THE WOODBINE FORMATION

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THE WOODBINE FORMATION

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By

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Preface

A study of the Woodbine formation was suggested to the writer by Professor F.L. Whitney of the Department of Geology at the University of Texas in May, 1927. Although the writer has spent much time in the field, little has been accomplished toward the final solution of the problem, and it is evident that such a problem requires the full attention of the worker in the field over a long period of time, inasmuch as it is wholly of a paleontological character, and diagnostic fossils are difficult to obtain in a well preserved condition.

The writer wishes to express his sincere appreciation to the many gentlemen whom he has had the privilege of consulting and from whom he has obtained advice. To Professor F.L. Whitney acknowledgement is made and appreciation expressed for helpful criticism, advice, and assistance in the identification of certain fossils. The writer wishes to extend to Mr. M. B. Arick appreciation for his constant companionship in the field and the privilege of sharing his automobile, without which the difficulties of travelling would have been vexatious.

The writer desires especially to thank Dr. E.H. Sellards, who kindly extended the privilege of the

use of the laboratory and library facilities of the Bureau of Economic Geology, and who has given from time to time suggestions, Dr. J.T. Lonsdale for the help extended in making photomicrographs, and Mr. W.S. Adkins for his valuable advice and assistance.

The writer wishes to state at the outset that a large amount of the material presented in this paper represents the results of the work of many able investigators of Cretaceous problems, without which it would be well-nigh impossible to attack a modern problem in Cretaceous stratigraphy.

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THE WOODBINE FORMATION

Nomenclature: The Woodbine formation was named after a locality in northeast Cooke County, by Robert T. Hill[1] in 1901. Owing to the then existing confusion created by the indiscriminate use of the term Dakota, Hill preferred to apply a local name, Woodbine, to this group of sands and clays. This formation has a complicated nomenclatorial history, having been originally described by Dr. G.G. Shumard[2] as the Tertiary system in the year 1886, and later, as the Arenaceous and Marly Clay, or Red River group.[3] Hill,[4] in 1887, designated the group of red sands and varicolored clays as the Timber Creek group or Lower Cross Timbers formation. J. A. Taff,[5] in 1892, divided this group into two formations, the lower, or Dexter formation, consisting

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1 Hill,R.T.: "Geology and Geography of the Black and Grand Prairies," U.S. Geol. Survey,21st Ann. Rept., Pt.7, p.294.

2 Shumard,G.G.: A Partial Report on the Geology of Western Texas, p.127.

3 Shumard,B.F.: Trans. Acad. Sci. St.Louis, Vol.1, 1860, p.588.

4 Hill,R.T.: American Jour. Sci. 3d.Series Vol.XXXIII, April,1887, pp.291-301.

5 Taff,J.A.: Third Ann. Rept. Geol. Survey of Texas, Austin, 1892, p.271.

of a series of lignitic, laminated, sandy clays, and yellow sandstone; the upper, the Timber Creek beds, which consist essentially of dark red, ferruginous, crossbedded sands, heavy siliceous dark brown iron ore, and have a characteristic molluscan fauna. An initial grey clay was designated Basal clays.

In general, Taff's subdivision of the Woodbine was followed by Hill[6] who substituted the term Lewisville for Timber Creek beds, the latter name having already been assigned to a formation in New Jersey. The Dexter formation was extended to include the Basal clays of Taff.

Character and Composition of Rocks: Hill characterized the rocks comprising the Woodbine formation as follows:[7]

> The rocks of the Woodbine formation are largely made up of ferruginous, argillaceous sands, characterized by intense brownish discoloration in places, which are accompanied by bituminous laminated clays. These sands, like those of the Trinity division (Western Cross Timbers), are unconsolidated in places, but differ from them

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6 Hill, R.T.: "Geology and Geography of the Black and Grand Prairies, Texas," U.S. G.S. 21st Ann. Rept. Pt. 7, p. 294.

7 Ibid.

> by containing a greater proportion of iron and other mineral salts, which materially influence the character of the waters derived from them. The sands, which in the unoxidized substructure are usually white and friable, contain particles of iron occuring as glauconite and pyrite. These minerals oxidize toward the superficies, and their solutions consolidate the more porous beds of sand into dark-brown siliceous iron ore, occuring in immense quantities in certain localities. Other beds of sand break down into deep, loose soils. These support a vigorous timber growth and are especially adapted to fruit culture. The clays are usually sandy and sometimes bituminous, although in some places, as near Denton, of sufficient purity for making stoneware. They occur either as extensive beds or as laminae and thin strata interbedded in the sands.
>
> The presence of fossil vegetation, such as leaf impressions and lignite, distinguishes the beds of this division from the other formations of the Upper Cretaceous and attests its shallow water littoral origin.

Relations and Thickness: The Woodbine formation rests unconformably on either the Main Street[8] limestone or the Grayson marl in North Texas, but in Central Texas it rests upon either the Buda or the Del Rio. The upper beds of the Woodbine were thought to pass by gradual transition from sands into sandy clays and finally into bituminous clays of the Eagle Ford formation, and Hill accordingly established the

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8 Dumble, E.T.: "Geology of East Texas," Univ. of Texas Bull. 1869, p. 19.

top of the Woodbine formation at the first occurrence of Exogyra columbella Meek, a Colorado mollusk. At two localities in North Texas, the contact of the Woodbine with the Grayson marl was noted. In a run on the south side of Choctaw Creek two miles east of the Denison and Bonham road, Hill[9] noted a thickness of twenty feet of purplish blue lignitic clays in contact with the Grayson marls. On the north bluff of Denton creek valley about fifteen miles east of Roanoke, Denton County, Hill[10] noted

> distinct disconformity between a Buda-like formation of limestone with characteristic fossils which occurs in the top of the Grayson marls and the base of the Woodbine formation,

which was interpreted as

> settling the question of the identity of upper terminal beds of the Comanche series of North Texas with the Buda limestone of the Austin section, and that the Woodbine formation lies completely above the latter and is not contemporaneous with it...

W.S. Adkins[11] has cited the occurrence of Buda lime-

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9 Hill,R.T.: "Geology and Geography of the Black and Grand Prairies,Texas," U.S.G.S. 21st Ann.Rep.Pt.7, p.300.

10 Hill,R.T.: "Further Contributions to the Knowledge of the Cretaceous of Texas and Northern Mexico," G.S.A. Vol.4,p.72.

11 Adkins,W.S.: "Geology and Mineral Resources of McLennan County," Univ. of Texas Bull. 2340,p.65.

stone in wells below the Woodbine formation in the Groesbeck and Mexia oil fields, Limestone County.

The sequence of beds of the Woodbine formation between the Trinity and Red River is quoted from Hill.[12]

> 1. The lowest beds are usually of impure clay, which is often sandy and lignitic.
> 2. An extensive formation of yellow ferruginous sandstone and brown silicious ironstone, in which impressions of dicotyledonous leaves are sometimes found. These are the Dexter sands of Taff.
> 3. Lignitic sandy clays and sands, frequently accompanied by sulphate of iron, magnesian salt, etc. The sands also oxidize into heavy, silicious, dark-brown iron ore in places. The subdivision is characterized by an extensive molluscan fauna, which is elsewhere alluded to and which may be characterized as the Aguileria cumminsi zone. These are the Lewisville beds.
> 4. Less ferruginous sands and clays, and in places more calcareous and fossiliferous, gradually passing into the bituminous shale of the Eagle Ford formation. The upper limit of these beds ends with the zone of Ostrea columbella Meek.

At the Acme Brick Pit, Denton, Texas, the following section was noted in the Woodbine formation:[13]

		Feet
5.	Lenticular mass, four members overlain by a red sandy clay....	15
4.	Light colored limonitic argillaceous member, ...	7
3.	Red sandstone	5
2.	Light colored limonitic argillaceous member	1

[12] Hill,R.T., U.S.G.S. 21st Ann. Rep.Pt.7, p.297

[13] Winton,W.M., and Adkins,W.S.: "Geology of Tarrant County," Univ. of Texas Bull.,1931,p.76.

1. Grayish sandy argillaceous member, containing several bands of almost black sandstone 14

42 feet

Fragments of plants and dark dissemenated specks and fragments of charcoal are freely distributed through the middle portion of the exposure. Dark bituminous massive clay was noted at the base of an open cut where material was being excavated for brick. It is reported that a test hole struck a hard limestone at eighteen to twenty feet below the surface at the pit. This limestone is interpreted as a hard layer in the Grayson formation.

The top of the Woodbine formation at Tarrant Station, Tarrant County, is sharply defined. Adkins and Winton[14] noted the occurrence of a brackish water fauna in the uppermost sandstone ledge at this locality, to the accuracy of which observation the writer will testify. The following assemblage of molluscan fauna was found in a shell breccia at Tarrant Station, in a draw near the first railroad bridge west of the Dallas-Tarrant county line:

Barbatia micronema Meek
Ostrea soleniscus Meek
Ostrea carica Cragin
Exogyra sp.
Ostrea sp.

[14] Ibid.

The dark blue, bituminous, laminated shales of the basal Eagle Ford formation rest upon this shell breccia.

Hill[15] has noted the occurrence of

> yellow decomposing bands of limestone in beds of 6 inches alternating with shales containing Cyprimeria, Ostrea soleniscus, Arca, and Exogyra columbella

at Cook Springs between Denison and Sherman, Grayson County.

The Woodbine formation is exposed in the cut on the Pottsboro cutoff of the Missouri-Kansas-Texas railroad about four miles northwest of Denison and eight miles from Pottsboro. At this point, the beds of the upper Washita and lower Woodbine are tilted to steep angles, incident to their having been wrapped around the southwestern limb of the Pottsboro nose of the Preston anticline. About three hundred and fifty feet northeast of the wooden bridge that crosses the railroad, a six inch layer of limonite-replaced molluscan fossils were seen.

Railroad Cut on Pottsboro Cutoff of Missouri-Kansas-Texas Railroad about four miles northwest of Denison.

