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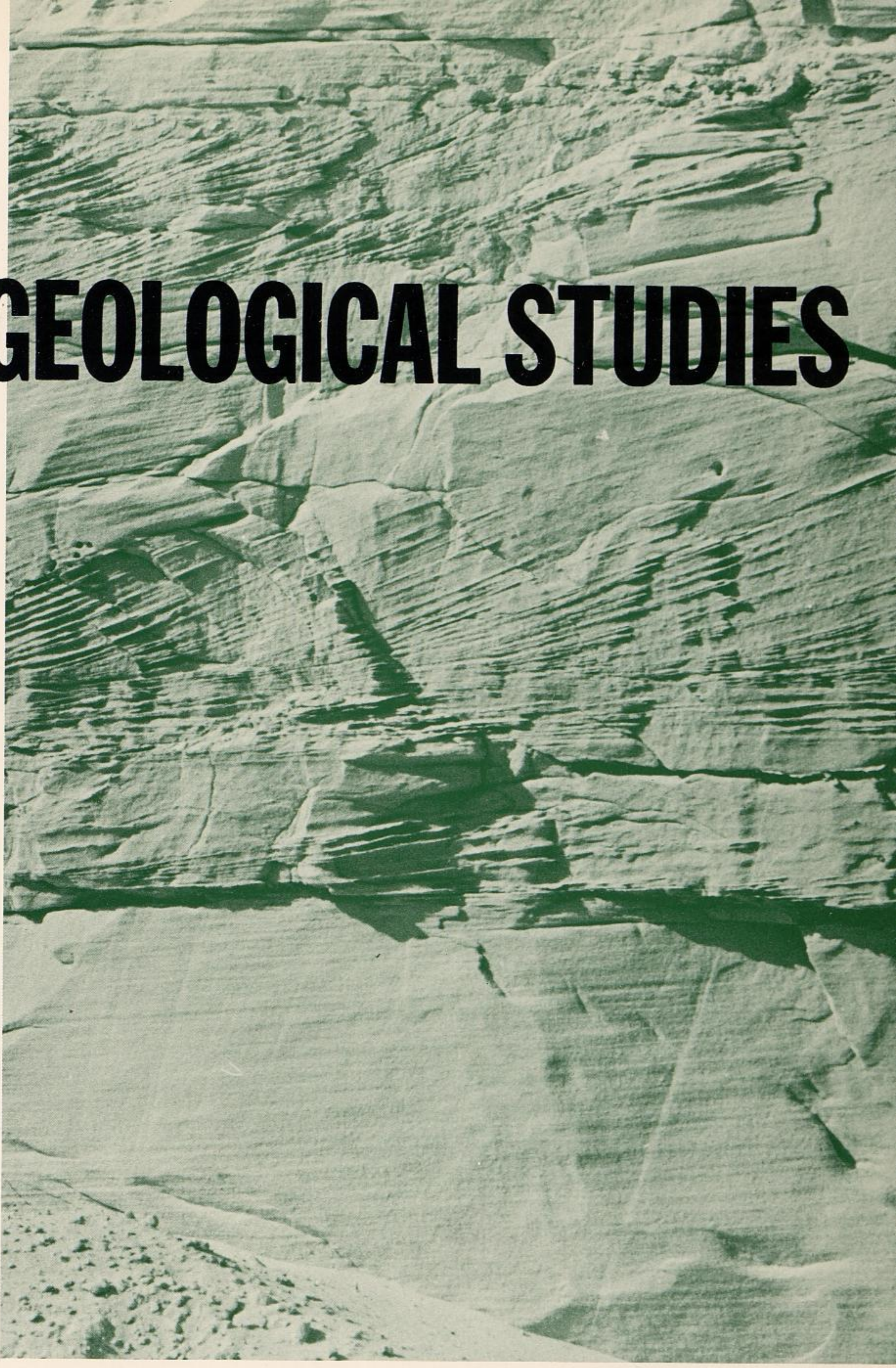

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Bulletin No. 36

BAYLOR UNIVERSITY - WACO, TEXAS
1845

The Paluxy Sand in North-Central Texas

MARK THOMAS OWEN

"Creative thinking is more important than elaborate equipment--"

FRANK CARNEY, PH.D.
PROFESSOR OF GEOLOGY
BAYLOR UNIVERSITY
1929-1934

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BAYLOR GEOLOGICAL STUDIES

BULLETIN NO. 36

The Paluxy Sand in North-Central Texas

Mark Thomas Owen

BAYLOR UNIVERSITY
Department of Geology
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CONTENTS

