South Bosque, near Bickle No. 2 well.

965 High point on Bosque Escarpment 5 miles southeast of McGregor.

966 East side of Santa Fe track 4.5 miles south of McGregor.

967 Two miles southwest of Moody, near Bell County line.

968 Point of escarpment near Bishop, 3.5 miles east of south of McGregor.

Buda Formation.

A fossiliferous limestone about 2.5 feet thick exposed at Bosqueville is considered to be the northern attenuated representative of the Buda in this region. For section and fossils see discussion of the "Comanchean-Upper Cretaceous contract."

The Comanchean-Upper Cretaceous Contact

The Eagleford shale directly overlies the Del Rio clay without intervening Buda or Woodbine of the typical facies, at all points along the contact in McLennan County except the localities shortly to be discussed. This situation exists from central Hill County, near Aquilla, southwards to a point between Salado and Prairie Dell, Bell County, a distance of about 70 miles. North of Aquilla the Woodbine, and south of Prairie Dell the Buda, lies between the Eagleford and Del Rio formations. The interval between these two formations however contains locally near Bosqueville in central McLennan County a thin limestone and sandstone, and at a few other localities here described the contact is marked by thin sandy oyster beds or limy ledges, considered to belong to either the Del Rio or the Eagleford, as is indicated in the corresponding descriptions.

The various sections along the Del Rio-Eagleford contact will now be described in order, from north to south:

The Eagleford Escarpment enters McLennan County just east of the M. K. and T. Ry., (Rotan branch) and passes south along the east bank of Aquilla Creek to the alluvial bottoms 2.7 miles southwest of Tokio, and thence along the east side of Aquilla Creek to its mouth. Along this whole escarpment wherever the contact is visible the Del Rio and Eagleford formations are in direct contact. There is no strip of soil corresponding to the Woodbine outcrop, in northern McLennan County; the timbered red sand belt seen locally west of Aquilla Creek is an upland river deposit, and is generally underlain by black Eagleford soil. Near the M. K. and T. Ry. bridge across Aquilla Creek, about one mile above the Hill-McLennan County line the line of contact of the Eagleford and Del Rio formations occurs. About 100 yards downstream from the bridge a few feet of Del Rio clay is exposed beneath the river gravel. Between this point and the iron bridge on the county line road two cut banks contain exposures of the contact.

Eagleford-Del Rio contact on Aquilla Creek, three-fourths mile upstream from the Hill-McLennan County line (Locality 951).

	Feet
Gravel and sand, partly consolidated	6+
Eagleford:	
Shale, slate-colored, thinly laminated, with sandy and iron stone layers	6+
Sandstone, gray, hard	0.4
Shale, blue, sandy	0.15
Sandstone, gray, iron-stained	0.1
Shale, blue, with sandy partings	0.2
Shale, blue	0.15
Sandstone, grayish, iron-stained, fossiliferous, with a thin parting of sandy shale; fossil wood	0.6

	Feet.
Shale, slate-colored, thinly laminated, with thin sandy streaks	2.4
Whitish soft sandstone	0.1
Shale, slate colored, laminated, with gray and iron-stained soft flaggy sandstone seams and ironstone concretions; locally large concretions	10.1
Sandstone, light gray, soft; fossils	0.2
Shale, blue	0.2
Sandstone, fine grained, soft, gray	0.05
Shale, blue	0.5
Sandstone, red, hard; thickness and color variable; locally absent	0.3
Del Rio:	
Shale, gray, coarsely laminated, plastic, calcareous; Del Rio fossils	1.0
Limestone, white, chalky, fossiliferous	0.35
Shale, grayish, calcareous	0.4
Limestone, white, argillaceous, fossiliferous	0.4
Calcareous clay, bluish-gray: fossils: *Gryphea mucronata*, *Gryphea* sp., *Exogyra* sp., *Pecten subalpinus*, *Pinna* sp., *Plicatula* sp	6.0

The limestone layers contain high Washita fossils, which however are not distinctively Buda species, and are therefore placed in the Del Rio in the preceding section. Farther south, on Aquilla Creek and at Bosqueville one or two such fossiliferous limestone layers are present in the top of the Del Rio clay.

Section on Eagleford Escarpment, 0.2 mile south of iron bridge across Aquilla Creek, 2 miles west of Tokio (Locality 953).

Eagleford:	Feet
Blue shale with ironstone concretions	5.0
Sandstone, yellow to red, and gray locally concretionary	0.1
Blue shale	10.0
Platy light yellow sandstone	0.1
Slate-colored lustrous flaky, finely laminated, non-fossiliferous shale	1.5
Coarse platy gray sandstone, sparsely fossiliferous	0.1
Sandstone, gypsiferous, red, soft, ironstained	0.1
Del Rio:	...
White to gray chalky, fossiliferous, nodular limestone; high Washita fossils	0.4-0.6
Grayish, light colored, limonite stained, fossiliferous, plastic limy clay interiorly bluish and jointed. Fossils: *Exogyra*	

	Feet.
arietina, *Gryphea mucronata*, *Gryphea* sp., *Pecten texanus*, *Plicatula* sp., *Nucula* sp., *Turritella* sp., *Turrilites* sp., exposed in gullies	15+

The area along Aquilla Creek and east of it shows numerous Del Rio exposures. A locality (955) on Aquilla Creek at the first east-west road north of the Tokio-Gholson pike is not detailed here on account of its similarity to the other sections.

The Del Rio-Eagleford contact is concealed in the Brazos valley, and does not reappear north of the South Bosque region. A contact (960) occurs on the southeast bank of the Bosque about one half mile below the junction of the South Bosque and the Middle Bosque Rivers. A contact occurs on the east bank of the South Bosque near the Mitchell tract (963). The section of the next locality (964) is here given. A clear contact locality (965) is at a high point on the Bosque Escarpment about 5 miles southeast of McGregor; its section is similar to that of adjacent localities. On the point of a hill 3.5 miles east of south of McGregor, near Bishop, is a contact locality (968). On the east side of the Santa Fe tract 4.5 miles south of McGregor on the McGregor-Moody road is one of the best localities in the county (966). About 2 miles southwest of Moody near the McLennan-Bell County line the contact between the two formations is exposed (967). The only intervening strata are thin fossiliferous soft clayey limestones of apparently Del Rio age, and thin sandy ironstained oyster slabs of apparently Upper Cretaceous age.

This series of localities clearly establishes the fact that over most of McLennan County at the outcrop the Del Rio and the Eagleford formations are in direct disconformable contact.

Eagleford-Del Rio contact one-half mile downstream from junction of South Bosque and Middle Bosque Rivers (Locality 960).

Eagleford:	Feet
Slate colored thinly laminated shale with yellow (ferrous) and red iron stain, and layers of flaggy sandstone and ironstone concretions.	12+
Indurated sandy iron-stained shale	0.8
Sandstone, iron-stained; oyster bed; fish teeth.	0.1

	Feet.
Del Rio:	
Grayish-blue, plastic calcareous clay. Fossils: *Pecten subalpinus*, *Gryphea mucronata*, *Gryphea* sp., *Ostrea* sp., *Exogyra* sp., *Pecten texanus*, *Pinna* sp.	9+

Eagleford-Del Rio contact on South Bosque River, 2 miles southwest of South Bosque station, near Mitchell tract (Locality 963).

	Feet
Eagleford:	
Laminated slate colored shales with flaggy sandstones	20+
Ironstone	0.1
Laminated slate colored shale	1.5
Sandstones, gray, oyster breccia	0.05
Slate colored laminated clay, with yellow and red iron-stain	4.5
Hard pyritic shelly sandstone	0.1
Del Rio:	
Grayish-blue shelly plastic calcareous clay. Fossils: *Gryphea mucronata*, *Gryphea* sp., °*Flickia* (?) *bosquensis*, °*Acanthoceras worthense*, °*Acanthoceras* sp.	6.0
White coarse grained thinly laminated sandstone	0.1
Grayish-blue fossiliferous clay. Fossils: *Exogyra arietina*, *Gryphea mucronata* (abundant)	8+

Eagleford-Del Rio contact on east bank of South Bosque River,, 2 miles south of South Bosque station, near Bickle tract (Locality 964).

(Elevation of contact, 550 feet)

	Feet
Eagleford:	
Blue shale and fossiliferous sandy flag layers	25+
Blue shale	20
Yellow fossiliferous sandy limestone; *Inoceramus* sp., *Ostrea* sp., *Nucula* sp., gastropods	0.3
Blue shale	1.5
White fossiliferous limestone	0.2
Blue shale with limonite stained streaks	2.0
Iron-stained Ostrea shell breccia; forms a terrace on top of the Del Rio clay	0.2
Del Rio:	
Gray-blue calcareous clay; *Gryphea mucronata*	8.0
Platy sand flag layer	0.1
Bluish clay	5.0
Three hematite layers interbedded with blue clay; pyrite fossil zone; fossils:	

°*Turrilites worthensis*
°*Turrilites* spp.
°*Baculites* n. sp.
°*Scaphites* aff. *evolutus* Pervinquiere
°*Flickia* (?) *bosquensis*
°*Scaphites hilli*
°*Acanthoceras worthense*
°*Engonoceras* sp.
Gryphea mucronata

Gryphea sp.
Pecten subalpinus
Exogyra arietina
°*Arca washitaensis*
°*Plicatula* sp.
°*Turritella* spp.
Hemiaster sp.
Peltastes sp.

Blue clay.. 11+

The Bickle No. 2 well nearby penetrated the lower part of the Del Rio formation.

Eagleford-Del Rio contact east of Santa Fe track, 4.5 miles south of McGregor (Localiity 966).

	Feet
Eagleford (basal shale):	
Shale, blackish when fresh, blue on exposure. Calcareous flags containing *Inoceramus* have fallen down the slope of the hill from the Middle Flag Member..................	22.5
Red, iron-stained oyster breccia; yellow and red incrustations; *Ostrea* sp. (apparently Upper Cretaceous forms).....	0.2
Del Rio:	
Light gray calcareous clay; pyrite fossils abundant; *Exogyra arietina* rare..	11.5

Fossils:

°*Scaphites* aff. *evolutus* Pervinquiere
°*Nautilus* n. sp.
°*Acanthoceras worthense*
°*Acanthoceras* sp. aff. *suzannae* Perv.
°*Engonoceras* sp.
°*Baculites* sp.
°*Turrilites worthensis*
°*Turrilites* spp.
Plicatula sp.
°*Pecten subalpinus*
°*Arca washitaensis*
°*Nucula* sp.
°*Pleurotomaria* sp. (small)
°*Turritella* sp.
Gryphea mucronata
Hamulus sp.
Fish teeth
Crustacean claw

Light gray-blue iron-stained clay; pyrite fossils; *Exogyra arietina* abundant.................................. 15+

Fossils:

°*Acanthoceras worthense*
°*Engonoceras* sp.
°*Turrilites worthensis*
°*Turrilites* spp.
Gryphea mucronata
Pecten subalpinus
Pecten texanus
Plicatula sp.
Gryphea sp.
Hamulus aff. *onyx*

Eagleford-Del Rio contact near Bell-McLennan County Line, 2 miles southwest of Moody (Locality 967).

	Feet
Eagleford:	
Bluish black laminated shale and flaggy sandstone..........	15
Thin calcareous iron-stained sandstone; oysters............	0.2

Del Rio: Feet.

Bluish gray clay; fossils: *Ostrea* sp., *Gryphea* sp., *Gryphea mucronata*, *Pecten texanus*.............................. 4

Section in the Bosqueville Area.

In the Bosqueville area the Eagleford shale does not directly overlie the Del Rio clay, but the two are separated by limestones and limy sandstones of small but variable thickness and of very local extent. These strata lying between the Del Rio and Eagleford formations will for convenience be referred to here as the "Bosqueville Rock."

The main locality at which this rock outcrops is in the town of Bosqueville, 5.7 miles northwest of Austin and 18th Sts., Waco, on the Patrick road, and 0.8 mile north of the Bosque River, in Keyes' Branch, a short east flowing lateral of the Brazos. Its surface and subsurface extent will be described presently. At the crossing of the Patrick road over Keyes' Branch the indurated reddish limestone is about 2.5 feet thick and forms a small waterfall. This layer is immediately underlain by Del Rio clay, which here contains two thin chalky limestone layers, the top one being pasted against the bottom of the Bosqueville rock. These ledges and the adjacent clay contain Del Rio fossils. (Compare with locality 951). Overlying the indurated limestone layer are thin strata of alternate calcareous sandstone and sandy shale. These layers show irregular bedding and locally contain large dense lens-shaped or hemispherical brown indurated sandstone concretions up to 2 feet in diameter which have been used in Waco and elsewhere for ornamental purposes (socalled "cannon ball" concretions). The concretions are sparsely fossiliferous. They contain some calcium carbonate as a matrix but on weathering the surface turns dark brown and becomes relatively more sandy. The sandy strata have similar weathering. The bedding is more massive west of the Patrick road; about halfway between the Patrick and the China Springs roads this sandstone shows pronounced cross-bedding.

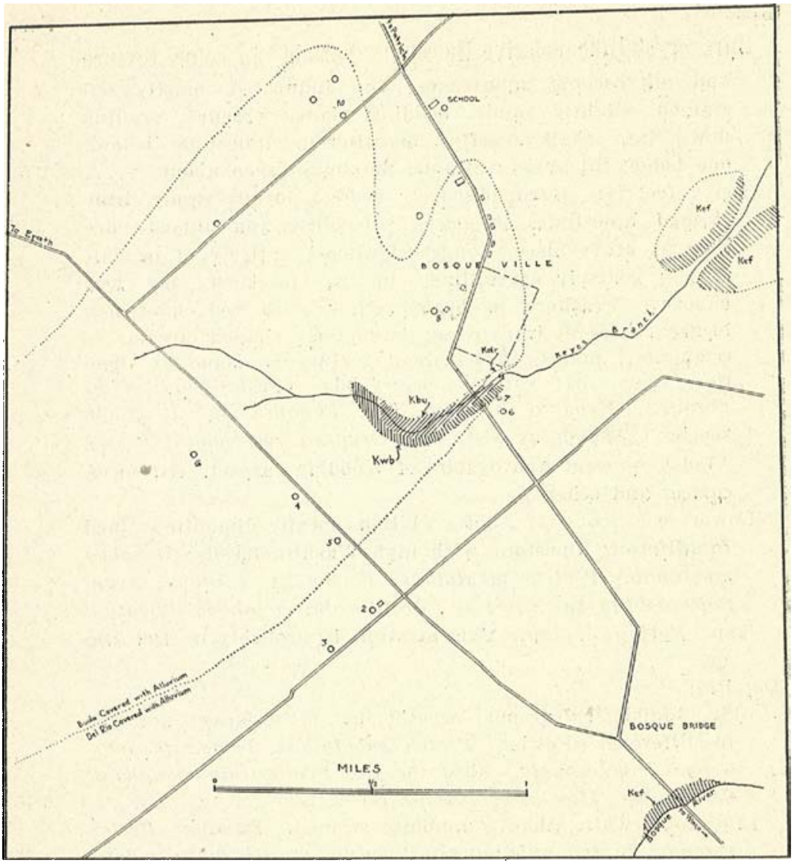

Fig. 5. Map of the Bosqueville region.

Section in Keyes' Branch, Bosqueville, Texas.

Pleistocene: Middle terrace gravel and sand.

Woodbine (?):	Feet
Sandstone, gray, fossiliferous.	0.5
Sandstone, yellow, soft, receding exposure.	0 6
Sandstone, yellow, locally red, fossiliferous, harder than preceding, of variable thickness; about.	0.3
Sandy shale, yellowish-brown, variable thickness; about. . . .	0.5

The foregoing strata have variable bedding; locally are consolidated, or cross-bedded, or contain "cannon-ball" concretions. The strata mainly weather to a dark red-brown color. Fossils: oysters of Woodbine aspect.

Buda: Feet

Hard crystalline massive limestone, variable in color, texture and microscopic appearance; top indurated, mostly red stained, slightly sandy, bedding planes obscure; grading down into chalky, softer fossiliferous limestone below; one ledge, thickness variable, maximum seen about....... 2.5

Top 2 feet is: Hard, obscurely bedded, locally sandy, iron-stained limestone, at places sub-oolitic and almost pure lime at other places composed almost entirely of organic debris; coarsely crystalline, blue-gray interiorly, on fresh exposure weathers to brown-yellow with red splotches; local cavities of iron oxids; irregularly shaped circular to triangular, mainly iron-stained inclusions, some of them the casts of various pelecypoda (*Protocardia*, etc). Fossils: *Exogyra arietina* (?), *Exogyra* sp. (a Buda species,) *Spondylus hilli* (?), *Gryphea mucronata*, *Pecten* (*Vola*) *roemeri*, and oysters of Woodbine aspect. *Ostrea* cf. *carica*, and others.

Lower 0.5 foot is: Soft, whitish, locally limonite-stained fossiliferous limestone with high Washita fossils: *Gryphea mucronata*, *Pecten subalpinus*, *Pecten* cf. *texanus*, *Acanthoceras* (?) sp., *Lima* sp., *Protocardia vaughani*, *Plicatula* sp., *Pyrina* (?) sp. This stratum is probably of Del Rio age.

Del Rio:

Clay, bluish, calcareous, weathering yellow-gray; jointed, fossiliferous. Fosils: *Pecten subalpinus*, *Pecten texanus*, *Gryphea mucronata*, *Plicatula* sp., *Protocardia vaughani*, *Cardita* sp., *Hemiaster calvini*, etc....................... 0.75

Limestone, white, chalky, limonite stained. Fossils: *Pecten texanus*, *Pecten subalpinus*, *Plicatula* sp., *Gryphea mucronata*, *Gryphea* sp; the Pectens are abundant............ 1.0

Clay, calcareous; Del Rio fossils........................ 2+

Paleontology: (a) Woodbine. (?). The top sandy strata at Bosqueville contain oysters which, although sparse and fragmentary, resemble Woodbine oysters, notably *Ostrea narica*, *Ostrea* sp. indet., and *Ostrea soleniscus* (?). In these upper layers no intermixture of Washita fossils was observed. Large very fossiliferous blocks of sandy limestone near China Springs contain similar fossils. The thin sandstone layers at Bosqueville have been weathered along the stream bed, which contains loose *Ostrea* cf. *carica*, other oysters, *Exogyra* sp. (plicate, about form and size of *texana*) and other fossils.

(b) Buda: This layer contains an intermixture of Buda fossils and high Washita fossils not confined to the Buda, with apparently Woodbine fossils. No differences of inclusion or preservation between these different fossils were noted. The basal softer portion of the hard ledge does not seem to contain typical Buda species; its fauna is identical with that of the two chalky layers near the top of the Del Rio elsewhere in the county.

Areal Distribution: The area of occurrence of the Bosqueville rock lies about 0.8 mile from the Brazos River, and is superficially covered with soil, red and white clay, coarse to fine river gravel, and varicolored, mainly white, river sand. The limestone outcrops in a few restricted areas: (a) at Rock Crossing of Keyes' Branch in Bosqueville, and thence up this branch, between the Patrick and China Springs roads; (b) west of Bosque Bridge, along the China Springs road; (c) near the north bank of the North Bosque River about one mile above the Eichelberger Crossing: and (d) in residual patches on hilltops near China Springs. Its subsurface extent in this area is known from the records of dug water wells.

Throughout this area the top soil is underlain by sand or gravel, in the bottom of which surface water is found. This is underlain by either the Bosqueville rock or the Del Rio for mation ('joint clay'), a water-tight yellowish fossiliferous clay.

Certain wells in and around Bosqueville reached the Bosqueville rock while others reached the Del Rio clay without penetrating the limestone and sandstone. Mr. Keyes' windmill well east of his house reached Del Rio without penetrating Bosqueville rock; his house well within a few yards of the Bosqueville outcrop reached that rock. Of four dug wells on the property of Mr. John Washington on the China Springs road 0.8 mile west of Bosque Bridge, the two more western ones struck the Bosqueville rock and the others did not. The Boggs dug well 1.7 mile south of Bosqueville did not strike the rock. These and the outcrop localities delimit the east edge of the rock.

In Bosqueville, the Methodist Parsonage well and a well dug by Mr. Beaver in front of Mr. Washington's house struck the rock, as did also the two easternmost wells dug by Mr. Luther Gregory on the Washington place between the Patrick and

China Springs roads. Wells of Mr. Washington back of his house and of Mr. Calvert near the Bosqueville schoolhouse did not get the rock. (See accompanying map).

About 1.4 miles south of Bosqueville on the road paralleling the North Bosque River, the Bosqueville rock is exposed in a field, and south of the same road a considerable amphitheatre of eroded Del Rio (section given under discussion of Del Rio formation) is capped with a thin limonite stained fossiliferous sandy limestone about one foot thick, which overlies the top of the Del Rio clay. This rock has been reported as much as 12 feet thick in dug wells in this neighborhood. Westwards along the China Springs road the surface of the fields is locally strewn with slabs and blocks of fossiliferous Bosqueville rock which, at China Springs, are considered to be residual from a formerly continuous ledge.

1. Boggs well, 1.8 mile south of Bosqueville:

	Feet
Red clay	0-6
Gravel and sand	6-15
Indurated yellow calcareous clay, sandy and pebbly, and cemented pack sand; had to be blasted	15-25
Gravel, rounded boulders up to 2″ in diameter; worn Gryphea etc	25-28.5
Limestone, hard, white, unfossiliferous	28.5-29
Gravel, water under pressure	several feet

2. Well on Mr. John Washington's land, along Waco-China Springs Road at first cross road, 0.8 mile west of Bosque Bridge. (Corner well).

	Feet
Black soil	0-15
Red clay	15-23
Yellowish sand, white sand and clay	23-25
Water bearing gravel	25-28
Hard Del Rio clay, yellowish, fossiliferous: *Cardium* sp., *Pecten texanus*, *Pecten subalpinus*, *Ostrea* sp., *Plicatula* cf. *incongrua*, *Gryphea* sp., *Enallaster* spines, *Protocardia* sp.	28-30
Yellowish marly limestone. An irregular lenticular stratum of marly fossiliferous slightly crystalline limestone. Evidently Del Rio	30-30.5

3. South well on same tract as No. 2:

Black soil	0-10
Red clay and gravel, white sand	10-19

	Feet
Reworked Del Rio clay, fossils and pebbles present, bedding planes disturbed	19-20
Typical unindurated Del Rio clay	20-21

4. West well on China Springs road, same tract as No. 2:

Black soil	0-10
Sand	10-13
Red clay with some sand and gravel	13-20
White sand with well rounded pebbles and shells, mainly *Gryphea*	20-25
White sandy limestone, quickly weathering to gray with characteristic red blotches, fossiliferous; hard, was blasted; Bosqueville rock	25-27
Yellowish joint clay. *Pecten texanus, Pecten subalpinus, Remondia, Gryphea, Plicatula* cf. *incongrua;* Del Rio	27-30

5. Well on same tract, between No. 2 and No. 4:

Black soil	0-7
Gravel and soil	7-16
Bosqueville rock	16-18

6. Windmill well east of Mr. Keyes' house, Bosqueville:

Soil	0-4
Soil and gravel	4-24
Gravel, water at bottom	24-29
Joint clay	several feet

7. Water well back of Mr. Keyes' house, Bosqueville:

Soil	0-1
Yellow sand	1-2
Gravel, about	2-22
Bosqueville rock	22-24

8. Methodist Parsonage well, Bosqueville:

Soil and yellow-red clay	0-13
Blue gumbo ("slate")	13-14.5
Yellow gumbo	14.5-16
Gravel	16-17.5
Hard rock, Bosqueville	17.5-20.5

9. Well of Mr. Beaver, Bosqueville, east side of Patrick Road:

	Feet.
Clay and gravel	0-35
Bosqueville rock	35-36

Drilled through this rock; beneath, water under pressure.

10. Washington farm, between Patrick and China Springs roads on first cross road northwest of Bosqueville two wells nearest Bosqueville showed:

	Feet.
White sand and gravel	0-19
Bosqueville rock	19-23
Joint clay (Del Rio)	23-60

11. Same tract as No. 10, 75 to 100 yards farther west:

Soil	0-15
Gravel	15-23
Joint clay (Del Rio)	23-27

China Springs Area:

The topographically high area west of Erath suggests that the Del Rio hills here have been partially protected from erosion by a cap of Bosqueville rock, and scattered remnants of the rock show that such is the case. The upland "concrete gravel," as exposed at Erath, also protects the Del Rio from erosion. Water wells on the adjacent slopes reach Del Rio, with its characteristic fossils, without intervening Bosqueville rock. The upland concrete gravel overlies the Bosqueville rock wherever both are present. Due to the topography good exposures are rare.

On the China Springs-Eath road 0.8 mile from China Springs, shelly yellow-brown limestone blocks of Bosqueville rock have been extensively dragged to the edges of the fields. These rocks are of the same sandy fine crystalline texture and contain the same fossils as at the Bosqueville locality. It is improbable that this rock was found in situ and it is considered as a residual fragmentary stratum irregularly covering high areas of Del Rio in this vicinity. Essentially similar rock is seen in a draw by the gin at the edge of China Springs on the China Springs-Waco road. This rock is stated to have been dragged from adjacent hillsides. The surface around China Springs is about middle Del Rio, since abundant *Exogyra arietina* and other characteristic fossils are seen and about 40 feet of Del Rio was penetrated in various water wells in the town.

Mexia-Kosse Region: The Bosqueville rock is not continuous with the main mass of the Woodbine or the Buda, as is shown

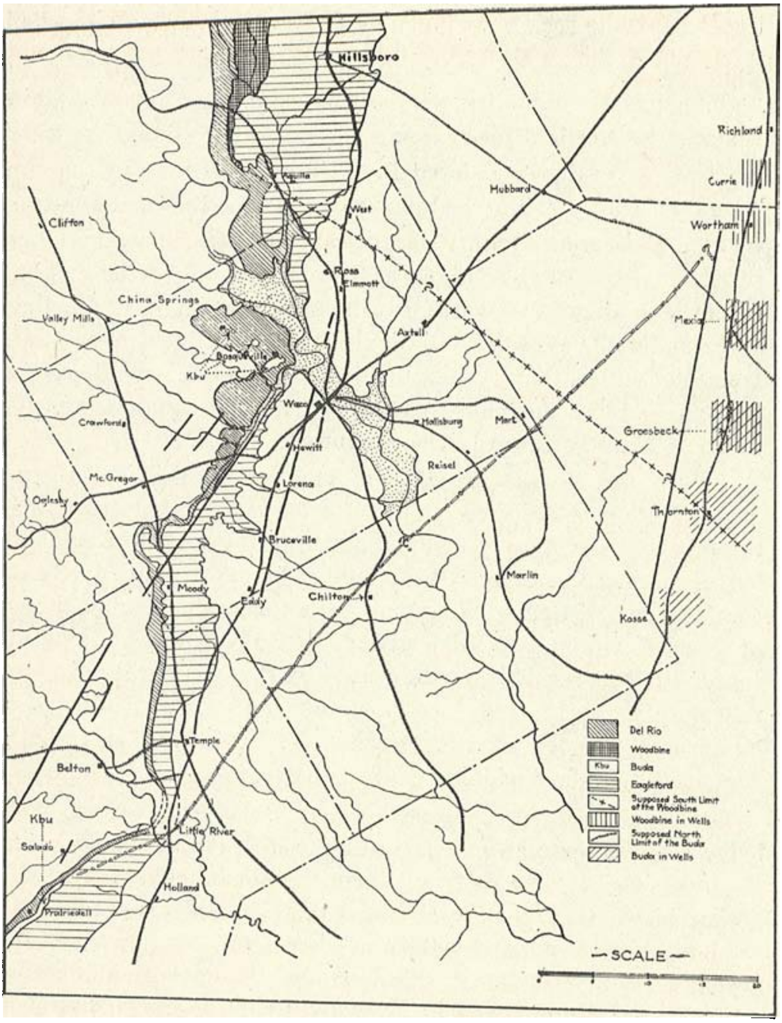

Fig. 6. Relations of Buda and Woodbine formations in McLennan County. (Note: The Shelton well at Axtell contains Buda).

in localities along the Bosque Escarpment and in wells in McLennan County. In wells along the Mexia structure north of Kosse there is a variable amount of Woodbine, decreasing in thickness towards the south. This Woodbine is very irregular from place to place but at most localities is capped by a hard gray, slightly calcareous sandstone which superficially resembles the Bosqueville rock. As much as 12 feet of the Woodbine sandstone cap is recorded. In the Kosse region neither caprock nor underlying Woodbine has yet been recognized. This Woodbine is stated to overlie directly a mass of rather soft limestone which has been generally considered Buda in age. It may be that few layers of clayey white nodular fossiliferous limestone seen at certain McLennan County localities (951, 953, 956) and here provisionally classed at high Del Rio on account of their apparent lack of diagnostic Buda fossils, represent in part the limestone under the Woodbine in Mexia Wells. In passing eastward from McLennan County this limestone formation would seem to thicken and become more calcareous; in McLennan County it thickens slightly towards the northeast.

Age of the Bosqueville Rock: The age of this rock is not yet definitely established. Such fossils as have been found in the top layers suggest Woodbine age, and the fossils of the hard ledge distinctly suggest Buda age. As it is scarcely likely that the hard ledge is Woodbine with the mechanical inclusion of Buda fossils, it is possible that both Buda and Woodbine are represented in the Bosqueville rock. If this is true the Bosqueville locality is the only recorded outcrop of the Buda-Woodbine contact south of the Brazos. R. T. Hill[7] has recently described a Buda-Woodbine contact in Denton County, Texas.

The apparently Woodbine oysters contained in the hard ledge may indicate an extension of the hitherto supposed range of these fossils. The dug well records indicate that this rock is absent just east of Bosqueville, and that its underground extent in this region is approximately as shown on the accompanying geologic county map. So far as can be discovered it is not present in any other well in McLennan County.* This rock is therefore an outlier, widely separated from the main body of its formation. (The nearest Buda outcrop is near Prairie Dell, distant 68 miles; the nearest Woodbine outcrop, in Hill County, is distant about 23 miles.) Lithologically similar rock

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[7]Hill, Further contributions to the knowledge of the Cretaceous of Texas and northern Mexico, Bull. G. S. A., 34, No. 1, 72, 1923.

*The Shelton well at Axtell contains Buda limestone at 1610-1669 feet, or a part of this interval.

has been described from wells in the Mexia district, and it is probable that pre-Eagleford erosion left the Buda or Woodbine, or both, with irregular margins and outliers, one of which was here uncovered by Pleistocene erosion, prior to the deposition of the river gravel mantle. That this outcrop was formerly much more extensive and is now on the verge of disappearance has been indicated above. It seems therefore to be established that the correct formation sequence in this region is (from older to younger): Del Rio (Grayson), Buda, Woodbine, Eagleford. The Kosse section and the McLennan County section are rather similar, but the Mexia section more resembles the section north of Hillsboro.

UPPER CRETACEOUS

Woodbine Formation

The only rock supposed to be Woodbine at the surface in McLennan County is an insignificant thickness of calcareous thin-bedded sandstone, partly cross-bedded and concretionary, which directly overlies the Buda limestone at Bosqueville (see Bosqueville section). No Woodbine is known from any well record in McLennan County. At Aquilla in southern Hill County the Woodbine is probably not over 10 feet thick. From that point the subsurface margin of the Woodbine apparently passes southeastward, reaching the Mexia Structure at some point north of Kosse. If this is true the Bosqueville outcrop is an outlier, and hence other outliers may possibly be found beneath the Eagleford in the McLennan-Falls County area.

For descriptions of the McLennan County Woodbine, see discussion of the "Comanchean-Upper Cretaceous Contact."

Eagleford Formation

The Eagleford formation in McLennan County consists of three members: (a) a basal shale, (b) a middle flag series, and (c) an upper shale. It is disconformably underlain by the Del Rio or the Woodbine formation, and conformably overlain by the Austin Chalk. Its thickness in this county is about 160 feet. The section is essentially that of south-central Texas, but the thicknesses are greater.

The shale members consist of slate-colored, thinly laminated, gypsiferous and pyritic, bituminous shales. They are not sharply separated from the flag member since all parts of the formation locally contain thin seams of sandstone, sandy limestone, ironstone and bentonite. However in the middle flag member these kinds of rock are predominant. The shales and flags locally contain bright yellow, brown and red masses and incrustations mainly of iron salts, and great quantities of large selenite crystals. The formation carries abundant *Inoceramus* sp. cf. *labiatus* and other species, oysters, pyritic and other ammonites, and fish and reptilian remains. From the Brazos to the Red River, including the type locality, Eagle Ford, Dallas County, the Eagleford formation is prevailingly of the shale facies. The Middle Flag member is intercalated near the Brazos and persists to the Rio Grande. A flag facies (Boquillas Flags of Udden) extends over much of southern Texas and into Chihuahua and Coahuila (Peyotes, etc.) From Mohovano Böse has described Turonian limestone containing ammonites.