	Feet	Inches
Woodbine formation:		
16. A bed of mottled yellowish brown arenaceous clay	10	0

[15] Hill, R.T.; U.S. Geol. Sur., 21st Ann. Rept. Pt. 7, p. 301

		Feet	Inches
15.	A bed of sandy, yellowish-blue-grey clay somewhat more arenaceous than the lower bed. This bed grades upward into a yellowish-brown, soft sandstone. Above the sandstone there is a bed of fine-grained, soft yellowish sand containing numerous iron concretions. This bed also is mottled red by ferric oxide stains. (Estimated thickness) Dip. 5°.....	41	7
14.	A bed of yellowish-blue-grey sandy clay containing small masses and concretions of limonite which form several well defined layers near the top. The top of the bed is marked by a ferruginous shell bed four inches in thickness, and which contains numerous pelecypods and gastropods. (Estimated)	62	3
	The apparent dip is 3°10'.		
13.	A bed of sandy clay with alternating beds of soft ferruginous sandstone ranging in thickness from two to four inches...	12	6
	The apparent dip is 35°.		
12.	A bed of red to brown soft sandstone.....	2	0
	The apparent dip is 35°		
11.	A series of alternating beds of red sandstone from 2" to 18" in thickness separated by thin beds of sandy gray shale averaging about 2" in thickness. The sandstone beds are prominent in the lower part while in the upper part the shale becomes thicker containing, throughout, veins and masses of impure limonite.....	22	8
10.	Apparent dip, 35°.		

		Feet	Inches
10.	A layer of cross-bedded, lenticular, white to red sandstone containing thin veins, bands, and segregations of impure limonite.....	8	5
9.	A bed of light buff, sandy clay alternating with a bed of gray sandy clay. Above this is another layer of light buff colored sandy clay.	7	10
8.	A layer of cross-bedded, massive, yellowish-brown friable sandstone; thin bands of ferruginous sand in base; color grades from yellowish-brown in base to light yellow in top	14	5
7.	A layer of massively bedded grayish-white sandstone with a more or less irregular contact on upper surface with overlying yellowish-brown sandstone	3	4
6.	A bed of yellowish-brown clay grading upward into a light yellow at the top	13	10
5.	A bed of pure yellow clay grading upward light blue to brownish-red.	15	1
4.	A bed of gray massive irregularly bedded sandstone containing, at the base, a thin band of yellow ferruginous sandy clay	11	6
3.	A thin band of ferruginous sandy clay containing thin layers of impure limonite black-blue in color with a metallic luster	1	3
2.	A bed of lead colored clay containing bands of light yellow and red clay grading upward into alternate beds of brown and light gray sandy clay	5	5
1.	A bed of yellow to brown clay grading upward to a thinly laminated blue to gray clay shale containing bands of black carbonaceous material and bands of red clay.....	10	11
	Total thickness of Woodbine	243	0

Grayson formation:	Feet	Inches
1. A bed of yellowish, white marl with layers of clearly defined limestone nodules containing a large number of Gryphaea mucronata and Turrilites brazoensis and Hemiaster sp.	18	4
Total thickness of Grayson:	18	4
Main Street Formation:		
12. A layer of marl containing flags of limestone	2	9
11. A layer of limestone more arenaceous than the lower layers; otherwise similar to them; very fossiliferous. Fossils: Exogyra arietina; Exogyra plexa; Kingena wacoensis.....		8
10. A thin layer of marl similar to 5. Kingena wacoensis.....		7
9. A layer of limestone containing numerous Kingena wacoensis. Otherwise it is similar to 3	1	6
8. A thin layer of marl similar to 5 containing fossils which are calcitized to some extent. Kingena wacoensis; Exogyra plexa		3
7. A layer of limestone similar to 3 containing Exogyra plexa; Exogyra arietina; Ostrea quadruplicata; Pecten sp.....		9
6. A thin layer of marl similar to 5 with Pecten sp.;Exogyra arietina; Exogyra plexa		2
5. A layer of limestone similar to 3 with Exogyra arietina; Exogyra plexa		8
4. A thin layer of ferruginous, sandy marl, with Exogyra plexa	1	0
3. A layer of ferruginous, arenaceous, white, coarse-grained limestone which turned yellow on exposure. Kingena wacoensis Exogyra plexa	1	4

		Feet	Inches
2.	A layer of marl containing Exogyra arietina; Exogyra plexa.....		6
1.	A layer of impure, bluish, semi-crystalline limestone containing irregular veins of calcite	1	1
	Total thickness of Main Street	12	3

It is not possible to measure the entire thickness of the Dexter sandstone or the Lewisville beds on surface exposures owing to the great variability in dip planes, which is doubtless due to cross-bedded nature of deposition. Stephenson[16] has noted that the Woodbine formation is not less that three hundred to four hundred feet in thickness in Grayson County; a well drilled at Ladonia in the southeast corner of Fannin County penetrated, at depth between 1800 feet and 2425 feet about 625 feet of sand and clay which is interpreted as Woodbine age. Hill[17] assigned the following thicknesses to the Woodbine formation at the localities indicated:

Aquilla Creek, northern McLennan County, 45 feet;
Cottonwood Creek, northwest of Hillsboro, Hill County, 95 feet;
Fort Worth, Tarrant County, 300 feet thick;
Denison, Grayson County, 500 feet thick;
Cleburne, Johnson County, 200 feet thick.

16 Stephenson, L.W.: "A Contribution to the Geology of Northeastern Texas and Southern Oklahoma", U.S.G.S. Prof. Paper 120-H., p.145.

17 Hill, R.T.: U.S. G. S. 21st Ann. Rep., p.296.

A well drilled by Banker's Trust Company five and one half miles southwest of Blooming Grove, Navarro County, penetrated about three hundred and forty-one feet of sediments assigned to Woodbine age.[18]

Stephenson[19] has indicated the relationship of the Woodbine formation to underlying formations in southeast Oklahoma and southwest Arkansas, where the sands of the Woodbine transgress from west to east over lower and older formations of the Lower Cretaceous until they rest upon the sands of the Trinity division in southwestern Arkansas. In the light of this fact, the Woodbine formation ~~accordingly~~ was regarded as the beginning of the Gulf series of sedimentation.

Eastward from the westernmost feather-edge belt of outcrop of the Woodbine sands, basal dark bituminous shales occur between the red sands of the Woodbine and the flags of the Eagle Ford.

Inliers of Woodbine formation have been observed at many localities removed a number of miles from its belt of outcrop. At Palestine salt dome,

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[18] Records of Bureau of Economic Geology.

[19] Stephenson, L.W.: A.A.P.G., Vol.11, No.1, p.3.

eighty-five miles east of the main belt of outcrop, the Woodbine formation is lifted fully five thousand feet above its normal position; a small amount of heavy gravity petroleum[20] was recovered from the Woodbine formation at the Keechi salt dome, where the Woodbine formation was similarly uplifted.[21]

Relation to East Gulf Coast and Western Interior:

The Woodbine formation was first referred to the Dakota[22] formation by Dr. C.A. White.[23] It is now, on the basis of floral content, related to the Tuscaloosa formation of the East Gulf Coastal Plain, and to the Dakota formation of the Western Interior.[24] Of forty-three species of plants studied by Dr. E.W. Berry from Arthur's Bluff, Lamar County, twenty-two species are common to the Tuscaloosa, five are common to the Eutaw, and one extends up to the Ripley formation. It seems clear that the

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[20] Producers Oil Company, No.1 Barrett and Greenwood produced between one and two barrels of heavy gravity oil from a sand found at 1686 feet.

[21] Dumble, E.T.: "Geology of East Texas," Univ. of Texas Bull. 1869, p.19.

[22] The term Dakota group was first used by F.B.Meek in his description of the Meek and Hayden section of the Cretaceous of Nebraska Territory.

[23] White, C.A.: Proc. Phila.Acad.Sci. 1887, PtI, pp39-47.

[24] Berry, E.W.: "The Flora of the Woodbine Sand at Arthur's Bluff, Texas," U.S.G.S. Prof.Paper 129 G, pp. 157-158.

Tuscaloosa and Woodbine formations are equivalent at least in part. Thirty species of the flora are common to the Dakota, and of the thirty, all but ten are forms of true Dakota flora.

Berry believes that the Tuscaloosa bears the same relation to the Eutaw as the Woodbine does to the Eagle Ford and the Dakota to the Benton.

Berry is inclined to consider the Woodbine flora as Turonian in age.

Areal Extent: The most eastern extension of the Woodbine formation was noted at Morris Ferry on Little River, Little River County, Arkansas.[25] The lower Bingen of Veatch is the eastward continuation of the Woodbine and should properly be referred to it in the Arkansas section.[25a]

The red sands of the Woodbine follow the northern and western outcrop of the truncated prism of Coastal Plain formations, extending farthest south to Bosqueville, McLennan County, where they have a thickness of about two feet. The unconsolidated sands give rise to a characteristic growth of post-oak and black-jack timber, which has been designated the Eastern Cross Timbers.[26]

[25a] Stephenson, L.W.: Bull. A.A.P.G., Vol.11, No.1, p.3.

[26] Hill, R.T.: U.S. G.S., 21st Ann. Rept., p.298.

[25] Hill, R.T.: Geol. Soc. Am. Vol.V, 1894, p.312.

Near Covington, Hill County, the red sands are parted with an horizon of dark clay which increases in thickness south, at the expense of the sands. This dark clay horizon has been regarded as extending to the latitude of Austin, and it has been the efforts of the writer to determine if such relationship exists between the Austin section and the Aquilla Section.

The red sands of the Woodbine are immediately under the flags of the Eagle Ford formation along the western belt of outcrop, and may be seen along this belt as far south as Aquilla, northern McLennan County. South of Bosqueville, the red sands attenuate and disappear. The most southerly occurrence of diagnostic Woodbine fossils are found at Bosqueville, where a typical Lewisville fauna occurs in a solid, very hard sand rock cemented with lime. Much of the hard "Bosqueville rock"[27] was disintegrated and eroded away prior to deposition of the overlying formations.

Central Texas Relations: It was thought that the Woodbine shales could be correlated with the basal dark shales of the Eagle Ford at Austin on the basis

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27 Adkins, W.S.: "Geology of McLennan County,", Univ. of Texas Bull. 2340, p.66.

of occurrence of microscopic spool-shaped calcitic bodies possessing rhombohedral cleavage which have been variously refered to as "crinoid arms," "pinnules of crinoid arm," "Lithistid sponge spicules," and "sponge spicules." These bodies will hereafter be designated "sponge spicules."

For convenience, the two types of "spicules" common in lower Eagle Ford will be designated type "A" and type "B", the former being the spool-shaped body and the latter the drum-stick shaped "spicule", as indicated in Plate I.