	Page
Abstract	5
Introduction	5
Purpose	5
Location	5
Procedure	5
Previous Works	7
Acknowledgments	8
Stratigraphy	8
Areal and Thickness Distribution	8
Glen Rose Limestone-Paluxy Sand Contact	9
Paluxy Sand-Walnut Clay Contact	9
Sedimentology	12
Sand and Silt	12
Clay	13
Provenance	13
Paleontology	14
Depositional Environment	15
Lake Merritt Member	15
Georges Creek Member	21
Eagle Mountain Member	25
Depositional History	30
Conclusions	31
Appendix	32
References	34
Index	35

ILLUSTRATIONS

Figure Page

1. Geologic map of the Paluxy Sand showing outcrop localities 6
2. Diagrammatic facies cross section of the Trinity and Fredericksburg Groups in north-central Texas 9
3. Structure contour map of top of Paluxy Sand 10
4. Isopach map of Paluxy Sand 11
5. Glen Rose Limestone-Paluxy Sand contact 12
6. Paluxy Sand-Walnut Clay contact 12
7. Paluxy Sand-Walnut Clay contact 12
8. Frosted, well-rounded sand grains with polished, angular sand grains 13
9. Bimodal grain size distribution, fine sand and coarse silt 13
10. Gastropods and pelecypods from the Paluxy Formation 14
11. Facies distribution of the Lake Merritt Member in north-central Texas 15
12. Cross section A-A′ 16
13. Cross section B-B′ 17
14. Cross section C-C′ 18
15. Cross section D-D′ 19
16. Sand and silt, intertidal facies, Lake Merritt Member 20
17. Tidal bedding, Lake Merritt Member 20
18. Flaser bedding, Lake Merritt Member 20
19. Ripple marks, Lake Merritt Member 20
20. Horizontal laminae, Lake Merritt Member 21
21. Sand-filled burrows, Lake Merritt Member 21
22. Facies distribution, Georges Creek Member, north-central Texas 22
23. Sand, fluvial facies, Georges Creek Member 22
24. Sand and silt, intertidal facies, Georges Creek Member 22
25. High-angle cross-bedded sand, Georges Creek Member 23
26. Trough cross-bedded sand, Georges Creek Member 23
27. Ripple marks, Georges Creek Member 23
28. Feeding trials, Georges Creek Member 23
29. Horizontal sand and clay beds, Georges Creek Member 24
30. Channel deposit, Georges Creek Member 24
31. Trough cross-bedding, Georges Creek Member 24
32. Caliche horizon between Georges Creek Member and Eagle Mauntain Member 25
33. Caliche horizon, Georges Creek Member 25
34. Facies distribution, Eagle Mountain Member, north-central Texas 26
35. Sand from the fluvial facies, Eagle Mountain Member 26
36. Sand and silt, intertidal facies, Eagle Mountain Member 26
37. Trough cross-bedded sand, Eagle Mountain Member 27
38. Trough cross-bedded sand, Eagle Mountain Member 27
39. Horizontal sand laminae, Eagle Mountain Member 27
40. Horizontal graded sand laminae, Eagle Mountain Member 27
41. Channel deposit, Eagle Mountain Member 28
42. Sole markings, Eagle Mountain Member 28
43. Floodplain deposits, Eagle Mountain Member 28
44. Contact between horizontal sand and clay beds and edge of a fluvial channel, Eagle Mountain Member 29
45. Longitudinal cross-bedded sand and clay beds, Eagle Mountain Member 29
46. Fossiliferous clay of the subtidal facies, Eagle Mountain Member 29
47. Clay-filled burrows, Eagle Mountain Member 29
48. Depositional model showing facies distribution of Lake Merritt and Georges Creek Members 30
49. Depositional model showing facies distribution of Eagle Mountain Member 30

The Paluxy Sand in North-Central Texas

Mark Thomas Owen

ABSTRACT

The Paluxy Formation is a blanket sand that crops out throughout much of north-central Texas. It is a quartzarenite composed of medium to very fine quartz sand and coarse silt. Most grains are sub-angular to sub-rounded and moderately to well sorted.