Exposures. The Eagleford outcrop is narrow in the region of the Brazos River, and widens in both a north and south direction. Along the lower course of the Bosque River the Bosque Escarpment is steeper than elsewhere in the county, and the basal Austin Chalk caps its rim and protects the upper Eagleford shale member from erosion. On leaving the Brazos the Austin Chalk outcrop recedes from the escarpment, which therefore breaks into a series of knolls and rolling uplands on which erosion of the Eagleford has cut down to the resistant Middle Flag Member. In the south third of the county the Eagleford outcrop covers a large area of hill country, the greater and western part of which is predominantly flaggy, while the eastern part, just beneath the edge of the Austin Chalk, is shaly.

The Eagleford outcrop near West has a width of about 4 miles, while in the southwest corner of the county its maximum width is 8 miles and its average width about 3½ miles. However the outcrop narrows greatly in the vicinity of the Brazos, being at South Bosque about 1¼ miles, between South Bosque and the Speegleville road about ½ mile, and on Keyes' Branch north of Bosqueville about ¼ mile. In the Brazos Valley the

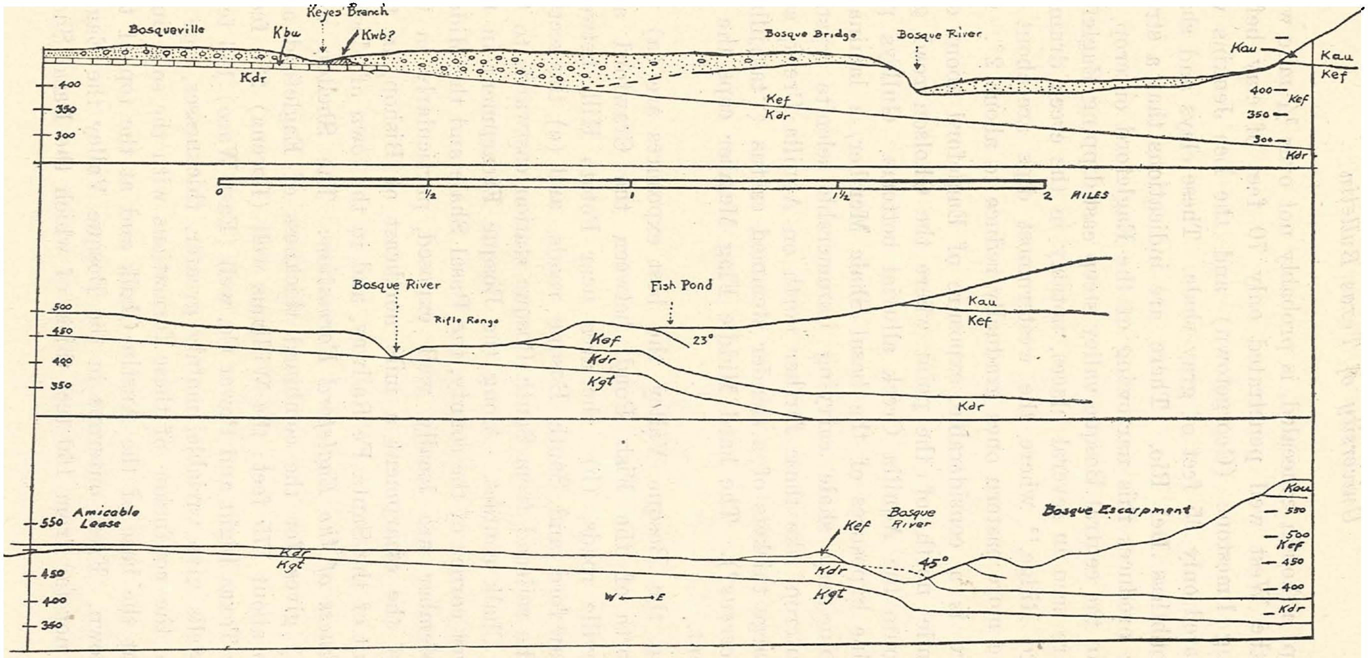

Fig. 7. Profiles across the Bosque Escarpment.

outcrop, although concealed, is probably not over ¼ mile wide, since the West well penetrated only 70 feet of clay before reaching limestone (Georgetown) and the Lee Jenkins well penetrated only 85 feet of gray shale. These clays and shales are doubtless Del Rio. There are indications that a strong flexure produces this narrowing of the Eagleford outcrop, because in the central Bosque valley steep east-dipping Eagleford flags are seen in several places, notably in the creek draining "Potato Ridge," where the westernmost dips are about 45° and the more eastern ones gradually reduce to about 2°.

There is a considerable exposure of Eagleford about one-half mile north of the point where the Gholson road goes down onto the Aquilla Creek alluvial bottoms. Gulleys produce fine exposures of the basal Shale Member, a laminated dark blue-gray shale carrying innumerable selenite crystals. This outcrop, like those farther north on Aquilla Creek, supports large thickets of a slender stemmed cactus ("tasajilla," *Echinocereus?*). The hard Middle Flag Member caps the escarpment.

Along the Bosque Valley the best exposures are (a) the area north of the Fish Pond, between the Crawford and Speegleville roads, (b) the area near Potato Hill, between the Crawford and South Bosque roads, and (c) the section along the railroad from South Bosque station eastwards to the Austin Chalk contact. Along the Bosque Escarpment in the southwest corner of the county, the Basal Shale and the Middle Flag Member are locally well exposed, particularly in the point of the escarpment a mile northeast of Bishop, in the Blue Cut of the Santa Fe Railway, and in the town of Moody.

Thinkness of the Eagleford Formation: The Shelton well (Axtell) gives for the combined thickness of Eagleford and Del Rio about 175 feet; the Williams well (Lorena) 225 feet; and the Texas Light and Power Co. well (East Waco) 186 feet. Other wells give variable, mainly greater, thicknesses, due in part to the confusion of these formations with the soft limestones at the base of the Austin Chalk and at the top of the Georgetown. From outcrops in the Bosque Valley the Eagleford is not far from 160 feet thick, of which the Basal Shale is about 40 feet, the Upper Shale about 35 feet and the Middle Flag Member the remainder.

BENTONITE LAYERS IN THE EAGLEFORD FORMATION

In the Eagleford formation, particularly the Middle Flag Member, there occurs a series of bentonite layers which are rather characteristically spaced, are of very wide distribution, and apparently will be of value in long range stratigraphic correlation. These occur in McLennan County (Bosque Bridge, South Bosque, Moody, etc.), at Austin, and elsewhere in central Texas, and Dr. Udden reports them from near the quicksilver mine at Terlingua, Brewster County.

J. K. Prather[8] proposed the formation name "South Bosque Marl" for the combined Middle Flag Member and Upper Shale Member of the Eagleford formation. He gives the following section, probably from somewhere near the Bosque Farm, i .e., in the face of the Bosque Escarpment near the Crawford (Fish Pond) road:

Section of Upper and Middle Eagleford on Bosque Escarpment near the Fish Pond, about 4 miles south of west of Waco. (Prather, 1902).

	Feet
Austin:	
Limestone	60
Eagleford (Upper Shale):	
Marl of clay-yellow color, with gypsum, selenite crystals and limonite. Fossils: *Inoceramus*, etc	107
(Middle Flags):	
Argillaceous limestone	2
Marl	4
Argillaceous limestone	1
Marl	3
Argillaceous limestone, in bands	2
Marl	15
Argillaceous limestone; *Inoceramus*, *Ostrea*	6
Total Eagleford:	140

Beneath this section there is probably about 40 feet of lower Eagleford shale. Prather records from the Eagleford formation, mainly from near the Bosque Farm:

[8]Trans. Texas Acad. Sci., IV, pt. 2, No. 8, pp. 6-8, 1902.

Ostrea congesta Conrad
Ostrea sp.
Inoceramus sp.
Reptilian remains
Fish teeth and vertebrae

Section of Eagleford formation at bridge over Bosque River 0.8 mile east of Bosqueville.

Gravel and sand.	
Eagleford:	Feet
Bluish sandy shale weathering yellow-brown, and thin flaggy sandstones	20
Yellow-brown sandstone	0.3
Slate colored, laminated sandy shale	6.5
Gray sandstone	0.25
Jointed slate colored shale, with two thin bentonite seams	7.5
Bentonite, iron-stained	0.05
Jointed, slate colored laminated shale	1.3
Bentonite, iron-stained	0.2
Jointed, slate colored, thinly laminated shale with a few bentonite partings	3.3
Fossiliferous brown sandstone	0.05
Shale, bluish, sandy	0.8
Bentonite, iron-stained	0.2
Shale, finely laminated, slate colored, jointed	4

Section of Eagleford at Potato Hill.

Austin:	Feet
White chalk, capping Potato Hill, exposed	10
Eagleford:	
Bluish shales, weathering brown, thinly laminated; sandy layers; fossils	35
Brown flaggy sandstone layers with thin interbedded layers of blue shale, iron-stained; inocerami, oysters and other pelecypods	15
Slaty-blue, thinly laminated shale, iron-stained	20 +

This section continues down the creek to the east of Potato Ridge and west of this ridge to the Bosque; near the Bosque the strata are steeply dipping. The base of the Upper Shale Member, just above the Middle Flag Member of the preceding section contains a large microfauna of oxidized pyrite fossils, among which are:

°*Schloenbachia* sp.	°*Hamulina* sp.
°*Mortoniceras* sp.	°*Lytoceras* sp.
°*Pachydiscus* sp.	°*Hemiaster* (?) sp.
°*Flickia* (?) sp.	°Pelecypods
°*Baculites* sp.	°*Natica* sp.
°*Ptychoceras* sp.	°*Hamites* (?) sp.

Potato Hill is an outlier of Austin Chalk just west of the Bosque Escarpment and about ¾ mile northwest of the point where the South Bosque road cuts down through the escarpment.

Eagleford Formation in Brickyard Pit sotheast of St. Louis and Southwestern Ry, and about one mile east of South Bosque station.

	Feet
Eagleford (Middle Flag Member):	
Slate-colored shale, weathering light brownish-yellow.......	6.0
Very calcareous sandstone............................	0.2
Shale..	1.0
Calcareous sandstone................................	0.3
Slate-colored laminated shale........................	2.0
Calcareous sandstone................................	0.25
Slate-colored laminated shale........................	1.8
Indurated grayish shale..............................	0.35
Laminated shale, thin bentonite seam at base..............	3.4
Calcareous sandstone................................	0.3
Laminated, Slate-colored shale, with thin bentonite seams...	1.9
Calcareous sandstone................................	0.35
Laminated slate colored shale with bentonite seams.........	0.5
Hard gray calcareous sandstone........................	0.3
Basal Shale Member:	
Blue, thinly laminated shale..........................	15 0
Very calcareous sandstone............................	0.15
Blue laminated shale, exposed.........................	12

The Middle Flags contain ammonites, *Inoceramus, Ostrea, Pecten*; the basal blue shale *Ostrea, Gryphea, Inoceramus* and pyrite fossils. At the abandoned brick kilns nearby the shale contains various unaltered pyrite fossils, °*Turritella*, °*Arca*, °*Cardium (?)*, °*Inoceramus*, (?), etc.

Eagleford formation on North Fork of Cow Bayou, near Spring Valley, one-fourth mile downstream from Waco-Moody road.

	Feet
Eagleford:	
Slate-colored laminated shale, weathering yellowish-brown..	12
Gray very calcareous sandstone..........................	0.25

	Feet.
Laminated slate colored shale; *Ostrea*, *Inoceramus* and ammonites	3.7
Thin gray sandy hard shale	0.05
Jointed laminated slate colored shale	6.4
Gray calcareous sandstone	0.6
Soft blue shale with six bentonite seams	1.15
Compact light blue shale	0.3
Soft, laminated slate colored shale	0.45

Eagleford formation in Blue Cut of Santa Fe Railway, between McGregor and Moody.

Middle Flag Member:	Feet
Thin flaggy brown sandstone	1.0
Soft yellow shale	1.0
Projecting layers of thin flaggy sandstone, and thin yellow sandy shale	1.0
Gray sandy shale, weathering brown	2.5
Jointed, thinly laminated slate colored shale	7.5
Bentonite seam, iron-stained	0.75
Calcareous sandstone	0.25
Blue shale	0.2
Calcareous sandstone	0.2
Blue shale	0.25
Limestone, sandy, blue-gray	0.25
Blue laminated shale	1.1
Limestone, sandy	0.5
Lower Shale Member:	
Bluish shale, weathering brown	1.65
Bentonite	0.35
Limestone, shaly and sandy	0.15
Blue shale	0.2
Bentonite	0.05
Blue shale	1.1
Bentonite	0.5
Blue shale	4.0
Thin flaggy calcareous sandstones and thin shale layers	6.2

This exposure contains *Acanthoceras, Inoceramus, Ostrea,* pelecypods, fish teeth and vertebrae, carbonized wood, and other fossils.

Eagleford formation at bluff in north part of the town of Moody.

Middle Flag Member:	Feet
Flaggy sandstone	1.0
Sandy shale and flaggy sandstones	7.0

	Feet.
Brown sandstone	0.7
Soft sandy brown shale	1.0
Bentonite, iron-stained	0.7
Hard sandy shale	1.2
Bentonite	0.7
Yellowish shale	0.7
Bentonite	0.05
Gray shale	1.1
Bentonite	0.1
Gray shale	0.5
Gray laminated sandstone	0.2
Gray sandy shale with two bentonite seams	1.5
Sandstone, gray	0.1
Sandy shale with thin bentonite partings	2.2
Gray calcareous sandstone	0.1
Sandy gray shale with thin sandstone seams	0.5
Grayish shale with thin sandy layers and four bentonite seams	3.0
Blue, finely laminated shale	2.0

For sections of the basal Eagleford shale and its contact with the underlying formations, see under "The Comanchean-Cretaceous Contact," especially Locality 964.

Paleontology: (a) *Vertebrates*: At certain levels in the Eagleford formation well preserved remains of fish skeletons abound; and in McLennan County these are sometimes found, but fish vertebrae and teeth are much more abundant. It has long been known that the Eagleford of McLennan County is rich in vertebrate remains. In 1918 Dr. Udden discovered near the foot of the Bosque Escarpment north of the Fish Pond a well preserved reptilian skull, which though not in place, evidently came from the Upper Cretaceous and probably from the Eagleford. This skull has been identified as *Mososaurus* sp.

J. K. Prather (Trans. Texas Acad. Sci., IV, 85-87, 1901) reports Cretaceous vertebrates, mainly Eagleford, "collected within a radius of six miles of Waco," as follows:

"*Clidates*
Ichthyodectes
Protosphyraena penetrans
Oxyrhina extenta
Xiphactinus audax
Cimoliosaurus

Mososaurus
Pleisiosaurus
Squalodonts
Cestracidont sharks

"Besides numerous fishes as shown by the teeth and vertebrae found. These vertebrae specimens were sent by me to the U. S. National Museum, where they were studied by Dr. F. A. Lucas. The same forms have been found in Kansas and Dr. Williston, of the University of Kansas, and Dr. Lucas are of the opinion that the formations from which the Texas specimens were taken (Eagle Ford Shales and Austin Chalk) are identical with the Niobrara of Kansas."

R. T. Hill[9] reports Cretaceous vertebrates from near Waco: "The following fossil vertebrates from the top of the Eagle Ford formation at its contact with the Austin Chalk were collected at Bosque farm southwest of Waco, Texas, by Mr. J. L. Prather and have been determined by Mr. F. A. Lucas of the United States National Museum.

Clidates
Ichthyodectes
Xiphactinus
Protosphyraena
Oxyrhina extenta
Pleisiosaurus (fragments)

and possibly

Cimoliosaurus"

O. P. Hay[10] described the following fossil fishes from the McLennan County Cretaceous:

Pycnodus comminuens Hay. Right splenial and teeth. Locality: Walker Crossing of the Bosque River. Coll. Baylor Museum (type). Horizon: probably Eagleford.

Typodus valens Hay. Portion of vomer, with teeth. Locality: Hog Creek, near Speegleville. Coll. Baylor Museum (type). Horizon: Lower Cretaceous.

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[9] U. S. G. S., 21 st. Ann. Rept., pt. 7, p. 328.
[10] Univ. Texas Bull. 71, 1916.

Fish remains are abundant along the Bosque Escarpment, especially between the Speegleville and the South Bosque roads, and at various places north of the Brazos along the Fort Graham road.

(b) *Ammonites.* Large "cart-wheel" ammonites have been reported from the Eagleford in Johnson and McLennan counties. A large flat whorled ammonite in the Baylor Museum is said to come from this level.. Dr. Udden reports a heavy rather blunt-keeled ammonite with outer volution about one foot thick from the basal Eagleford blue shale south of the Colorado River near Austin. He also states that in the basal Eagleford near Brackett, Texas, large ammonites are rather widespread. Dr. R. T. Hill reports having collected in the Eagleford near Lorena, ammonites of various genera somewhat similar to those described by Böse from Mohóvano, Coahuila, but the collection has not yet been studied. Somewhat similar ammonites were found in the Eagleford shales near Sherman Junction, Grayson County, at a locality discovered by Dr. Sellards and investigated by the writer. These large nacreous ammonites were mainly in ironstone concretions.

An extensive limonite and hematite microfauna, mainly ammonites, occurs in the base of the upper Eagleford shale member at various points along the Bosque Escarpment, notably on the road running southeast from the Crawford road at the Fish Pond, 5 miles southwest of Waco, near Potato Hill between the Crawford, Fish Pond road and the South Bosque road, and at the foot of the escarpment north of the Fish Pond. This fauna, now being studied, is distinctive and is very different from the Comanchean faunules; it contains abundant *Schloenbachia* n. sp., *Mortoniceras* n. spp., *Pachydiscus* n. sp., *Flickia* (?) sp., *Baculites* sp., *Ptychoceras* sp., *Hamulina* (?) *Lytoceras* (?) sp., *Hamites* sp., echinoids, pelecypods, gastropods, etc. Locally these small fossils are concentrated on ant hills located in the shale above the middle Eagleford flags.

It has been debated but not settled, whether in south-central Texas the base of the Eagleford is missing. The fossil zonation and the ash beds should afford a basis for determining whether the 600 or more feet of Eagleford in north-central

Texas is completely, or to what extent, represented in the 40 feet or so at Austin.

PYRITE FAUNAE KNOWN FROM TEXAS LOWER AND UPPER CRETACEOUS.[11]

Pyrite, hematite, or limonite fossils can be found in the Texas Lower and Upper Cretaceous in most blue shale or clay formations which are relatively free from sand. In the interior of the formation, as in well samples, in fresh cuts and steep exposures which are not along lines of water seepage, the clay contains pyrite concretions and the fossils are pyritic; upon greater exposures the fossils are often hematitic, while on gently sloping exposures after prolonged weathering, the fossils are almost exclusively limonitic. The hematite fossils are best preserved.

The following horizons and localities are so far known in the Lower and Upper Cretaceous:

Taylor (Terlingua beds): Terlingua-Alpine road, five miles north of Terlingua, Brewster County.

Austin: Medina County (Liddle).

Eagleford: Brickyard, one mile east of South Bosque; Waco-Crawford road, one-half mile east of Bosque River; one mile north of Fish Pond on Fish Pond road; Potato Hill near South Bosque; three and one-half miles west of Cedar Hill, Dallas County (Bur. Econ. Geol.)

Del Rio: Austin (rare); Quihi, Medina County (Liddle); Del Rio; one mile south of Villa Acuña, Coahuila, on hillsides to east of road to San Diego River (Turritella, Turrilites, Nucula, Arca, etc.); Reed Plateau and elsewhere near Terlingua; Solitario; Mariposa.

Grayson: Denison; Fort Worth; Burleson; Roanoke (Winton); Waco (5.5 miles west on Speegleville road); South Bosque; throughout McLennan County.

Mainstreet: Artillery Range, near China Springs (Pace).

Pawpaw: Fort Worth; Blue Mound, and throughout Tarrant County; Denison; Bennington, Okla., Bokchito, Okla.; Gainesville; Riovista.

[11]See Univ. Texas Bull. 1856.

Weno: Bowen, N. M., above tunnel of El Paso-Southwestern Ry. (Schloenbachia sp., Acanthoceras worthense, Mortoniceras worthense, etc.)

Denton: Denison, near Haslet (Tarrant County) Denton County (Winton); Johnson County (Winton).

Fort Worth: Base, at Fort Worth.

Duck Creek: Fort Worth; throughout Tarrant County; Fink; Denison; Gainesville; Denton County (Winton); Johnson County (Winton).

Kiamitia: Fort Worth (Winton and Scott); 7 and 12 mile Mesas, Fort Stockton; Leon Springs; Kent. There is so far no record of these fossils from the Fredericksburg and Trinity divisions.

Austin Formation

The Austin Chalk forms an irregular strip averaging about 5 miles in width across the center of McLennan County from the Hill County line, near West, to the Falls County line, near Eddy. Its west border, underlain by Eagleford shales caps the Bosque Escarpment. Along this important upland chalk strip the main travel routes from north to south-central Texas run, and on it some of the principal towns in the county are built. The west border of the Chalk crosses the M. K. and T. Railway about 3 miles north of Abbott and enters McLennan County just west of the Dallas Interurban. On crossing the Brazos it forms a considerable reentrant partly flanked by tall cliffs of the basal Chalk. South of the Brazos the western border of the Chalk is irregular, and where it is cut through by the Black Prairie drainage, as west of Lorena, erosion into the Eagleford has left several Chalk outliers to the west. The east border of the Chalk is overlain by the Taylor formation and shows very little topogaphic relief. Austin chalk exposures with typical fossils are seen on the Hill-McLennan County line three miles north of east of the M. K. and T. Railway. The contact passes south, with small reentrants in the larger streams, and, mostly concealed, reaches the east part of the city of Waco, where it is exposed in Waco Creek. South of Waco the contact lies west of the Robinson-Rosenthal-Golinda road, and avoiding the high interstream areas, follows the valleys downstream for considerable distances.

The eastern Chalk border is difficult to map accurately due to its similarity to the base of the Taylor. In the southern part of the county there is a zone of large thick-keeled ammonites near the top. These are found at localities 2 miles south of west, and 2¾ miles southwest of Robinson, 2 miles south of west of Rosenthal, and elsewhere. The argillaceous upper Chalk is well exposed near a schoolhouse at the North Cow Bayou crossing of the Levi-Bruceville road near the Falls County line. The upper Chalk contains a zone of ammonites at a bridge 1¾ miles east of Hewitt on the Robinson road. On the other hand the top of the Chalk in Waco is a firm white limestone characterized by a ribbed *Inoceramus* and *Ostrea* sp. and is overlain by bluish-black laminated Taylor shale. (Plate 2b.)

In the city of Waco the Austin-Taylor contact is exposed in Waco Creek from 11th street to 3rd street.

Just north of 3rd street is a small patch of Austin Chalk. There are no exposures between this and the river. Just north of the 4th street bridge is an Austin exposure; just south of the bridge is a Taylor exposure. Between 4th and 5th streets on Waco Creek is a small exposure of the top of the Austin Chalk with characteristic ribbed inocerami and oysters. At the 5th street crossing there is no exposure. At 6th street there is about 5 feet of Austin in the bed of the creek overlain by ½ foot of Taylor; this is overlain by several feet of gravel of the second terrace. Excavations on Baylor University campus south of this point show some Taylor, and the top of the Chalk is probably at a very shallow depth. At 7th street, same relations as preceding. At 8th street there is no exposure. At 9th street in the bed of the creek the top 5 feet of the Chalk is exposed. At 10th street on upstream side of bridge, the top of the Austin is faulted against the base of the Taylor. At 11th and Gurley the top of the Chalk is dipping east, as is seen in two places; near Gurley street in the bed of the creek a small fault with upthrow to the east faults the basal Taylor against the top Austin; beds on both side of the fault have an easterly dip; the displacement is about 4 feet. Upstream from this point no exposures were seen.

Bruceville-Lorena Area. In this area the main exposures are along creeks, which afford a rather full section of most levels of the Chalk. The area between Bruceville and the McKie well has many outcrops; the west border of the Chalk is poorer.

Bosque and Brazos Valleys. The face of the Bosque Escarpment and the roads cutting through its rim give good exposures of the basal Chalk. The cliffs along the Bosque (Lover's Leap) and most of the Cameron Park area have excellent exposures of the Chalk. It is here overlain by river terraces; one of the park roads cuts several times across the meanders of a Pleistocene stream, the cross-section of whose bed in the Chalk can be plainly seen. Lovers' Leap has the best continuous Chalk exposures in the county. Probably only a small thickness at the base is concealed. Here the base of the Chalk is very argillaceous, blue and flaky, and its massive beds weather into rounded projecting and receding ledges and at places to a smooth cliff face. Large fallen blocks weather rapidly by exfoliation and by slaking. The Austin Chalk is rather watertight except along joints and faults and on account of extensive recementation makes an impervious formation. Along the Brazos it has extensive calcite veins. The bluffs at the mouths of White Rock and Aquilla Creeks expose the basal Chalk.

Chalk North of the Brazos. The best exposures are in the valley of Whiterock Creek. Near the Harrington well considerable small scale faulting occurs. There are exposures near the town of West, but here it is difficult to follow the sequence of beds due to thick soil and flat topography.

Thickness: The Shelton No. 1 well near Axtell apparently had Austin Chalk from 1086 to 1503 feet. Probably the thickness in McLennan County does not exceed 425 feet.

Paleontology. In the basal Chalk there is a zone of an *Inoceramus* whose diameter reaches 2 feet or more. These fossils occur in Cameron Park, at the Reuter street crossing of Blue Branch, near the point where the Lorena-Temple road crosses South Cow Bayou near Bruceville, and elsewhere. This zone is very widespread in south-central and Trans-Pecos Texas. In the Cameron Park are various ammonites and inocerami. A large *Mortoniceras texanum* with the apertural "horn" almost complete was excavated from the foundation of the Amicable Building. The Austin Chalk fauna includes a great variety of mollusca and other fossils, some forming rather distinct zones. Near Waco are found *Hemiaster texanus, Pecten bensoni, Pecten,* spp., radiolites *Durania austinensis) Baculites,* inocerami, ammonites, etc.

Taylor Formation

The Taylor formation occupies the portion of McLennan County, aside from stream deposits, east of the Austin-Taylor contact above described. The formation is mainly a bluish to grayish calcareous clay, and produces gentle rolling topography except on interstream divides, which are high and broad and in general west of the Brazos trend with the dip of the beds. North and east of the Brazos the Taylor divides are largely controlled by the direction of the Tehuacana Creek and its tributaries. The formaton contains argillaceous chalk members and some thin sand strata. Due to the inconsecutive nature of the outcrops the best conception of the Taylor as a whole can be obtained from the records of recently drilled wells.

Chalk Members in the Taylor: The Axtell and Battle sections, as recorded in well logs, differ somewhat from each other: that at Axtell has considerably more chalk in the Taylor, although it is situated farther west and reached the top of the Austin Chalk about 200 feet shallower. It is supposed, from the presence of chalk in the Taylor along the Mexia Anticline that the Taylor becomes more chalky towards the east, at least in its upper part, and that the Chalk strata interbedded with the clay in McLennan County represent inshore interfingerings or stringers of the main chalk mass. The Taylor thickens to the east. The Battle well has numerous scattered thin chalk layers, none over 10 feet thick. The Axtell log records 115 feet of chalk and clay lying from 971 to 1006 feet above the Austin-Taylor contact, 86 feet of material mainly chalk at 480 to 566 feet above that contact, and 106 feet of chalk at 40 to 146 feet above the contact. There are some indications of still higher chalk members of at least local extent, in the Taylor formation. The town of Marlin is built on a chalk member near the top of the Taylor, which contains *Exogyra ponderosa,* oysters, etc. E. L. Porch has noted on the farm of Col. Brown, about 2 miles east of Mart in Falls County, stream cuts in a chalk member in the Taylor formation. About 15 feet of chalk is exposed, grading upwards into calcareous clay; the base of the chalk was not seen. Ammonites (*Baculites,* etc.), small terebratuloid brachiopods and inocerami were found in these exposures.

Sand Members in the Taylor: The Axtell log records "sand, streaked and packed," at 48-69 feet. The Battle log records "sandy shale, show of oil" at 420-428 feet; sandy shale from 700 to 800 feet; "sand and shale with oil and gas show" at 1227-1240 feet; and "hard sand, oil showing" at 1240-1245 feet. There are strips of sandy land in the Taylor outcrop in which the sand appears to be residual and not an upland stream deposit. Such a sandy belt is crossed on the Mart road 2.3 miles north of east of the junction of this road with the Harrison-Reisel road, and again along the strike of the same belt, near the H. and T. C. Railway about 1½ miles below Reisel. Sand belts are reported from elsewhere in eastern McLennan County.

Bentonite Layers in the Taylor Formation: The following information was furnished by Dr. Udden: Bentonite has been found in central Texas at levels supposedly near the top of the Taylor at 200 feet in a well at Garfield, 12 miles east of Austin. At low levels in the Taylor, in Bexar County 10 feet or so of bentonite is known at a level about 150-200 feet above the base of the Taylor; and the volcanics at Thrall, Williamson County is supposed to be near this low Taylor level. Near Oneaville, Bell County, is a bentonite layer whose exact level is unknown to the writer. There is so far no record of these bentonite layers in the Taylor of McLennan County.

CENOZOIC AND RECENT

High Upland Gravels

(PLIOCENE?)

On high divides in the west half of the county, as around Erath and China Springs, at points 200 or 250 feet above the Brazos are found rather consolidated gravels and sand in scattered residual areas. These on cursory examination seem unrelated to the present drainage, and may represent an earlier system of terraces, possibly pre-Pleistocene in age. So far as known, no fossils have yet been found in these deposits. The rock is a dense, firmly cemented gravel locally called "concrete gravel." The cementing material is indurated and calcareous, and blocks fracture across the included pebbles. The inclusions consist of limestone, quartz and chert pebbles and rudistid fragments. An upland gravel is reported from near Axtell and other places in the eastern part of the county.

River Terraces

(PLEISTOCENE)

There are at least three well defined Brazos River terraces near Waco, and possibly more. These also occur in proximity to the laterals of the Brazos. All three are stated to have rather similar proportions of sand, gravel and iron. The top of the low terrace lies near Waco about 25 feet, the middle terrace about 40 feet, and the top terrace 60 or more feet, above the Brazos. The top of the middle terrace at Waco has an elevation of about 410 feet. The Brazos, above the mouth of the Bosque, makes extensive terraces along its right bank and locally on its left bank. From the mouth of the Bosque to Waco the river occupies the southwest side of its flood plain, cutting against the base of tall Austin Chalk cliffs, and consequently the terraces are for the most part developed only northeast of the river. Below Waco the flood-plain is wide and low, and terraces occur on both banks.

TOP TERRACE: White Rock Gravel & Sand Co., 40-foot cliff face; "White Rock" pit; Raleigh Hotel (elev. 420); Waco High School (elev.435).

MIDDLE TERRACE: Waco, from river to about 6th Street (elev. 410), in building excavations; Baylor University, Robinson road, in Waco Creek, and excavations; 3rd and Bosque streets, Waco, in pit.

LOW TERRACE: Gravel pit near Filtration plant (elev. 395?)

Pleistocene Fossils: Dr. O. P. Hay states that the fossils so far found from these three terraces in McLennan County are similar, and do not afford a basis for subdividing the Pleistocene. He has kindly furnished a list of the fossils seen by him:

Mylodon sp. (probably *harlanii* Owen). Ground Sloth. Femur. Locality: Hog Creek, 3 miles northwest of Speegleville; Museum Baylor University.

Bison, extinct species. Humerus, two cervical vertebrae. Locality: Creek near Crawford. Department of Geology, University of Texas.

Fossil horse. Third metatarsal bone. Locality: Potts-Moore gravel pit, near Waco. Dr. Mark Francis, College Station.

Mammut americanum. Mastodon. Two cross-crests of tooth. Locality: Hog Creek, Speegleville. Baylor University Museum.

Mammut americanum. Mastodon. Upper left third molar Locality: "Bosque River, 15 miles from Waco."