These "sponge spicules" occur profusely in the lower bituminous shales of the Eagle Ford formation at Bouldin Creek, Travis County. A thorough search of the section at Aquilla proved negative with respect to discovery of any "sponge spicules" whatever.

The following microscopic characteristics were noted in the samples collected from a brick pit on Aquilla Creek, about three-fourths of a mile north of the McLennan-Hill County line, below the Eagle Ford:

17. 2 feet below Eagle Ford flags:
Sample consists of rounded quartz grains, with fragments of selenite, red and yellow limonite, pyrite, amber like fragments, Globigerina sp.,

hematite, Inoceramus prisms.

11. 3 feet below Eagle Ford flags:
Sample same as above, with addition of hexagonal prisms, and chitinous substance.

10. 4 feet below Eagle Ford flags:
Sample consists of twin monoclinic crystals of selenite in abundance; quartz grains rounded; red and yellow limonite. HCl on sample produced very slight reaction.

9. 5 ½-6½ feet below Eagle Ford flags:
Sample consists of rounded quartz grains in abundance; selenite. HCl produced no reaction.

8. 6½-8½ feet below Eagle Ford flags:
Sample consists of subangular quartz grains in abundance; limonite. HCl produced no reaction.

7. 9½-1½ feet:
Sample, fine silt predominated; limonite. Most of sample washed away. HCl produced no reaction.

6. 10½-11½ feet:
Sample, red and yellow limonite and rounded quartz grains about equally distributed.

5. 11½-14 feet:
Fine silt in predominance; red and yellow limonite; few angular quartz grains noted. HCl produced no reaction.

4. 14-15 feet:
Sample, very fine grains of subangular quartz cemented with limonite and argillaceous material; selenite.

3. 15-17 feet:
Sample, very fine grains of subangular quartz cemented with limonite or argillaceous material; selenite; fine silt; limonite. HCl produced no reaction.

2. 16-18 feet:
Same as above with addition of amber.

1. 18-21½ feet:
Same as above; few glistening non-magnetic black specks noted.

Since the inception of search for the "sponge spicules" in the Aquilla section, bodies of very similar form have been found in the upper part of the Washita division at Austin. The sponge spicule, type "B", are present in the upper dark shales of the

Eagle Ford on Brushy Creek, northern Travis County, and very similar objects have been found in the Navarro formation by Miss Oleta Richey. The identity of the "sponge spicules" has not been definitely established.

Section at brick pit on Aquilla Creek, three-fourths of a mile north of the McLennan-Hill County line.

		Feet	Total thickness to bottom of strata Feet
	Eagle Ford flags containing Ostrea carica (?).		
11.	Yellow clay mixed with surface wash.....	1	1
10.	Gun-metal color clay-shale and pebbles of red sandstone. Badly mixed with surface wash.	1	2
9.	Gun-metal color clay-shale and light yellow to orange fine sand	2	4
8.	Orange to light yellow friable fine sand and light grey clay in subsidiary amount.....	1	6.5
7.	Orange to red and white fine grained sandstone and silt ...	1	7.5
6.	Light grey clay and fine yellow sand.	2	9.5
5.	Same as above, with indeterminable plant imprints; Corbula sp.	1	10.5
4.	Light grey clay and subsidiary quantity of fine yellow and orange colored sand, with Corbula sp., charcoal, small indistinct Turrilite (?), Mantelliceras (?) and Yoldia sp....	2.5	13
3.	Same as above, no fossils	1	14
2.	Same as above; indeterminable plant imprints and limonite concretions.	1	15
1.	Light grey shale with small quantity light yellow fine sand and limonite concretions, and indeterminable imprints of		

plants; selenite inclusions	17.5	32.5

There is no definite paleontologic evidence that the dark shales at Aquilla are of Woodbine age. R. L. Cannon has called attention to the fact that they lie between the upper and lower sands of the Woodbine, which relation establishes their age as Woodbine. Dark shales can be traced south beneath the Eagle Ford flags from Hill County to Aquilla, and as far south and west as Austin via Bell County. The dark, bituminous shales below the flags of the Eagle Ford near Midway in Bell County are below a horizon containing Acanthoceras sp.[28], the Buda being absent, and the shales resting over the Del Rio formation. At Austin, the dark shales of basal Eagle Ford lie in contact with the Buda, which shows evidences of erosion of the top surface.

Cottonwood Creek section, northwest of Hillsboro, showing upper part of Woodbine formation. (after Hill)[29]

	Thickness	Thickness to bottom of strata
13. Eagle Ford clay from the parting upward, few feet exposed	10	10
12. Pack sand	10	10
11. Clay and sand, alternating in thin beds	15	25
10. Sand and sandy clay, which bear great numbers of Ostrea and		

[28] E.H. Sellards; L.W. Stephenson, personal communication.

[29] Hill, R.T.: U.S.G.S., 21st Ann.Rept., p.310.

bivalves of the Timber Creek beds	6	31
9. Arenaceous clay, varying in thickness of layers and percentage of sand and clay....	10	41
8. Slightly arenaceous laminated blue clay	10	51
7. Stratified pack sand	5	56
6. Arenaceous, laminated blue clay	4	60
5. Soft, false-bedded sandstone	8	68
4. Laminated sandstone	6	74
3. Laminated clay and sand, equal proportions	10	84
2. Very arenaceous, finely laminated clay	3	87
1. Soft pack sand		

The above section contains Lewisville fossils. Certain resemblances with the Aquilla section can be seen, such as the predominating sand at the top of the section and the occurrence of brackish-water fauna.

Jim Edds No.1 well, Three States Oil Company, Standard rig. Elevation, aneroid barometer from Belton, E.H.S.Elev. topog. map; 550 feet.

Samples and statement of Edds[30] indicate the following approximate record:

Shale and marl (Taylor)	0-390 feet
Rocks alternating hard and soft, alternating light and blue in color (Austin)	390-800 feet
Black shale "Pencil slate" (Eagle Ford)	800-850 feet
Hard lime (Buda)	

Samples of the Black shale show that it is the Eagle Ford. A granite water worn pebble about one inch in diameter is said to have been taken from this well from the

[30] Records of Bureau of Economic Geology

base of the Eagle Ford. Proof that the pebble came from the well is not conclusive although it is said to have come up in the bailer.

Samples examined from the Carle shaft, Bexar County, show essentially a similar assemblage of fauna as the Bouldin Creek Fauna.

Sample three feet from bottom of Carle mine: consists of Bryzoan (?) "sponge spicules" type "A" and "B"; Globotruncana sp.; Operculina sp.; Anomalina sp.; a large object similar to Type "A" sponge spicule was perforated similar to Bryozoa.

The basal Eagle Ford at San Marcos is essentially a light yellow clay. No petroliferous or dark colored shales are present at that locality.

Section of basal Eagle Ford at southwest entrance of Cemetary at San Marcos, southwest of town.[31]

	Feet	Inches
b. Flags, 3/4 to 2½ inches, ...	6	5
a. Clay	8	
Buda limestone		

First Bentonite layer was in top of clay;
Second Bentonite layer was 20 inches above the top of clay;
Third Bentonite layer was 31 inches above the top of clay;
Fourth Bentonite layer was 45 inches above the top of clay;
Fifth Bentonite layer was 57 inches above the top of clay;
Sixth Bentonite layer was 64 inches above the top of clay.

Samples from wells drilled in Travis and Bell Counties indicate that the Eagle Ford may rest upon

[31] Measured by Professor F.L. Whitney.

the Buda formation.

> Samples from Hardy No.1,R.R. Penn, located three miles northeast of Rogers in Bell County, Texas. Elevation 467 feet. Described by G.H. Clark and O.M. Richey.[32]
>
> Sample consists of cuttings of dark gray calcareous shale and light grey limestone. Pyrite, calcite and quartz noted in the washed material. *Globigerina* sp.; *Pulvinulina*, sp.; *Textularia* sp., *ostracods*, *Anomalina* sp., echinoid spines, and *Inoceramus* prisms present ..... 1336-1348 feet
>
> Sample consists of a core of brownish gray limestone in which crystalline calcite was noted. *Anomalina* sp. and *Textularia* sp. noted in this section. Note: this core is from the Buda ..... 1348 feet

The following samples[33] from a well that passed through the Eagle Ford and Woodbine formation in Navarro County is of interest. This well evidently penetrated about three hundred and forty-one feet of Woodbine formation. The samples recorded from the upper portion of the test show marked similarities to those of the basal black shales at Bouldin Creek. The "cylindric organic bodies" recorded from 1467 feet may be the objects referred to as "sponge spicules" heretofore.

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32 Records of Bureau of Economic Geology.

33 *Ibid.*

Description of samples from the Bankers' Trust Company's No.1 McCormick. Well located 5½ miles southwest of Blooming Grove, Navarro County, Texas. Samples described by D.D. Christner, J.A.Udden, R.T. Short.

The sample consists of fragments of a core consisting of two kinds of rock. One is a fine-grained, grey calcareous sandstone containing many dark colored phosphatic nodules, fish bone fragments, fish scales, and impressions of Inoceramus labiatus (?). Much pyrite is present. The other rock is a dark grey shale containing many fish scales and an impression of Inoceramus labiatus .....1290 feet.

The sample consists of very loosely cemented, friable, slightly calcareous, fine-grained sandstone containing several fish scales, some dark phosphatic nodules and pyrite. Most of the sand grains are from 1/4 to 1/8 mm. in diameter .....1360 feet.

Note: These samples (1290-1360 feet) are evidently from the Eagle Ford. (D.D.C.)

A piece of a core of gray, medium grained, loosely cemented, sandstone containing some indistinct laminations of a slightly darker color than the main body of the rock. Nearly all the sand grains are from 1/4 to 1/8 of a millimeter in size .....1460-1463 feet

Dove gray clay containing thin layers of white non-calcareous sandstone. The clay is of a very fine and even texture. Some fragments of woody material were noted in the clay. The woody material has been altered to charcoal, and occurs in pieces a half inch long. Black phosphatic grains occur in the sandy layers. In the washed material some cylindric organic bodies were noted. These were found to be calcareous and are clearly organic. They are about one millimeter in diameter. A few are somewhat flattened. Black phosphatic grains and a small fragment of amber colored chitinous material are also present .....1467 feet

Note: These samples (1460-1463 feet and 1467 feet)are evidently from the Eagle Ford of the Woodbine.(D.D.C. and J.A.U.)