The Paluxy Sand can be divided into three members on the bases of depositional environment and petrologic and stratigraphic relationships. The Lake Merritt Member is the lowermost unit and consists of horizontally bedded sand, silt, and clay. Evidence indicates that it was deposited in an intertidal environment and represents the final phase of a regressive depositional cycle. The Georges Creek Member directly overlies the Lake Merritt Member and is characterized by channel bar and floodbasin deposits of a braided stream system. This fluvial facies grades downdip into a subtidal facies. The Georges Creek Member is overlain by the Eagle Mountain Member which is composed of point bar and floodplain deposits of a meandering river system. The Eagle Mountain fluvial facies grades downdip into an intertidal and subtidal facies.

INTRODUCTION*

PURPOSE

Outcrops of the Paluxy Formation in north-central Texas were studied primarily to understand the depositional environments and stratigraphic relationships within the formation. There have been several regional studies of the Paluxy Formation but none have dealt with specific depositional environments and stratigraphic relationships throughout the outcrop area. Information and data compiled by studying the Paluxy Sand in this area can be useful in understanding the formation in the subsurface where it is an aquifer in central Texas and a major oil-producer in the East Texas Basin. This study divides the Paluxy Formation into three members based on depositional history and offers a depositional model for the Paluxy Sand. Petrologic and stratigraphic relationships between the Paluxy Sand and other formations of the Trinity and Fredericksburg Groups of central Texas are also considered in this report.

LOCATION

The area of investigation includes the outcrop area of the Paluxy Formation in Bosque, Brown, Burnet, Comanche, Coryell, Eastland, Erath, Hamilton, Hood, Jack, Johnson, Lampasas, Mills, Parker, Tarrant, Travis, Williamson, and Wise Counties in north-central Texas (Fig. 1). The study area is between latitudes 30° 45′ N and 33° 10′ N and longtitudes 98° 15′ W and 98° 0′ W.

PROCEDURE

Procedures involved in preparation of this thesis included library research, laboratory analyses, field research, and well log interpretations. Library research consisted of a comprehensive review of all available literature concerning the Paluxy Sand and the recognition of ancient sedimentary environments. Laboratory analyses involved detailed microscopic examination of loose sand and silt grains, thin sections, and hand samples. Folk's nomenclature (1974) was used to describe grain morphology. Composition of clay samples was determined by X-ray diffraction. Many clay samples were also washed and screened for microfossils. Field research included measuring, describing, and photographing different outcrop sections. Several cores of Paluxy Sand from the Balcones Research Center in Austin, Texas, were closely examined. Electric logs and drillers' logs were used to construct a structure

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*A thesis submitted in partial fulfillment of the M.S. degree in Geology, Baylor University, 1977.