Gomphotherium elegans Hay. Upper right second molar. Locality: Hog Creek, near Speegleville. Baylor Museum. (Proc. U. S. N. M. vol. 53).

Elephas columbi Falconer. Mammoth. Two teeth, last milkmolars, and both sides of upper jaw. Locality: White rock sand pit, above Waco; third (highest) terrace. Baylor Museum.

Elephas columbi Falconer. Mammoth. Part of lower jaw of young. Locality: White Rock pit

Elephas columbi Falconer. Mammoth. Two upper hindermost molars. Locality: Third and Bosque Sts., near river (second terrace). Baylor Museum.

Elephas imperator. Two much worn lower molars. Locality: White Rock sand and gravel pit; third (upper) terrace. Baylor Museum.

Elephas imperator. Fragments of lower molars. Locality: Potts-Moore Gravel Pit; second terrace. Baylor Museum.

Camelops hesternus Leidy. Camel. Metapodial and part of right side of lower jaw; jaw contains last premolar and third molar. Locality: White Rock Gravel Pit. Baylor Museum.

Smilodon (?) sp. Upper half of right humerus. Locality: White Rock Gravel Pit. (See: Hay, Univ. Texas Bull. 71, 1916.)

Alligator mississippiensis. Left ramus of lower jaw. Locality: White Rock pit; upper terrace. Baylor Museum. (See: Hay, Univ. Texas Bull. 71, 1916).

In 1923 was found: *Elephas* sp. Two molars, portions of jaw and leg bones. Gravel pit near Paul Quinn College, East Waco; middle terrace. Department of Geology, Baylor University.

The present-day streams contain an extensive fauna of pelecypods and gastropods, of which the following are the commonest species in McLennan County[12]:

LIVING MOLLUSCA FROM BOSQUE RIVER, McLENNAN COUNTY, TEXAS

Mussels	Snails
Lampsilis anodontoides Lea.	Praticolella berlandieriana Moricand.
Lampsilis texasensis Lea.	Polygyra texasiana Moricand.
Lampsilia purpuratus Lamarck.	Polygyra roemeri Pfr.
Lampsilis amphichaena Frierson.	Bulimulus dealbatus mooreanus Pfr.
Lampsilis berlandieri Lea.	Helicina orbiculata tropica Jan.
Lampsilis gracilis Barnes.	Planorbis tumidus Pfr.
Plagiola macrodon Lea.	Physa mexicana Ph.
Unio tetralasmus Say.	
Quadrula forsheyi Lea.	
Quadrula aurea Lea.	
Anodonta imbecillis Say.	
Tritogonia tuberculata Barnes.	

Essentially the same fauna occurs in the Brazos and all other streams of the region.

STRUCTURAL GEOLOGY

The rock sheets in McLennan County dip in a direction south of east, toward the Gulf of Mexico. A formation lying on the surface in the west corner of the county will lie at a depth of more than 2300 feet in the east corner of the county. East of the Bosque Valley the regional dip is about three times as steep as in the west part of the county. This gulfward dip of the strata is interrupted locally in McLennan County by the presence of lines of folding and faulting running in a direction a little east of north.

Bruceville-Waco Line of Structure

Such a zone of faulting has been described by Hill, Pace and others as extending in a direction about parallel to the strike of the formations, through the Austin Chalk outcrop from a

[12]Information on taxonomy of mollusca was supplied by Mr. J. K. Strecker who has made an intensive study of the fauna of Central Texas. See: John K. Strecker, The Mollusca of McLennan County, Texas. Nautilus, xxii, No. 7, 1908, pp. 63-67.

point about 2 miles east of Eddy to the southern part of the city of Waco. This fault zone consists of two or more parallel faults or flexures which, on account of the scarcity of exposures, are seen mainly in the creeks which cut across the fault zone. Such faulting has been observed in the south and north forks of Cow Bayou, in Bullhide Creek and in the branches of Castleman and Lake Creeks. "On all streams south of Waco two faults, from 20 to 60 feet apart and with the intervening beds highly tilted, occur near the eastern edge of the Austin outcrop. Within a quarter of a mile on either side of this are faults that seemingly have less throw. The larger fault is seen in South Waco at Eleventh street in the channel of Waco Creek, and as suggested above, may be seen in all the ravines south, such as Lake, Castlemn, Cow Bayou and their tributaries" (Pace). All of these faults are inconspicuous as they seem to involve relatively small displacements. All faults observed east of Bruceville and Lorena showed displacements of only a few feet. In a branch of Castleman Creek east of Hewitt there are two small faults with their east sides downthrown, situated about 150 feet apart. On either side are joints; both joints and faults are marked by striated calcite veins. The joints trend in various directions, south to southwest. Near the Eleventh street bridge over Waco Creek there is a fault of about 4 feet displacement, with the top of the Austin Chalk upthrown to the east and faulted against the base of the Taylor (see Plate 2b.) The dips on both sides of the fault are toward the east. Due to the alluvial mantle in and around Waco it is difficult to discover the lines of faulting probably existing in the underlying Austin Chalk. It therefore seems useless at the present time to project lines of faulting beneath this area. The Bruceville-Waco line if projected would pass near the fissure springs on Reuter street, described by Dr. Pace, and in Cameron Park and, continued north of the Brazos would pass up the valley of Whiterock Creek near the Harrington well where there is considerable small scale faulting in the Austin Chalk. Dr. Pace reports a fault of at least 15 ft. displacement in the Austin Chalk in Blue Branch, North Waco. There is another possible line of faulting east of this and parallel to it, crossing Waco Creek at Eleventh street, between Gurley and Baylor Sts., and passing near Waco Springs on the Brazos, near First and Austin Sts. Such a line, with the east side upthrown, might explain some of the anomalies in old well records in the city of Waco.

Bosque Escarpment Line of Structure.

Steep dips occur at various places in the Eagleford flags near the foot of the Bosque Escarpment. These dips align with each other and indicate a trend of slightly east of north. From the available data it is impossible to decide whether this line of disturbance represents a sharp flexure, a fault at the surface, or a buried fault with a flexure as its surface expression. In any case the displacement or flexing causes the beds east of the line to lie lower than those west of it. No springs, fissures, calcite veining or other evidence of faulting have been noted along this line, and hence provisionally the structure is considered as a rather sharp monoclinal flexure in eastward dipping beds. On the Speegleville road 0.5 mile east of the Bosque bridge there is a steep east dip in Eagleford flags in a roadside cut. No evidences of faulting were seen at this place. On the Fish Pond (Crawford) road west of the Fishing Club and 1.15 miles north of east of the Bosque River in the Eagleford flags, there is a low east dip which increases suddenly to 24° E., without evidences of faulting. Many steep east dips occur in the Eagleford flags along a small creek which drains the escarpment near Potato Ridge and empties into the Bosque about a mile downstream from the junction of the South Bosque and the Middle Bosque Rivers. This structural line if projected, passes near the abandoned brick pit east of South Bosque, in which the dips are larger than usual. Finally, steep dips probably connected with this structural line occur at a point on the Moody road 0.75 mile south of the Blue Cut of the Santa Fe Ry., between McGregor and Moody. The (partial) dip here is about 13° NE., which a short distance south reverses to about 2° SW. There is no evidence of faulting. This may represent cross folding. These points align closely with each other, and coincide with the +100 ft. contour based on the Edwards Limestone (see Structural Map), and this line of disturbance therefore lies at the division line between the west part of McLennan County, which has gently dipping strata, and the east part, which has more steeply dipping strata.

This projected line is approximately continuous with the main Balcones Fault line mapped by Hill as passing through south-central Texas to a point between Nolanville and Belton, Bell County, north of which it was not mappable as a fault. If these two structural lines should prove to correspond, the Balcones Fault along this line has changed to a fold near the southern border of McLennan County. (Hill's more eastern line of faulting in Bell County passes from near Eddy to near Waco, in the Austin Chalk outcrop, as already described).

Dr. Pace has also described a line of faulting visible within the west edge of the Austin Chalk at points where the various county roads cut down through the Bosque Escarpment.

The South Bosque oil field lies on an anticline of small closure, which trends nearly parallel to the strike of the Comanchean formations. This low structure has along the crest isolated highs, from which the production comes, and does not appreciably affect the amount of regional dip. Surface indications of the reversal of dip in this structure are visible in its northward extension, where it is cut across by the Middle Bosque and by Hog Creek. (See structural map).

On the North Bosque at a point south of west of Erath, Ben K. Stroud has studied and mapped a fold extending parallel to the strike of the formations. He states[13]: "There is a fold, parallel to, and about 10 miles west of the Bosque fold. It was found dry upon drilling. There is also a third parallel fold just east of McGregor."

Dr. Pace has also described a fault of small displacement, which is possibly continuous from near Bosqueville to near South Bosque; it is reported from the McNamara place near Bosqueville, from Hog Creek between the Crawford road bridge and the mouth of the creek, and on the Middle Bosque along a continuation of the same line.

Thrust fault at Lorena: On the M. K. and T. Ry., 300 feet

[13]Letter, February 27, 1923.

north of the station at Lorena is a small thrust fault with a trend north of east. The north block dips about N55° E, about 2° to 4°; the south block dips S50° E about 45°; calcite masses are abundant. This is possibly a cross fault; it does not line up with any other faults known to the writer. Dr. Pace has reported some cross-faulting in the region of the B. G. McKie well, west of Bruceville.

Contour Map on the Edwards Limestone: The accompanying contour map shows in a generalized way the position of the top of the Edwards Limestone in McLennan County. Contour maps constructed from the elevations of various other key horizons in the Lower Cretaceous reveal essentially similar relations. Both the elevations and the depth to the Edwards are doubtful in some wells, and therefore the contours are only approximately correct.

It is noticeable that the gulfward dip of the Edwards west of the +100 ft. contour is more gentle than east of that line. Between the +100 ft. and the +200 ft. contours in the Bosque Valley, the distance is greater due to the local South Bosque anticline, which could be shown with smaller contours. The courses of the Bosque and the Brazos Rivers on crossing the Austin chalk outcrop are noteworthy. The Bosque runs more or less along the strike near the 100 ft. contour, and then turns abruptly down the dip, entering the Austin chalk outcrop. The Brazos likewise runs along the strike near this contour, and then meanders across the Austin chalk exposure, running alternately in the dip and the strike.

The narrowness of the Eagleford outcrop just west of Waco may be in part due to faulting with downthrow to the east, and the courses of the rivers a local adjustment to this condition. The Bosque Valley faulting however does not involve much displacement of the beds.

The Chalk Bluff of the Brazos below the mouth of Aquilla Creek sections a sunken block, the axis of the bounding faults running south of east. In this V-shaped graben the strata have been shortened by crumbling so that the drag is reversed. This block probably is a part of the cross faulting system. The displacement is only a few feet.

Summarizing, it may be stated that faults of any consider-

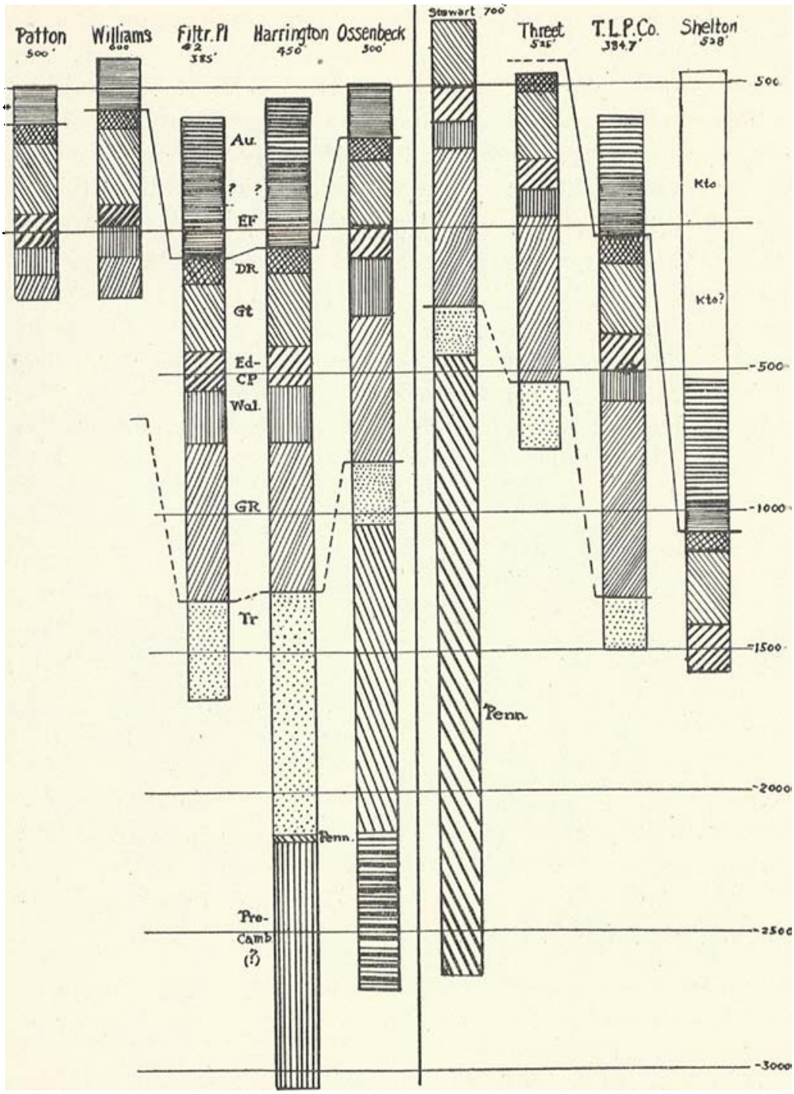

Fig. 8. Correlation of well logs in McLennan County.

able displacement have nowhere been seen in McLennan County. It is difficult to detect faults in the surface exposures of the east half of the county, and since few wells have been drilled there the faulting conditions are unknown. If faults of small displacement occur in the soft formations (Del Rio, Eagleford, Taylor), they are doubtless sealed, and in relation to petroleum act as in unfaulted areas. The Del Rio and Eagleford appear in logs as one formation due to the absence of intervening beds in McLennan County. The major structural feature of the county is the sudden increase in the steepness of the dip, at the east edge of the Bosque Valley; this is associated with folding, as in the South Bosque field, and with a monoclinal flexure or minor faulting with the east side downthrown.

It is apparent that the folding in the west part of the county, that along the Bosque Valley and that in the Black Prairie, are a part of a larger regional folding which embraces the Balcones and Mexia lines of structure and probably several other lines between these and to the east and west of them.

ECONOMIC GEOLOGY

Oil and Gas

Many Comanchean and Upper Cretaceous formations in the McLennan County region are to a small extent petroliferous. Possibly all the Upper Cretaceous formations will carry oil in small quantity under suitable structural conditions and where a reservoir is present. The Eagleford shales are bituminous and produce oil showings at many places in the county. A horizon near the level of the basal Walnut formation produces widespread oil showings; this may be equivalent to the South Bosque horizon, but this cannot be positively stated.

The following horizons are more or less petroliferous at various places in central Texas.

Navarro: Does not outcrop in McLennan County. Nacatosh sand in North Texas.

Taylor: No records of oil in McLennan County. Somerset field, Bexar County; Corsicana and Powell, Navarro County; Thrall oil field, Williamson County (metamorphosed igneous).

Austin: Altavista and Mission fields, Bexar County.

Eagleford: At depths of from 500 to 1000 feet in the Waco wells (Hill); Myrick farm, 4½ miles southwest of Lorena, dark oil reported from 21 feet in a dug well (1923); 2½ miles west of Bruceville on Erath place, oil reported at 300 feet, probably near the base of the Eagleford. Patton No. 1 well, 3 miles south of west of Lorena, oil reported at 124 feet.

Woodbine: Absent as oil reservoir in McLennan County; producing horizon Mexia and northwards; Caddo field of Louisiana.

Edwards or Georgetown: At Bruceville, 600-700 feet in Fredericksburg or Washita (Hill); producing horizon, Luling, Caldwell County.

Walnut: Probable horizon in South Bosque field; Walt Crane place on Crawford road, between Bosque River and Hog Creek, at about 500 ft.; "Crawford at 400 feet in the Walnut clays" (Hill); oil and sulphur water at 800 feet at Lorena, possibly in this horizon; oil show reported at 650-700 feet at Moody; small oil show reported at Tokio at 700 feet; heavy oil supposedly from near this horizon on John Kolls farm, 4 miles southwest of Belton at 256 feet; these represent Walnut or upper Glenrose horizons. Indications of petroleum are seen at the outcrop of the basal part of the Walnut formation in the valley of the North Bosque River (Hill).

Glenrose: Oil shows from Moody, Tokio, South Bosque ("deep tests"), and elsewhere in western McLennan County may be referable to the Glenrose formation.

Trinity: Valley Mills, at 700 feet, a few drops of oil on upper Trinity water; Waco and elsewhere in water wells.

Lower Cretaceous: Waco City wells; wells at Fish Pond, about 5 miles southwest of Waco; Eddy artesian wells; Panola County; Kosse, Limestone County.

South Bosque Oil Field

Oil has been produced in South Bosque since about 1902. The wells are 450-475 feet deep and their average yield on pumping is near 2 barrels a day. The field as developed is of restricted area, production so far having come from a strip about ½ mile wide extending north of east from near South Bosque station to Hog Creek, a distance of about 3 miles. There is a small refinery at South Bosque station. The Humble pipeline crosses the field. The wells start in the base of the Del Rio clay or the top of the Georgetown limestone. The gravity of the oil is 42° Beaumé. The production of the field has dropped in recent years; in 1921 the average amount shipped was about one tank car per day.

Oil Horizon: The horizon of the South Bosque oil is a thin sand stratum near the base of the Walnut formation. The Paluxy, often stated to be the horizon of the oil, is absent in McLennan County. Indications of petroleum are noticeable at the outcrop of the basal Walnut in the North Bosque River

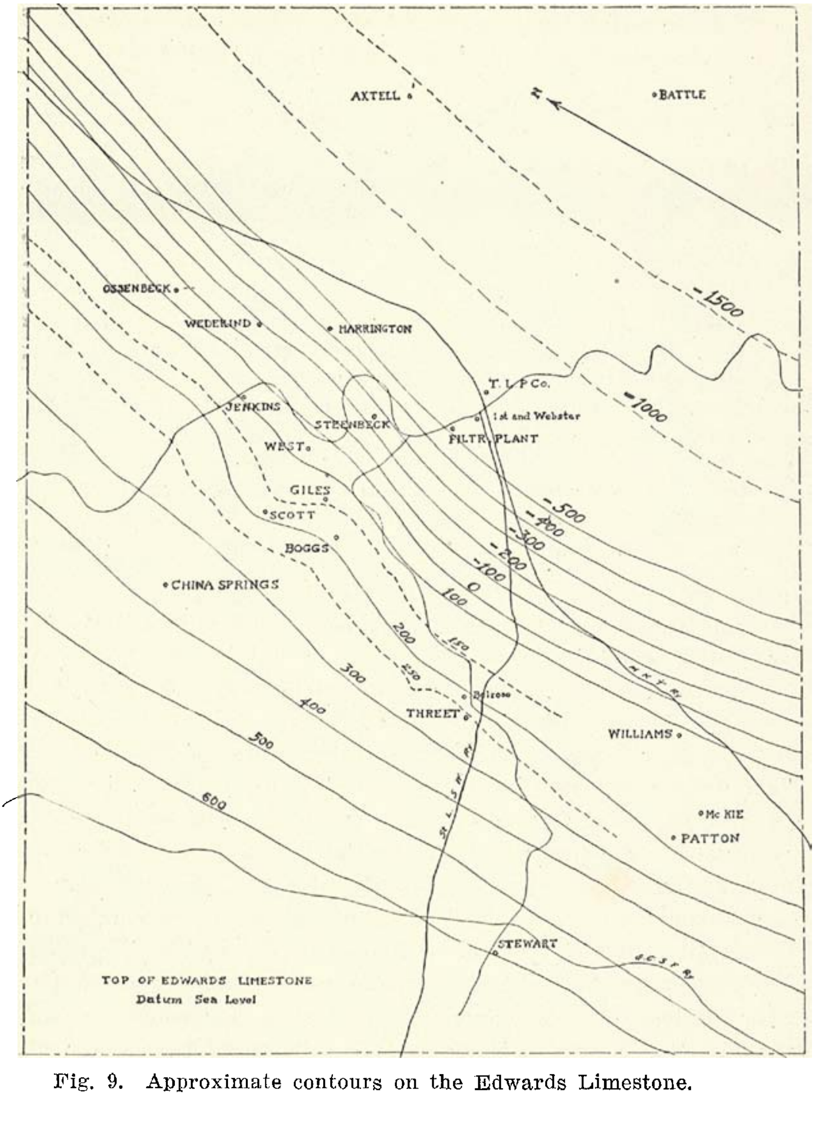

Fig. 9. Approximate contours on the Edwards Limestone.

Valley. The oil horizon varies in thickness and in lithology, even within the South Bosque field. In general it becomes more shaly towards the south, and where it is shaly dry holes are encountered.

The following reported thicknesses indicate the relations of the strata near the oil horizon (Thickness in feet):

	"False cap"	Shale	"Cap Rock"	Oil Horizon	Lime-stone
NORTH FIELD	1	1+	3–4	2.5–3	..
Bellrose test	..	...	4	6	33
Threet test	..	...	...	3	8
Amicable 1	1	3	1	4	..
Amicable 2	1	3	5.5	1+	..
Amicable 9	..	...	4	1+	..
Morgan 1	..	...	5	9	..
SOUTH FIELD	½–0	1±	1±	2½–3	..
Bickle 1	..	...	2	2	..
Mitchell 1	..	...	1	2	..

The "false cap" is a limestone stratum about a foot thick in the north part of the field; southwards this thins and in some wells is absent. Beneath it and above the "cap rock" is a thin calcareous shale. The recorded thicknesses of the "Cap rock" are variable and unreliable; it averages about 4 feet, and thins towards the south. The oil horizon is 3 to 4 feet thick. In the north part of the field it is a quartz sand with local shale streaks; southwards it is at places largely or entirely of shale.

The base of the oil horizon is water bearing; this water increases on the west flank of the structure, and to the south, where the sand has been locally flooded. The wells can be pumped twice daily, accumulating oil during the intervals.

Structural Conditions: The accompanying contour map was compiled in part from logs and samples of recently drilled wells and in part from the reported depths of old wells. Information about many old wells is conflicting and unreliable. It appears from the available data that the structure is an anticline with small closure and that the production from the old (south) part of the field comes from a small dome on the crest of the structure, while the main production from the newer north field comes from a similar high whose center lies on the Stevenson tract. The section penetrated in all wells is essentially the same, with the local variations just described. The top of the oil sand, a level generally recognized in drilling, was used as a key horizon. The wells start in the base of the

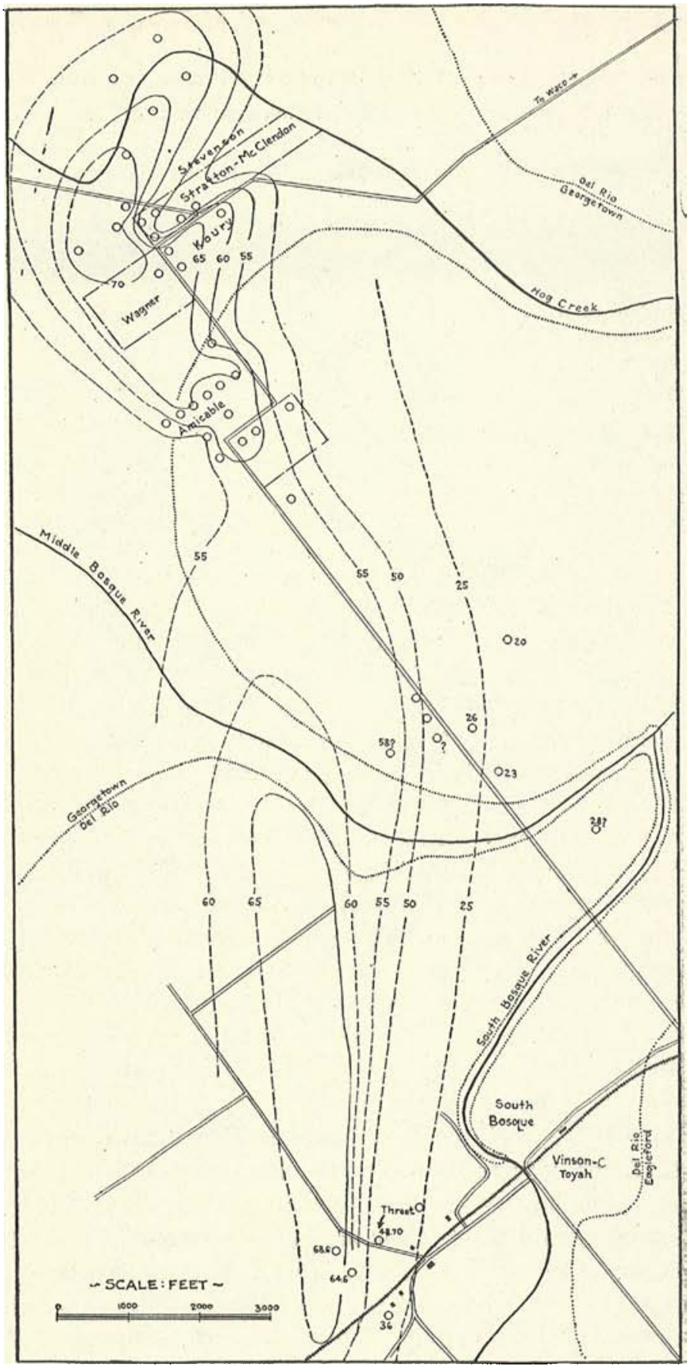

Fig. 10. Map of the South Bosque oil field.

Del Rio or the top of the Georgetown, and the oil sand lies near the base of the Walnut formation. Del Rio, with *Exogyra arietina*, was recognized in some Amicable wells. The Georgetown, with a water horizon at about 160 feet, is recognizable. The Edwards is a pure crystalline limestone. Shell banks of *Gryphea marcoui* characterize the Walnut formation.

The following tabulation gives the approximate elevations, depths to oil horizon, and elevation of the oil horizon in feet above or below sea level, for certain of the South Bosque and nearby wells:

		Elev.	Depth	Sea Level
Morgan	1	489?	425	64
Kercheval-Stroud			426	
Stevenson	1	518.3	448	70.3
	2	513.7	448	65.7
	3	510	446	64
	4	522.4	448?	74.4?
	5	518.6	448?	70.6?
	6	520.8	448?	72.8?
Stratton-McClendon	1	515.7	460	55.7
	2	517.3	460?	57.3?
	3	515.7	460?	55.3?
	4	513.3	460?	53.3?
	5	512.7	452	60.7
Wagner	1	517.9	448?	69.9?
	2	516.6	448?	58.6?
Carpenter-Fallis	1		459	
Koury	1	512.4	451	61.4
	2	515	449	66
	3	515.8	450?	65.8
	4	515.4	450?	65.4
Amicable	1	513.6	454	59.6
	2	514.4	458.5	55.9
	3	513.7		
	4	515.1	450	65.1
	5	515.2	451	64.2
	6	515.7	453	62.7
	7	517	452	65
	8	518.2	454	64.2
	9	518.7	461	57.7
Pyron	1	475?	?	
	2	475?	455	20
Clay	1	508?	417	91?
	2		426.5	

		Elev.	Depth	Sea Level
Bickle	1	534?	479	55?
	2	513.4	479?	34.4?
	3	509.7	479?	30.7?
Zipper	1	510?	527	—17?
Mitchell	1	530.4	521	9.4
Moore	1	478.4?	454	24.4
Threet	1	521.7	473	48.7
Sinclair-Deal Phelps	1	522.6	454	68.6
	2	518.6	454	64.6
Grimm (Letsinger)	1	515?	460	55?
Belrose	1	515?	472	43?
Vinson-Toyah	1	490?	418	72?
Badger-Moore	1	475(468)	460?	15
Bosque Petr. Co. (1919)	1		478	
Kilion	1	521.7	486	36?
(Roberts Survey)	1		486	
Bellrose Deep Test		502	466	36
Wait Crane		500	500	
Hander	1	500?	603	—103?
	2	450?	650	—110?
Corbell	1		575	
Sharp-Shrader			391	

Other Structural Possibilities

If further wildcat wells are to be drilled in McLennan County it would be better to locate them along some known line of structure than on no structure at all. Since it is not clear whether the flexure along the east edge of the Bosque Valley has reversal or not, no positive recommendations regarding it can be made at present. However, along this projected line there is a distinct reversal near the Blue Cut of the Santa Fe Ry. Even in case this structure involves faulting it would be advisable to drill on the down dip (east) side of the fault to test the possibility of small production similar to that of the South Bosque field. It should be noted that the old water well drilled at the Fish Pond, rather near to this line of structure, indicated small production, which properly located wells might be able to prove.

The north extension of the South Bosque Anticline has not been sufficiently drilled to indicate whether there is another small dome on the axis north of the new field, and with roughly the same spacing between highs or not; there are some slight indications that this may be the case. There is no distinct probability at present that such tests would find oil at any level below the South Bosque horizon.

There is a possibility that the tilted blocks between fault lines along the Bruceville-Waco (Austin Chalk) faults, or the area contiguous to the easternmost of these faults on its down-dip side may contain sealed reservoirs and hence trap small amounts of oil.

Finally there are probably structural lines in the eastern third of the county, which have not been discovered due to the soft nature of the surface formation.

Water

The water supply may be divided into (a) Artesian wells, (b) surface wells, (c) springs, and (d) streams. The city of Waco derives its waters from pumped wells in the Trinity reservoirs, Brazos River water, and wells in the river sand.

Artesian Water

McLennan County lies in the main artesian belt of central Texas. Waco, formerly known as the "Geyser City" on account of the number and size of its flowing wells, is located in a narrow zone along the Balcones line of structure, east of which the artesian reservoirs of the Comanchean through their gulfward dip rapidly become too deeply embedded to be available. The first flowing wells near Waco were drilled to the upper Glenrose reservoir at about 1100 feet. After 1889 when drilling experiments in Fort Worth and Waco had demonstrated the existence and value of the Trinity reservoirs, numerous Waco wells were drilled to that level. In 1891 there were 11 flowing wells in and around Waco; in 1897 Hill reported 27 flowing wells and 8 non-flowing wells in McLennan County. Subsequent wide spread drilling and waste of artesian resources has lowered the water pressure so that only a few wells, such as the Watt well, now flow.

The principal waters available in McLennan County wells are:

Georgetown: A small water stratum about 70 feet above the base of the Georgetown is widespread in the county; it is a stratigraphic marker in the South Bosque oil field and elsewhere. It has no economic importance.

Glenrose: Within a few feet of the top of the Glenrose limestone, there is a widespread water stratum. (1180′ in Padgett well, 1194′ in Filtration Plant No. 2, 1195′ in Harrington well, 750′ in Ossenbeck well, etc.)

The upper half of the Glenrose seems to have several water strata in various wells Some wells show irregularities in the relations of the Glenrose water strata. Hot water occurs in the Harrington well at 1330-1350 feet. In this well also, two waters were reported in the basal Glenrose.

Upper Trinity (T_1): Widespread in central Texas; underlies the whole of McLennan County. (1320′ in Ossenbeck well, 1810-1830′ in Harrington well, 1782′ in Padgett well, etc.)

Middle Trinity (T_2): Widespread, perhaps the most important artesian reservoir in the county. This is situated 150 feet below the Upper Trinity and 100 feet above the lower Trinity.

Lower Trinity (T): Most wells in the county do not drill to this reservoir. (1950′ in Filtration Plant well, 2075′ in Harrington well, 2048′ in Texas Light and Power Company well).

Fourth Trinity (?): 2048′ in Filtration Plant well 2108′ in Harrington well. Apparently absent in some wells.

Depths and analyses of artesian waters of McLennan county are given in the following pages.

Surface Wells

Near Bosqueville shallow wells obtain water from the base of the river terrace gravel and sand which overlies the Buda limestone or the impervious Del Rio clay. This water occurs at depths of less than 35 feet. Between Bosqueville and Patrick the Del Rio is covered by 18-25 feet of the same gravel and water is obtained at the contact of the gravel and the Del Rio or by digging a collecting space in the watertight top of the Del Rio. On the Wortham place 1¾ miles northwest of Bosqueville a dug well penetrated 18 feet of gravel and entered about a foot into the Del Rio. Two wells 1½ miles southeast of Patrick penetrated 25 feet of gravel and another at the Patrick road crossing over Rock Creek had 22 feet of gravel.