Gray silty clay and a lesser amount of very fine to fine grained non-calcareous, white sand. A very small amount of calcareous material and some concretions of clay-iron-stone are present. In the washed material many small black grains of phosphatic material are present. The sand grains are of clear quartz and average from 1/16 to 1/4 mm. were also noted.Pyrite is present ....1489 feet.

Note: This sample (1489 feet) is evidently from the Eagleford or Woodbine. (D.D.C.)

The sample consists of one inch of a three inch core of light greenish-gray, non-calcareous, friable sand. The rock has a dappled appearance due to the presence of many very irregular, wavy, thin layers of greenish clay, Many traversions were noted running through the core both horizontally and vertically. These traversions are filled with lighter colored sand than the bulk of the rock. These traversions are found in cross section. The size of the sand grains is as follows: .5% from 1-½ millimeters; 35% from ½-¼ millimeters; 60% from ¼-1/8 millimeters; 4.5% from 1/8 to 1/16 millimeters. Most of the sand grains consist of clear quartz. Rounded grains and crystals of zircon, tourmaline, rutile, hornblende, and feldspar are present. Some black ilmenite grains were also noted. According to Bailey, who determined the mineral grains and crystals, the amount of heavy minerals in this sand is unusually large .....1555-1557 feet

A piece of a core of very fine grained, hard, almost quartzitic, slightly calcareous, sandstone. Most of the sand grains are of clear quartz and average less than 1/8 of a millimeter in diameter. The sand grains are very well sorted ...1575-1577 feet.

Two inches of a three inch core of dark gray almost stony marl. Irregular thin

wavy laminations of a darker material than the main body of the rock were seen. Some pockets and irregular layers of stony marl are also present. In one part of the core a profusion of small fish scales was noted. Shell fragments, Globigerina sp., Anomalina sp., Textularia sp., and many other small foraminifera were seen. Imprints of vegetation were noted. Labelled as "Top of Core" 1657 feet

Like sample from 1657 feet, labelled as "Top of Core." Very slightly bituminous fumes were given off when heated in closed tube. Marked as "Bottom of Core" 1657 feet

Note: These samples (1555 feet to 1657feet) are apparently from the Woodbine. (J.A.U. and D.D.C.)

Four inches of a four-inch core of light grey limestone containing irregular wavy beds of dark, impure, shaly limestone. Many small Exogyra arietina shells were noted. Several fish scales and fragments of fish plates and many pyritized shell fragments were also seen. In thin section the limestone is seen to contain a great abundance of Orbulina. Many spinous Globigerina sp., Textularia sp., Cristellaria sp., Anomalina sp., echinoid fragments are present. Pyrite is present. 1701 feet

Note: This sample is believed to be from a limestone layer of the Grayson Marl, equivalent in age to the Del Rio clay (Sample from 1701 feet). (D.D.C.).

Dark shales at the base of the Eagle Ford formation have also been recorded from Milam County, where they are referred to as "lignite."

Bouldin Creek Section: At Bouldin Creek, Travis County, there is fifteen feet of massive, conchoidly fractured, shale impregnated with petrolemm. Minute bands of sulphur-yellow decomposed material are present in the lower four feet, which is some-

what flakey and less tight than the upper part of the section. The top surface of this shale is undulating, being about two and a half feet from crest to crest of undulation. Resting immediately over this shale is a conglomeratic layer two and one half to three inches thick, composed of fish scales, fish teeth, Ostrea sp., coprolites, and phosphate pebbles, which has the same undulating attitude as the underlying shale body. At one point, a one-inch layer of shell breccia can be seen about fourteen inches below the fishbed conglomerate, one extremity of which fades into a large calcareous concretion, and the other extremity runs obliquely upward into another calcareous concretion, the shells disappearing within five inches of the fishbed conglomerate layer. (See Plate II).The upper portion of the dark shale body is characterized by the appearance of large concretions of light grey colored sandy calcareous material immediately under the fishbed conglomerate. At Watters Park, Travis County, on Walnut Creek, the fishbed conglomerate is seen to part, giving way to a calcareous concretion. Some of these concretions have the remains of tree limbs as a nu-

cleus. The dark shale has fine grains of charcoal disseminated throughout its thickness. At Bouldin Creek, Exogyra sp. is present throughout the upper seven feet of the shale, and is found likewise in the flags of the Eagle Ford, in association with Prionotropis sp. five feet above the massive shales.

The micro-fauna of the lower fifteen feet of dark shales was investigated.

Description of samples from Bouldin Creek, Travis County.

32 feet below Austin-Eagle Ford contact:
Sample contains Bairdia sp., Globigerina sp., Globotruncana sp., Marginulina sp., Frondicularia sp., "Sponge spicules", type "A" and "B", fish tooth.

0-1 feet below fishbone bed:
Inoceramus prism; amber-like material; chitinous fragments; Globigerina sp.; "Sponge spicules" type "A" and "B"; Marginulina sp.; echinoid spines; Globotruncana sp.

1-2 feet below fishbone bed:
Bairdia sp.; Globigerina sp.; angular quartz grains; pyrite; amber-like material; Inoceramus prisms; fish teeth; "sponge spicules" type "A" and "B"; pyrite; hematite.

2-7 feet below fishbone bed:
"Sponge spicules" "A" and "B"; Globigerina sp.; Guembelina sp.; Pseudotextularia sp.

0-1 foot above Buda limestone:
Yellow and red limonite; hematite; selenite; fine silt aggregations.

A horizon of molluskan fauna was found eight feet below the fishbone conglomerate bed. The fauna includes the following:

Turritella sp.

Plicatula sp.

Ostrea sp.

Anchura sp.

Anamia sp.

Turrilites sp.

Micrabacia sp.

Macro-Paleontology of the Woodbine Formation: The following molluscan fossils have been found by various persons in the Woodbine formation of northern Texas.

Barbatia micronema Meek

Arca galliennei var. tramatensis Cragin

Ostrea soleniscus Meek

Ostrea carica Cragin

Aguileria cumminsi White

Cytherea leveretti Cragin

Trigonarca siouxensis Hall and Meek

Turritella renauxiana d'Orbigny

Cerithium tramatensis Cragin

Cerithium interlineatum Cragin

Exogyra sp.

Mantelliceras(?)

Turrilites (?) sp.

Pteria salinensis White

Natica humilis Cragin

Nerita sp. Cragin

Turritella coalvillensis Meek

Yoldia sp.

Scaphites sp. Cragin

Plants sp.

Crab sp.

None of these fossils occur in either the overlying Eagle Ford or the underlying Comanche series, and so far as known, the fauna is the most peculiar yet found in beds occupying the typical Woodbine position.

Böse[34] and Professor F.L. Whitney called attention to the dissimilarity between Exogyra columbella Cragin (see Plate III)and Exogyra columbella Meek. Exogyra columbella Cragin[35] found in the Bouldin Creek section, Travis County, is not Exogyra columbella Meek of northern Texas, which Hill[36] designated as the top ter-

[34] Böse,E.: "On a New Exogyra from the Del Rio Clay,etc" Univ. of Texas Bull. 1903,p.12.

[35] Cragin,F.W.: "A Contribution to the Invertebrate Paleontology of the Texas Cretaceous," 4th Ann. Rept. Geol Surv. Texas, 1893,p.184.

[36] Hill,R.T.: U.S. G.S. 21st Ann.Rep.pt.7,p.297.

minal marker of the Woodbine formation in north Texas. Exogyra columbella Cragin is ~~more~~ similar to Exogyra laeviuscula of Roemer, differing from the latter in the severity of the spiral twist of the beak. Both forms are quite smooth in the unbonal region. The Cragin form ranges from seven and one half feet below the lower fishbed to five feet above, and is associated with Inoceramus labiatus and Prionotropis (?) sp. Professor Whitney has noted certain peculiarities between the Exogyra from the lower bituminous shales and those in the Eagle Ford Flags, which may be specific and probably have a bearing on the stratigraphy.

The shales at Aquilla section heretofore mentioned will yield determinative fossils upon diligent search. A fragment of what appeared to be the keel of a Mantelliceras was found thirteen feet below the flags of the Eagle Ford associated with a fragment that appeared to be either a Turrilites or an undeterminable Ammonite. Corbula sp. and Yoldia sp. were also found at that horizon. The Mantelliceras would establish the age of the beds as Cenomanian.

On the evidence of the occurrence of various species of Acanthoceras in the lower shales, the Eu-

ropean equivalent of the Lower Eagle Ford is Cenomanian age. Böse[37] has correlated the Cenomanian as beginning with the middle of the Georgetown, about the Pawpaw horizon, and continuing upward to the flags of the Eagle Ford. Through this horizon, the lowest fossils in the range of development is Submantilleceras, followed by Mantelliceras, then Acanthoceras. One investigator[38] has made a zone fossil of Acanthoceras aff. rhotomagense de France, placing it at the base of the Eagle Ford shales, above the Woodbine. The writer, however, does not feel that sufficient study of the field relations, extensive collecting, and the necessary labor for the establishment of a zone marker, has been done to establish the Acanthoceras zone at the base of the Eagle Ford shales. In north Texas, it is reported that the occurrence of this form is rare; in Bell County, however, there is an extensive fauna of Cephalopods near the base of the Eagle

37 Böse, E.: "Geology of Southern Texas and Northern Mexico," Univ. of Texas Bull. 2745, pp. 11-16.

38 Scott, Gayle: "The Woodbine Sand of North Texas Interpreted as a Regressive Phenomenon," Bull. A. A. P. G. Vol. 10, No. 6, 1926.

Ford, the following being present: Acantho-ceras cunningtoni var. cornutum; Acanthoceras sp. It is estimated that a dozen or more species[39] of Acanthoceras and Mantelliceras-like ammonites occur in the central Texas region.

The discovery of an assemblege of molluscan fossils at Bouldin Creek eight feet below the flags of the Eagle Ford indicate fossils of a kind unknown in the adjacent formations and peculiar to the horizon. The following list of fossils has been tentatively prepared:

(a) Plicatula aff. arenari Meek (Macomb's Expedition from Santa Fe to junction of Grand and Green rivers, Geol. Rept. p. 126,Pl.1, Figs. 5 a,b,and c).
Locality: Covero, New Mexico; Lower Cretaceous of Dr. Newberry's section, in association with Exogyra columbella Meek).