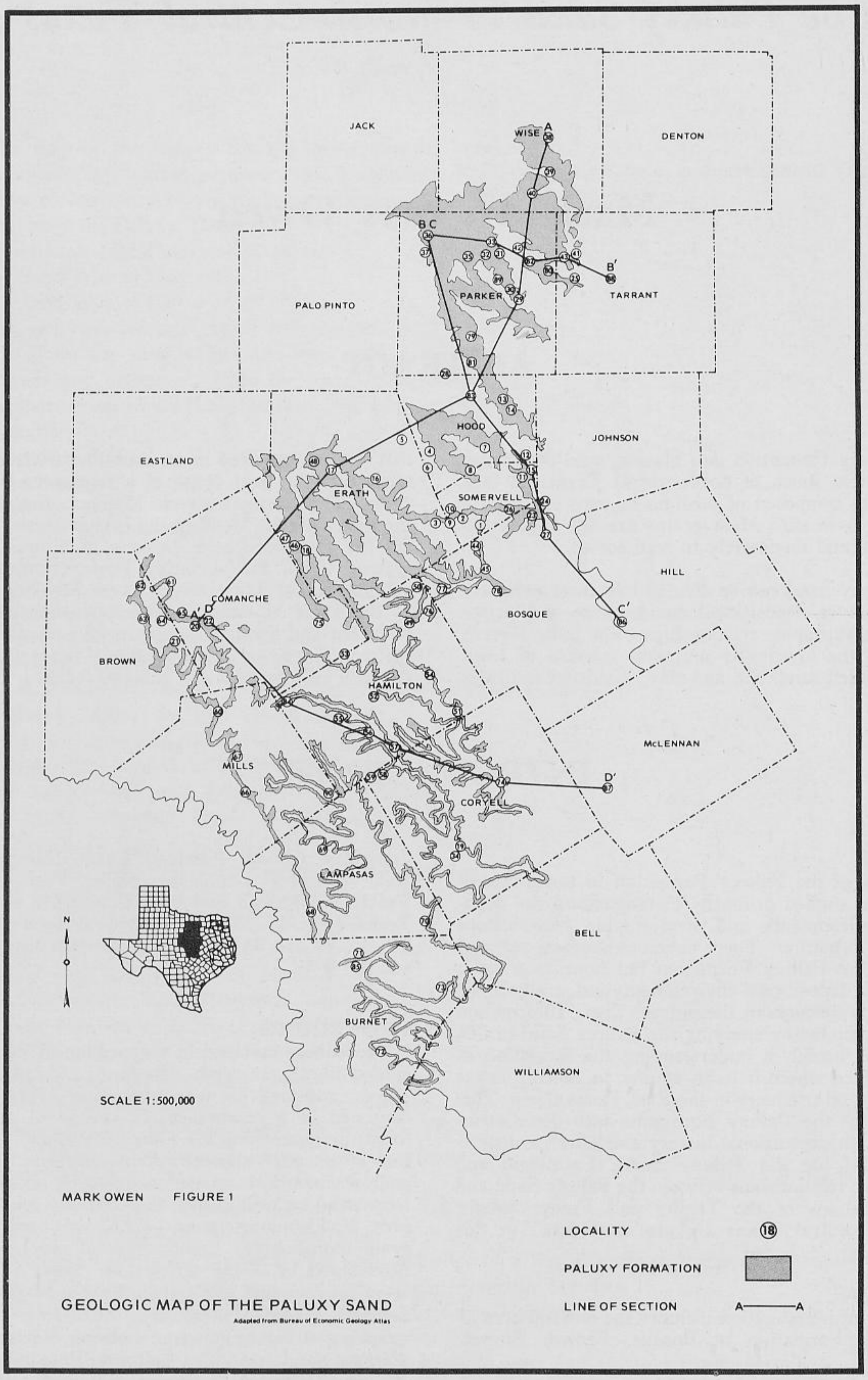

Fig. 1. Geologic map of the Paluxy Sand showing outcrop localities. *Adapted from* **Texas Bureau of** Economic Geology Atlas.

contour map and an isopach map. Preliminary environmental interpretations were based on the character of the resistivity and spontaneous potential curves.

PREVIOUS WORKS

Little information concerning the Paluxy Sand was available before 1887, when R. T. Hill began investigating the Lower Cretaceous section in central Texas. Hill named the Paluxy Sand for outcrops near the town of Paluxy and along the Paluxy River in Hood and Somervell Counties. In 1937, Hill interpreted the Paluxy Sand as the initial phase of a sedimentary cycle and referred to it as the basal unit of the Fredericksburg Group. Until that time the Paluxy Sand was considered part of the upper Trinity Group (Table 1). Lozo (1949) substantiated Hill's interpretation of the stratigraphic position of the Paluxy Sand through electric well log interpretations.

Atlee (1960) studied the Paluxy Sand in Coryell, Erath, Hamilton, Hood, and Somervell Counties. His work dealt primarily with lithology, facies relationships, and the economic aspects of the Paluxy. Atlee interpreted the depositional environments in the Paluxy Formation as ranging from fluvial to shallow marine.

Moore and Martin (1966) examined facies relationships and depositional environments of the Paluxy Sand in Burnet, Lampasas, and Travis Counties in south-central Texas. They recognized five facies and stated that the Paluxy Sand represented a coastal environment transitional between continental and marine environments.

The Paluxy Sand has also been extensively studied in the central Texas area by D. L. Amsbury (personal communication). Most of his preliminary results have not been published. However, in 1967, he published an abstract describing a caliche horizon in the Paluxy in Brown, Comanche, Erath, and Mills Counties.

The stratigraphic relationships of the Paluxy Formation to other formations of the Trinity and Fredericksburg Groups in north-central Texas were studied by Fisher and Rodda in 1967. Their work also included investigation of physical, chemical and mineral properties, and economic resources of the Paluxy Sand in that area. Boone (1968) and Dreyer (1971) worked on the "Basal Trinity Sands" and briefly discussed the relationship between the Trinity Group and the Paluxy Formation.