West of China Springs some water is obtained in shallow dug wells in the Del Rio clay. In eastern McLennan County there are many shallow wells in upland gravel or sandy loam overlying the Taylor clay. A similar gravel and sand occurs north of the Brazos, as at Tokio where as much as 20 feet of sand, gravel and soil overlies the Eagleford shale. Analysis of shallow well water is given in the following pages.

Springs

Large springs occur along the Balcones Fault from Belton and Salado southwards, but these are absent in McLennan County due to the practical disappearance of faulting along this structural line. Near the city of Waco there are some small springs: those on Reuter street and in Cameron Park are apparently located on an extension of the Bosque Valley flexure. Waco Springs on the Brazos near First and Austin Sts. seems to be related to small scale fissuring in the chalk; the water supply is partly derived from the overlying gravel terraces. upon which the city is built.

Stream Water and Impounded Water

Waco now derives a part of its water supply from the Brazos River and from wells sunk in the river sands; this is treated at the filtration plant before being let into the city mains. The Brazos water contains a high percent of mineral salts derived from the Pennsylvanian and from Permian and Triassic beds along the edge of the Llano Estacado (see analyses.) It is therefore only a question of time until the construction of a permanent water supply for Waco is undertaken. Proposals have been made to build a reservoir in the lower Bosque Valley, a site well adapted for this purpose on account of its topography, nearness to the city and the extent of its watershed. At a point about a mile above the mouth of the Bosque its valley is narrow and is flanked on both sides by Austin Chalk hills which would form a favorable inclosure for a reservoir of at least a half mile wide and several miles long. The underlying formation of the lower Bosque Valley is the Austin Chalk to within a half mile of Bosque Bridge, at which point the narrow Eagleford outcrop is crossed. Upstream from Bosque Bridge for many miles the Bosque Valley is underlain by impervious Del Rio and Eagleford clay and shale. The Bosque as far upstream as the mouth of Hog Creek has a low gradient and lies in a rather narrow alluvial valley; above that point its fall increases and it emerges more and more onto the uplands. Its water supply largely drains from Comanchean limestone prairies, and its course is through sparsely inhabitated country, so that it affords a satisfactory source of water.

Hot and Mineral Water

Warm or hot water is found in various McLennan County wells. These local changes in geothermal gradient are supposedly due to shallowly buried ancient and igneous masses along the Balcones Fault Zone, as the scattered basalt intrusions along this line farther south suggest. That similar events have happened along other structural lines in this region is indicated by the occurrence of serpentine at Thrall (Luling, Thrall and Chilton lie on nearly a straight line), and by the hot water wells at Marlin.

Valley Mills: Water wells at 950-1000 feet struck water of temperature about 90° F. or more. Horizon about middle of Trinity Basal Sand.

Waco: Several wells recorded by Hill, drilled before 1891, have water which averages 103° F. Horizon: Trinity. The Watt well (5th and Franklin) flows a considerable stream of hot water, now used for supplying a swimming pool, and for drinking. Horizon: mainly Upper Trinity sand.

West: City waterworks well, redrilled 1912. Temperature not ascertained.

Ossenbeck well: Hot water, 1410-1460; horizon apparently top ot Trinity sand, between first and second Trinity waters. Same horizon as the lower hot water in the nearby Harrington well. Plugged and now flowing through a 2-inch pipe.

Harrington well: In ehe driller's log hat salty artesian water was reported from two levels: at about 1330-1350 feet., in the upper part of the Glenrose, and at 1890-1925, in the middle part of the Basement Sands of the Trinity. When the casing was removed from this well, the mixed waters from the different levels flowed out of the top at the rate of two gallons per minute; this flow of warm water charged with mineral salts has continued since the abandoning of the well. Hill suggests that the level of this very mineralized water in this county is Upper Glenrose. The water from the Harrington well is used for medicinal purposes; its analysis follows.

DEPTHS TO ARTESIAN WATERS NEAR WACO

	Depth	Elev.	GR_1	GR_2	T_1	T_2	T_3	T_4
Filtr. Plant No. 1	2046	380?	1200		1705	1855	1960–2040	
Filtr. Plant No. 2	2056	380?	1191*		1705		2048–2054	
Padgett	1866	485?			1782			
Watt	2170	413			1745	1930	2140	
Texas L-P Co.	2147	384.8		1570?	1810	1958	2048	2108
1 st & Webster	2263	410	1200		1800	1969		
Jumbo No. 1	2410	450			1812?	1908	2214	
Waco (average)		414	1100		1765	1915	2015	2075
Fish Pond well	1389	475?			1386			
Threet test	1301	521.7	625,730,930		1075–1138	1246–1257		
Bellrose test	1295	466?			1960–1120	1162–1169	1195–1220	
Stewart No. 1	3340	700			950	1100	1145–1235?	
Harrington No. 1	3520	450?	1195–1240	1605–1670	1810–1830	1980–2005	2075–2180	
Ossenbeck No. 1	3200	550?	750	970	1320	1465		

*Sulfur.

WATER ANALYSES

1. Valley Mills, artesian water. Horizon: Lower Trinity.

2. Waco, Waterworks of Bell Water Company, 22nd and Cleveland sts. Horizon: Trinity.

3. Bosque Farm (W. L. Prather) near Fish Pond on Crawford Road, 5 miles southwest of Waco. Horizon: Trinity.

4. Waco, Moore well, artesian water. Horizon: Trinity.

5. McGregor, McGregor Water Company, artesian water. Horizon: Trinity.

6. North Waco, Filtration Plant. Artesian water. Horizon: Trinity.

7. Waco, Sleeper well, artesian water. Horizon: Trinity. (Baylor Bull. xxiv, No. 1, p. 24.)

8. Waco, Jefferson Street well, artesian water. Horizon: Trinity. (Baylor Bull. xxiv., No. 1, p. 24.)

9. Blair well, Bosqueville. Surface water, Pleistocene terrace.

10. Water from the Brazos River near Waco (No. 2860, Schoch, Univ. Texas Bull. 1814.)

11. Water from the Brazos River near Waco (No. 2863, Schoch, Univ. Texas Bull. 1814.)

For Nos. 1-5 see Hill: U. S. G. S., 21 st Ann. Rept., pt. 7, p. 448 and Schoch; Univ. Texas Bull. 1814, pp. 152-159. Nos. 6-9, analyses by Dr. W. T. Gooch, Baylor University. Nos. 10-11, see Schoch: Univ. Texas Bull. 1814.

TRINITY WATERS

	SiO_2	K_2O_3	Ca	Mg	Na	K	Co_3	So_4	Cl		Total Solids
(1)	25.90	----------	1.20	----------	385.60	----------	345.00	150.75	75.82	----------	1023.34
(2)	12.79	2.429	10.00	----------	373 99	----------	242 50	277.90	55.92	----------	975.23
(3)	7.20	2 74	107.50	8.06	63.45	36.04	122.35	181.70	45.60	----------	311.02
(4)	17.75	2.56 (Fe_2O_3)	7.88	4.10	327.00	----------	222.20	278.20	62.79	a	923.00
(5)	5.15	1.70	5.15	1.96	289.20	----------	230.35	189.50	49.05	----------	772 09
(6)	29.7	none	9.44	9.7	50.0		343.3 (HCO_3)	60.0	51.4	b	554.2
(7)	trace	trace	11.6	5.8	364.2		169.4 (HCO_3)	284.2	57.8	----------	893.0
(8)	trace	trace	9.8	5.8	186.8		343.1 (HCO_3)	90.8	52.7	----------	689.0
SURFACE WATER											
(9)	19.6	58.	167.6	trace	48.1		326.5 (HCO_3)	74.4	115.9	----------	----------
(10)	11.00	0.03 (Fe_2O_3)	60.00	6.30	69.00		118.00 (HCO_3)	84.00	119.00	5.60 (NO_3)	420.00
(11)	31.00	0.70 (Fe_2O_3)	218.00	26.00	346 00		119 00 (HCO_3)	555.00	533.00	1.50 (NO_3)	1848.00

Figures in parts per million.
a. Al_2O_3, trace.
b. Nitrites, none; nitrates, none; ammonia, 0.7.

Chemical analysis of mixed water from Harrington No. 1 well, 5 miles north of Waco, by Dr. W. T. Gooch.

	Grains per U. S. gallon
Silica (SiO_2)	0.466
Alumina (Al_2O_3)	7.404
Iron (Fe_2O_3)	trace
Lime (CaO)	3.78
Magnesia (MgO)	12.45
Sulfate (SO_3)	74.29
Chloride (Cl)	31.15

Probably combined as follows:

Silica (SiO_2)	0.466
Iron oxide (Fe_2O_3)	trace
Alumina (Al_2O_3)	7.404
Sodium chloride (NaCl)	49.649
Sodium sulfate (Na_2SO_4)	39.996
Sodium carbonate (Na_2CO_3)	68.174
Magnesia sulfate ($MgSO_4$)	37.171
Calcium sulfate ($CaSO_4$)	9.177
Sodium bicarbonate ($NaHCO_3$)	35.339
Residue on evaporation	248.3

Turbidity: 2.

When water comes from well it contains appreciable amounts of iron salts, probably bicarbonates, which are hydrolized and oxidized on contact with air and precipitated out as a flaky sediment. This water is warm. It is probably a mixture of waters from various strata. Hot salty waters were encountered in drilling (see log).

Clay Industries

The main clay beds in the county are the Taylor and Eagleford formations; the Del Rio is a shelly impure clay just below the Eagleford. These formations contain impurities which prevent them from being classified as high grade clays, but they are nevertheless suitable for many kinds of clay wares, including brick, earthenware, building tiles and some grades of crockery.

Brick

The shales of the Eagleford formation carry a considerable amount of gypsum, pyrite, iron oxides, ironstone and some sulphur; the flags are sandy. About a mile east of South

Bosque station an abandoned brickyard formerly operated by Mr. Newt Williams used mainly shales from the Basal Shale member of the Eagleford, which contains the above mentioned impurities. At this plant a plain red building brick was produced; no data on output or methods are available to the writer.

The Taylor formation outcrops in a belt covering the part of the county lying east of a line from the northeast corner to the east part of Waco, and thence to a point somewhat east of Levi. It is prevailingly a calcareous marl and clay with calcareous seams and concretions, ironstone, chalky strata and streaks of sand. These various substances would not impair its value for ordinary brick making. The Taylor has been used locally in the eastern part of the county in small scale brick plants.

Tile and Pottery

Earthenware pottery and certain classes of building and drain tiles could be made from Taylor marl if market conditions encouraged the establishment of local factories. No data are available on this industry in McLennan County.

Bentonite

In the southwestern part of the county in the Middle Eagleford Flags there are thin strata, maximum thickness about 1.5 feet, of bentonite. This may be seen near South Bosque, Spring Valley, Blue Cut, Moody and elsewhere. The bentonite is slightly iron-stained especially along joint planes, where there is some circulation of water. There are several bands of small thickness, interbedded with sandy shales and calcareous flagstones, but for the present these do not appear to be of sufficient thickness or purity to have commercial value.

Limestone Industries

Portland Cement

The main desiderata of a prospective Portland Cement plant are: proper raw materials, adequate transportation, cheap fuel, and an assured market. Of these factors only the first is essentially geological, and the others will not be discussed here. "It can hardly be stated too strongly that no degree of excellence in the limestone or shale can make up for expensive fuel supply, for poor transportation facilities, or for narrow market areas" (Eckel.) At present there are cement plants at Dallas, Houston, San Antonio and El Paso. With increase in population the demand will necessitate other cement plants in central Texas, and Waco, with its proximity to the east Texas oil fields and lignite deposits, will be found to fulfil the main requirements for this industry. The actual costs, materials and analysis for a particular location are primarily technological, and only the general geological features will be noted here.

Portland cements vary considerably in composition, but in general the raw mixture before burning should contain about 75% of calcium carbonate, 20% of silica, alumina and iron oxid, and the remaining 5% of magnesia, alkalies, etc. In case the available raw material does not have the desired composition, the mixture is obtained by adding determined quantities of shaly material to the limestone to be used. In Texas a mixture of Austin Chalk and Eagleford shale taken from near their contact has been found essentially to fulfil the requirements. There are doubtless in the county other combinations of formations, or of portions of formations, which upon analysis would be found suitable. Therefore locations at which railroad transportation lies close to the Austin Chalk-Eagleford contact are possible sites for Portland Cement plants. Points on this escarpment have the added advantages of excellent drainage and a gravity haul.

This formation contact crosses the north county line just west of the Dallas interurban and passes west of south to the M. K. and T. Ry. (Rotan branch), which it crosses about 3 miles south of Tokio; thence the contact passes to the Brazos bottoms several miles from existing railroads. South of the Brazos it lies near the top of the high line of bluffs forming the east edge of the Bosque valley, and crosses the St. L. S. W. Ry. less than two miles east of South Bosque station. From this point it passes south of west, forming reentrants which nearly touch the M. K. and T. Ry. at Lorena and at Bruceville, and leaves the county southwest of Eddy. At most places along this escarpment there is available with little or no overburden a quantity of both materials greatly in excess of the maximum estimated requirements of a plant for a long term period. At many such places, after detimbering, the sparse soil would be quickly removed by rain action, leaving no overburden.

Doubtless the examination of materials and locations in other formations, as at the Austin-Taylor contact, or the soft argillaceous basal part of the Austin Chalk in central McLennan County, would reveal a suitable combination of resources. The following chemical analyses (Schoch: Univ. Texas Bull. 1814) are introduced for comparison of rocks along the Bosque Escarpment with those of the same formations used in making Portland cement near Dallas.

AUSTIN CHALK FOR PORTLAND CEMENT

	Dallas 920	McLennan 1010
Moisture	0.49	1.01
Silica	6.54	5.20
Al_2O_3	3.22	1.51
Fe_2O_3	2.12	1.29
MnO	0.04	....
CaO	46.72	50.00
MgO	0.61	0.82
K_2O	0.54	none
Na_2O	0.38	none
CO_2	....	39.27
SO_3	0.55	none
Loss on ignition	38.64	.....
Total	99.90	99.10

920: Dallas County, from quarry of Texas Portland Cement Company.

1010: McLennan County, blue limestone from cistern on Bosque farm, 4 miles west of Waco.

UPPER CRETACEOUS SHALES, DALLAS AND WACO

	130	131	132	217	218	219
SiO_2	45.07	56.71	57.26	51.22	72.36	71.40
Al_2O_3	15.78	19.74	18.45	20.34	7.84	8.20
Fe_2O_3	4.92	5.74	8.25	6.82	1.72	2.30
MnO	0.02	0.02	.....	.....	.....	.....

	130	131	132	217	218	219
CaO	7.98	1.28	1.52	7.94	6.48	6.34
MgO	1.18	1.91	none	trace	2.23	2.44
K_2O	1.70	1.67	. . . . .	0.14	1.20	1.22
Na_2O	0.08	0.36	. . . . .	. . . . .	1.70	1.60
CO_2	. . . .	. . . . .	. . . . .	6.23	3.30	3.25
P_2O_5	. . . .	. . . . .	. . . . .	0.02	. . . . .	. . . . .
SO_3	9.71	0.25	. . . . .	none	. . . . .	. . . . .
TiO_2	. . . .	. . . . .	. . . . .	. . . . .	0.12	0.14
H_2O	6.51	4.00	13.00	1.05	3.72	3.70
Organic	6.89	8.62	. . . . .	. . . . .	. . . . .	. . . . .
Total	99.84	100.30	99.68	93.56	100.67	100.59

130, 131, 132: Eagleford shale, quarry Texas Portland Cement Co., Dallas.

217: McLennan County, Upper Cretaceous marl from Waco.

218: McLennan County, Upper Cretaceous red and brown burning clay, Waco.

219: McLennan County, "Calcareous clay from Waco."

Road Materials

There is no limestone in the county which is entirely practicable for road metal. The Austin Chalk is a firm limestone when watersoaked, but upon exposure to air slakes and exfoliates and on roads quickly crumbles to a dust. It has good cementing qualities, but low toughness, low resistence to wear and to compression. The same properties disqualify the scattered chalks in the Taylor formation. The Georgetown limestones have variable physical properties. In general they are soft, impure and argillaceous, and have low resistance to wear. However, there are levels in the Fort Worth and Duck Creek members of the Georgetown in which semi-crystalline limestones occur, which might be locally useful for road construction. The basal Duck Creek limestone as seen at the bridge east of Crawford and on the Valley Mills road at the McLennan-Bosque county line, is the hardest limestone in the Georgetown. It is thought that this limestone is, however, too soft to be of general use on roads. The Edwards limestone indurates upon surface exposure, but in quarries and cuts is soft, even pulverulent, and is impracticable as a road material. The Middle Eagleford

Flags contain some hard sandy material, but the amount of shaly strata intermixed would make its general utilization impracticable.

The hardest rock in the county is the Bosqueville rock, but it is of small areal extent, is thin, and is covered with so much overburden as to make its exploitation unprofitable except perhaps at a few places where in connection with sand and gravel pit work it might ultimately form a profitable combination. No data on the physical properties of this rock are available, but the writer has seen the rock from wells exposed to weathering for about two years, in which time it crumbles somewhat by solution of calcium carbonate from the surface, the bulk of the rock retaining its hardness; used as crushed rock on roads it would probably cement somewhat.

As a result, the most generally used road material is gravel and sand, of which there is an abundant supply well distributed over all parts of the county. The pits, operated by the county and by private concerns, can easily supply the demand for the ordinary grades of gravel and sand, particularly for roads, with but small hauling expense.

Test of sample from the Austin Chalk, 9 miles north of Waco

Physical tests: (Univ. Texas Bull. 1839, p. 93)		Chemical analysis: (Univ. Texas Bull. 1814, pp. 53, 180)	
Sp. Gr.	2.25	Moisture	1.01%
Weight per cu. ft.	140	Silica	5.20
Water absorbed, lbs. per cu. ft.	1.46	Al_2O_3	1.51
		Fe_2O_3	1.29
Percent of wear	8.7	CaO	50.00
French coef. wear	4.6	MgO	0.82
Hardness	0	K_2O	none
Toughness	2	Na_2O	none
Cementing value	176	CO_2	39.27
Compression, lbs. per sq. in.	3175	SO_3	none
		P_2O_5	none
		Total	99.10

The physical test "shows that this is a soft rock, with low toughness and resistance to wear, excellent cementing value and low resistance to compression. It is not recommended as a road building material nor for railroad ballast."

Building Materials

There is no limestone extensively used for building in McLennan County. Certain parts of the Georgetown could doubtless be used to a certain extent for building, for this formation has essentially the same lithology as in central Bell County (Belton, Salado), the north limit of the belt of houses built of Edwards and Georgetown limestones, which extends along the outcrop of these formations through south-central Texas. The unweathered Fredericksburg limestones are too soft and too massively bedded for this purpose, but at places where the strata are more flaggy the weathered slabs might be so used.

Some of the gravel and sand found in the county is suitable for building purposes. Dr. Pace describes the Waco Sand and Gravel Company's pit southeast of Waco out South Third street, from which high grade sand and gravel suitable for building are pumped from a terrace pit overlying the Taylor marl. Lime can be made from most of the limestones in the county. The Edwards near Crawford and elsewhere is an exceptionally pure limestone, from which high grade lime could be manufactured in unlimited quantity. Eventually, when lumber becomes prohibitively scarce and it is more generally realized that for the Southwest the logical building materials are brick, tile, stone, concrete and adobe, the limestone and clay industries in this region will undergo great development.

High Purity Limestone of the Edwards

In the northwestern part of the county, especially on Bluff Creek near Crawford, the Edwards and Comanche Peak formations are largely made up of a limestone containing over 99% of calcium carbonate, which is suitable for commercial purposes demanding a limestone of high purity. The best exposures are along Bluff Creek at the crossing north of Crawford and the crossing of the Crawford-Coryell City road about 3½ miles northwest of Crawford, but the outcrops near the Santa Fe railroad are extensive and accessible to exploitation. As exposed on Bluff Creek the material appears in alternating massive receding and projecting ledges (see Bluff Creek section, and Plate 1), of soft whitish limestone, with considerable crystallization of pure calcite and with practically no iron or other impurities, so that on prolonged weathering very little discoloration results. The texture is in part granular, and the rock is loaded with fossils, especially chamids, rudistids and an organic calcareous debris, which suggest that the rock possibly represents a rudistid-coral reef facies in the Fredericksburg. The chemical analysis follows:

SAMPLE OF LIMESTONE FROM CRAWFORD, McLENNAN COUNTY

(Phillips: Univ. Texas Bull. 365, p. 174, Schoch: Univ. Texas Bull. 1814, pp. 44, 177; the limestone "is reputed to be the purest limestone in the state.")

Silica	trace	
Al_2O_3	0.60	
Fe_2O_3	trace	
CaO	55.60	
CO_2	43.68	
Total	100.08	[99.88]

There is an unlimited supply of this material, much of it with a negligible overburden of soil. This pure limestone phase is local, as is seen by the sections near Valley Mills, which show the more impure northern phase of the formations, and it would require some local prospecting and analyses to determine the most suitable locality for commercial development.

Other deposits of similar Fredericksburg limestone are known from adjoining counties:

(a) At a point about 4½ miles west of Oglesby, Coryell County, on the south side of the Cotton Belt Ry. and the south side of the Leon River, is a hill capped by Edwards and containing Comanche Peak on the slopes, from which the upper purer limestone has been partly blasted off forming a quarry face visible for miles. This rock is of similar composition, lithology and fauna to the Bluff Creek rock.

(b) About 1½ miles northeast of the preceding locality in spurs along the east edge of the Lampasas Cut Plain, north of the railroad, there are considerable areas of the same limestone.

Some of this has been hauled for railroad ballast, as at South Bosque station.

(c) Just north of the Santa Fe track about 3½ miles west of Belton is a quarry face exposing at the top about 30 feet of brown-red massive to thin bedded limestone, beneath which is about 35 feet of bluish to gray limestone, mainly shell breccia, with a profuse fauna of corals, rudistids, echinoids, pelecypods and other fossils. The top of this limestone is stated to consist of about 96% of calcium carbonate and 3% of silica. This locality is lower stratigraphically than the Bluff Creek locality, being near the Comanche Peak horizon, and has a somewhat diferent fauna.

All of these localities are directly accessible to transportation.

Gravel and Sand

Gravel and sand are produced from two main sources in this county: (a) from the Pleistocene river terraces, and (b) from the recent river deposits.

Terrace Deposits

The middle and upper terraces are the main source of the terrace gravel and sand. Large pits, including the White Rock pit, are located north of the Brazos near the junction of the Gholson and Dallas pikes. These pits, situated 40 to 70 feet above the river, form extensive excavations in the second and third terraces. The Potts-Moore Gravel Company operates pits in various parts of the county. The Waco Sand and Gravel Company has pits in South Waco and elsewhere. The county has pits near Waco, China Springs and in the eastern part of the county. Various important pits on the Crawford road, in the bend of the Brazos opposite Lovers' Leap and elsewhere supply road material. For fauna of these deposits, see section on the Pleistocene.

Recent Deposits

Sand and gravel are dredged from the Brazos river channel at places near Waco. About ¾ mile below the railway bridges this Recent river bed material is dredged by the Waco Sand and Gravel Company with a cable scoop, screened and loaded onto railway cars. The Brazos will prove to be an extensive source of washed sand and gravel in this county. Dr. Pace reports similar dredging north of the river bridges at Waco.

Soils

The soils of the western part of the county are mainly residual from the geologic formations of the Grand Prairie. Both the Edwards and the Georgetown formations produce stony outcrops; the first stage of weathering of these is the formation of a thin, rocky clay and in areas of more prolonged weathering these formations are mostly covered with a fairly deep brown, slightly reddish clay. The relatively small Del Rio area weathers quickly to a blackish clay somewhat similar to that of the Austin Chalk outcrops.

The Black Prairie is an extensive belt of black rather waxy soil which is residual from the various Upper Cretaceous formations (Eagleford, Austin, Taylor, in McLennan County), and the soils vary somewhat with the underlying formation. The Eagleford forms prevailingly a heavy dark drab to black clay; the Austin Chalk a dark brown to black clay, and the Taylor a sticky, waxy, deep black clay. There are over the different formations all intermediate stages of weathering from rock to soil, since the Austin Chalk outcrops on escarpments and denuded rock, often with a sparse timber growth, and the middle part of the Eagleford has sandy flags, at most places untimbered. The various peculiarities of timber growth on the different formations of the Texas Cretaceous have been repeatedly described and require no further mention; the timber is largely cleared in this county but at places, especially on approaching stream valleys, the characteristic growths persist.

In addition to soils directly derived from the underlying rocks, there are transported materials which overlie or become mixed with the residual soils. Such are the sandy loams between Aquilla Creek and the Brazos, which are light brown, locally very sandy loams with rounded pebbles, situated at considerable elevations above the Brazos. This transported material together with the material from degraded and reworked Pleistocene terraces produces in restricted areas in the main stream valleys a diverse assortment of soils. The agricultural possibilities of these different soil types are explained in the soil survey of the Waco Area (Bureau of Soils, 1906). The black land prarie is prevailingly a cotton belt. On some of the sandy loam areas east of Waco, small scale irrigation by pumping from shallow wells is practised for raising vegetables for the local market.

Building Foundations

The average thickness of Austin Chalk in several wells in the business district of Waco is over 250 feet. The Austin Chalk when exposed to the air and to drying slakes and crumbles, but underground affords firm support to buildings. This limestone is extensively jointed, and at places has minor faulting; along both joints and faults there is some water circulation, which appears to increase rather than diminish the firmness of the rock as a building foundation. The chalk in the business district is overlain by a variable amount of gravel and sand belonging to the second and third Brazos river terraces. In the Watt well (5th and Franklin streets), 40 feet of this material is recorded, and in the Waco city well (1st and Webster streets), 23 feet. Excavations for large buildings penetrate the gravel and stop in the Austin Chalk; the foundations of the Amicable Building (5th and Austin streets), were excavated in the middle chalk, and unearthed characteristic fossils, *Mortoniceras texanum*, Inoceramus, oysters, etc. West, Ross, Hewitt, Lorena, Bruceville and Eddy are underlain by considerable Austin Chalk; Moody is on the Eagleford Flags; McGregor on the middle Georgetown limestone; Crawford and Patton are underlain by the Edwards limestone; and the towns in the eastern part of the county are based on the Taylor formation.

WELL RECORDS

The following section includes a record of most of the deep wells of McLennan County. The description of samples of well cuttings has been made in the subsurface laboratory of the Bureau.

Log of John Bennet well located 5 miles southwest of Crawford; drilled November 3-17, 1921.

	Depth in Feet From To
Black Soil	0-1
Yellow soil and rock	1-16
Georgetown:	
Gray lime	16-32
Blue mud	32-42
Gray lime	42-105
Blue mud and gravel	105-110
White lime	110-120
Mud	120-122
Hard rock	122-125
White lime	125-190
(Small amount of water at 130)	
Soapstone	190-203
Edwards:	
White lime	203-230
Light shale	230-260
Soapstone	260-302
Light shale	302-310
Gumbo and gravel	310-350
White lime	350-380
Shale	380-435
Glenrose:	
Blue rock	435-438
Soapstone and shale	438-445
Hard rock	445-450
White lime	450-465
Gray lime	465-488
Dark gray sand	488-505
Dark to light rock	505-533

Log of Maryland-Texas Syndicate, Ed Boggs well, located due west of South Bosque Oil Field, on west bank of Bosque River, 2 miles south (upstream) from Bosqueville. Elevation about 450.

	Depth in Feet From To
Gravel	0-8
Yellow clay	8-20
Georgetown:	
White lime	20-30

	Depth in Feet From To
Light grey lime	30-97
Blue shale	97-105
Grey lime (shale)	105-170
White crystalline lime	170-190
Grey shale	190-205
Grey lime	205-215
Blue shale	215-235
Grey lime	235-250
Grey shale	250-260
Edwards Comanche Peak and Walnut:	
Blue shale	260-270
Grey shale	270-290
Gumbo	290-390
Grey lime and shell	390-400
Grey shale	400-440
Gumbo	440-450
Grey lime shell	450-465
Crystalline lime and sand; water and much pyrite	465-480
Glenrose:	
Light grey rotten lime	480-555
Broken grey lime with thin layers of sand rock	555-609

Log of W. F. Crocker water well, located in the town of Tokio; surface formation, Eagleford with overlying upland gravel; drilled 1907.

	Depth in Feet From To
Clay and soil	0-28
Black slate (Eagleford and Del Rio)	28-403
Slight water at 400	
Blue chalky limestone and black and blue shale	403-768
Hydrogen sulfide water at 768; small pockets of oil at about 400.	

Log of Ben Giles well, May 2, 1921, to May 13, 1921. (2 miles south of Bosqueville.)

	Depth in Feet From To
Black soil	0-5
Yellow clay	5-25
Gravel	25-27
Del Rio:	
Blue clay-shale	27-95

	Depth in Feet From To
Georgetown:	
Gray lime, soft	95-130
Gray lime, hard	130-165
Gumbo	165-190
Lime, white	190-225
Gumbo	225-235
Lime, white	235-285
Black clay, gumbo	285-295
Edwards to Walnut:	
Lime, white	295-340
Blue shale	340-350
Gray lime	350-385
Gray shale	385-400
Blue shale	400-465
Gray lime rock	465-467
Blue shale, dark	467-475
Lime, white	475-485
Shelly shale	485-495
Gray lime	495-505
Blue shell	505-510
Gray lime	510-515
Blue shale	515-525
Gray lime	525-535
Black shale	535-540
White lime	540-555
Blue shale	555-565
Glenrose:	
White lime	565-604.5

Log of the Waco Oil & Refining Company's well, Harrington No. 1, located 5 miles north of Waco, in the M. Moore Survey.