(b) Plicatula aff. hydrotheca White (1879,11th Ann. Rept. U.S. Geol. Surv. Terr.,p.279,Pl.6.Figs. 3 a, and b. Cretaceous strata, probably equivalent with the lower portion of the Colorado group; head of Water-pocket canyon, southern Utah.
"Only the original types, which are imperfect casts in sandstone, have been found. It is possible that better collections would show that this species is the same as Plicatula arenaria Meek, but with only the imperfect material now in hand it is necessary to keep them separate.")
(See Plate IX).
(c) Pteria aff. salinensis White
(d) Fragments of Turrilites
(e) Coral similar to Micrabacia sp.
(f) Ostrea aff. noctuensis.

[39] W.S. Adkins, personal conversation

(g) Anchura Kiowana Cragin

c,f,g, are from the so-called Dakota formation, which J.B. Reeside Jr. is inclined to refer to Purgatoire formation[40]

"...It seems that it is better to regard the fossils of the so-called Dakota formation as of the same age as those of the Purgatoire formation and attribute the differences between them to some now unknown difference in the conditions under which the sediments were deposited. The fauna .....is more like that of the Washita group than that of the succeeding Benton shale or that of any known Dakota beds, and a correlation based on the fauna must be a correlation with the Washita rather than with the Benton."

(h) Anchura (Drepanocheilus) aff.ruida White (1879, Ann. Rept. U.S. Geol. Sur. Terr. for 1877,p.312,7, Figs. 4a and b. Locality and position: Sink Spring and Upper Kanab valley, Utah, occuring about 350 feet above the base of the Cretaceous section at the latter locality.)

(i) Ostrea aff. malachitensis Stanton
("From Pugnellus sandstone near Malachite post-office about 20 miles above Pueblo,Colo." Pugnellus sandstone 15 ft. to 40 ft., thick, coarse massive gray, sandstone capped by 1 to 2 feet of brown, calcareous, sandstone containing Ostrea lugubris, impressions of Prinocyclus wyomingensis," just below the Niobrara limestone.)

The following fossils were found at Bouldin Creek one foot below the Eagle Ford Flags:

(j) Anomia sp.
(k) Turritella sp.
(l) Mactra sp.
(m) Lucina sp.

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40 Reeside, J.B. Jr. "The Fauna of the so-called Dakota Formation of Northern Central Colorado and its Equivalent in Southern Wyoming", U.S.G.S. Shorter Contributions to General Geology, 1922,p.200.

Fossil Bacteria in the Eagle Ford Formation: During the course of study of the fauna of the lower Eagle Ford, the writer found certain truncated, smooth, glossy, dark brown and yellow objects in the fish-bed conglomerate at the basal flags. A mineralogical examination revealed that they are composed of calcium phosphate with a small percentage of pyrite, and are a mineral known as callophane.

The pebbles range in size from one millimeter to three centimeters in length, with a variable thickness. Buckland[41] observed that "some coprolites, especially the small ones, show no traces at all of contortion." Some of the coprolites may show no contortion due to the early death of the individual in which it reposed, hence, not having passed through the lower intestine.

Further search disclosed the presence of typical coprolite pebbles with a characteristic spiral grove. A number of the smooth pebbles have faint markings, as will be seen in the photograph, (Plate IV). Thin sections of the pebbles were made with a view to examining the internal structure. (See Plate VI).

41 Buckland, W.J.: Bridgewater Treatise on Geology, Vol.1, p.165

Examination with oil immersion lens at magnification of 970 diameters revealed the presence of two types of bacteria. One type is stained probably with pyrite, and has the morphology of Micrococcus with characteristic colonial groupings of the single spheres, either clustered in opaque mass, or in scattered colony. (See Plate VII). The second type is unstained, the spherical cells with clear outlines, and the enveloping material is colored a clear brown, and the contents clear. There is no tendency to form groups, for the callophane material is seen literally to swarm with the cells. The latter type resembles bacteria described by Bernard Renault[42] as Micrococcus lepidophagus var. c.

The presence of bacteria in the calcium phosphate pebbles in such numbers as those of the second type, in which they are seen literally to impregnate the pebble, suggests the genesis of the pebble as being deposited by a fish, containing at the time of deposition, of course, only slight amount of bone

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[42] Renault, Bernard, in Moodie, Roy L., Paleopathology, Univ. of Ill., Plates 312-320; pp. 295-300.

tissue, which probably served as a nucleus for the further attraction of more phosphate-loving bacteria, probably analogous to the action of accretion and growth of concretions about a nucleus, which may be similar to the concretionary material.

The bacteria of both types can be seen throughout the thickness of the slide, different groups coming into view by movement of the barrel of the microscope with the fine adjustment screw.

Recently the writer has investigated the black shales of the lower Eagle Ford formation. Under the oil immersion lens, similar dark spherical objects are seen, and are arranged in chains when colonies are found. They occur in individual groups, or singly, profusely distributed through the sample. The contemporaneous occurrence of bacteria in petroliferous shales at Bouldin Creek is of interest in relation to the probable origin of petroleum from bacterial association.

Economic Importance of the Woodbine Formation: The Woodbine sands were first studied in relation to their artesian water content. These sands are an important catchment for ground water in the northeast Texas region. Locally, the upper sands, or Lewisville sands, may contain waters of high con-

centration of mineral salts. The underlying Dexter sands contain, however, large quantities of potable water, except in the vicinity of oil fields, where connate waters supplant the pluvial waters.

The sands of the Woodbine formation are one of the important petroleum producing horizons in Central-East Texas, northeast Louisiana, and southwest Arkansas. The seven pools in Limestone, Freestone, and Navarro counties have, since the year 1920, yielded a total of 217,103,206 barrels[43] of petroleum from a total productive acreage not exceeding 7,800 acres. Up to the close of the year 1927, the average yield per acre on the basis of the above total, was, accordingly, 27,809 barrels of petroleum, a figure which compares well with other large oil fields in the United States.

The Woodbine has been found to yield oil at an inland salt dome at Boggy Creek, Cherokee County, where the formations on the surface are uplifted about five thousand feet above their normal position.[44]

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[43] Oil and Gas Journal, Feb. 9, 1928, Year of Disappointment in East-Central Texas Fields, p. 301.

[44] Dumble, E.T.: "Geology of East Texas," Univ. of Texas Bull. 1869, p. 19.

The top of the Woodbine at Wortham lies at an average depth of 2975 feet below the surface, or 2525 feet, corrected to sea level. The upper 40 to 50 feet of the Woodbine is the oil producing zone. An impervious break is believed to separate the pay horizon into an upper and lower member, the upper member being 15 to 25 feet of sandy shale or thin lenses of sand and shale, and the lower, separated from the upper by "shell" or "break", is a sand probably 20 to 22 feet thick,[45] the top of which was a good horizon marker for subsurface mapping purposes. The lower "pay" sand has proved the best yield of oil at Richland, Currie, and Wortham fields.

Deeper producing sands have been found at Mexia and Currie fields in the Woodbine formation. The "Kollman sand," at Mexia, lies from 200 to 230 feet below the top of the Woodbine. In March, 1922, a well was drilled into this member, and produced 700 barrels initially.[46] The "Morrow pay" at Currie is

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[45] Hill, H.B. and Sutton, C.E.: "Petroleum Engineering in Wortham Oil Field," U.S. Bureau of Mines. April 1927.

[46] Oil Weekly, Aug., 19, 1922, New Sand, at Mexia Wakes 'Em Up. p.35.

about 230 feet below the top of the Woodbine formation. Wells with initial production as high as 5,000 barrels per day of oil testing 41°A.P.I. have been finished in this "pay". The lateral extent of the lower "pay" at Mexia and Currie is very limited, and probably does not exceed 1,000 feet in width east from the fault plane.

A local dome in the Mexia structure has yielded over 130,000 barrels of oil per acre total production up to the close of the year 1927. Several tracts in Mexia and Powell pools have produced total yields of over 400,00 barrels per acre. A tract at Powell, similarly located with respect to a local dome, produced a total of 138,810 barrels per acre up to May 29, 1924, immediately after the peak production had passed.[47] A table of the production history of five fields is given on the next page.

Conclusion: The Cretaceous sediments in Central Texas have a total thickness of 2850 feet, from

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47 Wagner, Paul: "Powell Field Exceeds Estimates," National Petroleum News, June 11, 1924, p.72.

Production History of Five Principal Oil Fields of East-Central Texas

Field	Date Discovered	Peak Production Date	Peak Production Barrels	Total Amount Oil Produced to Close Year 1927	Acres Proved	Avg. Amt. Oil Prod. per Ac. Barrels	Percentage Decline Years after Peak: 1Year	2Years	3Years
Mexia	11/20/20	2/12/22	176,001	84,038,338 Bbls.	3,704	22,639	60%	74%	82%
Currie	12/14/21	7/24/22	13,165	5,601,933 Bbls.	375	14,939			66%*
Richland	2/ 8/24	9/ -/25	22,541	6,139,415 Bbls.	240	22,541			75%
Powell	1/ 1/23	11/14/23	319,921	97,313,149 Bbls.	2,612	37,256	77%	88%	92%
Wortham	11/22/24	1/15/25	153,800	20,750,320 Bbls.	715	29,021	92%	96%	97%

Authorities: Oil and Gas Journal[48] and American Petroleum Institute[49]

*Five years after peak production.

48. Oil and Gas Journal: Year of Disappointments in East-Central Texas Fields, Feb. 9, 1928, page 301

49. American Petroleum Institute: Petroleum Facts and Figures, page 111.

evidence of wells drilled at Luling.[50] At other localities, test wells have drilled through the Cretaceous sediments into schist or gneiss. This condition prevails in the area extending from Travis County north to Denton County.[51] In the eastern Red River series of counties, the sub-Cretaceous material consists of metamorphic sedimentary rocks; in Cooke[52] County where extensive well drilling has been done, an Ellenburger east-west trend "high" has been found underlying the Cretaceous marine. The total thickness of the Cretaceous rocks in North Texas is 5000 feet.[53] A gradual thinning of the forma-

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50 United North and South Oil Company No.1 Tiller.