Van Camp, in 1968, studied the lower contact of the Paluxy Sand with the Glen Rose Limestone in Erath, Hood, and Somervell Counties and concluded that the contact was conformable. Hendricks (1957) concluded that the contact between the Paluxy Sand and Glen Rose Limestone in Parker County was abrupt but conformable. However, Atlee (1960) considered the contact between the Paluxy Sand and the Glen Rose Limestone to be unconformable in central Texas. Moore and Martin concurred that the contact was unconformable in south-central Texas. Jones (1966) studied the contact between the Paluxy Sand and the overlying Walnut Clay and concluded, in agreement with Atlee, that it was unconformable in central Texas. Moore and Martin also agree that the upper contact is unconformable in south-central Texas.

Nomenclature chart for the Comanchean Series in north-central Texas.

		Hill 1891	Hill 1901	Hill 1937	Lozo 1949	Atlee 1962	Fisher 1967	Owen 1977
Comanchean Series	Fredericksburg	Goodland Ls Caprina Ls Comanche Peak Chalk Walnut Clay Paluxy Sand	Edwards Fm Comanche Peak Fm Walnut Clay	Edwards Fm Comanche Peak Fm Walnut Clay Paluxy Fm	Edwards Fm Comanche Peak Fm Walnut Clay Paluxy Fm	Edwards Fm Comanche Peak Ls Walnut Clay Paluxy Sand	Edwards Ls Comanche Peak Ls Walnut Clay	Edwards Ls Comanche Peak Walnut Clay Paluxy Fm: Eagle Mt Mbr Georges Creek Mbr Lake Merritt Mbr
	Trinity	Glen Rose Beds Trinity Sand	Paluxy Fm Glen Rose Fm Travis Peak Fm	Glen Rose Fm Travis Peak Fm	Glen Rose Fm Travis Peak Fm	Glen Rose Ls Hensel Sand Pearsall Fm Sligo Ls Hosston Sand	Paluxy Sand Glen Rose Ls Twin Mountains Fm	Glen Rose Fm Twin Mountains Fm

The author is in general agreement with Van Camp and Hendricks concerning the lower contact of the Paluxy Sand. It is abrupt and conformable, and the upper contact of the Paluxy Sand is unconformable throughout the area.

ACKNOWLEDGMENTS

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Special appreciation is extended to Dr. Richard C. Selley, Imperial College of Science and Technology, London, for kindly reviewing the manuscript before publication.

STRATIGRAPHY

The Paluxy Formation, a Lower Cretaceous sand that is part of the Comanchean Series, can be divided into three members in north-central Texas on the bases of depositional environments, and petrologic and stratigraphic relationships. The Lake Merritt Member is the lowermost unit and represents strandline deposits of the regressing early Cretaceous Sea. The type locality consists of 6 meters of horizontally bedded sand and clay. The Lake Merritt Member was named for an exposure near Lake Merritt in central Mills County (loc. 67).* The Georges Creek Member directly overlies the Lake Merritt Member and is separated from it by a disconformity. The uppermost Lake Merritt bed is typically a ripple-marked, indurated, extensively bored, calcite-cemented sandstone. The surface has a sharp contact with the overlying member. Medium-sized sand grains from the Georges Creek are absent in the Lake Merritt, suggesting cementation before initial Georges Creek deposition. This indurated bed can be traced laterally across most of the study area. Together, these factors suggest that a hiatus occurred after deposition of the Lake Merritt Member and before Georges Creek deposition. The Georges Creek Member is predominantly a fluvial unit. The type locality consists of 10 meters of cross-bedded sand along Georges Creek in eastern Somervell County (loc. 15). The Georges Creek Member is unconformably overlain by the Eagle Mountain Member. The unconformable relationship between these two members is indicated by the development of a prominent caliche horizon at the top of the Georges Creek Member. The Eagle Mountain Member is characterized by fluvial and shallow marine deposits and represents the last phase of Paluxy deposition. The type locality, at Eagle Mountain Lake in western Tarrant County, is composed of 19 meters of cross-bedded sand alternating with clay beds (loc. 41).