	Depth in Feet From	To	Thickness
Austin:			
White shale with lime shells	0	115	115
White shale and lime shells, white	115	130	15
Blue slate with shells	130	170	40
Blue shale lime shells, white	170	195	25
Lime, blue slate	195	230	35
Blue slate, muddy (set 15½ casing 250 feet)	230	260	30
Blue slate, muddy	260	310	50
Blue slate	310	370	60

	Depth in Feet From	To	Thickness
Eagleford and Del Rio:			
Blue shale	370	455	85
Blue slate, white lime	455	500	45
Blue slate	500	570	70
Blue slate, lime	570	620	50
Georgetown:			
Lime, brown	620	665	45
White lime, very firm	665	690	25
Blue slate, lime brown	690	725	35
Slate, lime	725	765	40
Sand, some water, not much lime	765	810	45
Lime	810	855	45
Edwards, Comanche Peak and Walnut:			
Lime, white, hard	855	880	25
Lime, white, hard	880	910	30
Lime, slate	910	995	85
Slate, brown	995	985	?*
Slate	985	1015	30
Lime, brown	1015	1025	10
Lime, shells and blue slate	1025	1050	25
Lime and dark slate	1050	1075	25
Lime shells and blue slate	1075	1100	25
Lime	1100	1175	75
Glenrose:			
Lime, sand water lime	1195	1240	45
Lime	1240	1270	30
Lime, very firm	1270	1285	15
Lime	1285	1310	25
Artesian water at 1300 feet	1300	1310	10
Lime	1310	1316	6
Lime	1316	1330	14
Lime, very white and water hot, set 12½ casing 1340 feet	1330	1350	20
Lime at 1400 feet	1400	1415	15
Ossified lime	1415	1425	10
Lime	1460	1470	10
Lime	1470	1560	90
Slate	1580	1605	25
Limey water	1605	1670	65
Blue slate and lime shells water sand, hole full	1670	1725	55
Lime	1725	1770	55
Basal Sands:			
Lime, water sand, slate, blue (W. S. 1810-1830)	1770	1825	55

	Depth in Feet From	To	Thickness
More water, lime, sand water blue slate	1825	1860	35
Blue slate,	1860	1890	30
Blue slate, sand dark, hot water	1890	1925	35
Lime slate	1925	1950	25
Slate, blue	1950	1965	25
Blue slate and red mud	1965	1980	15
Blue slate, red mud, water sand, more water	1980	2005	25
Sand	2005	2010	5
Lime and red mud	2010	2020	10
Red mud, dark sand	2020	2030	10
Sand, blue, slate, hard lime	2030	2045	15
Lime	2045	2065	20
Lime sand	2065	2075	10
Water sand	2075	2095	20
Water sand, lime, sand dark, shows oil	2095	2110	15
Water sand	2110	2125	15
Sand	2125	2135	10
Water sand, course light gravel	2135	2155	20
Sand	2155	2180	25
Lime	2180	2185	5
Sandy lime	2185	2190	5
Lime, red, mud lime, red sandy lime, (Set 10-inch casing 2200 feet)	2190	2205	15
Red carboniferous ossified sand, may be rock	2205	2210	5
Same	2210	2215	5
Pre-Comanchean:			
Carboniferous, may be a rock	2215	2225	10
Carboniferous, sand rock	2225	2240	15
Red carboniferous rock	2240	2255	15
Carboniferous red sand, may be rock	2255	2270	15
Red, carboniferous I believe it a rock	2270	2275	5
Same	2275	2290	15
Red, carboniferous, not one rock but lot of little ones	2290	2295	5
Same	2295	2305	10
Same	2305	2315	10
Same	2315	2325	10
Same	2325	2330	5
Red mud	2330	2345	15
Red mud, blue slate	2345	2355	10
Same	2355	2360	5
Blue slate	2360	2380	20

	Depth in Feet From	To	Thickness
Blue slate, blue lime	2380	2390	10
Blue lime, blue slate	2390	2405	15
Blue slate lime	2405	2425	20
Blue slate with lime shells	2425	2445	20
Blue slate	2445	2465	20
Lime, blue slate, sand water salt	2465	2475	10
Water sand, ossified	2475	2490	15
Sand	2490	2505	15
Sand, hard	2505	2515	10
Sand	2515	2525	10
? ?	2525	2530	5
Sand, 2470 feet	2530	2535	5
Sand	2535	2565	30
Blue slate	2565	2575	10
Blue slate sand and lime	2575	2580	5
Sand lime and salt water	2580	2585	5
Black sandy lime	2585	2590	5
Sand and lime, very hard	2590	2595	5
Black lime and iron	2595	2600	5
Ossified lime, hard, 8¼ casing set 2600	2600	2610	10
Black lime	2610	2615	5
Black lime and iron	2615	2625	10
Black sand lime	2625	2630	5
Black sand lime	2630	2635	5
Slate, black lime	2635	2645	10
Lime	2645	2678	33
Black lime	2678	2685	7
Lime	2685	2690	5
Black lime	2690	2705	15
Black lime (6⅝ casing set 2790 feet)	2705	2810	105
Black lime, crevis	2810	2840	30
Black lime	2840	2870	30
Black lime, showing of gas	2870	2980	110
Broken formation	2980	3060	80
Hard shell	3060	3070	10
More gas running 5 3-16 inch pipe	3070	3165	95
Hard shell	3165	3180	15
Black lime, sharp and fine	3180	3185	5
Black sand, water coming in	3185	3190	5
Lime, hard	3190	3205	15
Gray lime, more gas	3205	3215	10
Slate and lime	3215	3240	25
Limey shale	3240	3325	85

	Depth in Feet From	To	Thickness
Brown sandy lime..................	3325	3335	10
Lime and sand shells..............	3335	3360	25
5 3-16 casing set again. Water cut off 3360 to 3395 drilling in dead water. Sandy lime 3395 feet, water broke in or got new water 3395 to 3345 feet sandy lime shells.			
Black shell.......................	3435	3455	20
Set 5 3-16 casing again, shut off water	3455		
Changed very often lime to sandy lime.	3435	3500	45
Gray sandy formation, nothing in it..	3500	3520	20
Water was shut off at 3455 feet, and hole is still dry. December 17, 1920.			

Note—Following notes from J. C. Kilgore: 5 6-7 inch casing set at 3455 feet. At 3529 feet 4 or 5 barrels water for 24 hours. Salt said to have been taken from the bit at 3500 feet. Gas in this well came from 2980 to 3425 feet, (Kilgore). Very hard drilling places, 2 inches in 12 hours.

Description of samples from the Waco Oil & Refining Company's well Harrington No. 1. Submitted in part by A. D. Brinkerhoff, Texas Electric Ry. Co., Dallas, Texas, and in part by J. C. Kilgore, Sec., Waco Oil and Refining Company, Waco, Texas. By. J. A. U.

	Depth in Feet.
This sample, said to have come from somewhere between 2200 and 2300 feet, consists of a pebble of gray and reddish chert like pebbles from Pleistocene gravels. It is nearly two inches in longest diameter and shows natural battering and rounding with some cracks or irregular grooves that might be expected to show some trace of cementing matrix, if the pebble were derived from some deep lying conglomerate. I take it that this has fallen in the hole from above....................................	2200-2300
Greenish gray shale with considerable brown, black and greenish shale. Some pieces show calcite veins. Some quartz grains, some calcite and some pyrite present. In one thin section irregular streaks of calcite noted. Some of the black shale is quite indurated. In closed tube very faint bituminous fumes and fumes of ammonia are noted	2370
Three pieces of rock taken at depth around 2600′ and stated to occur from 2596 feet below the surface to 2815 feet, measure from a half to two and a half inches in diameter.	

Depth in Feet

All three consist of a highly indurated sandstone of fine texture with irregular and ill defined layers of black shale of almost schist-like appearance. The specimens are cut by thin veins of somewhat slowly effervescing calcite (dolomitic?) veins. These measure from one-sixteenth to one-hundredth of an inch in thickness and show small faulting. Two such veins cross the larger piece and two are seen in one of the smaller fragments. The carbonate in one of the latter has been partly dissolved out, leaving a natural open fissure (vug). Several indistinct veins are filled irregularly with pyrite. There is another set of veins which show as black lines in section. These run parallel and straight through parts of the specimens. The black remains after thorough ignition. These suggest small shearing planes impregnated with manganese. Still another set of very small and mostly straight discontinuous veins running to sharp edges are segregation veins filled with quartz showing minute comb-like structure with central fissure plane. In thin section the body of the rock is seen to consist of sandgrains of quite uniform size of about one-tenth mm. in diameter. In closed tube quite strong fumes of ammonia were noted and slight bituminous fumes condensed into minute droplets on the inside of the tube. One of the specimens showed a flat slickenside surface about a half square inch................ 2596-2815

Gray sandstone of fine texture mixed with some argillaceous material. The sand is angular, and some of the larger grains are seen to be yellow and red flint. Pyrite and calcite present. One thin section showed a calcite vein.... 2650

Dark gray arkosic quartzite in which the largest grains measure fully one-fourth mm. in diameter, and some schist (or shale). The schist is in part apparently graphitic, giving a faint streak of graphite. Some of the schist is limonite, giving a distinct brownish streak, and becoming magnetic after heating. Some of the schist or shale is brownish and bluish. Pyrite present. Some calcite noted filing irregular cavities in the rock. Some fragments of concretionary indurated carbonate of iron noted. Pre-Cambrian?.. 2650

Dark gray arkosic quartzite and some light gray arkosic quartzite, with some vari-colored schist or shale. Pyrite noted. Very small quartz vein noted in one fragment... 2650

Gray arkosic sandstone showing a few rounded grains. Calcite and pyrite noted. Some argillaceous material present. No fumes of ammonia or bitumen..................... 2660

Very dark gray arkosic schist or shale with some schist or

	Depth in Feet
shale free from sand. Some thin sections show minute veins twisted and faulted. Some sand grains are fractured. Pyrite present. Slight ammonia fumes noted on heating in closed tube	2670
Black arenaceous hard shale and very dark gray sandstone with argillaceous matrix. Both are micaceous and contain some pyrite. No fossils were seen. In closed tube fumes of sulphur and ammonia were noted	2670
This sample consists of two large fragments (One 1 in. in diameter) of a hard dark rock, consisting of arkose quartzite imbedded in black argillaceous material. The fragment is cut by calcite and quartz veins, branching, and crossing. One veinlet was seen to be filled with pyrite. Two thin sections of this rock have the same appearance	2680
Gray sandy schist or shale with some fragments of a soft schist or shale that has the color and lustre of graphite. No fumes of ammonia or of bitumen noted	2680
A mixture of quartzitic sandstone, from gray to black and some limestone fragments (apparently introduced), with a few fragments of black hard shale or schist. Pyrite present. Ammonia fumes noted on heating. Pre-Cambrian?	2680-2700
Almost black, argillaceous, indurated sandstone. One thin section was seen to consist of very small angular grains of quartz. The sample contains considerable calcite, some yellowish. Analysis for graphite was made. Sample contains 9.8% free carbon	2700
Schist (or shale) in which are seen in thin section angular grains of quartz. Some fragments have the appearance of graphite schist. Slight fumes of ammonia noted when heated in closed tube. Pyrite present	2730
Angular quartz sand and some black shale (schist?) A small amount of crystalline calcite present. Several hexagonal quartz crystals noted (also two tapering pyramidal crystals having six faces?) Some reddish quartz present. The shale has the appearance of being graphitic. Pyrite noted. Pre-Cambrian	2900
Black shale (or schist?) and quartzite. Quartz crystals present. White, clear, and pink or salmon colored,, quartz grains noted. Considerable pyrite present	2900
Dark gray sand, a few fragments of black shale. Some stray calcareous fragments noted. More than 75 per cent of the washed sample is between one-fourth and one-eighth mm. in diameter	2905-2925
A gray indurated sandstone with a little dark shale and con-	

Depth in Feet

siderable pyrite. The sand consists of grains from one-eighth to one mm. in diameter, and the larger grains are mostly rounded. A tuberculated ostraced noted, perhaps from higher up in the hole. Pre-Cambrian.............. 2928

Mostly sand, evidently from indurated sandstone. Some dark shale present. The sample contains much pyrite. The sandstone consists of small rounded grains. One pink quartz grain of larger size was noted and some fragments of dark and greenish chert-like material........ 2935

Like the sample from 2935.............................. 2960

Worn quartz sand and very fine textured black shale. Some fragments consisted of highly indurated gray quartz silt. The sample as submitted consisted of nearly 50% of iron from bit or casing and the sample is badly stained by iron rust. No fossils were noted. Only very faint fumes of ammonia were noted upon heating in closed tube........ 3060

Fine gray sand. Some of the grains composing this sand are somewhat rounded and slightly etched and are mostly between one-fourth and one-sixteenth mm. in diameter. No fossils noted. No fumes noted in closed tube test........ 3069

Black fine-textured and schist-like shale. In thin section the shale shows indistinct texture, with very small clear spots and some dark opaque spots. Under high power magnification some imperfectly crystalline clear grains were believed to have been seen. In closed tube faint bituminous and strong ammonia and sulphur fumes were noted. Probably just below .... .3069

Gray quartzitic sandstone and black arenaceous shale. No fossils were seen. In closed tube faint fumes of ammonia were noted 3100

Sample consists of finely ground yellowish quartzite-like sandstone with fine subangular sand grains. Some fine grained limestone and a few fragments of yellowish chert and bituminous schist-like shale are present............ 3165

Like sample from 3165.................................. 3175

Fine, subangular etched sand, practically all less than one-fourth mm. in size; some fragments of yellowish quartzite-like sandstone; some bituminous schist-like shale; and a few fragments of yellow and gray chert and limestone 3185

Like sample from 3185 3190

Fine, subangular etched sand mostly less than one-fourth mm. in diameter; yellowish quartz-like sandstone; some rounded, polished sand grains and a few fragments of limestone and dark gray schist..................... 3195

Fine, subangular yellowish etched sand, some larger rounded

Depth in Feet

and polished sand grains, and a few fragments of quartzite-like sandstone and gray schist-like shale. Practically all of the sand grains are less than one-fourth mm. in size 3200

Fine subangular etched sand, mostly between one fourth and one-eighth mm. in size; some fragments of yellowish quartzite like sandstone and gray schist-like shale; and a few grains of round highly polished sand............ 3205

Dark gray schist-like shale of uniform fine texture, and sand and fragments of sandstone almost as indurated as quartzite. The grains of quartz are in many cases enlarged by secondary crystallization and show crystalline faces. Some show fine surficial etching on one side and have have crystal faces on the other......................... 3210

Yellowish quartzite-like sandstone, sand grains which show some crystalline faces, and a few fragments of dark gray schist-like shale. Not many sand grains are more than one-fourth mm. in size, most of them being between one-eighth and one-fourth mm............................ 3215

Like sample from 3215 3220

Dark gray fine grained schist-like shale and light gray quartzite-like sandstone. In thin section the shale is seen to contain some subangular sand grains about one-twentieth mm. in size. A number of clear, exceedingly thin bodies either needles or plates seen from edge, appear.......... 3255

Like sample from 3255.................................. 3265

Light gray very fine grained quartzite-like sandstone and some dark gray schist-like shale....................... 3285

Dark gray fine-grained schist-like shale................... 3295

Light gray very fine-grained quartzite-like sandstone and dark gray schist-like shale, as found at 3295............ 3315

Like sample from 3315.................................. 3325

Fine subangular slightly etched sand, fragments of light gray quartzite-like sandstone and some dark gray schist-like shale, and a few grains of rounded, polished sand. A few fragments of calcareous material are present 3335

Light gray quartzite grading into dark gray schist-like shale; calcite crystals and a few pyrite crystals. The calcite as well as the pyrite crystals are probably from veins...... 3425

Like sample from 3425, but no pyrite was noted............ 3430

Dark gray schist-like shale and gray quartzite. Polished surfaces of the shale show a number of minute fractures. Some calcite veins and a few pyrite veins were noted in fragments. A thin section shows the grains of the sandstone to have many minute fractures.................. 3435

	Depth in Feet
Dark brown magnetic iron oxide. In the sample is perhaps twenty per cent of quartz sand. It was not possible to determine whether the sample represents iron ore or is derived from the iron used in drilling. A few small grains of very dark indurated shale noted	3300-3495
Quartz sand with much magnetic ferruginous material, perhaps from drilling, and a few fragments of dark schist-like shale	3300-3495
Like above sample from 3300-3495	3300-3495
Sample consists largely of dark gray magnetic iron concerning which it is not possible to say whether it is iron filings or natural material. In washed material, which is very fine, were noted fragments of gray schist, rounded sand grains, and a few fragments of coaly matter. A few feet above	3492
Dark gray schist-like shale and gray quartzite-like sandstone. Magnetic iron oxide from tools (?) and casing (?) are present	3492
Sample consists of iron filings (?), probably from the tools or casing, and fine angular clear and brownish sand, which is practically all less than one-eighth mm. in size. A few fragments of gray schist-like shale are present	3495
Sample consists mostly of black pulverized magnetic iron. Some fine yellowish quartz sand, less than one-fourth mm. in diameter, is present. The grains are mostly etched but some show crystal faces produced by secondary growth	3505
Fine sand such as was found at 3505	3510
Fine yellowish sand, and some fragments of dark gray schist-like shale and yellowish quartzite-like sandstone. The sand grains are all less than one-fourth mm. in size and show mostly etched surfaces. However, some crystalline faces, produced by secondary growth, were noted	3520
Like sample from 3520, but schist-like shale is absent	3537

NOTE.—The sand grains in samples 3165 to 3137 are mostly etched but some show crystal faces, produced by secondary growth Some grains show etching on some sides and crystals faces on others. The schist-like shale yielded faint bituminous fumes when it was heated in closed tube

The samples from 2596 to 3697 are regarded as pre-Cambrian. J. A. Udden.

Depth when visited 3541′. Last casing rested at 3455′, 5-7/8 inches. At 3529′ some water was obtained, amounting to 4 or 5 bbls. per 24 hours, and now flowing only 4 or 5

Depth in Feet

gallons per hour. Rate of drilling about 2 feet per 12 hour tower, maximum 7 feet per 12 hour tower. At about 3500 feet salt stratum reported. Salt said to come upon the bit and taken off and tasted. Gas from 2980 to 3425 feet, strong at 3400 feet. Water at 3395′, either natural at that level, or breaking in from above. E. H. S.

Log of Rice Harrison water well, located 4 miles west of Crawford; drilled October 6 to November 2, 1921.

	Depth in Feet
Old well 6″	0-120
Walnut:	
Blue rock	120-145
Gray lime	145-175
Blue mud	175-185
Light shale	185-230
Glenrose:	
White lime	230-250
Shell and mud	250-330
White lime	330-360
Blue mud	360-365
Soapstone	410-455
Sand; mineral water	455-460
White lime	460-500
Yellow to gray sand fresh water	500-508
Rock	508-519
Yellow sand	519-520
White lime	520-550
Soapstone	550-552
Blue rock	552-560

Log of Highland Place well, Waco.

Recent:	
Black dirt	0-5
Austin:	
White rock	5-25
Blue gray rock, solid	25-105
Brown rock, very hard	105-115
Light gray rock, solid	115-185
Nearly white rock	185-225
EF & DR.:	
Blue rock	225-450
Blue soapstone	450-750
Gt., Edw., Cp., Wal., & Gr.:	
White rock with layers of gray mud	750-950

	Depth in Feet
Soapstone	950-965
White rock	965-1000
White rock with layers of gray mud	1000-1095
White rock, hard	1095-1650
Honeycomb rock, Trinity sand	1650-1702

Log of Lee Jenkins well No. 1. Located 14 miles west of Waco, on south bank of Brazos River, 7 miles up Brazos from Bosqueville; elevation about 425.

	Depth in Feet
Del Rio:	
Sand and gravel	0-40
Gray shale	40-125
Georgetown:	
Gray lime	125-165
Gray shale	165-175
Edwards to Walnut:	
Gray lime	175-345
Gray shale	345-370
Hard "flint"	370-373
White chalk lime	373-400
Gray lime	400-500
Glenrose:	
White lime	500-515
Gumbo	515-540
Gray shale	540-580
Gray lime	580-600

Log of Jumbo No. 1 well, first artesian well made in Waco, located at Bells Hill, 22nd and Cleveland Streets, Owner, Waco City Waterworks, Fowler, contractor. Begun 1912, completed 1913. Cable rig used in upper part, rotary rig from 1808-2410 feet. Depth of well, 2410 feet.

	Depth in Feet
Sandstone	1808-1862
Shale	1862-1866
Sandstone	1866-1894
Lime rock	1894-1906
Gravel	1906-1909
Sand rock	1909-2080
Black sand	2080-2217
Rock	2217-2270
Red shale	2270-2352
Shale	2352-2360
Rock	2360-2410

NOTE: 1300′ of water at 1800′, main supply at 1908–2214′. Pressure 60 lbs.; yield 500,000 gallons per day. D. E. Hirschfield, Waco Recorder.

First 1800′ mentioned in a list with other wells, in the 21st. Annual Report, U. S. G. S., Vol. 7, p. 540.

A mixed sample was taken from the dump. In this was found fragments of white limestone and shale, both of the kinds common in the Comanchean. No limestone resembling the rocks from the Carboniferous was to be found. There were fragments of pelecypods. Some fragments of white limestone had thin veins of calcite. Many foraminifer tests were noted. A narrow elongated form of a Textularia was conspicuous. Echinoid spines noted. Globigerina common. I infer that the Carboniferous was not reached in this well. J. A. U.

Description of sample of cuttings from Jumbo No. 1 well, Waco, McLennan County, Texas. From dump made in deepening the well in 1912-1913. Representing strata anywhere from 1800 to 2400 feet below the surface. By J. A. Udden, Oct., 1914.

Gray shale and some soft chalky limestone, giving fumes of sulphur when heated in closed tube. Fossils include fragments of pelecypod shells, spines of sea urchins, Globigerina, Textularia and forms resembling Bolivina, Pleurostomella and Lagena.

Log of the Verde Oil Company's well, B. G. McKie No. 1, located on Farnum Frye Survey, about 3 miles west of Bruceville, and 5 miles east of Moody, about 20 miles southwest of Waco.

	Depth in Feet		
	From	To	Thickness
Chalk rock	0	40	40
Hard rock	40	62	22
Chalk rock	62	83	21
Hard shale	83	140	57
Broken chalk	140	180	40
Shale and shell rock showing of dead oil at 213′	180	228	48
Chalk rock	228	271	43
Shale	271	334	63
Chalk rock	334	342	8
Gummy shale	342	359	17
Lime rock and shell	359	367	8
Gumbo	367	377	10
Lime rock and shell	377	406	29

	Depth in Feet From	To	Thickness
Shale	406	410	4
Broken lime and shell	410	450	40
Hard lime with streaks of pyrites	450	500	50
Broken lime and shell	500	522	22
Lime rock and pyrites	522	524	2
Chalk	524	552	28
Shale	552	565	13
Lime rock	565	569	4
Hard shale and shell	569	576	7
Broken lime	576	583	7
Shale, shell, and boulders	583	648	65
Gumbo	648	656	8
Hard shale and shell	656	674	18
Gumbo	674	678	4
Broken lime and shell	678	686	8
Gummy shale	686	697	11
Broken lime	697	705	8
Shale and shell	705	716	11
Lime rock	716	719	3
Shale and shell	719	732	13
Broken lime and shell	732	775	43
Shale and shell rock	775	793	18
Shale, shell rock, some lime	793	800	7
Broken lime, shell and shale	800	823	23
Shell and shale	823	835	12
Broken lime, shale and shell	835	850	15
Black shale	1820	1821	
Lime	1821	1826	
Lime	1826	1829	
Lime	1829	1834	
Shale	1834	1837	
Shale, hard, gray	1837	1848	
Shale	1848	1850	

Description of samples from Verde Oil Company's well, B. G. McKie No. 1. Located on the Farnum Frye Survey, about 3 miles west of Bruceville. Submitted by B. J. McKie, Waco, Texas.

Depth in Feet

Very light gray, almost white, foraminiferal limestone, gray noncalcareous shale, and some fragments of gray banded shale (consisting of bands of gray shale and white limestone) and gray crystalline foraminiferal limestone. Several pyrite concretions were seen. In thin section the light gray limestone is seen to have a

Depth in Feet

fine grained texture and to contain minute Globigerinas and other foraminfera. A section of the gray crystalline limestone shows an abundance of foraminifera, especially Globigerina, and contains pyrite. Fossils: Inoceramus prisms, Textularia (several species), Globigerinas, fragments of pelecypod shells (several of Pecten), echinoid plates and spines, large smooth Cristellarias, Cythereis, and smooth ostracod. The shale is of Eagleford age. 400-410

Like sample from 400-410 feet. In thin section the gray limestone is seen to contain a fragment of shell with transverse prisms 430

Very light gray, almost white, soft foraminiferal limestone and some gray mostly noncalcareous shale. Some pyrite in minute scattered crystals and in small concretions, is present in the limestone. Fossils noted in washed material include fragments of pelecypod shells, Inoceramus prisms, Globigerina, Textularia (several varieties), anomalina, and a few echinoid spines and smooth ostracods 656-674

Light gray and very light gray limestone and gray shale. Fossils noted in washed material include many fragments of pelecypod shells, Inoceramus prisms, some echinoid spines, Globigerinas, Textularias (several species), Anomalina, and Cristellaria. A few Cythereis and smooth ostracods and fragments of pyritized cast of gastropod were noted. 678-686

Very light gray limestone which in thin section is seen to be very fine grained and to contain some small calcite crystals and a few organic fragments. In washed material were noted many fragments of thick pelecypod shells, some Globigerinas, Textularias (several species), a few Anomalinas, smooth ostracods, Cythereis, echinoid plates and spines, and one Spiroloculina 686-697

Mostly light gray limestone and gray shale. Fossils noted in washed material: Many fragments of thick pelecypod shells, a few Globigerinas, Cristellarias, Anomalinas, and Textularias, and a Nodosaria texana (of Weno or Pawpaw age) and fragments of this form. Several fragments of right valves of Exogyra arietina (of Del Rio age) were noted. In a single stray fragment of typical Eagleford rock a fish scale was noted. 732-737

Mainly gray shale with some light gray limestone. Fossils include many fragments of thick pelecypod shells, a

	Depth in Feet
few echinoid spines, and several Globigerinas, Textularias, and Cristellarias	800
Mainly gray shale and some light gray limestone. Fragments of thick pelecypod shells, a few echinoid spines, Cristellarias, and Globigerinas, were noted in washed material.	830
Mainly gray shale splitting into long thin fragments and and some light gray limestone. Fragments of pelecypod shells, a few Textularias and Globigerinas, a smooth ostracod, and a young Exogyra arietina were noted in washed material.	842
Gray shale and some very light gray limestone. A few small fine grained light gray calcareous sandstone concretions containing pyrite were noted in washed material. Fossils noted in washed material: Fragments of thick pelecypod shells, a few Globigerinas, Cristellarias, echinoid spines, and a smooth ostracod and fragment of a Neithea shell. Still Comanchean.	850

NOTE: Samples from 400-410 to 850′ are mixed, so that it is impossible to determine the different horizons. Fragments of typical Eagleford, which is found in sample from 400-410′ were noted as far down as 800′, evidently having fallen down.

In samples on the derrick floor, stated to be from near the bottom of the hole, the writer saw *Orbitulina texana* Roemer in fragments of slightly argillaceous bluish-gray limestone. Apparently the hole at 1850 is in lower Glenrose limestone.

Log of the Ossenbeck well No. 1, drilled on Bezdek Farm, 12 miles north of Waco, and 7 miles southwest of West, McLennan County. Completed July 21, 1921. By F. J. Ossenbeck, Tulsa, Oklahoma.

	Depth in Feet
Austin Eagleford and Del Rio:	
Black soil	0-10
Blue shale	10-270
Washita and Fredericksburg:	
White chalky lime	270-600
Blue shale	600-750
Trinity:	
Water (4 bailers)	750-755
Light shale	755-800
Lime	800-875
Dark shale	875-900
White lime	900-970

	Depth in Feet
Hole full water	970-975
White lime	975-1075
Sandy lime	1075-1100
Hard lime	1100-1200
Shale and lime shells	1200-1250
Sandy lime	1250-1320
Artesian water	1320-1350
Hard lime	1350-1370
Shale	1370-1375
Lime	1375-1410
Hot Artesian water	1410-1460
Lime	1460-1465
Water sand	1465-1490
Shale (cavy)	1490-1540
Pennsylvanian:	
Black lime	1540-1676
Soft shale	1676-1722
Sandy lime	1722-1760
Black lime	1760-1814
Black shale (cavy)	1814-1840
Gray sandy lime	1840-1884
Black lime	1884-1951
Gray sandy lime	1951-1995
Light sand	1995-2018
Soft gray lime	2018-2040
Sandy lime	2040-2084
Hard sandy lime	2084-2135
Hard brown sand	2135-2140
Sandy lime	2140-2155
Sandy black shale	2155-2195
Hard gray sand	2195-2203
Black slate	2203-2220
Hard sandy lime	2220-2245
Sandy shale	2245-2258
Hard gray sand	2258-2285
Black slate	2285-2292
Brown sand	2292-2296
Black slate	2296-2315
Black lime	2315-2320
Brown sand, rainbow 2320′	2320-2325
Black hard lime	2325-2330
Sandy black slate	2330-2378
Sandy lime	2378-2407
Black slate sandy	2407-2440

Casing Record.

270 feet of 12½ inch casing
1041 feet of 10 inch casing
1540 feet of 8¼ inch casing
1840 feet of 6⅝ inch casing

NOTE: Well drilled 300 feet deeper up to 2650 feet alternating shale, lime streak and breaks with sandy shale sands 10 to 15 feet thick. Lime, black and very hard going to 3200 feet, according to Mr. Dowler, the driller.

Log of Padgett well, Waco, from U. S. G. S., 21st Annual Report, Part 7, pages 541-542.

	Depth in Feet
Dark soil changing to light calcareous loam	0-18
Austin to Walnut:	
Soft white limestone	18-128
Blue joint clays	128-290
Light brown carbonaceous shales	290-330
Brown calcareous marl	330-345
Blue joint clays	345-466
Brown lignitic calcareous shales	466-526
Brown calcareous marl	526-564
Blue joint clay	564-975
Brown carbonaceous lignitic shales	975-1020
Cream colored calcareous marl	1020-1176
Glenrose:	
White limestone	1176-1730
Basement sands:	
Blue calcareous shale	1730-1760
Soft very fine grained gray sandstone	1760-1775
Red plastic shale	1775-1782
Soft very fine grained light gray sandstone	1782-1799
Blue shale	1799-1804
Soft very fine grained light colored sandstone	1804-1823
Blue plastic shale	1823-1833
Soft very fine grained white sandstone	1833-1861
Blue plastic shale	1861-1866

The upper part of this log as it stands is incapable of interpretation. However the assignment of only 110 feet of Austin Chalk is certainly erroneous, and would require special structural conditions in the neighborhood of the well, assuming that it is located in the town of Waco. The tops of the

Glenrose and of the Basement sand are fairly definite in this log and these points when contoured with surrounding wells show no exceptional structural conditions for this well. Since it is unlikely that a local high would be shown in the top of the well and not in the bottom, one must conclude that the top part of the log requires re-interpretation. It is suggested that the Austin Chalk possibly extends as low as 345 feet, because the base of the Chalk over central McLennan County is very soft, and might be reported by a driller as clay. This is well seen in the chalk bluffs at the mouth of the Bosque. Oil was reported from 466-526, which is almost certainly Eagleford.

Log of Patton No. 1, located on Sloan Survey, 3 miles south of west of Lorena.

	Depth in Feet
Eagleford and Del Rio:	
Yellow shale	0-20
Blue shale	20-86
Light brown shale and blue lime	86-128
Light blue shale	128-198
Georgetown:	
Lime rock, white	198-333
Lime rock with water	333-339
Chalky lime	339-447
Edwards:	
Lime and shale	447-540
Blue shale	540-555
Walnut:	
Lime and shale	555-600
Lime and shale	600-620
Light blue shale	620-660
Glenrose:	
White lime	660-697
White lime	697-730
Water, flowing	730-735

Log of Ross Gin well, located at south end of town of Ross, surface formation Austin Clalk; elevation about 575 feet. Drilled April, 1923.

	Depth in Feet
Soil	0-20
Austin Chalk	20-300
Chalk and shale	300-390
Gumbo (Eagleford)	390-...

Log of Foster and Company well, Schencker No. 1, location near Battle, Texas. Elevation, about 568 feet.

	Depth in Feet
Clay	0-50
Black lime and shale	50-150
Hard shale	150-200
Gumbo	200-225
Hard shale	225-300
Lime rock	300-310
Hard shale	310-400
Lime	400-420
Sandy shale, oil show	420-428
Hard shale	428-450
Lime rock	450-455
Gumbo	455-500
Hard shale	500-525
Gumbo and shale	525-600
Hard shale	600-648
Lime rock	648-655
Gumbo and shale	655-700
Sandy shale	700-800
Shale and gumbo	800-950
Limestone	950-956
Gumbo	956-975
Shale	975-1000
Gumbo	1000-1040
Hard lime	1040-1050
Shale and gumbo	1050-1100
Shale	1100-1160
Gumbo and shale	1160-1200
Rock	1200-1202
Gumbo	1202-1225
Rock	1225-1227
Sand and shale; oil and gas show	1227-1240
Hard sand, oil show	1240-1245
Shale	1245-1275
Chalk	1275-1600

Probable Correlation:

Taylor	0-1275
Austin	1275-1600

Log of Scott No. 1, completed November 17, 1920. Elevation, about 475 feet. (2 miles west of Bosqueville.)

	Depth in Feet
Del Rio:	
Black soil	0-3
Red clay	3-23
Water gravel	23-48
Yellow clay	48-55
Blue clay	55-90
Georgetown:	
White lime rock	90-150
Hard lime rock	150-155
White lime rock	155-173
Hard lime rock	173-175
White lime rock	175-200
Blue clay	200-235
Blue shale	235-240
White lime rock	240-300
Soft lime rock	300-315
Blue shale	315-335
Edwards to Walnut:	
White lime rock	335-350
Blue shale	350-355
Black shell	355-358
Blue shell	358-370
White lime, soft	370-380
Blue gumbo	380-395
Blue Gumbo and lime	395-435
Blue gumbo	435-455
Light blue gumbo and coarse sand; sulphur	455-470
Soft lime	470-482
Lime	482-495
Blue gumbo and shale	495-525
Black gumbo	525-528
White rock	528-529
Blue gumbo	529-530
Blue gumbo and lime	530-533
Hard rock	533-534
White lime	534-545
Blue shale, soft	545-550
Blue gumbo	550-555
White lime	555-574
Hard sand, oil sand	574-575
Glenrose:	
White lime	575-604

Log of Sharp-Shrader well, one mile west of Ocee, up Hog Creek.

	Depth in Feet From	To
Black soil	0	4
Yellow soil and gravel	4	16
Georgetown, Edwards and Comanche Peak:		
Gray lime	16	75
White lime (water at 85 feet)	75	148
Blue mud	148	152
Light shale	152	230
Blue mud	230	285
Shell and gumbo	285	305
Walnut:		
Light shale	305	375
Hard rock	375	385
Soapstone	385	387
Rock	387	391
Sand, dry	391	393
Glenrose:		
Hard rock	402	410
Gray lime	410	445
Shale	445	485
White lime	485	500

This well struck the South Bosque sand at 391-393 feet, but produced no oil.