51 Records of Bureau of Economic Geology.

52 Hawtoff,M.: "Petroleum Developments in Cooke County, Texas," Univ. of Texas Bull. 2710, fig. 6.

53 Udden, J.A.: "Oil Bearing Formations of Texas," Bull. A.A.P.G., Vol.III, p.81.

tions beginning with Washita time is evident passing from the Red River to Travis County. The Eagle Ford formation attenuates from about 500 feet in Grayson County to 42 feet in Travis County; the sands of the Woodbine decrease from 625 feet at Ladonia, Fannin County, to 341 feet at Blooming Grove, Navarro County, measured on a line north-south and parallel to its margin of outcrop. Turning west, the Woodbine attenuates to a thickness of 87 feet of sands and clays, on an east-west line across dip between Blooming Grove, Navarro County, and Cottonwood Creek, northwest of Hillsboro. Continuing south on the outcrop, the Woodbine continues to thin, having a thickness of 45 feet of sands and clays at a brick pit on Aquilla Creek, southern Hill County and finally decreasing to two feet of red sand, at Bosqueville, seven miles northwest of Waco. (See Sketch, Plates X, XI)

On a similar north-south projection, the Washita division decreases from 410 feet in Grayson County to 82 feet in Travis County.[54]

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Cuyler, Robt. M.: M.A. Thesis, University of Texas, 1927.

These Cretaceous sediments, deposited in a series of intermittent ebbing and flooding seas, marked by numerous diastems in the Eagle Ford and Georgetown formations, are seen, therefore, to overlap progressively over the Central Texas region both from the Red River region and from the Rio Grande embayment. The Woodbine formation is absent in the Rio Grande Embayment.

The Woodbine formation is, on floral evidence, related to the Tuscaloosa formation of the East Gulf Coast, and to the Dakota formation, of the Western interior section of Meek and Hayden. This series of marginal deposits marks the beginning of the cycle of deposition known as the Gulf Series, and fringes the margin of the Upper Cretaceous in the North American continent. In the Western interior, these sediments overlap Permian or Pennsylvanian rocks, in the Texas region, Lower Cretaceous, and in the East Gulf Coast, Paleozoic and schistose rocks.

The Woodbine formation, is interpreted as a huge lentil of sands and clays, marking the deepest part of the East Texas Syncline, and it probably

received its deposits both from the southwest and the northeast. In this respect, the Woodbine formation is not dissimilar to the Kiamitia and Pawpaw formations.

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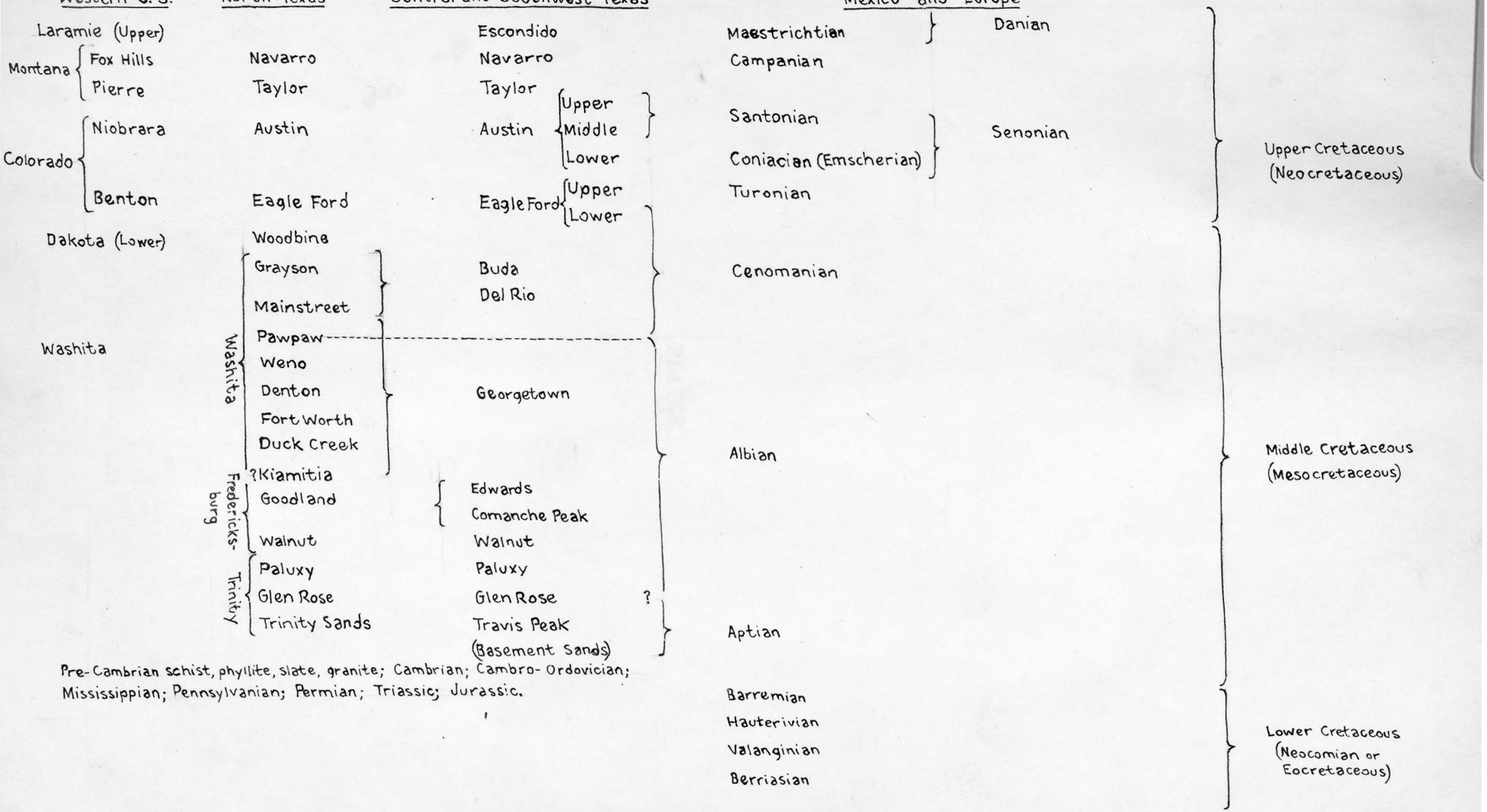
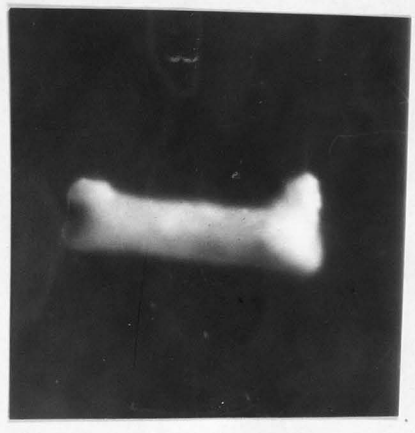


STANDARD CRETACEOUS CORRELATION

After: E. Bose: U. of T. Bull. 2748
E. Haug: Traité Géologie

PLATES

Type "A"



Type "B"

Plate I. "Sponge spicules"
x 60

Plate II. Section at Loudan Creek showing contact of Eagle Ford flags and lower bituminous shales.

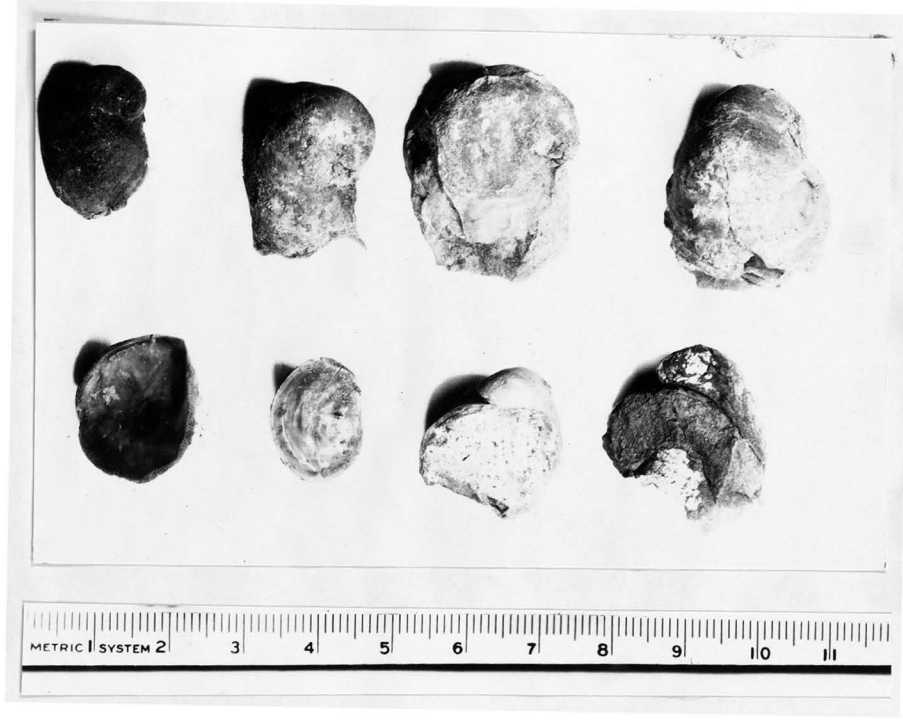


Plate III. Exogyra sp. from bituminous shales, Bouldin Creek. One to seven feet below Eagle Ford flags.