Initially Hill (1891) considered the Paluxy the lowermost formation of the Fredericksburg Group (Table). In 1901 he designated the Paluxy as the uppermost unit of the Trinity Group, but in 1937 again he placed it as the basal unit of the Fredericksburg Group. Since then there has been some question concerning the proper stratigraphic position of the Paluxy Formation (Table). Hill defined Lower Cretaceous Groups on the basis of inferred depositional history. Each of Hill's groups or "divisions" consisted of a basal, transgressive sandstone overlain by a carbonate unit. According to Hill, the Paluxy Formation repesents the basal, clastic unit of the Fredericksburg Group, and the Walnut, Comanche Peak, and Edwards Formations represent the overlying transgressive Fredericksburg carbonate units. Detailed stratigraphic work shows that Hill's concepts of cyclic Early Cretaceous sedimentation, although applicable to other parts of the Lower Cretaceous, cannot be applied to the Trinity-Fredericksburg transition.

The boundary between the major regressive-transgressive cycle in proximity to the Trinity-Fredericksburg transition occurs at a disconformity within the Paluxy Formation. The lower part of the Paluxy Sand represents the final phase of regression, and the upper part of the Paluxy represents the initial phase of transgression. Obviously, the boundaries between major depositional cycles and mappable rock bodies do not coincide. The Paluxy Sand is considered the basal formation of the Fredericksburg Group because it is lithologically homogeneous, and the disconformity in the lower part of the formation is subtle and not a valid mapping criterion.

AREAL AND THICKNESS DISTRIBUTION

The Paluxy Sand is a blanket sand that is exposed throughout much of central and north-central Texas and is present in the subsurface in Louisiana and east Texas. The outcrop pattern is especially well developed in Bosque, Comanche, Coryell, Erath, Hamilton, Hood, Parker, Somervell, and Wise Counties (Fig. 1). In the western and northern part of the area, beyond the regional extent of the Glen Rose Limestone, the Paluxy Formation merges with the lower Trinity Sands and forms an undifferentiated sand section called the Antlers Sand (Fig. 2).

The Paluxy Sand strikes northeast and dips southeast at a rate ranging from 1.3 meters per kilometer in the western part of the study area to 14.5 meters per kilometer in the eastern part of the area (Fig. 3). Maximum thickness is estimated to be 72 meters near Decatur in central Wise County (Fig. 4). No complete

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*Abridged locality descriptions are in Appendix I. Detailed descriptions (90 pages) can be obtained from the Department of Geology, Baylor University for reproduction costs.

section was exposed in this part of the study area. The most complete measured section included 46 meters of Paluxy Sand in northwest Parker County (loc. 36). Thickness data were derived primarily from composite measured sections and drillers' logs. The formation thins downdip to the southeast, and thinning trends become less pronounced in the southern part of the area (Fig. 4). This thinning is probably the result of a transition from predominantly continental deposits in the north to predominantly marine deposits in the south. The Paluxy Sand pinches out in the subsurface in central Bell, Burnet, and McLennan Counties and is the lateral equivalent of the Bull Creek Limestone Member of the Walnut Formation (Moore and Martin, 1966, p. 985).

GLEN ROSE LIMESTONE-PALUXY SAND CONTACT

The contact between the Glen Rose Limestone and the overlying Paluxy Sand is conformable throughout most of the study area and can be gradational, abrupt, or interfingering. In Parker and Wise Counties in the northern part of the area, localities 39 and 80, the upper Glen Rose Limestone is composed of sandy, fossiliferous limestone, and the lower Paluxy Sand consists of calcareous, fossiliferous sandstone. This lithologic change is indicative of a mixed gradational contact. However, boundaries between the two rock types are often abrupt and well defined. It is relatively easy to recognize the contact in the field. Elsewhere, in this area, the contact is interfingering where the Glen Rose Limestone is lenticular and discontinuous within the outcrop (Fig. 5). The upper Glen Rose Limestone beds in Hood, Erath, and Somervell Counties contain as much as 50 percent quartz sand which again indicates a gradational contact (loc. 1, 11, 27). The Glen Rose surface does not appear to have been exposed to subaerial erosion (Van Camp, 1968, p. 18). The contact between the Glen Rose Limestone and the Paluxy Sand in the western part of the study area is also conformable and gradational. In parts of Brown, Comanche, and Mills Counties the upper Glen Rose Limestone is silty marl and the lower Paluxy includes marly siltstone. Bed boundaries between the formations are indistinct and difficult to recognize in the field (loc. 60, 64, 67). The exact placement of the contact in the stratigraphic section in this area is purely academic because the upper Glen Rose Limestone and the lower Paluxy Sand are lateral equivalents. The Glen Rose Limestone is composed of sandy, fossiliferous limestone in Burnet, Coryell, and Lampasas Counties in the southern part of the area of investigation. Formation boundaries are indistinct in this area and the contact is conformable and gradational (loc. 71, 73). The lower Paluxy Sand represents strandline deposits, and the upper Glen Rose Limestone represents nearshore deposits of a regressing early Cretaceous Sea. Therefore, the contact between the formations is the result of regressive onlap (Scott, 1930, p. 52).