Log of Tudor Oil Company well, Shelton No. 1, located one-fourth mile northeast of Axtell. Elevation of Axtell, 524 feet.

	Depth in Feet
Surface soil, clay and gravel	0-40
Limestone, medium hard	40-48
Sand, streaked and packed	48-69
Clay and gravel	69-80
Lime rock, hard and streaked	80-132
Blue shale and gumbo	132-168
Boulders	168-175
Limestone and sandstone	175-195
Brown and blue gumbo	195-215
Gumbo, slate and gravel	215-240
Brown gumbo and showings of chalk	240-461
Gravel and boulders	461-469
Hard shale	469-507
Boulders and brown gumbo	507-520
Hard white limestone	520-526
White gumbo	526-530

	Depth in Feet
White chalk, brittle	530-548
Hard rock	548-550
Gumbo and boulders	550-563
White chalk rocks with streaks of gumbo	563-573
Chalk, medium hard	573-606
Shale and gumbo	606-627
Gumbo and boulders	627-634
Hard rock	634-638
Gumbo and boulders	638-663
Brittle rock containing gas; oil show?	663-670
Gumbo and shale	670-675
Hard rock	675-700
Hard gravel	700-709
Tough gumbo and boulders	709-792
Tough blue gumbo	792-860
Shale and gumbo	860-869
Boulders	869-877
Tough blue gumbo	877-912
Tough white gumbo	912-936
Tough gumbo and hard shale	936-940
Hard rock	940-944
Shale and gumbo	944-967
Hard boulders	967-972
Gumbo and boulders	972-1032
Chalk rock, hard	1032-1046
Brown shales	1046-1086
Austin Chalk:	
Chalk rock, pyrite	1086-1124
Chalk	1124-1402
Austin Chalk with streaks of gumbo	1402-1503
Eagleford:	
Gypsum and gumbo	1503-1509
Brown shale and slate	1509-1527
Tough blue gumbo	1527-1563
Pack gravel	1563-1575
Slate and soapstone	1575-1596
Lime and shale	1596-1610
Limestone with streaks of shale and gumbo	1610-1675
Gumbo, brittle	1675-1678
Washita and Fbg. (?):	
Limestone, pyrite and sand	1678-1775
Limestone, shale and sand	1775-1815
Gumbo and boulders	1815-1845
Lime and gumbo	1845-1935
Gumbo	1935-1939

	Depth in Feet
Lime	1939-1942
Gumbo	1942-1947
Lime, pyrite and sand	1947-1981
Lime, medium soft	1981-1996
Soft white gumbo	1996-2005
Gray lime with streaks of gray shale	2005-2040
Alternating gray lime and shale	2040-2100

Log of Steenbeck No. 1, located in big bend of Brazos, south side of river, opposite Lovers Leap cliff, about 3 miles north of Bosque bridge.

	Depth in Feet
Recent:	
Yellow clay	0-10
Gravel	10-20
Eagleford:	
Gray lime	20-25
Gumbo	25-290
Del Rio:	
Brown clay and gumbo	290-320
Sand; light showing of oil	320-350
Light gray shale	350-365
Georgetown:	
Gray lime	365-575
Edwards?:	
White lime and shale	575-605
Light gray lime	605-625

Log of St. Louis Oil Pool well, Stuart No. 1, located about two and three-fourths miles south, one-half mile east of McGregor, in the northwest corner of J. L. Johnson Survey, and the northwest corner of Ella V. Stuart Tract. Drilling commenced December 5, 1919. Elevation from topographic map 750 feet.

	Depth in Feet		
	From	To	Thickness
Black soil	0	4	4
Georgetown to Walnut:			
Hard white lime	4	40	36
Broken white lime	40	210	170
Soft blue shale	210	225	15
Broken white lime	225	235	10
Soft blue shale	235	330	95
White lime	330	340	10
Blue shale	340	350	10

	Depth in Feet From	To	Thickness
White lime	350	380	30
Blue shale	380	425	45
Glenrose:			
White lime (535 to 560, 4 to 6 bailers water)	425	575	150
Blue shale	575	595	20
White lime, hole full water	595	770	175
Hard limestone, hole full water	770	890	120
Blue shale (set 12½″ casing 910′)	890	910	20
Soft white lime	910	975	65
Basement sands:			
Green shale	975	980	5
1st. Trinity water sand (steel line measures 950′, water in hole)	980	1045	65
Red rock	1045	1050	5
Blue shale	1050	1057	7
Very hard white lime	1057	1067	10
Blue shale	1067	1075	8
Sand, light gray rock	1075	1090	15
Blue shale, caves, set 1120′, 10″ cas.	1090	1130	40
Red rock, caves	1130	1135	5
2nd Trinity water sand, 1100′ water.	1135	1145	10
Pennsylvanian:			
Pink and black sandy lime conglomerated with varied colored sands	1145	1235	90
Hard black slate	1235	1690	455
Brown shale	1690	1698	8
Hard black slate	1698	1715	17
Brown shale	1715	1718	3
Hard black slate, showing sharp gray sandy lime	1718	1820	102
Hard black slate, slightly sandy	1820	2094	274
Steel line run to measure 2094′			
Black lime very hard	2094	2290	196
Brown sand	2290	2295	5
Very hard black lime	2295	2517	222
Gray sand	2517	2520	3
Black lime, very hard	2520	2860	340
Black slate, good drilling	2860	3130	270
Blue shale, soft and caved, shows stripes of black shale	3130	3170	40
Brown shale	3170	3220	50
Black sandy slate, hard	3220	3240	20

	Depth in Feet From	To	Thickness
Black shale, good drilling	3240	3290	50
Blue shale, very bad cave running 6 ⅝ inch casing to shut off	3290	3340	50

T. D. 3512′. Reported to end in black shales, which caved and held the tools. One report is "very hard" below 3500′.

Steel line measurements made at all important changes in formations.

Note in the drilling of the 766′ of black lime it was not possible to make more than 5′ without sharpening bit.

Description of samples from Stuart well No. 1. about 3 miles south of McGregor, on the Jesse Russell survey. Submitted by Dr. L. Pace, Baylor University, Waco, Texas. By J. A. U.

	Depth in Feet
Black siliceous limestone and black chert. In thin section occasional sand grains (?) are seen in the black material. Strong fumes of bitumen and ammonia fumes noted in closed tube	1940
Black siliceous sponge spicule rock. In thin section a network of indistinct sponge spicules is seen in a bituminous and siliceous matrix. In closed tube, strong bituminous fumes and fumes of ammonia were noted	2120
Black siliceous rock and gray limestone. In thin section the gray limestone is seen to contain organic fragments in a matrix which is in part granular and in part crystalline. Dark areas of bituminous material appear in the matrix of some fragments. Sections of ostracod valves and an occasional sponge spicule were seen in some fragments. Dim outlines apparently of sponge spicules were noted in the siliceous rock fragments. In closed tube bituminous fumes sufficient to sustain a flame, and ammonia fumes were given off	2310
Black siliceous rock which is slightly calcareous. Isolated rhombic crystals are seen in some fragments. In thin section some clear veins apparently of calcite are seen cutting fragments of granular and bituminous limestone. In one fragment of siliceous rock many such small veins are seen. In this fragment irregular areas of granular material are seen which are bounded on one or more sides by minute veins which separate them from the clearer body of the fragment. In closed tube strong bituminous fumes and weak ammonia fumes were noted	2380

	Depth in Feet
Gray to dark gray limestone. In thin section the rock is seen to be coarsely granular and crystalline in texture with occasional organic fragments imbedded. Small sponge spicules noted. Irregular lines and blotches of bituminous material are seen in all fragments. Minute veins occur in some. In closed tube bituminous fumes and sulphur and ammonia fumes were noted	2440
Black calcareous, siliceous rock and gray and dark gray limestone. In thin section one fragment of the siliceous rock is seen to be of a shaly texture with many minute cracks or veins which are branching and criss-crossed in a network. A rhombic crystal was seen under high power magnification in this fragment. Another fragment of the black siliceous rock has a wavy laminated appearance with considerable number of clear crystalline areas some of which are rhombic and some which are possibly sand grains. Several grains of green glauconite were seen. The matrix is highly impregnated with bitumen. One side of the fragment is cut sharply by a straight vein-like area of clear crystalline material which is unstained by bitumen. No organic remains were noted in these two fragments. The bulk of the sample consists of this kind of material. The gray and dark gray limestone are alike in texture, varying in color with the amount of bituminous matter. Both are crystalline and have splotches and dots of bitumens. Some fragments are more coarsely crystalline and are more dolomitic than others. No organic remains were noted in this material. In closed tube faint bituminous fumes and fumes of sulphur and ammonia were noted	2700
Dark grey almost black fine-grained slightly calcareous shale containing a few grains of fine sand and pyrite. Several Slickensided surfaces were seen. No fossils were noted. When heated in closed tube, bituminous fumes and sulphur fumes were liberated	3340-3500
Like sample from 3340-3500 feet	3512

All probably Bend down to 2440 feet.

Log of Stroud well, located near Speegleville, Texas.

0- 35	Surface
35-380	Lime with occasional sand streaks of shale
380-400	Soapstone
400-635	Lime carrying water

Log of the Texas Light and Power Company's well No. 1, located about one-half mile in an easterly direction from the Waco, Texas, postoffice. Contractors R. H. Dearing & Sons, Dallas, Texas. Driller H. H. Green. Well was begun March 28, 1912, completed July 27, 1914. Rotary rig was used. Surface elevation at well mouth was 384.7 feet, which refers to U. S. G. S. Bench Mark at east end of M. K. & T. bridge at East Waco. Diameter of well at mouth, 8 inches; at bottom, 5 7-8 inches. 749 feet of 8-inch pipe; 1236 feet of 6-inch pipe. Flows 800,000 gallons per day. Water rises 184 feet above surface.

	Depth in Feet From	To
Austin:		
Hard, white rock, mixed with layers of blue shale	40′4″	232
Eagleford:		
Bluish shale, medium hard	232	418
Georgetown:		
Hard white rock, including lump of extra hard white rock found in layers	418	635
Hard, white rock	635	880
Edwards to Walnut:		
Hard, white rock	880	900
Hard white rock	900	925
Hard white rock	925	955
Medium hard white rock	955	988
Medium hard light bluish rock	988	1000
Blue shale, medium hard	1000	1035
Glenrose:		
Hard white rock	1035	1075
Medium hard rock and light, blue shale	1075	1170
Medium hard, blue shale	1170	1230
Hard white rock	1230	1280
Hard white rock	1280	1315
Hard white rock, lump without cavings, was balled up on end of bit	1315	1360
Hard white rock	1360	1404
Hard white rock	1404	1437
Hard white rock	1437	1465
Medium hard white rock	1465	1497
Hard white rock	1497	1535
Rock, hard and white	1535	1570
Medium hard white rock, some water	1570	1595
Hard white rock	1595	1608
Medium hard white rock	1608	1635
Medium hard white rock	1635	1658

	Depth in Feet From	To
Medium hard white rock, balled up on end of drill	1658	1664
Medium hard, white rock	1664	1690
Basal Sand:		
Same. Small red particles in this	1690	1714
Same, with small amount of water	1714	1740
Same, with small amount of water, and some fairly hard particles. Traces of sand at 1775-1723	1740	1780
Began to run out of the white lime rock into sand rock	1770	1785
Sand rock, a bluish gray and white marl	1785	1810
Gray sand with red specks. Water sand	1810	1840
Light gray water sand with layers of hard sand rock, bluish gray, 1 to 6 in.	1840	1846
Shale, close and sticky	1846	1930
Alternate layers of a dingy white lime rock and a light blue shale. The lime and shale had some fine grit. It cut the bits off some, more than the white lime above the first Trinity reservoir	1930	1938
A blue marl that was sticky and hard to cut; had sand in it	1938	1940
Hard bluish gray sand rock, very hard	1940	1948
Red shale, fine red sand, a little water. Set 6″ pipe at 1948, lapping into 8″ pipe 30 or 40 feet size of well hole from bottom of 6″ to bottom of hole, 5⅞″	1948	1958
Red water sand, very fine, and mixed with a red and blue shale. Well went to flowing at that depth and was cleared of the muddy water used in drilling. At that depth the sand continued to be dirty and fine for 70 or 80 feet, mixed with red, blue and green shale and hard layers of gray sand or a lime rock	1958	2034
Flow of about 150,000 gallons per 24 hours	2034	2048
Hard lime rock, blue and red shale	2034	2048
Water sand of a better quality but mixed with red and blue shale and thin layers of sand rock. At this depth the well was flowing about 450,000 gallons per 24 hours	2048	2100
Layers of a dingy white lime and red shale with some blue shale	2100	2108

	Depth in Feet From	To
Coarse water sand. Well flowed about 800,000	2108	2138
A fine water sand, mixed with a little gray shale, well has 82 lbs. pressure at surface. Altitude, 387′.	2138	2147

It looks like we went through four of the Trinity strata of water with the one that I cased out, when I set the 6″ pipe at 1948′. I struck this strata of water at about 1770′. We did not have a correct measurement on our drill line of pipe at about this depth. H. H. Green.

Description of samples from the Texas Light and Power Company's well No. 1. Located on east bank of Brazos River, at Waco. By J. A. U.

	Depth in Feet
Chalk, typical Austin Chalk, containing fragments of shells, Globigerina cretacea and Textularia globulosa Anomalina ammonoides abundant. Sulphur and ammonia noted on heating in closed tube. A small bivalve noted	40-232
Gray shale, not calcareous, with some pyrite. Heated in closed tube it shows oil and gives fumes of ammonia and of sulphur. Globigerina, Textularia, Anomalina, fragments of shells with prismatic structure, and fragments of fish scales noted	232-418
Gray and white limestone. The white limestone is finely granular with imbedded, scattered foraminifera. The gray limestone has more foraminifera and many are filled wholly or partly by a black mineral probably pyrite. In closed tube the rock yields oil and fumes of ammonia and sulphur. Pyrite and fragments of shells are present in the cuttings. Separate spheres of a Globigerina? from 0.03 to 0.06 mm. in diameter are profuse in the sections of the gray rock and common in the white rock. Globigerina cretacea, Textularia and Anomalina noted	418-635
Some gray and some white limestone of fine texture, containing fragments of foraminifera and small crystals of calcite. In closed tube gives a faint odor of sulphur. Pyrite present and a few fragments of larger shells. Few entire foraminifera. Some fluted spines noted. Echinoderms? A circular 10-rayed disc present. Some quartz sand present in the sample...	635-880
Light gray and soft white limestone, giving faint fumes	

	Depth in Feet
of sulphur and ammonia. The gray rock has imbedded black particles. Both gray and white rock are very finely granular and contain scattered pieces of transparent calcite. Fossils include fragments of shells, Textularia globulosa, fluted spines, and an oval fossil, probably a Lagena	880-900
Gray and white soft limestone, giving fumes of ammonia and sulphur, and containing fragments of shells. Some pyrite present as bright green grains. Rock with black particles and scattered pockets of calcite. Fossils include fluted spines, smooth hollow spicules, Lagena, Nodosaria (cf. mucronata) ten-rayed discs, a narrow form of Textularia, pieces of perforate foraminiferal tests, Textularia globulosa, Frondicularia sp., Globigerina cretacea	900-925
Light gray and white soft limestone, and some dark and shaly limestone, giving fumes of sulphur and ammonia in closed tube, and containing rare fragments of shells. Fossils include prismatic shell fragments, Textularia globulosa, Anomalina, Bolivina? Some rounded sand grains noted	925-955
Light gray soft limestone, containing many fragments of shells and some pyrite. Gives fumes of sulphur and ammonia in closed tube. In thin section the rock is finely granular with distant small grains of calcite and with many small particles of black color, probably pyrite. Some sand grains present. Textularia, Globigerina and Anomalina, also a Nodosaria and fluted spines	955-988
Soft white limestone and dark shale, many fragments of shell present. The limestone consists of granules about 0.01 mm. in diameter and in this matrix are few or many traversions of clear calcite. Few rhizopod shells noted	988-1000
Gray organic fragmental limestone and black hard shale. Many fragments of shells present, and also pyrite. Textularia globulosa, Anomalina and Bolivina noted. Some sand present	1000-1035
Gray organic fragmental limestone, in part oolitic with some gray stony marl or shale. Contains many fragments of shells. Some fragments of tests have circular perforations 0.02 mm. in diameter. Textularia, Anomalina, Lagena (?), and several echinoid spines noted	1035-1075
Organic fragmental light gray limestone with some dark	

	Depth in Feet
gray shale. Fumes of sulphur and ammonia in closed tube. Perforated foraminiferal tests noted	1075-1170
Gray limestone and nearly black shale. The limestone is a foraminiferal ooze, with tubular and other tests in a matrix of calcite. Textularia and Globigerina present. Some sand noted	1170-1230
Dark gray shale and light gray limestone. The limestone is largely organic. A few foraminifera noted	1230-1280
Gray limestone and nearly black shale. The limestone is organic fragmental, with foraminifera, and contains oolitic structures, black, pyritic	1280-1375
Gray limestone and dark gray shale. The limestone is an organic breccia and contains many large fragments of shells. The usual foraminifera noted and also a Nodosaria. Some pyrite present	1375-1360
Gray organic fragmental limestone and some black shale. Pyrite present, and a few foraminifera	1360-1404
Gray and dark gray limestone and dark shale. Some gray limestone has dark spots. Foraminifera few. Anomalina and Orbitulina texana noted. Shell fragments and pyrite present	1404-1437
Gray and dark-spotted organic limestone and some dark shale. Some oolitic spherules and incrusted fragments of shells present. Foraminifera few. A narrow form of Textularia seen, Globigerina, Lagena Nodosaria and Orbitulina texana noted	1437-1465
Gray limestone, organic fragmental, with dark spots. Foraminifera scarce. Orbitulina texana noted. In closed tube rock yields fumes of bitumen and sulphur	1465-1497
Gray limestone, fragmental, with dark spots. Some shell fragments present. Anomalina? and Orbitulina texana noted	1497-1535
Gray organic fragmental limestone, with included grains of darker material and some almost black shale. Orbitulina texana noted. A small Lagena and Anomalina	1535-1570
Gray limestone, in part composed of fine organic fragments and in part of an oolitic and more coarsely fragmental rock. Some spherules are black from pyrite. Large shell fragments present. Orbitulina texana, Globigerina, and Anomalina ammonoides noted . .	1570-1595
Gray organic fragmental limestone containing dark round particles in some fragments. Fragments of pelecypods and Orbitulina texana present and a narrow form of Textularia	1595-1608

	Depth in Feet
Rock as in preceding sample. Orbitulina texana and a Nodosaria noted	1608-1635
Gray limestone and some dark shale. The limestone consists of organic fragments and contains some dark particles. It is minutely porous. Orbitulina texana noted and several large fragments of shells. Some sand present	1635-1658
Dark shale and gray marl. Anomalina noted.	1658-1664
Gray organic fragmental limestone and dark gray shale. Fragments of pelecypod shells, Orbitulina texana, Textularia globulosa and apexes of gastropods noted.	1664-1690
Like the preceding sample	1690-1714
Mainly gray limestone, variable in texture. Some fragments contain dark oolitic grains. Sand present. A small Gryphea and an Anomalina (?) noted.	1714-1740
Dark marly shale and gray and white limestone. Some of the limestone is minutely porous. Orbitulina texana, Anomalina and pelecypod fragments noted.	1740-1780
Soft white limestone of very fine texture. No fossils noted	1780-1790
Dark marly shale and gray limestone. Some red sand. Bolivina noted	1790-1800
Somewhat angular white quartz sand of the texture as indicated below:	

Diam. of grains in mm.	Percentages	
½—¼	.1	
¼—⅛	40.9	
⅛—1-16	59.0	1790-1800

Sand, limestone and dark shale, many fragments of fossils. Orbitulina noted and a small fluted spine fragment. Some sand, well rounded. Fumes of sulphur and ammonia noted on heating material in a closed tube. Pyrite present. Sample adhering to drill. Green shale and sand with some calcareous material. Fumes of sulphur noted. All sand grains have polished surface. About five per cent. consists of chert of varied color. Fragments large shell noted.	1800-1805
Shale and sand, with some calcareous material, giving fumes of sulphur in closed tube. Some sand grains are from red flint. Most is clear quartz. Some fine grains have secondary facets. Textularia and fragments of Orbitulina were noted. Sand grains show polish	1800-1805
Limestone, with some sand and shale. Some limestones contain imbedded round grains of a dark greenish	

	Depth in Feet
gray material Pyrite and shell fragments noted, also fragments of foraminifera with perforated tests and a hollow fluted spine. Some sand is coarse. Many grains are red. Gives fumes of sulphur and bitumen	1805-1820
Mostly sand, moderately coarse and containing many pink and red grains. There are some smooth rounded greenish grains somewhat resembling glauconite. Textularia, Globigerina and an Anomalina (?) noted. In closed tube gives odor of bitumen and reacts for ammonia	1820-1830
Limestone and sand. Pyrite, fragments of shells and a dark limestone noted. Gives bituminous odor on heating in a closed tube	1830-1835
Mostly soft limestone and dark shale, with some sand. Much pyrite present. Bituminous and sulphur fumes noted	1835-1848
Soft limestone and dark shale, giving fumes of sulphur and ammonia. Fragments of Cretaceous foraminifera noted. Pyrite present	1835-1850
White limestone, mostly. Orbitulina and fragments of oyster shells noted. Pyrite noted. Fumes of sulphur and ammonia given on heating in closed tube. Fluted echinoid spine, Serpula, and an apex of a small gastropod noted. Some white limestone contains dark grains imbedded	1850-1860
Limestone and some gray sandstone of fine texture. Fragments of mollusk shells common. Orbitulina, a fluted echinoid spine and a perforated foraminifera test noted. Gives fumes of sulphur and ammonia	1860-1865
White sand	1865-1880

Notes on the section so far penetrated:

The section shown by these samples does not differ materially from the Waco section as already known from other wells, and from outcrops west of the city. It is essentially as below:

	Samples	Depth in Feet	
Austin Chalk	1	40	232
Eagleford	2	232	418
Washita beds	3-7	418	955
Fredericksburg, including the Edwards limestone, the Walnut formation and part of the Glenrose	8-17	955	1404
Trinity, including part of the Glenrose			

	Samples	Depth in Feet	
and part of the basal shales and sands	18-34	1404	1800

It is evident that the bottom of the Trinity sands has not been reached at 1800 feet.

Log of the Waco City Water Works well. Location: First and Webster Streets, Waco, Texas. Cable rig used.

	Depth in Feet
Soil and gravel	0-23
Austin chalk lime	23-160
Blue marl and shale	160-620
Limestone and marl	620-1000
Soft blue shale	1000-1200
Soft lime with mineral water	1200-1275
Hard white lime	1275-1700
Hard lime water, shale breaks	1700-1800
White sand bearing water	1800-1850
Shale and shell (casing set)	1850-1970
Sand with second water	1970-2183
Red and blue shale with hard shell	2183-2263

In all, 214 feet of water-bearing sand

NOTE: Diameter of well at bottom, 8¼ inches. Length of casing, 1970 feet. Water at 1969 feet. Yield, 600,000 gallons per day, estimated. Recorded by S. J. Quay, Supt., Waco, Texas.

Description of samples from the Waco City Water Works' well. Location: Waco, at First and Webster Streets, Texas. Submitted October 16, 1914. Judge Wm. M. Sleeper, Chairman Board; S. J. Quay, Superintendent; E. L. Fulkerson, Secretary. Depths were given of only the first and last two samples. But the samples are numbered in consecutive order, every second number missing. It is therefore to be presumed that number 3 to 29 represent in order from above downward, the depths between 1970 and 2190 feet. Described by J. A. U.

Sample No.		Depth in Feet
1.	Gray sand, very fine. Label says "very little water"	1964-1970
3.	Gray sand, medium fine. Many grains show crystalline faces. Some pyrite, green shale, and some fragments of coal noted. Lable says: "some water."	
5.	Gray sand, moderately fine. Some grains with crystallline faces. A few calcareous grains and pieces of shale. "Some water."	
7.	Gray sand, with considerable shell. "Some water."	

Depth in Feet

9. Gray sand of fine texture. "Water."

11. Gray quartz sand of moderately fine texture. Many grains show crystalline texture. "Water."

13. Gray sand, moderately fine, quite clean. Lignitic coal noted in fragments showing woody tissue. "Water."

15. Gray sand, quite clean. "Water."

17. Gray sand of medium texture. "Water."

19. Coarse gray, rounded quartz sand. "Water."

21. Coarse gray quartz sand. Several grains with secondary crystalline faces well developed. Some pyrite and considerable gray indurated marl present. Also some limestone fragments. "Good water."

23. Coarse gray, mostly rounded, sand, and some brown, some greenish and some gray shale. Many calcareous fragment noted. "Water."

25. Medium sized quartz sand, with some red and some greenish shale. Some indistinct circular disk-like bodies noted among the finest fragments. "Water."

27. Medium sized quartz sand, with some red and some greenish shale. Some indistinct circular disk-like bodies noted among the finest fragments. "Water."

27. Medium sized gray sand with some red and green shale. Sand in part of rounded in part of angular, grains. A little pyrite noted. Label says: "Water."

28. Gray partly rounded, quartz sand and some varicolored shale. With the shale was noted a single fragment of the shell of a lamellibranch. "Some Water."

29. About one-third of the sample is gray sand, the rest is varicolored shale. No fossils noted. "Very little water."

30. Mostly gray marly shale and a little fine sand. Anomalina and fragments of Globigerina noted, with the shale. "No water." Thickness 30 feet. About.....2100

Dark purple, greenish and dark gray shale. A few fragments of a fine-textured gray and micaceous sandstone present. These were soft and showed thin seams of clayey material. "No water.".....2200-2230

Note: All the material described as shale is marly and very fine in texture. In general, it resembles the basal clays of the Trinity, to which it no doubt is to be referred.—J. A. Udden.

Log of the Waco Filtration Plant Well No. 1, located at west side of Vermont and Brazos River Streets, Waco, Texas. Cable rig used.

	Depth in Feet From	To
Austin:		
White lime	0	165
Edwards and Del Rio:		
Brown slate	165	350
Georgetown:		
Blue slate	350	565
Edwards, Comanche Peak and Walnut:		
White lime	565	1000
Blue slate, small sulphur water above 1200 feet.	1000	1070
Glenrose:		
White lime	1070	1555
Blue slate	1555	1660
White lime	1660	1705
Basal Sand:		
"Trinity" water sand	1705	1735
Brown Sandy slate	1735	1800
Blue gumbo	1800	1855
Brown water sand	1855	1885
Sandy lime	1885	1900
Red slate	1900	1905
Sandy lime	1905	1940
Black slate	1940	1950
White sand rock	1950	1955
White lime	1955	1960
Water sand	1960	2040
Sandy lime	2040	2046

Note: Water at 1705-1735 feet, 1855-2040 feet main supply lower. Pressure of 63 pounds, initial yield, 710,000 gallons per day. S. J. Quay, Waco, Texas.

Log of Waco Water Company, Filtration Plant Well No. 2, 1917. (Log from Dr. Pace).

	Depth in Feet
Austin:	
Lime rock	0-186
Georgetown:	
Blue slate	186-392
Gray slate	392-484
Hard gray slate	484-571
Edwards, Comanche Peak and Walnut:	
Lime	571-807

	Depth in Feet
Hard lime	807-812
Marl	812-825
Lime	825-957
Marl	957-980
Slate	980-1038
Lime with blue shells; a little soft water	1038-1116
Gumbo	1116-1130
Glenrose:	
Lime	1130-1245
(A small stream of water at about 1194 feet).	
Stratified lime	1245-1544
Hard black lime	1544-1587
Hard black slate	1587-1595
Gray lime	1595-1656
Blue slate	1656-1657
Stratified lime	1657-1697
Basal Sands:	
Sandy lime	1697-1705
Trinity sand	1705-1720
Sandy lime	1720-1724
Sand	1724-1729
Sandy lime	1729-1741
Black slate	1741-1743
Trinity sand	1743-1758
Lime	1758-1760
Gumbo	1760-1878
Cap rock, very hard	1878-1883
Black sand	1883-1908
Sandy lime	1908-1923
Black sand	1923-1940
Red slate	1940-1945
Red sand	1945-1966
Gray sand	1966-1985
Black slate	1985-1987
Gray sand	1987-1997
Sandy lime	1997-2005
Gray sand	2005-2028
Very hard	2028-2030
White sand	2030-2046
Very hard	2046-2048
Water sand	2048-2054
Sandy lime	2054-2056

Log of Watt well, located at Fifth and Franklin Streets, Waco; elevation, 413 feet. Drilled about 1891. This water is warm, and is now used to supply a swimming pool and for drinking.

	Depth in Feet
Recent and Pleistocene.	
Clay	0-10
Gravel	10-40
Austin:	
White lime	40-350
Eagleford and Del Rio:	
Blue slate	350-565
Georgetown to Comanche Peak:	
White lime	565-1000
Blue slate	1000-1070
Walnut and Glenrose:	
White lime	1070-1550
Blue slate	1550-1660
White lime	1660-1705
Sand lime	1705-1709
White lime	1709-1745
Basement Sands:	
Trinity sand; no flow	1745-1750
Sandy marl	1750-1770
Gumbo	1770-1830
Sandy lime	1830-1855
Blue shale	1855-1925
Hard sand lime	1925-1930
Artesian sand	1930-2140
Red slate	2140-2170

Log of Wedekind well, located 2½ miles west of south of Ross, near Fort Graham road. Elevation about 500 feet. Drilled March to April, 1923 by E. S. Cluck.

	Depth in Feet
Austin and Eagleford:	
Chalk rock	0-40
Hard shale, gray to blue	40-200
Slate colored laminated shales	200-400
Gray shale, sandy	400-440
Slate colored shale	440-570
(6⅝ inch casing at 570).	
Del Rio:	
Shale with pyrite	570-620
Georgetown:	
Limestone, bluish, white when dry	620-695
Soft shale, darker than overlying limestone	695-700

	Depth in Feet
Gray limestone, some layers fossiliferous	700-810
Soft limestone	810-815

0-200 and possibly lower, is Austin Chalk; 200-570 showed much Eagleford, with calcareous material, probably caving. The hard ledge at 570 is thought to be an indurated flagstone well down in the Eagleford. The outcrop nearby has similar very hard flags.

Log of West well No. 1. Commenced May 17, 1921; finished May 30, 1921. (1 miles north of Bosqueville.)

	Depth in Feet From	To
Del Rio:		
Red soil	0	3
Red graveled clay	3	15
Yellow clay	15	25
Dark blue shale	25	85
Georgetown:		
Gray lime	85	145
White lime	145	205
Gray lime	205	215
Gumbo	215	220
White lime	220	250
Hard, white lime	250	280
Dark blue shale	280	285
Dark sand, water	285	290
White lime, hard	290	330
Edwards to Walnut:		
White lime	330	385
Blue shale	385	395
White lime	395	415
Gray lime	415	430
White lime	430	450
Blue shale	450	465
Gray shale	465	510
Blue shale	510	520
Shelly, blue shale	520	530
Gray lime	530	540
Blue shale and lime	540	550
Glenrose:		
White lime	550	565
Blue shale and lime	565	595
Shale with lime	595	602.5

Log of Williams No. 1, located one-half mile northwest of Lorena.