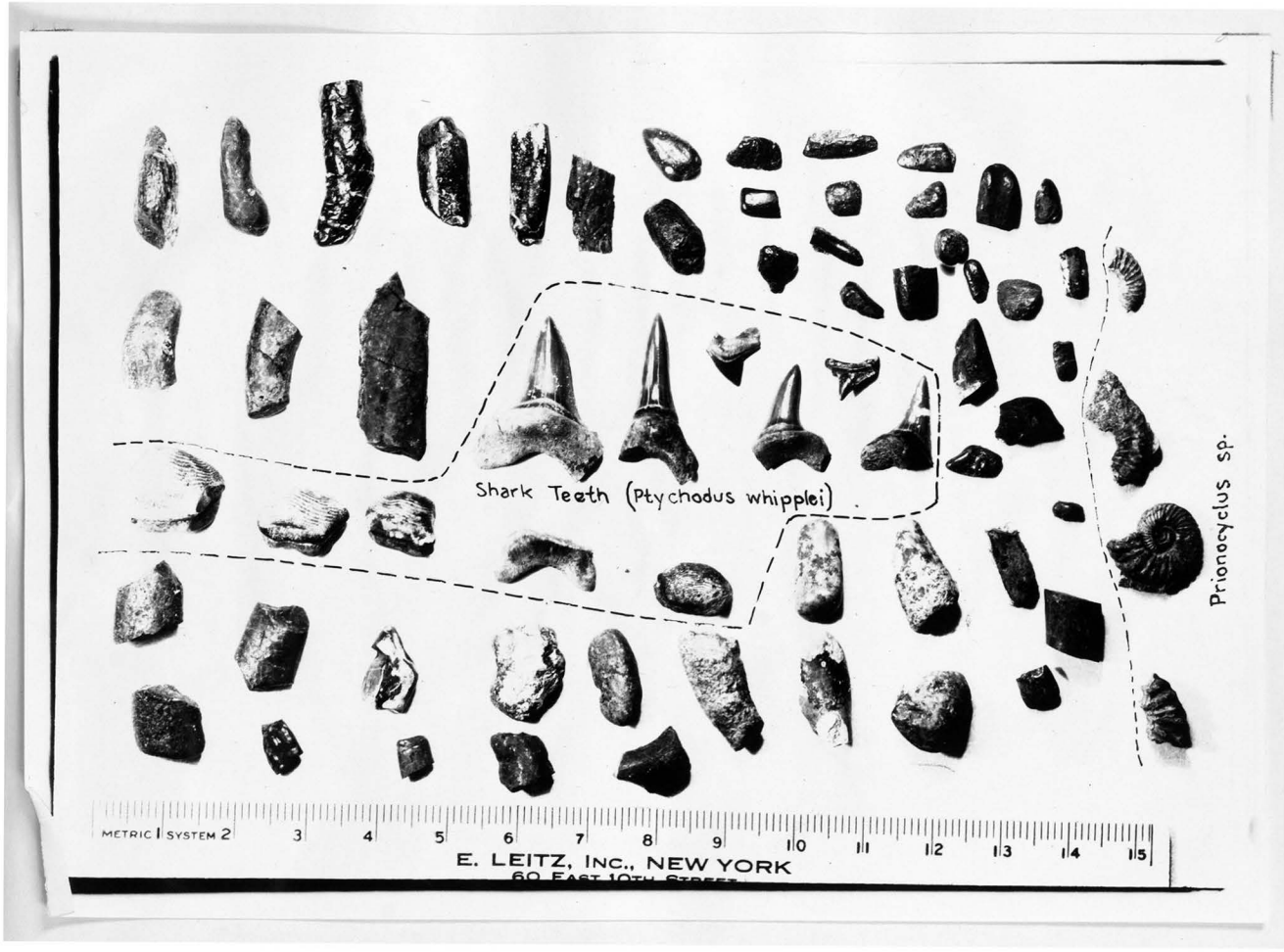


Plate IV. Coprolites, (callophane) and other fossils from the Eagle Ford formation.

Plate V. Slab of Eagle Ford "fishbed".
a. Coprolite (collophane)

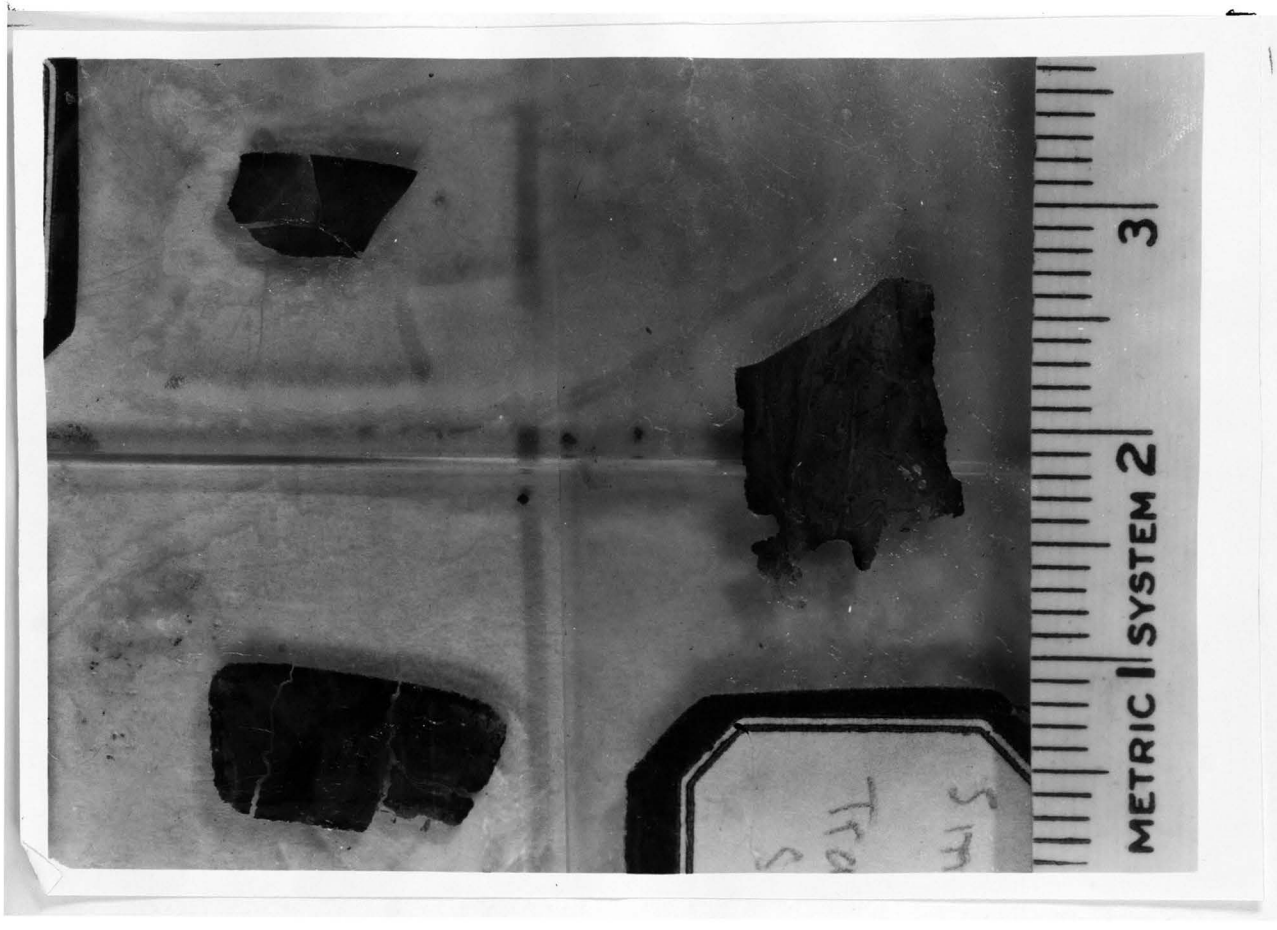


Plate VI. Sections of coprolites (callophane).

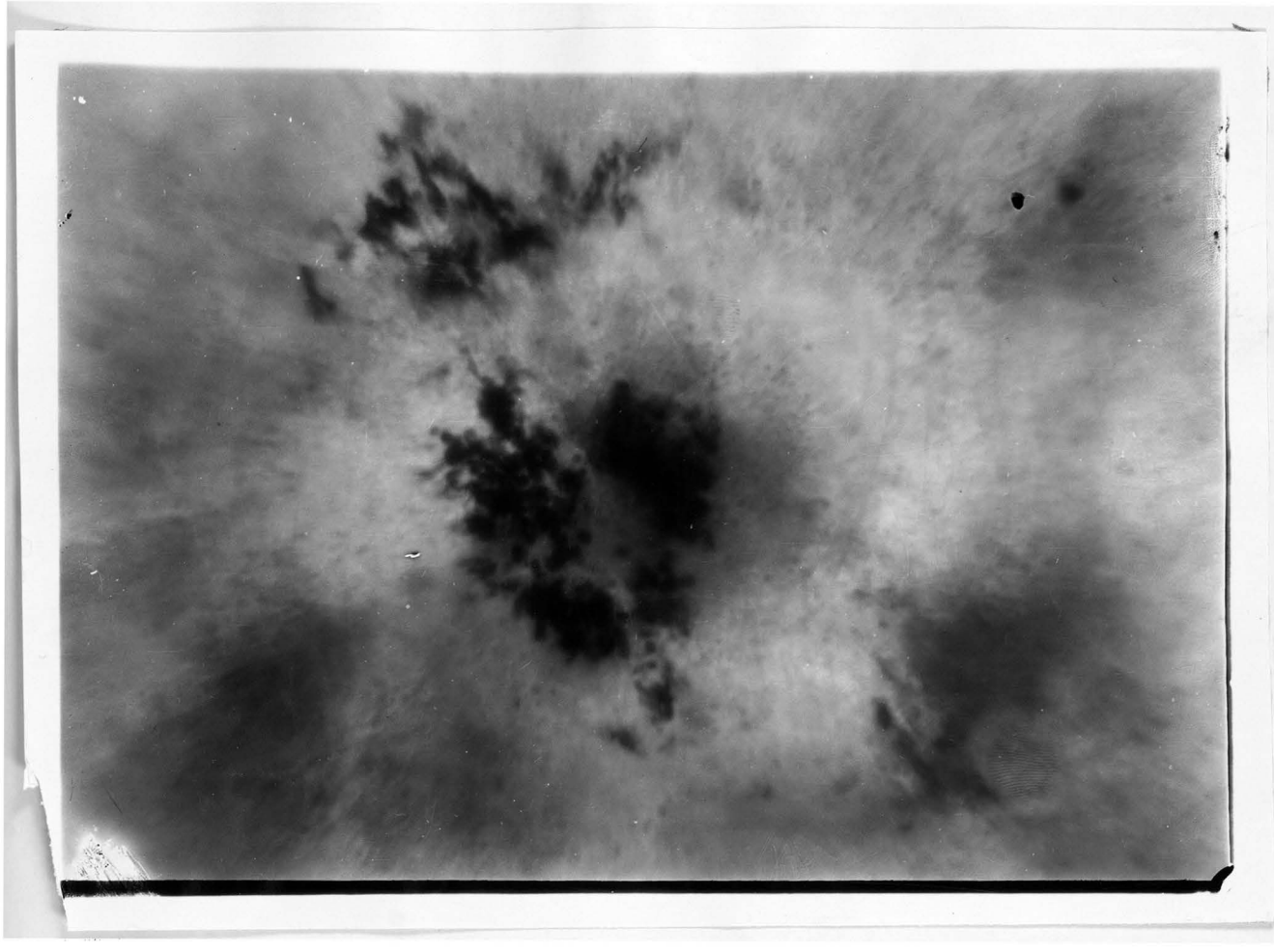
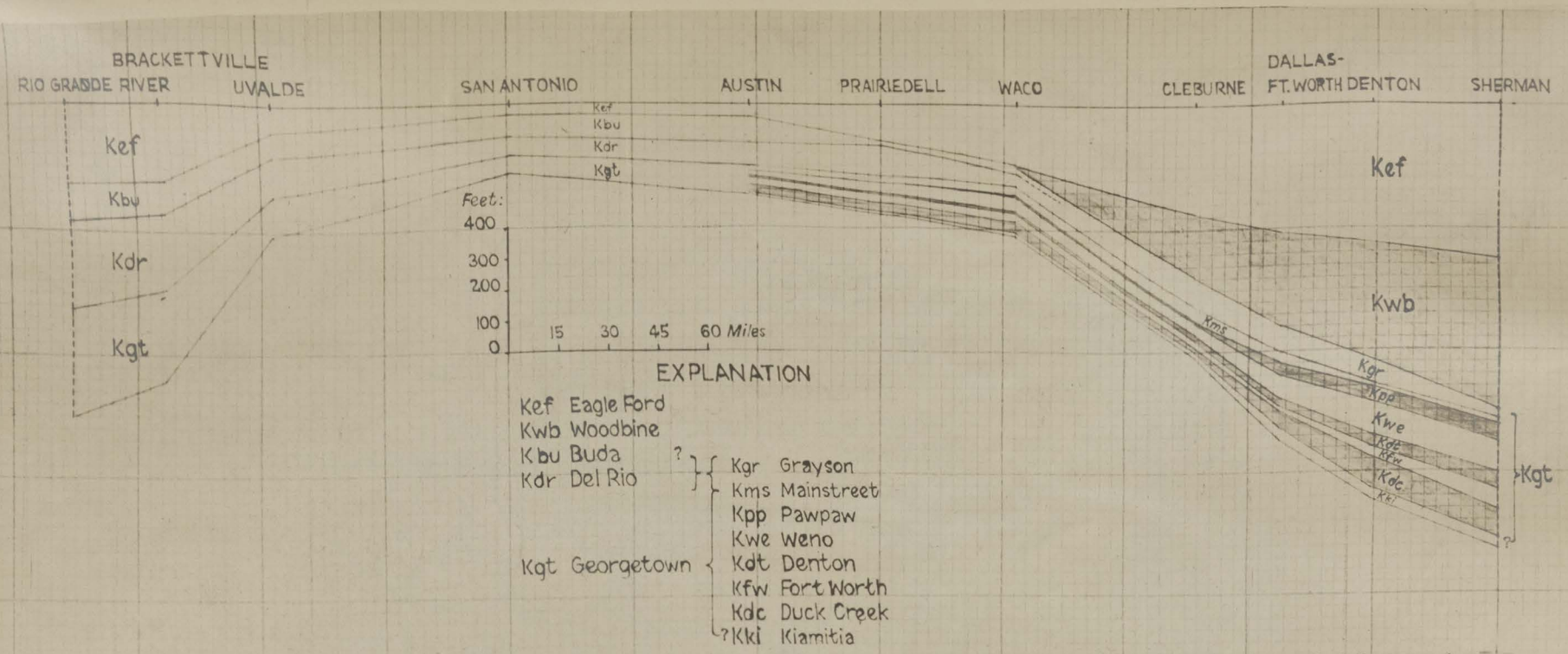


Plate VII. Photomicrograph of coprolite showing colonies of bacteria. x970

Plate VIII. Acanthoceras sp. from top of Woodbine at Bear Creek, near Tarrant Station, Tarrant County, Texas.

Plate IX. Mollusks from Bouldin Creek,
8 feet below Eagle Ford flags.

a. Anchura sp.
b. Plicatula sp.
Others indeterminable.



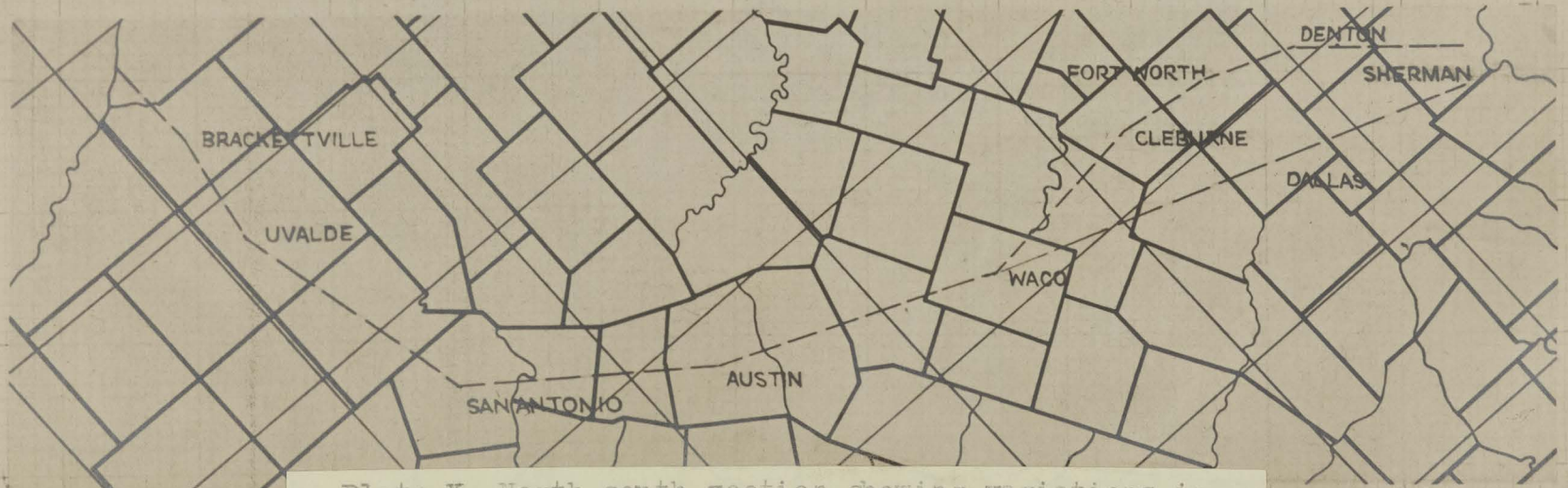


Plate X. North-south section showing variations in thickness of some Cretaceous formations between Red River and Rio Grande River.

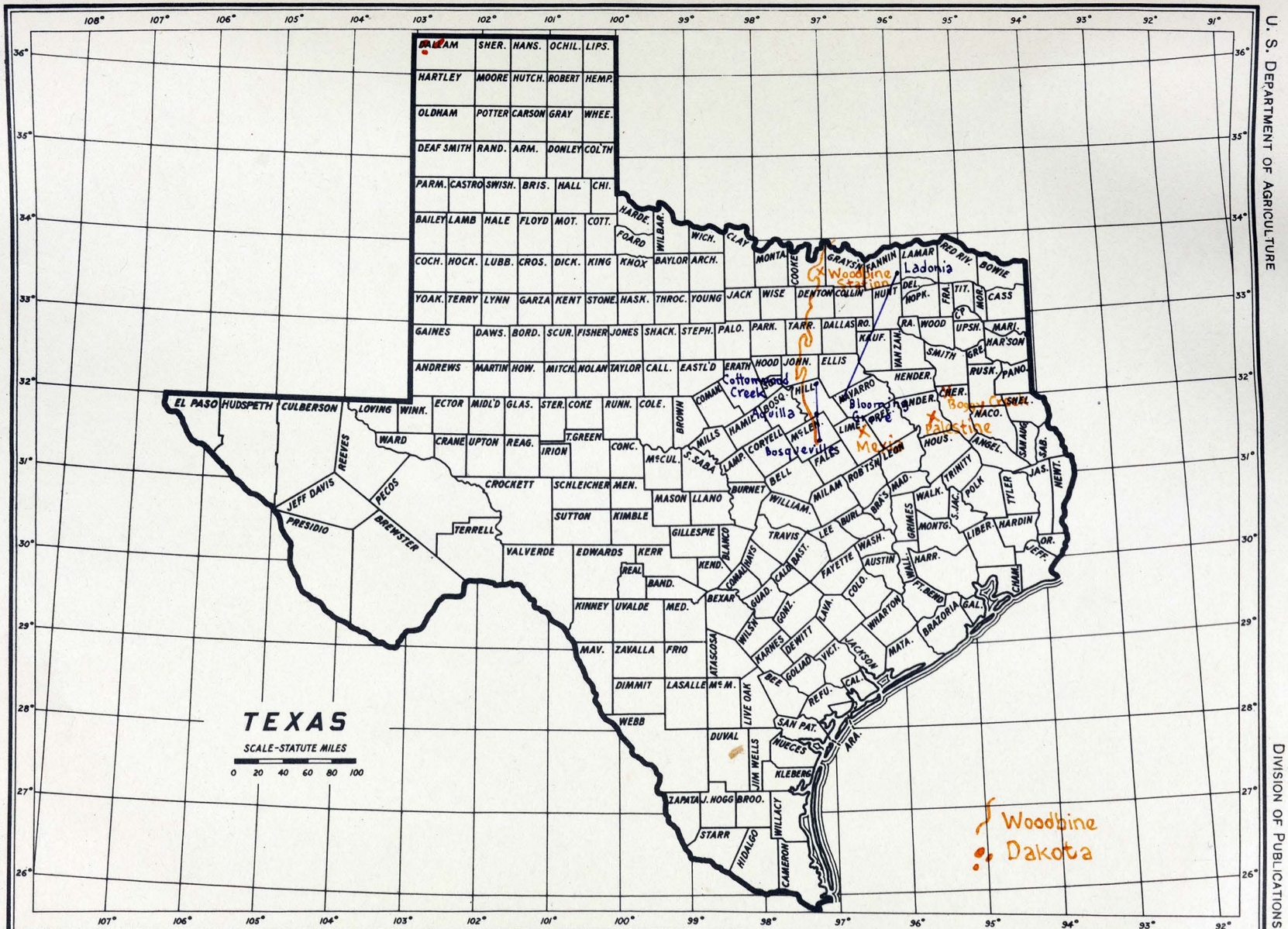


Plate XI. Map of Texas showing outcrop of Woodbine and equivalents. Blue line is on north-south attenuation of Woodbine mentioned in text, page 41.

July 1, 1917
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