	Depth in Feet
Soil	0-0.5
Austin Chalk:	
White lime	0.5-2
Eagleford:	
Yellow clay, no water	2-20
Blue shale, dark	20-50
Blue shale, light; pyrite	50-112
Shale, sandy, some gas	112-120
Blue shale	120-135
Black shale and blue lime	135-175
Shaly sand, brown	175-198
Blue shale	198-239
Georgetown:	
Hard gray lime rock, trace of gas	239-240
Lime and shale, blue	240-255
Blue shale and lime	255-315
Gray lime	315-335
White lime	335-373
Gray shale	373-378
Gray lime	378-380
Blue shale	380-390
Hard gray lime rock	390-391
Shelly shales and lime, fossiliferous	391-404
Hard gray lime	404-445
White crystalline lime; water	445-450
White lime and soft white shale	450-518
Edwards:	
Blue gumbo and shale	518-528
Gray shale	528-532
White shale	532-538
Gray shale	538-542
White lime rock, hard	542-557
Gray shale	557-562
Gray lime	562-565
Gray shale	565-566
Gray lime	566-570
Gray shale	570-575
White lime	575-582
Walnut:	
Gray shale	582-607
Shelly gumbo, fossils	607-625
Gray shale and gumbo	625-635
Shelly gumbo	635-650
Gray shale	650-660

	Depth in Feet
Gumbo	660-665
Shells (fossiliferous ledge)	665-668
Blue shale	668-675
Glenrose:	
White lime, pure	675-690
Blue shale, oyster shells (ramshorns, 2½ inches in diameter)	690-692
White lime	692-720
Blue shale with shells	720-722
Gray lime rock	722-727
Blue shale and shell	727-730
Gray lime rock	730-732
Shale, blue	732-735
Lime rock, gray	735-738
Hard sandstone	738-740
Shale, blue	740-743
Lime rock, gray	743-745
Shale, blue	745-750
Lime rock, gray	750-754
Shale, blue	754-760
Lime sand	760-765
Shale and lime	765-770
Lime	770-775
Lime sand	775-780
Shale	780-785
Lime, gray	785-790
Shale	790-815
Lime and shale with streaks of pack sand	815-825

SOUTH BOSQUE OIL FIELD WELLS

AMICABLE NO. 1

Clay tract; started October 1, 1921. DeManchey, driller. Elevation 513.6 feet.

	Depth in Feet
Black soil	0-5
Gravel	5-15
White lime	15-55
Grey lime and shale	55-100
Grey lime	100-150
White lime, crystalline, sulphur water; echinoid spine, Gryphea	150-155
White lime	155-200
Grey shale	200-225
White lime	225-235

	Depth in Feet
Grey shale	235-245
Gumbo	245-255
Grey shale	255-280
White lime	280-300
Gumbo	300-315
Grey shale and gumbo	315-340
Grey shale	340-350
Gumbo	350-375
Shelly gumbo and shale	375-390
Shale	390-395
Shelly shale and streaks of grey limestone	395-410
Blue shale	410-430
Grey lime	430-432
Blue shale	432-449
Lime rock, false cap	449-450
Blue shale	450-453
Cap rock	453-454
Sand with oil	454-458

AMICABLE NO. 2

Clay tract; DeManchey, driller

Black soil	0-6
Gravel	6-16
Del Rio:	
Blue shale; Exogyra arietina	16-17
Georgetown to Walnut:	
White lime	17-57
Grey lime and shale	57-100
Grey lime, hard	100-151
White lime; sulphur water	151-155
White lime	155-200
Grey lime	200-225
White lime	225-240
Gumbo	240-250
Grey shale	250-285
White lime	285-300
Gumbo	300-315
Grey shale, gumbo	315-340
Grey shale, gumbo	340-350
Gumbo and shell	350-375
Gumbo, shale and shell	375-380
White lime	380-390
Grey shale and shell	390-400
White lime	400-410

	Depth in Feet
Blue shale	410-430
Grey shale	430-432
*Blue shale	432-449
Limestone, "false cap rock"	449-450
*Blue shale	450-453
Cap rock, limestone	453-458.5
Oil sand	458.5

By line measurement; I helped measure it. W. S. A.

*Falls to all lower levels. W. S. A.

Open hole.

BELLROSE DEEP TEST

Location: South Bosque, near junction of South Bosque and Middle Bosque Rivers. Elevation: about 466 feet.

	Depth in Feet
Surface	0-4
Yellow clay	4-23
White sand and gravel	23-30
Gray lime	30-70
White lime	70-80
Blue shale	80-95
Gray lime	95-145
Blue shale	145-160
White lime	160-240
Blue shale	240-260
White lime	260-275
Blue shale	275-290
White lime	290-300
Blue shale	300-385
White lime	385-395
Blue shale	395-422
Hard gray lime	422-428
Blue shale, soapstone	428-451
White lime	451-453
Slate	453-462
Cap rock—hard silica	462-466
OIL SAND	466-472
Blue shell rock	472-505
White lime	505-625
Blue lime	625-630
White lime	630-760
Blue shale	760-775
White lime	775-985
Blue lime and white shale	985-1060
Fine sand; large flow of water	1060-1120

	Depth in Feet
Coal	1120-1123
Blue slate	1123-1143
Gray lime	1143-1145
Slate	1145-1148
Light sand rock, no water	1148-1151
Blue shale	1151-1162
Fine sand, 10 gallons water per minute	1162-1169
Slate	1169-1180
Red gumbo	1180-1187
Black sand, rainbow of oil	1187-1190
Red rock	1190-1195
Fine water sand	1195-1220
Blue shale	1220-1230
Sand	1230-1275
Red gumbo	1275-1279
Sand	1279-1284
Hard shell	1284-1295
Correlation:	
Recent and Pleistocene	0-30
Georgetown	30-290
Edwards, Comanche Peak, Walnut	290-505
Glenrose	505-1060
Basal sand	1060-1295

BICKLE NO. 1

Bickle tract, one-half mile southwest of South Bosque. Abundant water in well. November, 1920.

	Depth in Feet
Black soil	0-3
Black soil	3-10
Water gravel	10-20
Del Rio:	
Blue soapstone	20-25
Georgetown to Walnut:	
White lime rock	25-100
Blue soapstone	100-106
Blue lime rock	106-165
Sand, much water	165-166
White lime rock	166-220
Soapstone	220-255
Black clay	255-265
Lime and clay	265-305
Black clay	305-325
White lime, soft	325-340
Blue clay	340-400

	Depth in Feet
Lime rock, white	400-406
Blue clay	406-477
Cap rock	477-479
A grey crystalline limestone, fairly soft, much pyrite.	
OIL SAND	479-481
White lime	481-485

Produced 1 to 2 barrels oil per day. Note that the producing sand is deeper on going south.

BICKLE NO. 2.

Starts about 30+ feet up in Del Rio; penetrated Del Rio, Georgetown and probably Walnut, as seen by the presence of Exogyra arietina, Gryphea washitaensis and Exogyra texana in a slush pit. The well was damaged by shooting.

E. M. ZIPPER NO. 1.

Located about one-half mile southwest of preceding; drilled about 1907 by Darrington of Pennsylvania, 527 feet; oil, capped, still oozes oil and water.

CARPENTER AND FALLIS LEASE NO. 1

December 30, 1920—January 16, 1921

	Depth in Feet
Black soil	0-3
Yellow soil and gravel	3-15
Georgetown:	
White lime	15-80
Blue mud	80-85
Blue or gray rock	85-100
White lime	100-160
Water sand	160-163
White lime	163-260
Blue mud	260-270
Edwards to Walnut:	
White lime	270-323
Blue mud or gumbo	323-330
White lime	330-345
Gumbo	345-385
White lime	385-420
Shell and gumbo	420-450
Soapstone	450-454
Cap rock	454-459
OIL SAND	459-469
Soapstone	469-

CLAY NO. 1

Clay tract, one-half mile south of the Amicable wells

	Depth in Feet
Surface soil	0-6
Water gravel	6-16
Grey lime	16-20
White lime	20-36
Blue shale	36-55
White lime	55-65
Grey lime, fossils	65-78
White lime	78-84
Soft grey lime	84-90
White lime	90-105
Blue shale	105-108
White lime	108-112
Sand, white lime	112-138
White lime	138-183
Blue, shale, soft, sticky	183-188
Grey lime	188-205
Gumbo	205-213
Grey lime	213-222
Blue shale	222-246
Gumbo	246-248
Grey lime	248-260
Gumbo	260-330
Grey lime and quartz	330-354
White lime	354-360
Grey lime and quartz	360-377
Gumbo	377-384
Grey lime and water shells	384-386
Gumbo	386-390
Grey shale	390-400
Grey lime and shell	400-404
Gumbo	404-407
Hard grey lime; fossils	407-408
Gumbo	408-410
Hard grey lime; fossils	410-411
Blue shale	411-415
Cap rock	415-417
OIL SAND	417-418.5
Grey shale	418.5-425
Light grey lime, hard and soft streaks	425-440
White lime	440-468
Grey sand rock	468-472
White lime	472-473

CLAY NO. 2

Clay tract, one-half mile south of the Amicable wells

	Depth in Feet
Surface soil	0-4
Gravel	4-8
White lime, hard	8-20
Blue shale	20-23
White lime	23-38
Blue shale	38-53
White lime	53-56
Light blue shale	56-74
Grey lime, soft	74-78
Grey shale	78-115
Blue shale	115-120
White lime; sand, water	120-145
White lime	145-155
Grey lime, sand and quartz	155-165
White lime	165-169
Grey lime	169-183
Gumbo	183-188
Grey lime, soft	188-210
Gumbo	210-220
Grey lime, soft	220-254
White lime, soft	254-270
Gumbo	270-330
Grey lime and quartz	330-335
Gumbo	335-347
Grey lime and quartz	347-357
White lime, soft	357-362
Grey shale	362-378
Grey lime and shell	378-384
Grey shale	384-393
Grey lime and shell	393-397
Gumbo	397-400
Grey lime, fossils	400-404
Gumbo	404-408
Grey lime, quartz	408-412
Gumbo	412-414
Grey lime, quartz	414-419
Gumbo	419-423
Cap rock	423-426.5

CORBELL NO. 1

3.5 miles north of Hog Creek; no oil; westernmost well in field

	Depth in Feet
Loose rock and soil	0-1
Georgetown to Glenrose:	
White lime, hard and soft	1-30
Grey shale	30-130
Gumbo	130-132
White lime; sand, water; pyrite, "isingglass"	132-162
Soft grey lime	162-220
Grey shale	220-235
Gumbo	235-242
Grey lime and shell	242-275
Grey shale	275-295
Gumbo	295-300
Grey shale	300-320
Gumbo	320-330
Grey shale	330-342
Gumbo	342-349
Grey lime and shell	349-350
Grey shale and shell	350-360
Grey lime and shell	360-370
Grey shale	370-410
Grey lime and quartz	410-411
Grey shale	411-430
Grey lime, shell and quartz	430-431
Gumbo	431-435
Grey lime, sand and shell	435-465
Grey lime	465-530
White lime	530-570
Sand, grey lime, shale; water	575-590*
Grey lime	590-600
White lime	600-725
White chalk	725-743
Grey sand rock	743-745
White lime	745-800

KILLION WELL NO. 1

Roberts Survey

Black soil	0-3
Clay soil	3-10
Water gravel	10-19

*Copied original manuscript.

	Depth in Feet
Blue shale	19-40
Lime rock	40-100
Rock and shale	100-185
Water	185
Not given	185-236
Gumbo	236-260
Lime	260-277
Blue shale	277-293
Lime	293-304
Blue shale	304-305
Lime	305-334
Lime	334-340
Gumbo	340-370
Lime	370-371
Gumbo	371-374
Gumbo	374-403
Lime	403-406
Gumbo	406-412
Lime	412-421
Gumbo	421-424
Lime rock	424-445
Light shale	445-449
Blue shale	449-457
Shaley lime	457-462
Lime	462-465
Gumbo	465-474
Shaley lime	474-478
Gumbo	478-483
Cap rock	483-486
Oil sand or rock	486 492
Light shale	492-494

KOURY, BOSHARA AND COGGAN LEASE NO. 1

November 18-30, 1920

Black soil	0-5
Yellow soil and gravel	5-20
Georgetown to Walnut:	
White lime rock	20-71
Blue mud	71-81
Blue or gray rock	81-154
White sand rock	154-165
White lime rock	165-210
Blue mud	210-217
White lime	217-242

	Depth in Feet
Blue mud or gumbo	242-250
Gray rock	250-280
White lime	280-300
Gumbo	300-365
Shell and gumbo	365-375
White lime	375-405
Gumbo	405-428
Shell and gumbo	428-448
Cap rock	448-451
Oil sand	451-455

KOURY NO. 2

December 2-21, 1920

Black soil	0-4
Yellow soil and gravel	4-10
Georgetown:	
Hard yellow rock	10-19
White lime rock	19-60
Blue mud and rock	60-90
Gray rock	90-103
Blue mud	103-110
White lime	110-210
Blue or gray mud	210-235
Gumbo	235-245
Edwards to Walnut:	
Gray rock	245-300
Gumbo	300-355
Shell and gumbo	355-375
White lime	375-405
Shell and gumbo	405-444.5
Cap rock	444.5-449
OIL SAND	449-453.5

MITCHELL NO. 1

January 21, 1921.

Surface soil	0-5
Yellow clay	5-10
Water gravel	10-15
Yellow clay	15-20
Blue shale	20-30
Grey shale, hard	30-60
White lime	60-190
Sand and shell; water	190-195

	Depth in Feet
Grey lime, hard	195-210
White lime	210-275
Blue shale (gumbo)	275-440
Grey shale (gumbo)	440-490
Sticky blue gumbo	490-500
Grey lime	500-520
Cap rock	520-521
OIL SAND	521-523
Grey lime and quartz	523-530

MOORE NO. 1

Just north of Middle Bosque bridge of oil road to rt

Surface soil	0-2
Yellow clay and gravel	2-8
Georgetown to Walnut:	
White lime, rather hard	8-34
Blue shale	34-36
Light grey lime, hard to soft	36-69
Gumbo	69-78
Grey lime, soft	78-150
White lime, sand shell; water	150-165
White lime, soft	165-220
Grey lime, soft	220-250
Grey shale	250-260
Gumbo	260-270
Grey shale	270-285
White lime	285-300
Gumbo	300-380
Gray lime and shell, hard	380-385
White lime, soft	385-395
Grey lime	395-415
Gumbo	415-419
Gray lime, quartz and shell	419-422
Gumbo, hard	422-425
Grey lime and shell, hard	425-430
Gumbo	430-434
Grey lime shell, hard	434-440
Gumbo	440-443
Grey lime shell	443-445
Gumbo	445-447
Grey lime shell	447-449
Gumbo	449-450
Cap rock	450-454
OIL SAND	454-461

MORGAN NO. 1

North of Hog Creek, near crosssing of Crawford (Rifle Range) road:

	Depth in Feet
Surface soil	0-4
Gravel; water	4-16
Georgetown to Walnut:	
White lime	16-120
Yellow lime	120-140
White lime	140-173
Grey shale	173-174
White lime	174-203
Gumbo, grey shale	203-209
White lime	209-265
Grey shale	265-322
Grey shale, hard streaks of limy material	322-330
Grey shale, marine fossils	330-340
White lime	340-370
Grey shaly clay	370-409
Grey lime	409-414
Grey sandy lime; oil	414-425
Blue shale	425-426

PYRON NO. 1

February 23—March 15, 1921

Black soil	0-1
Yellow soil and gravel (water at 16 feet)	1-18
Del Rio:	
Blue mud	18-28
Georgetown:	
White lime	28-97
Light shale	97-107
Gray lime	107-170
Water sand	170-172
White lime	172-251
Light shale	251-264
Edwards to Walnut:	
Gray lime	264-272
Light shale	272-285
White lime	285-317
Shale	317-320
White lime	320-330
Gumbo	330-388
Shell and gumbo	388-412

	Depth in Feet
White lime	412-438
Shell and gumbo (5″ at 480 feet)	438-478
Cap rock	478-488
Rock and shale	488-492
Gumbo	492-498
Gray lime	498-524
Water sand	524-528

PYRON NO. 2

March 18-25, 1921

Black soil	0-3
Yellow soil and gravel	3-12
Blue rock	12-78
Light shale	78-150
White lime	150-160
Water	160-165
White lime	165-177
Light shale	177-295
White lime	295-307
Mud and shale	307-382
White lime	382-414
Shale and gumbo	414-419
Cap rock	419-455
OIL SAND	455-458

SINCLAIR-DEAL AND PHELPS CO. NO. 1

Sinclair-Deal and Phelps Co. lease; J. A. Cluck, driller; started Nov. 14, 1920; finished Dec. 17, 1920.

	Depth in Feet
Surface soil	0-2
Yellow clay and gravel	2-8
White lime	8 34
Blue shale	34-36
Light gray lime	36-69
Gumbo	69-78
Grey lime	78-150
White lime, sand and shell; water	150 165
White lime	165-220
Grey lime	220-250
Grey shale	250-260
Gumbo	260-270
Grey shale	270-285
White lime	285-300

	Depth in Feet
Gumbo	300-380
White lime	385-395
Grey lime	395-415
Gumbo	415-419
Grey lime, quartz and shell	419-422
Gumbo	422-425
Grey lime and shell	425-430
Gumbo	430-434
Grey lime and shell	434-440
Gumbo	440-443
Grey lime and shale	443-445
Gumbo	445-447
Grey lime and shell	447-449
Gumbo	449-450
Cap rock	450-454
OIL SAND	454-461

450 feet of 6″ casing.

STEVENSON NO. 1

Near north end of main field;

Yellow gravel and soil	0-6
Georgetown to Walnut:	
White lime	6-152
Blue soapstone	152-155
White and yellow lime	155-175
White lime	175-230
Blue soapstone	230-240
White lime	240-295
Blue soapstone	295-352
Gumbo	352-360
Shell and gumbo	360-370
White lime	370-400
Gumbo	400-435
Cap rock	435-448
OIL SAND	448-451

STEVENSON NO. 2

Commenced October 25, 1920, completed November 22, 1920.

Black soil	0-1
Yellow clay and gravel	1-5
White lime	5-232
Blue shale	232-242
Edwards to Walnut:	
White lime	242-293
Blue shale and gumbo	293-367

	Depth in Feet
White lime	367-400
Gumbo	400-431
Cap rock	431-448
OIL SAND	448-452

6″ casing left in hole: 433½ ft. No water.

STEVENSON NO. 3

Stevenson lease: commenced November 30, 1920, finished Dec. 18, 1920.

	Depth in Feet
Black soil	0-1
Yellow clay and gravel	1-12
Georgetown:	
White lime	12-60
Blue shale	60-68
White lime	68-232
Blue shale	232-242
Edwards to Walnut:	
White lime	242-293
Blue shale and gumbo	293-363
White lime	363-404
Gumbo	404-408
White lime	408-416
Gumbo	416-442
Cap rock	442-446
OIL SAND	446-449
Lime	449-450

Water seep at 140 feet. 6″ casing in hole 444 feet.

STRATTON-McCLENDON NO. 1

Wagner Lease

May 8-30, 1922

Black soil	0-5
Yellow soil and gravel	5-13
Georgetown:	
White lime	13-80
Blue mud	80-87
Gray lime	87-150
Light shale	150-340
Edwards to Walnut:	
Blue shale	340-390
White lime	390-420
Gumbo	420-445

	Depth in Feet
Gumbo and shell	445-450
Blue soapstone	450-455
Cap rock	455-460
OIL SAND	460-465

STRATTON-McCLENDON NO. 5

Wagner Lease
June 1922

Black soil	0-6
Yellow soil and gravel (water at 17 feet)	6-17
White lime	17-80
Blue mud	80-86
Gray lime	80-155
Sand, water and gravel	155-167
Gray lime	167-183
Blue shale	183-230
White lime	230-248
Blue mud	248-260
Gray lime	260-275
Light shale and mud	275-397
White lime	397-410
Gumbo and gravel	410-458.5
Cap rock	458.5-460
OIL SAND	460-165

THREET NO. 1 ("DEEP TEST")

Threet tract near schoolhouse at South Bosque Station. Commenced March, 1921. Elevation 521.7.

	Depth in Feet
Recent:	
Black soil	0-5
Clay, yellow	5-24
Gravel	24-28
Del Rio:	
Clay, yellow	28-32
Shale, blue	32-44
Georgetown:	
Limestone, white	44-100
Shale, blue	100-103
Shale, blue (Set 10″ casing, 3-22-21, one joint 13′-3″ and one joint 36′-3″)	100-103
Lime, white	103-151

	Depth in Feet
Lime, hard, white	151-168
Lime, soft, white	163-250
(Water at 180 feet, about 80 gallons per hour.)	
Shale, blue	250-254
Lime, soft, white	254-271
Shale, blue	271-281
Lime, white, hard	281-290
Shale, blue	290-294
Edwards Comanche Peak:	
Lime, gray, firm	294-297
Shale, blue	297-298
Lime, gray, firm	298-313
Lime, white, hard	313-333
Shale, dark	333-345
Shale, gray	345-365
Shale, dark	365-374
Shale, gray	374-390
Shale, dark	390-403
Walnut:	
Shale gray	403-427
Lime, white, soft	427-432
Shale, gray	432-444
Lime, white, soft	444-446
Shale, gray	446-452
Lime, gray, soft	452-453
Shale, gray	453-460
Lime, gray	460-461
Shale, gray	461-473
Sand, a showing of oil	473-476
Shale, gray	476-484
Rock, gray	484-487
(Set 484′ of 8″ casing)	
Shale, gray	487-499
Glenrose:	
Lime, white, soft	499-524
Lime, yellow	524-530
Lime, white, hard	530-550
Lime, white, soft	550-557
Lime, white, hard	557-559
Lime, white, soft	559-621
Lime, gray, hard	621-625
Lime, gray, soft	625-633
(a little water at this depth)	
Lime, gray, hard	633-659
Lime, gray, soft	659-730

	Depth in Feet
(water at 730 feet)	
Lime, gray, soft	730-774
Lime, white, hard	774-788
Shale, gray, soft	788-796
Shale, gray, hard	796-802
Shale, gray soft	802-816
Shale, gray hard	816-823
Lime, gray, soft	823-933
(water at 930 to 954)	
Lime, gray, soft	954-976
Shale, blue, soft	976-983
Lime, gray	983-1003
Lime, dark, showing of oil	1003-1007
Shale, white, firm	1007-1014
Lime, gray, firm	1014-1036
Shale blue	1036-1045
Lime, gray, hard	1045-1061
Shale, white	1061-1063
Lime, gray, soft	1063-1067
Shale	1067-1072
Lime, gray, hard	1072-1075
Basement Sands:	
Sandstone, white, soft; strong flow of water	1075 1138
Sandstone, dark, soft	1138-1142
Shale, trace of coal	1142-1144
Sandstone, gray	1146-1146
Sandstone, gray, hard	1146-1147
Shale, dark. firm	1147-1170
Shale, gray, muddy	1170-1179
Gumbo, pale brown, soft	1179-1180
Shale, dark, soft	1180-1182
Slaty shale, dark, firm	1182-1184
Sand, gray, soft	1184-1201
Shale, brown	1201-1207
Shale, dark brown	1207-1218
Sand, dark	1218-1223
Sand, dark, hard	1223-1224
Sand, light, soft	1224-1226
Sand, light, hard	1226-1227
Sand, light, soft	1227-1229
Sand, light, hard	1229-1230
Sand, light, soft	1230-1245
Red rock, hard	1245-1246
Sand, white, hard, water increased slightly in sand from 1246-1257′	1246-1257

	Depth in Feet
Shale, light, trace of coal	1257-1260
Shale, light, sandy	1260-1270
Shale, light, water	1270-1284
Shale, red, hard	1284-1288
Shale, white and red, hard	1288-1290
Coal	1290-1290.5
Shale, red	1290.5-1294
Sand, light	1294-1301

Set 1218 feet of 6⅝″ casing.

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Structural Geology: 10, 11, 38, 46.
Fossils: 1, 4, 6, 12, 17, 18, 26, 28, 29, 32, 40, 41, 42.
Soils: 22.

MCLENNAN COUNTY PLANTS

By

LULA PACE

This list of fern and seed plants is far from complete, but it is thought that it might be serviceable as a check list even as incomplete as it is.

A few of the introduced trees and more conspicuous plants are included. These are starred.

List of Plants

Polypodiaceae:

Polypodium polyodioides (L.) H. Polypod fern. On trees on Brazos.

Adiantum Capillus-Veneris L. Venus hair fern; maiden hair fern Limestone bluffs.

Pellaea atropurpurea (L.) Link. Rock fern. Bluffs of Edwards.

Cheilanthes alabamensis Kuntze. Lip-fern. Rock bluffs.

Marsileaceae:

Marsilea macropoda Englm. Marsilea. Ponds and muddy borders of streams.

Equisetaceae:

Equisetum arvense L. Equisetum, horse-tail. Railroad track.

Juniperaceae:

**Thuja occidentalis* L. Arbor Vitae (Various retinospora cedars also.)

Sabina sabinoides (H. B. K.) Small. Mountain cedar.

Sabina virginia (L.) Antoine. Red cedar.

Typhaceae:

Typha latifolia L. Cattail. In ponds and ditches. May.

T. angustifolia L. narrow leaved cattail. Ponds and ditches. May

Alismaceae:

Echinodorus radicans Englm. Burhead. Ponds. Summer.

Echinodorus cordifolius (L.) Griseb. Burhead. Ponds. July-Oct.

Sagittaria platyphylla J. G. Smith. Arrow leaf. Ponds. July-Oct.

S. Longiloba Englm. Arrow leaf. Ponds. Summer.

Araceae:

Muricauda Dracontium (L.) Small. Green dragon. Flood plains Summer.

Commelinaceae:

Tradescantia occidentalis Britton. Western spiderwort. Plains.

T. bracteata (?) Small. Spiderwort. Summer.

Commelina angustifolia Michx. Day flower.

C. virginica L. Day flower.

C. erecta (?) L. Day flower.

Tinania sp.?. Stamens like *Tradescantia,* petals like *Commelina* Moist bluffs and ravines.

Melanthaceae:

Toxicoscordion texense Rydb. Zygadenus. Spring.

Alliaceae:

Allium mutabile Michx. Onion. Sandy soil. Apr.-June.

A. Helleri Small. Onion. Rocky hillsides. April.

A. Microscordium (?) Small.

Androstephium coeruleum Greene. Rocky hills. April.

Nothoscordium bivalve (L) Britton. False garlic. Spring to fall especially after rains.

Liliaceae:

Erythronium albidum coloratum Sterns. Dogs-tooth violet, fawn lily. Ravine slopes. March.

Quamasia hyacinthina (Raf.) Britton. Wild hyacinth. Spring.

Convallariaceae:

Asparagus officialis L. Asparagus. Escaped. Apr-September.

Dracenaceae:

**Yucca gloriosa* L. Spanish dagger. June.

Y. rupicola Scheele. Bear grass. Rocky hills. May-June.

Y. arkansana Trelease. Bear grass. Rocky hills. Spring.

Smilacecae:

Smilax Bona-nox L. Smilax, Stretchberry. Common green-briar. floodplains and ravines.

Leucojaceae:

**Agave* sp?. Several varieties on lawns.

Atamosco texana Greene. Atamasco. Yellow rain lily. Aug.-Sept., after showers

Cooperia Drummondii Herb. White rain lily. June-October.

C. pedunculata Herb. White rain lily. April. Rocky soils.

Ixiaceae:

Nematostylis coelestrina (Bart.) Nutt. Blue lily. Hills.

Sisyrinchium pruinosum Bicknell. Blue-eyed grass. Prairies.

S. texanum Bicknell. Smaller purplish flower.

Juglandaceae:

Juglans nigra L. Black walnut. Flood plains.

J. rupestris Englm. Mexican walnut. Small tree, floodplains.

Hicoria pecan (Marsh) Britton. Pecan. Valleys.

Salicaceae:

**Populus alba* L. Silverleaved poplar.

**P. Nigra-Italica.* Lombardy poplar.

P. deltoides Marsh. Cottonwood. Along streams.

Salix nigra Marsh. Black willow. Along streams.

Fagaceae:

Quercus marylandica Muench. Black Jack oak. Sandy soils.

Q. Schneckii Britton. (Q. texana.) Texas oak. Floodplains.

Q. breviloba (Torr.) Sarg. Shin oak. Sand and rocky slopes.

Q. minor (Marsh.) Sarg. (Q. stellata.) Post oak. Sandy soils.

Q. macrocarpa Michix. Bur. oak. Flood plains.

Q. virginiana Mill. Live oak Low grounds.

Q. fusiformis (?) Small. Mountain live oak. Rocky hills.

Urticaceae:

Parietaria pennsylvanica Muhl. Pellitory, clear weed. Shaded places.

Urtica Chamaedryoides Pursh. Nettle. Moist ravines and thickets.

Artocarpaceae (Moraceae):

Morus alba L. Mulberry.

Toxylon pomiferum Raf. Bois d'arc. Osage orange.

Ulmaceae:

Ulmus crassifolia Nutt. Cedar elm, red elm. Sept.-Oct.

U. alata Michx. Winged elm, wahoo. Rocky slopes and ravines.

U. americana L. White elm. Flood plains. February.

Celtis reticulata Torr. Rough leaved hackberry. Rocky hills.

C. mississippiensis Bosc. Hackberry. Marsh.

Polygonaceae:

Eriogonum longifolium Nutt. Eriogonum. Sandy soil. Summer.

Rumex crispus L. Curl dock. Rich soils.

Persicaria portoricense Bertero. Persicaria. Ditches. Summer.

Persicaria portoricense Bertero. Persicaria. Ditches. Summer

Chenopodiaceae:

Chenopodium album L. Lambs quarters. Waysides. Summer.

C. Botrys L. Jerusalem oak. Waste places.

Atriplex canescens (?) (Pursh) James. Orache.

Amaranthaceae:

Amaranthus retroflexus L. Careless weed. Summer.

A. spinosus L. Spiny careless weed.

A. albus L. Careless weed, tumble weed.

A. blitoides S. Wats. Common pigweed.

Acnida tamariscina (Nutt.) Wood. Water hemp.

Corrigiolaceae:

Paronichia dichotoma (L.) Nutt.

Petiveraceae:

Rivina humilis L. Floodplains and ravines. Summer.

Phytolacca decandra L. Pokeweed. Good soil. Summer.

Allioniaceae:

Allionia—Two species. Summer.

Mirabilis multiflora (Torr) A. Gray.

Boerhaavia decumbens Vahl. Purple weed. Summer.

B. erecta L. Purple weed (Paler). Spring to fall.

B. viscosa (?) Dag-Rodg.

Tetragoniaceae:

Mollugo verticillata L. Carpet weed. Common.

Portulacaceae:

Talinum teretifolium Pursh. Gravel beds.

Claytonia virginica L. Spring beauty. Flood plains. February-April.

Portulaca grandiflora Hook. Rose moss.

P. pilosa.. L. Small flowered "moss."

P. oleracea L. Purslane. Common garden weed.

Alsinaceae:

'*Alsinopsis texana* (Robinson) Small.

Alsine media L. Chickweed Common on lawns. Jan.-Apr.

A. Baldwinii Small.

Caryophyllaceae:

Saponaria officinalis L. Hedge pink.

Silene antirrhina. Catchfly. Gum on some nodes below the flower. flower.

Ranunculaceae:

Aquilegia canadensis. L. Columbine. Rocky bluffs of Edwards.

Delphinium Ajacis L. Larkspur. Escaped. Spring.

D. albescens Rydb. White larkspur. Prairies Apr.-July.

Anemone decapetala Ard. Anemone, windflower. Prairies. Feb.-Mar.

A. caroliniana Walt. Slender anemone. Prairies. Feb.-Mar.

Viorna coccinca (Engelm) Small. Scarlet vase vine. Clematis. Rocky hills. April-July.

V. Viornia (L.) Small. Blue vase vine. Floodplains. May-Sept.

Ranunculus macranthus Scheele. Buttercup, crowfoot. Sandy floodplains. March-May.

Magnoliaceae:

**Magnolia grandiflora.*

Menispermaceae:

Cebatha carolina (L) Britton. Coral bead, sarsaparilla. Fields and valleys. June-Oct.

Nymphaeaceae:

Nymphaea.

Podophyllaceae:

Podophyllum peltatum L. May apple, Mandrake. Damp woods. Spring.

Berberis (*trifida*) *Trifoliolata* Moric. Agarita, Chapparal. Woods and hillsides. February.

Papaveraccae:

Argemone alba Lestib. White poppy. Rich soils. Summer.

Fumariaceae:

Capnoides montanum (Engelm) Britton. (*Corydalis capnoides.*) Fumitory. Corydalis.

Brassicaceae:

Bursa Bursa-pastoris (L) Britton. Shepherd's purse. Common weed with heart shaped seed pods.

Lepidium virginicum L. Pepper grass. Common weed.

L. medium Greene. Post oak woods. April-July.

Lesquerella gracilis (Hook) S. Wats. Common bladder pod.

L. recurvata. S .Wats.

Roripa Nasturtium (L.) Rusby. Water cress. Shallow streams.

Draba verna L. Whitlow grass. March-June.

D. cuneifolia (?) Nutt. Whitlow grass.

Sophia Sophia (L.) Britton Flaxweed. Spring.

S. pinnata (Walt.) Britton.

Capparidaceae:

Polanisia trachysperma T. & G. Clammy weed.

Sedaceae:

Sedum Nuttallianum Raf. Stonecrop. Rocky hills and gravel beds.

Platanaceae:

Platanus occidentalis L. Sycamore. Along streams.

Rosaceae:

Rubus trivialis Michx. Common dewberry. Ravines.

Geum vernum (Raf.) T. & G. Avens. Flood plains and ravines.

Sanguisorba canadensis L. Gravel beds.

Malaceae:

Crataegus sp? Hawthorne, red haw. Floodplains and ravines.

Amygdalaceae:

Amygdalus Persica L. Peach. Escaped.

**Prunus cerasus.*

Prunus (Two species).

Mimosaceae:

Morongia uncinata (Willd.) Britton. Sensitive briar. Common.

Prosopis glandulosa Torr. Mesquite. Common on prairies and edges of timber. April-Sept.

Cassiaceae:

Cercis canadensis. Redbud, Judas tree. Ravines and rocky hills.

Cassia Roemeriana Scheele Senna. Rocky soil.

Gleditsia triacanthos. Honey locust. Flood plains.

Parkinsonia aculeata L. Ratama, Parkinsonia. Not common.

Krameriaceae:

Krameria secundiflora DC. Sand bur. Purplish flowers. Common.

Fabaceae:

Sophora affinis T. & G. sophora. Pods constricted.

Lupinus texensis Hook. Blue bonnet. Texas lupine. April-June.

Medicago denticulata Willd. Bur clover, toothed medic.

M. arabica All. Spotted medic.

M. sativa L. Alfalfa. Escaped.

Melilotus officinalis (L) Lam. Yellow sweet clover. Recently introduced.

M. alba Desv. White sweet clover. Recently introduced.

Trifolium amphianthum T. & G. Pink clover.

Indigofera leptosepala Nutt. Indigo plant.

Cracca.

**Robinia pseudocacia* L. Black locust. ..

Sesban macrocarpa Muhl. Sesban. Ditches and near streams.

Geoprunum mexicanum Rydb. Ground plum. Rocky soil.

Astragalus brazoensis Buckl. Vetch. Triangular seed pod.

Lotus americanus Bisch.

Psoralea hypogaea Nutt Tuberous Psoralea. Rocky soil.

P. cuspidata Pursh.

Amorpha False indigo. Ravines.

Petalostemon pupureus (Vent) Rydb. Prairie clover.

Petalostemon sp?. Yellow prairie clover.

P. multiflorus Nutt. White clover. Hills.

Meibomia sp? Sticktight.

Lespedeza violacea (L.) Pars. Prairie clover.

L. prairea Britton.

Vigna Sinensis (L) Endl. Cow pea, China bean.

Vicia micrantha Nutt. Common vetch.

Lathyrus pusillus Ell. Pea.

Geraniaceae:

Geranium cariolanum L. Common geranium.

Erodium cicutarium (L.) L'Her. Cut leaved storks bill.

E. texanum A. Gray. Storks bill. Thin soils.

Oxalidaceae:

Oxalis (Ionoxalis) violaceae (L.) Small. Purple oxalis.

O. (Xanthoxalis) stricta (L) Small. Sour grass. Yellow oxalis.

Zygophyllaceae:

Kallstroemia maxima (L) T. & G. Caltrop Common weed.

Tribulus terrestris L. Bur nut, sand bur.

Rutaceae:

Xanthoxylon americanum Mill. Prickly ash, toothache tree.

Ptelea trifoliata L. Hop tree. Ravines and valleys.

**Citrus vulgaris* Risso. Sour orange.

Simarubiaceae:

Ailanthus glandulosus Desf. Tree of Heaven.

Meliaceae:

Melia Azederach L. China. Escaped.

**M. Azederach umbraculifera* Sarg. Umbrella china.

Polygalaceae:

Polygala Lindheimera A. Gray. Milkwort. Rocky hills.

Euphorbiaceae:

Croton Engelmannii Ferguson. Croton. Sandy soil. Summer.

C. capitatus Michx.

C. punctatus Jacq.

C. texensis Muell. Arg. Common croton. Summer.

Mercurialis annua L.

Acalypha ostryaefolia Ridd. Woods and flood plains.

Tragia nepetaefolia Cav. Nettle Fields and waysides. Summer and fall.

**Ricinus communis* L. Castor bean.

Cnidosculus (*Jatropha*) *texanus* Small. Bull nettle. Sandy soils.

Stillingia linearifolia Kl. & Garcke. Queen's delight. Hillsides.

Chamaesyce serpens Small. Euphorbia, carpet weed. Common.

Dichrophyllum marginatum Kl. & Garcke. Snow on the mountain. Prairie.

D. bicolor Kl. & Garcke. Bracts not so compact. Prairie.

Spondaceae:

Rhus toxicodendron L. Poison Ivy (Shrub) common in ravines and woods.

R. radicans L. Poison ivy (Vine). Common in ravines and woods

Schmaltzia (*Rhus*) *lanceolata* Small. Sumac. Summer.

Schmaltzia sp? Sumac. Spring.

S. trilobata Small. Skunk bush. Scented sumac. Woods and ravines.

Aquifoliaceae:

Ilex decidua Walt. Deciduous holly, possum haw. Ravines and woods.

Celastraceae:

**Euonymus japonica.*

E. atropurpureus Jacq. Bleeding heart. Flood plains.

Aesculaceae:

Rulac Negundo (L.) A. S. Hitch. (Negundo aceroides). Box elder.

R. Texana Small Box elder. Flood plains. March.

Sapindaceae:

Sapindus marginatus Willd. Wild china, soapberry. Flood plains.

Ungnadia speciosa Endl. Texas buckeye. Rocky slopes. April.

Cardiospermum Halicocabum L. Balloon vine. Good soil.

Frangulaceae:

**Zizphyhus jujuba*. Jujube. Waco.

Berchemia scandens Trelease. Rattan. Near streams.

Ceanothus americanus L New Jersey tea. Rocky slopes. April-May.

Vitaceae:

Vitis candicans Englm. Mustang grape. Ravines and flood plains.

Vitis sp? Small summer grape.

Cissus incisa Desmoul.

Ampelopsis cordata Michx.

A. arborea (L.) Rusby Pepper vine Common on low lands.

Parthenocissus quinquefolia (L.) Planch. Virginia creeper.

**P. tricuspidata*.. Boston ivy.

Malvaceae:

Abutilon incanum (Link) Sweet. Indian mallow. Common.

Modiola carolina (L.) G. Don. Mallow. Flood plains.

Malva rotundifolia L. Mallow. Waste places.

Callirrhoe involucrata (Nutt) A. Gray. Poppy mallow, hollyhock. Common. April-Sept.

C. digitata Nutt. Poppy mallow. Woods. April-June.

Malvastrum sp? False mallow.

Malvaviscus Drummondii T. & G. Pink mallow, Mexican apple. Woods.

**Gossypium herbaceum* L. Cotton.

Buettneriaceae:

Firmiana platinifolia (L.) R. Br. Chinese parasol.

Tamaricariae:

**Tamarix Gallica* L. Tamarisk, salt cedar.

Violaceae:

Viola missouriensis Greene. Violet. Common in ravines. April.

V. Rafinesqui Greene. Pansy. Flood plains.

Passifloraceae:

Passiflora incarnata L. Passion vine, Maypop. Fields and woods. Summer.

Loasaceae:

Mentzelia oligosperma Nutt. Mentzelia. Dry soils. Summer.

Opuntiaceae:

Opuntia Opuntia (L.) Coulter. Prickly pear. Common.

O. fusco-atra?. Englm.

O. leptocaulis P. DC. slender prickly pear. Sandy or rocky soils. June.

Lauraceae:

Benzoin aestivale (L.) Nees. Spice bush. Ravines and thickets. March.

Lythraceae:

**Lagerstroemia indica* L. Crepe myrtle.

Lythrum lanceolatum Ell. Loosestrife. Ditches and damp places. Summer.

Epilobaceae:

Isnardia palustris L. Marsh purslane. Ditches and ponds. Summer.

Oenothera laciniata Hill. Evening primrose. Common weed. Feb.-Oct.

O. laciniata grandis Britton. Large flowered. Not common. April.

O. rhombipetala Nutt. Evening primrose. Flood plains. June.

Hartmannia speciosa (Nutt.) Small. Showy evening primrose April-Oct.

Lavauxia triloba (Nutt.) Spach. Primrose. Common. Spring.

L. Watsonii (Britton) Small. Not common.

Megapteron Fremontii (S. Wat.) Britton. Primrose. Rocky slopes. June.

Meriolix Spinulosa (T. & G.) Heller, Primrose. Rocky soil. Spring.

Gaura parviflora Dougl. Small flowered Gaura. Common weed. April-Sept.

G. biennis L. Common Gaura. Prairies. April-July.

G. suffulta Englm. Gaura. Prairies.

G. Drummondii T. & G.

G. Michauxii (?) Spach.

Stenosiphon linifolium (Nutt.) Britton. Rocky slopes. Summer.

Gunneraceae:

Myriophyllum sp? Ponds.

Nyssaceae:

Svida asperifolia (Michx.) Small. Dogwood. Ravines. March.

Hederaceae:

**Hedera Helix* L. English Ivy.

Ammiaceae:

Eryngium Leavenworthii T. & G. Eryngo. Prairies. August-November.

E. Hookeri Walp. Damp ground. Paler and smaller. Summer.

Chaerophylum Teinturieri Hook. Chervil. Woods. April-Sept.

Apium Ammi (L.) Urban. Marsh parsley. Ditches and mud flats. Summer.

Sium cicutaefolium J. F. Gmel. Water parsnip. Ditches. Summer.

Foeniculum Foeniculum (L.) Karst. Fennel.

Angelica sp?

Daucus Carota L. Wild carrot. Common weed. Spring and summer.

Primulaceae:

Samolus floribundus. H. B. K. Pimpernel, brookweed. Wet rocks.

Ebenaceae:

Diospyros virginiana L. Persimmon. Hills? May.

Brayodendron texanum (Scheele) Small. Mexican persimmon. Ravines.

Sapotaceae:

Bumelia lanuginosa (Michx) Pere. Gum elastic. Rocky soils.

Oleaceae:

**Syringa vulgaris*. Lilac.

Fraxinus texensis (A. Gray) Sarg. Texas ash. Flood plains.

**Ligustrum vulgare* L. Privet.

**L. japonicum* Japanese privet.

Gentianaceae:

Erythraea texensis Griseb. Centauty. Edwards.

E. Beyrichii T. & G. Rose pink gentian. Edwards. May-July. Damp soil.

Eustoma Russelianum (Hook) Griseb. Blue gentian. Summer.

Sabbatia angularis (L.) Pursh. Texas star, pink gentian. Spring

S. campestris Nutt. Pink gentian.

Apocynaceae:

Vinca minor L. Periwinkle Escaped.

Asclepiadaceae:

Acerates sp? Green milkweed. Good soil. Not common.

Ascelepias tuberosa L. Butterfly weed sandy soil summer.

Ascelepias Lindheimera Englm. Milkweed

Asclepiadora decumbens (Nutt.) A. Gray. Milkweed. Prairies May-Sept.

Gonolobus laevis Michx. Climbing milkweed. Flood plains Spring.

Vincetoxicum cyanchoides (Englm) Vail. Dry soils.

Dichondraceae:

Dichondra carolinensis Michx. Dichondra. Moist woods and lawns.

Convolvulaceae:

Evolvulus sp?

Ipomea trifida G. Den. Common morning glory. Bindweed. Summer and fall.

Convolvulus hermanniodes A. White bindweed. Spring.

C. incanus Vahl. Bindweed. Hills. Summer.

Cuscutaceae:

Cuscuta arvensis Beyrich. Dodder, love vine. Common. Summer and fall.

C. Gronovii Willd. Dodder, love vine. On shrubs. Spring.

Hydroleaceae:

Nemophila phacelioides Nutt. Nemophila, water leaf. Valleys and woods.

Phacelia congesta Hook. Phacelia. Rich soils. May to Sept.

P. hirsuta Nutt. Pacelia. Woods. Summer.

Marilaunidium jamaicense L. Kuntz. Rich soils. Summer.

Polemoniaceae:

Phlox sp? Woods. Spring and summer.

Gilia rubra (L) Heller (*G. Coronopifolia* Pars) Texas plume. Standing cypress. Spring and summer.

Solanaceae:

Physalis pubescens L. Ground cherry. Moist woods. Spring.

P. mollis Nutt. Ground cherry. Common weed. Spring and summer.

Solanum triquetrum Cav. White nightshade. Along fences. Feb.-Nov.

S. nigrum L. Black night shade. Common weed in good soil. Summer.

S. Torreyi A Gray. Torrey's night shade. Common. Summer.

S. rostratum Dunal. Yellow night shade, buffalo bur. Common. Summer and fall.

S. elaeagnifolium Cav. Silver leaf night shade. Common. Spring to fall.

Datura meteloides D. C. Jimson weed. Waste places. Spring and summer.

D. Stramonium L Jimson weed. Waste places. Spring and summer.

Nicotiana repanda Willd. Wild tobacco. Flood plains and ravines. Summer.

Boraginaceae:

Lithospermum linearifolium Goldie. Puccoon. Prairies. April to Sept.

Lithospermum arvense L. Corn Gromwell.

Verbenaceae:

Verbena officinalis L. Vervain, verbena. Common weed. April-Sept.

V. xutha Lehm. Tall verbena. Not common. Good soil.

V. pumila Rydb. Small verbena. Common. February to October.

V. bipinnatifida Nutt Common verbena. February to November.

Lippia (Phyla) nodiflora (L) Greene. Lippia. Common. April to October.

Aloysia ligustrina (Lag.) Small. White bush. Not common. April to August.

Lantana horrida H. B K. Lantana. Spring to fall.

Vitex Agnus-Castus. L. Chaste tree, monks pepper. Floodplains.

Callicarpa americana L. French mulberry. Lilac fruit. Ravines.

Lamiaceae: ..

Teucrium canadense L. Gerrymander. Spring-summer.

Scutellaria Drummondii Benth. Skull cap.

S. resinosa Torr. Rocky slopes. April to July.

Marrubium vulgare L. Hoarhound. Waste places. Summer to fall.

Nepeta Cataria L. Catnep.

Brazoria scutellariodides (Hook) Engelm. And Gray. Skull cap.

Physostegia intermedia (Nutt.) A. Gray.

Lamium amplexicaule L. Dead nettle. Common weed in lawns and gardens. February to June.

Stachys agraria Cham. and Schl. Mint, hedge nettle. April to Sept.

Salvia coccinea L. Red Salvia. Spring to summer.

S. azurea Lam. Tall blue Salvia. Prairies. Spring and summer.

S. farinacea Benth. Blue sage or Salvia. Edge of timber.

Salviastrum texanum Scheele. Texas sage. Rocky Hillsides.

Monarda dispersa Small. Common horse mint. Lavender flowers.

M. lasiodonta Small. Horsemint. Yellow flowers. Flood plains.

Monarda sp? Smaller than dispersa, larger and paler flowers.

Rhinanthaceae:

Verbascum Thapsus L. Mullein rocky slopes. Summer and fall.

Veronica peregrina L. Speedwell.

Linaria canadense (L) Dumort. Blue toad flax. April to July.

Pentstemon Pentstemon (L) Britton. Small beard tongue. Ditches.

P. Cobaea Nutt. Beard tongue. Hills. April to June.

Castilleja indivisa Engelm. Painted cup. Prairies. May to Sept.

C. Lindheimera A. Gray. Orange painted cup. Rocky slopes.

C. purpurea G. Don. Purple painted cup. Rocky soils.

Acanthaceae:

Ruellia tuberosa L. Ruellia. Shaded places and roadsides.

R. parviflora (Nees). Britton. Sandy soil.

Dianthera americana L. Willow herb. Muddy flats in streams. Common.

Orobanchaceae:

Myzorrhiza Lodoviciana (Nutt.) Rydb. Parasite on roots of Ambrosia.

Bignonicaeae:

Campsis radicans (Tecoma radicans) Seem. Trumpet flower. Common vine. Spring to fall.

**Chilopsis liniaris* (Cav.) DC. Desert willow.

Martyniaceae:

Martynia louisiana Mill. Unicorn plant, Devil's claws. Waste places. April to Sept.

Plantaginaceae:

Plantago virginica L. Plantain. Broad leaved. April to Sept.

P. Helleri Small. Plantain. Rocky soil.

P. Purshii R. & S. Plantain. Rocky soil.

P. aristata. Long bracted plantain.

Loranthaceae:

Phoradendron flavescens (Pursh.) Nutt. Mistletoe. On trees.

Rubiaceae:

Richardia scabra St. Hil. Sandy soil. Summer.

Houstonia minor (Michx) Britton. Bluet.

H. angustifolia Michx. Pink houstonia. Common. May to Oct.

Cephalanthus occidentalis L. Button bush. Near streams.

Galium Aparine L. Bed straw, goose grass. Common

G texanum (T. & G.) Wiegand. Texas bed straw. Rocky soil.

Caprifoliaceae:

Sambucus canadensis L. Elder. Flood plains and rapines. Spring.

Viburnum rufotomentosum Small. Black haw. Woods. Spring.

Symphoricarpus Symphoricarpus L. Coralberry. Shaded bluffs.

S. racemosus Michx. Snowberry. Ravines and flood plains.

Lonicera albiflora? T. & G. Honeysuckle. April.

Valerianaceae:

Valerianella sp.?. Corn salad. Common. Spring.

Asaraceae:

Aristolochia tomentosa Sims. Pipe vine. Flood plains. June.

Cucurbitaceae:

Citrullus Citrullus (L) Small. Watermelon. Escaped.

Cucumis Anguria L. Gherkin.

Cucurbita foetidissima H. B. K. Ill scented gourd. Common.

Sicyos angulata L. cucumber.

Campanulaceae:

Specularia perfoliata (L.) A. DC. Venus looking glass. April to July.

S. biflora (R. & P.) A. Gray. Venus looking glass. April to Sept.

Lobeliaceae:

Lobelia cardinalis L. Cardinal flower. Moist soil. August.

Ambrosiaceae:

Xanthium speciosum? Kearney. Cocklebur. Fields and waste places.

Ambrosia aptera DC. Ragweed, bloodweed. Common. July to Oct.

A. psilostachya DC. ragweed Common.

Iva xanthifolia (Fresen.) Nutt. Marsh elder. Waste places.

Carduaceae:

Vernonia Baldwinii Torr. Ironweed. Common. Summer and fall.

V. interior? Small.

V. texana (A. Gray) Small.

V. Lindheimera Engelm & Gray. On rocky hills.

Eupatorium sp? Moist places.

Laciniaria punctata Kuntze. Blazing star. Common on prairies. July to Oct.

Laciniaria sp?

Coleosanthus cylindraceus Kuntze. Thickets. Summer.

Gutierrezia texana (DC.) T. & G. Broomweed. Common.

Grindelia inuloides Willd. Gum plant. Common on flood plain. Summer and fall.

G. squarrosa Dunal. Gum plant.

Heterotheca subaxillaris Britt & Rusby. Common weed. Summer to fall.

Xanthisma texanum DC. Sandy soil. Summer and fall.

Solidago canadense L. Golden rod. Common. Fall.

S. nemoralis Ait. Goldenrod. Woods.

Aphanostephus skirrobasis Trelease.

Aster multiflorus Ait. White aster, many heads. Common.

Aster Drummondii Lindl. Purple aster.

Chaetopapa asteroides. (Nutt.) DC.

Erigeron (Leptilon) canadense L. Horseweed Common. May to Oct.

Filago nivea Small. Indian tobacco. Slender wooly plant.

F. prolifera (Nutt) Britton. Indian tobacco. Not so slender.

Silphium albiflorum A. Gray. White rosinweed. Hills.

Silphium sp? Yellow silphium.

Lindheimera texana Gray & Engelm. Texas star, Lindheimera. Common.

Engelmannia pinnatifida T. & G. Engelmannia. Common on prairies.

Parthenium Hystorophorus L. Leaves resemble ragweed. Common.

Rudbeckia bicolor Nutt. Cone flower, Brown eyed Susan. Common.

R. amplexicaulis Vahl. Green cone flower. In ditches. Common.

Ratibeda sp? Cone flower.

Viguiera helianthoides H. B. K. Common.

Helianthus annuus. L. Common sunflower.

H. argophyllus T. & G. Silver leaved sunflower. Introduced from south Texas.

H. giganteus? L. Tall sunflower.

H. petioloaris Nutt. Sandy soil.

Verbesina virginica L. Frost weed. Common.

Ximenesia encelioides Cav. Gray foliage. Sandy soil. Summer.

Coreopsis Drummondii T. & G. Coreopsis. Sandy soil. April to July.

Marshallia caespitosa Nutt. Marshallia Rocky soil.

Polypteris callosa A. Gray.

Tetraneuris lineariflora (Hook) Greene. Yellow daisy. Common.

Helenium tenuifolium Nutt. Sneezeweed. Common.

H. microcephalum DC. Sneezeweed. Ditches.

Gaillardia pulchella Foug. Gaillardia. Common. April and May.

G. suavis Britton and Rusby. With fewer rays.

Achillea millefolium. Yarrow, Millfoil. Common.

Mesadenia tuberosa (Nutt) Britton. Indian plantain. July to Oct.

Senecio lobatus Pers. Common senecio.

Carduus undulatus purple thistle. Common. Summer.

C. austrinus Small. Thistle (Paler). Common.

Centaurea americana Nutt. Star thistle. Common. April to July.

Cichoreaceae:

Nabulus albus (L.) Hook. Rattlesnake weed. Flood plains.

Sitilias multicaulis (DC.) Greene. False dandelion. Common.

S. grandilfora (Nutt) Greene. Large dandelion. Not common.

Lygodesmia texana (T. & G.) Greene. Lavender flowers. Few slender leaves.

Lactuca virosa (scariola) L Prickly lettuce. Common. April to Sept.

Sonchus asper All sow thistle. Waste places. Common. April to Aug.

S. oleraceus L. Sow thistle. Common.

Taraxacum Taraxacum (L) Karst. Only seen in south Waco. Appearing in lawns on Speight Street about 1910.

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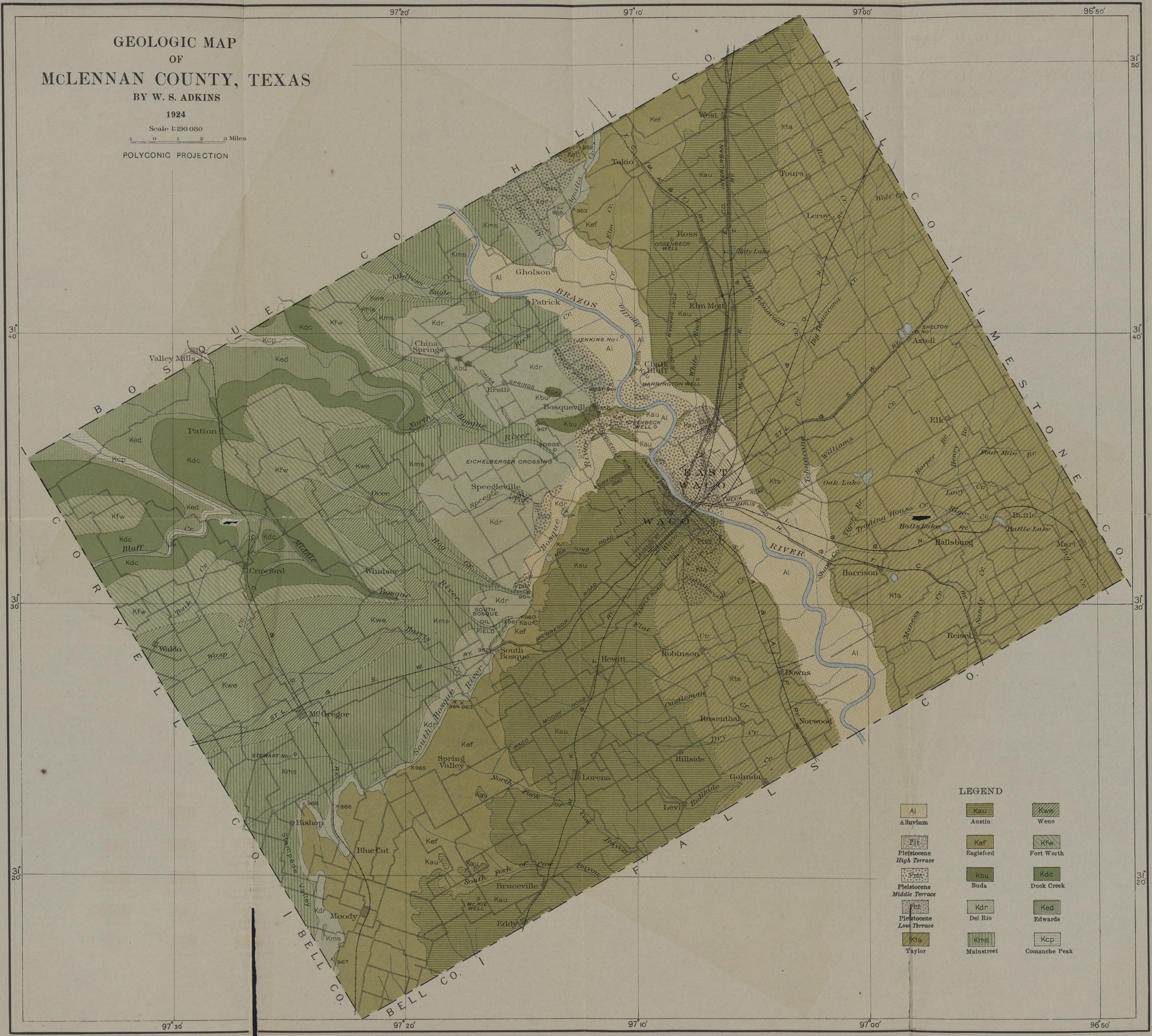
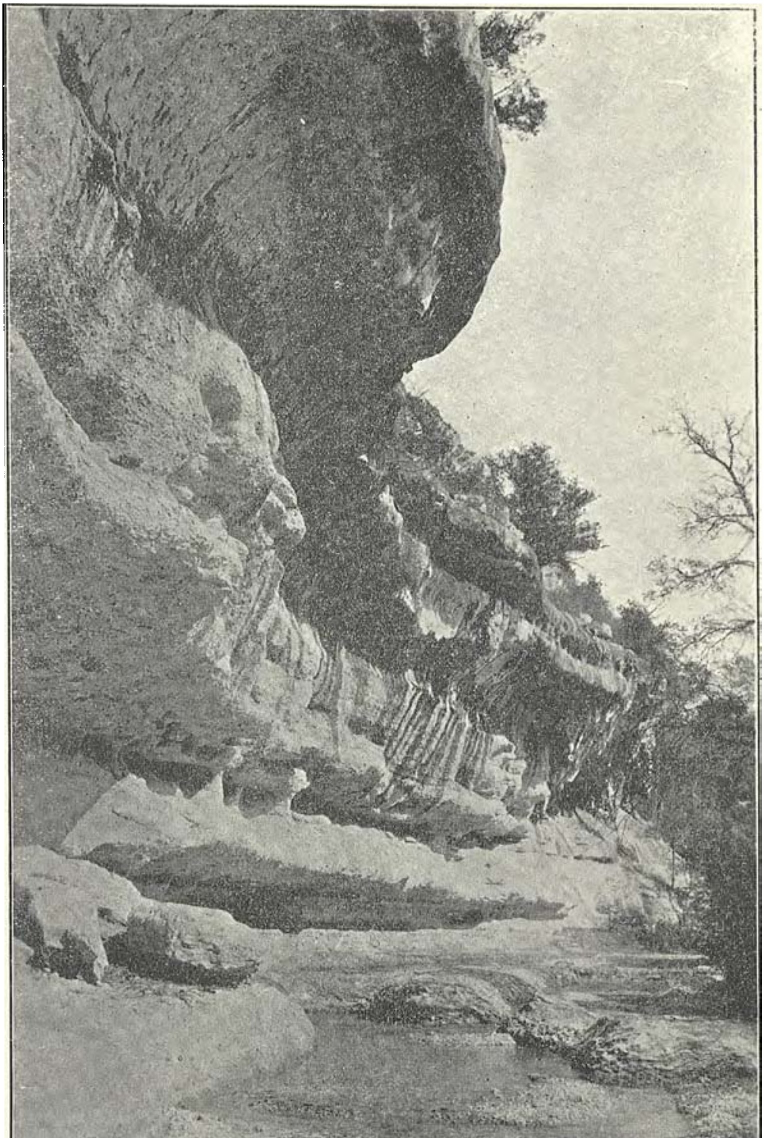
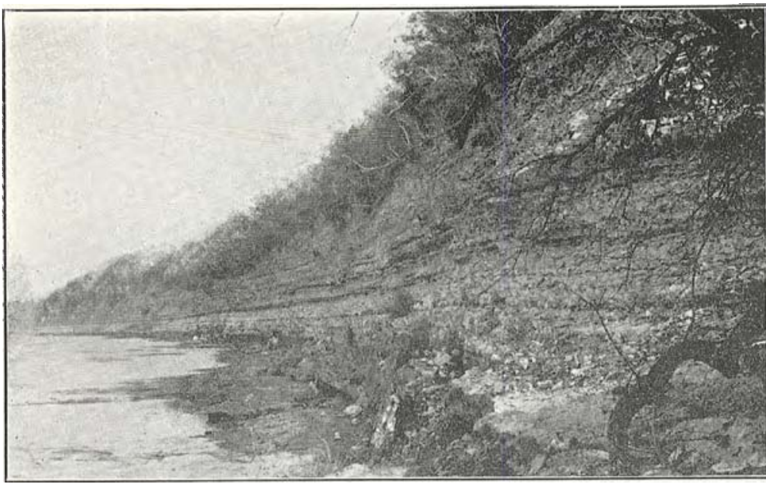
UNIVERSITY OF TEXAS
BUREAU OF ECONOMIC GEOLOGY AND TECHNOLOGY
J. A. UDDEN, DIRECTOR

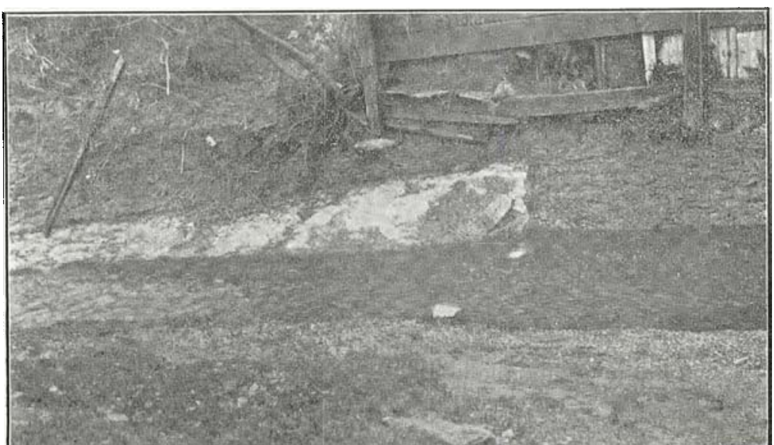




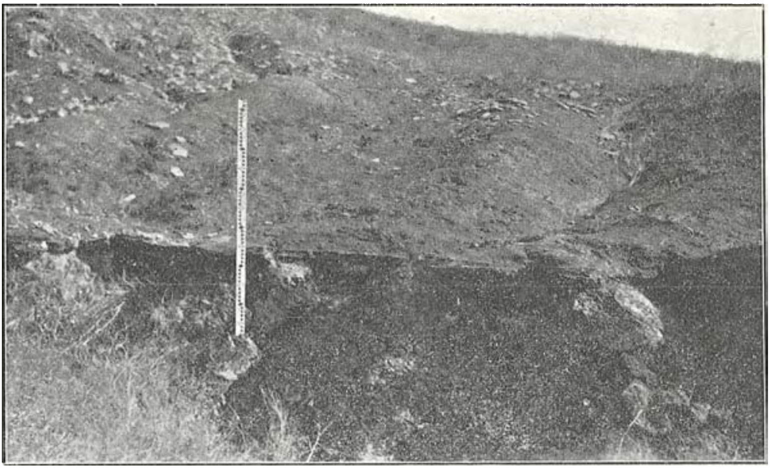
Edwards and Comanche Peak limestones on Bluff Creek, at crossing of Crawford-Coryell City road.



A. Georgetown formation on Middle Bosque River, near China Springs.



B. Fault at Austin-Taylor contact, Waco Creek and 11th Sts., Waco.



A. Del Rio-Eagleford contact at Locality 966, between McGregor and Moody.

B. "Bosqueville rock" (Buda) in Keyes' Branch at Bosqueville.