PALUXY SAND-WALNUT CLAY CONTACT

The contact between the Paluxy Sand and the overlying Walnut Clay is unconformable throughout most

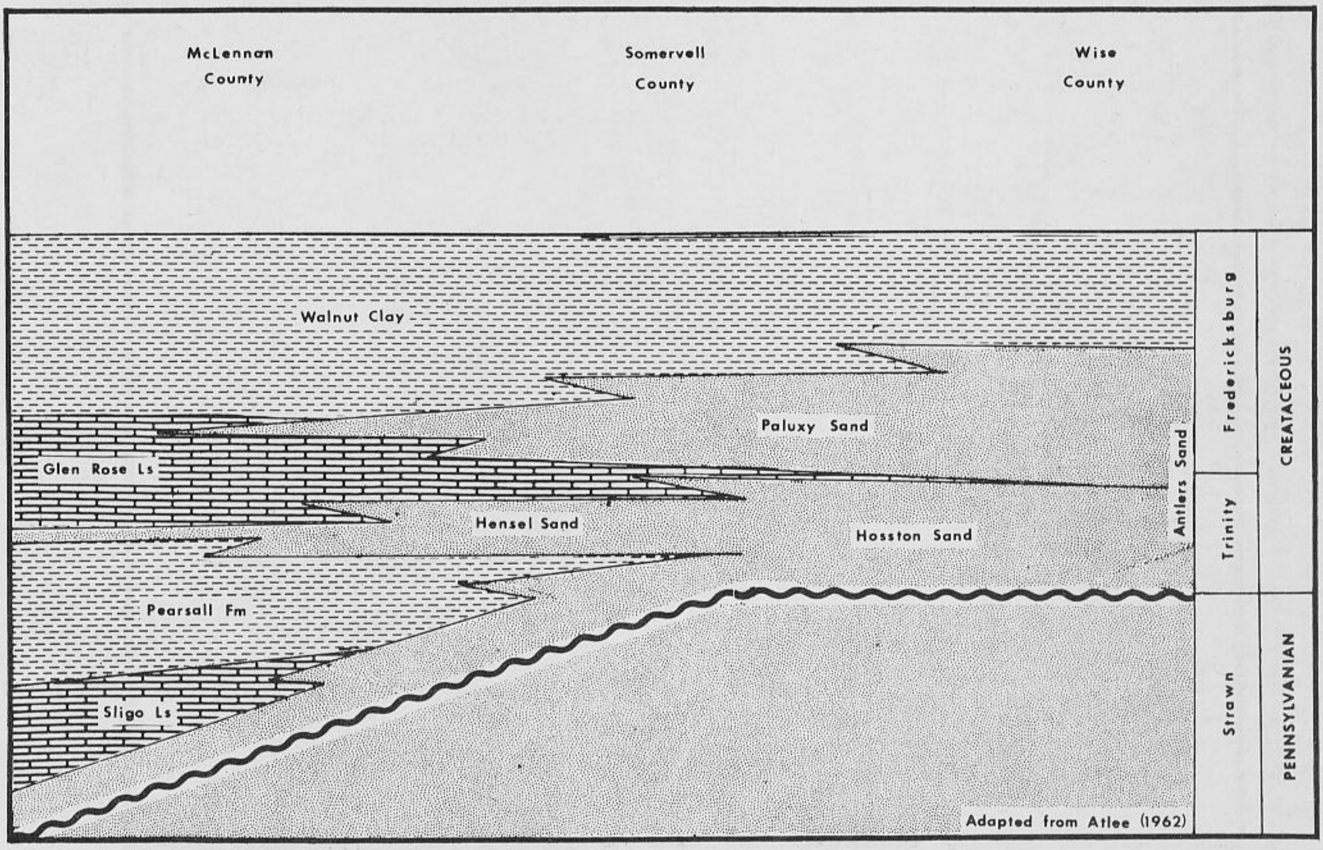

Fig. 2. Diagrammatic facies cross section of the Trinity and Fredericksburg Groups in north-central Texas. *Adapted from* Atlee, 1962.

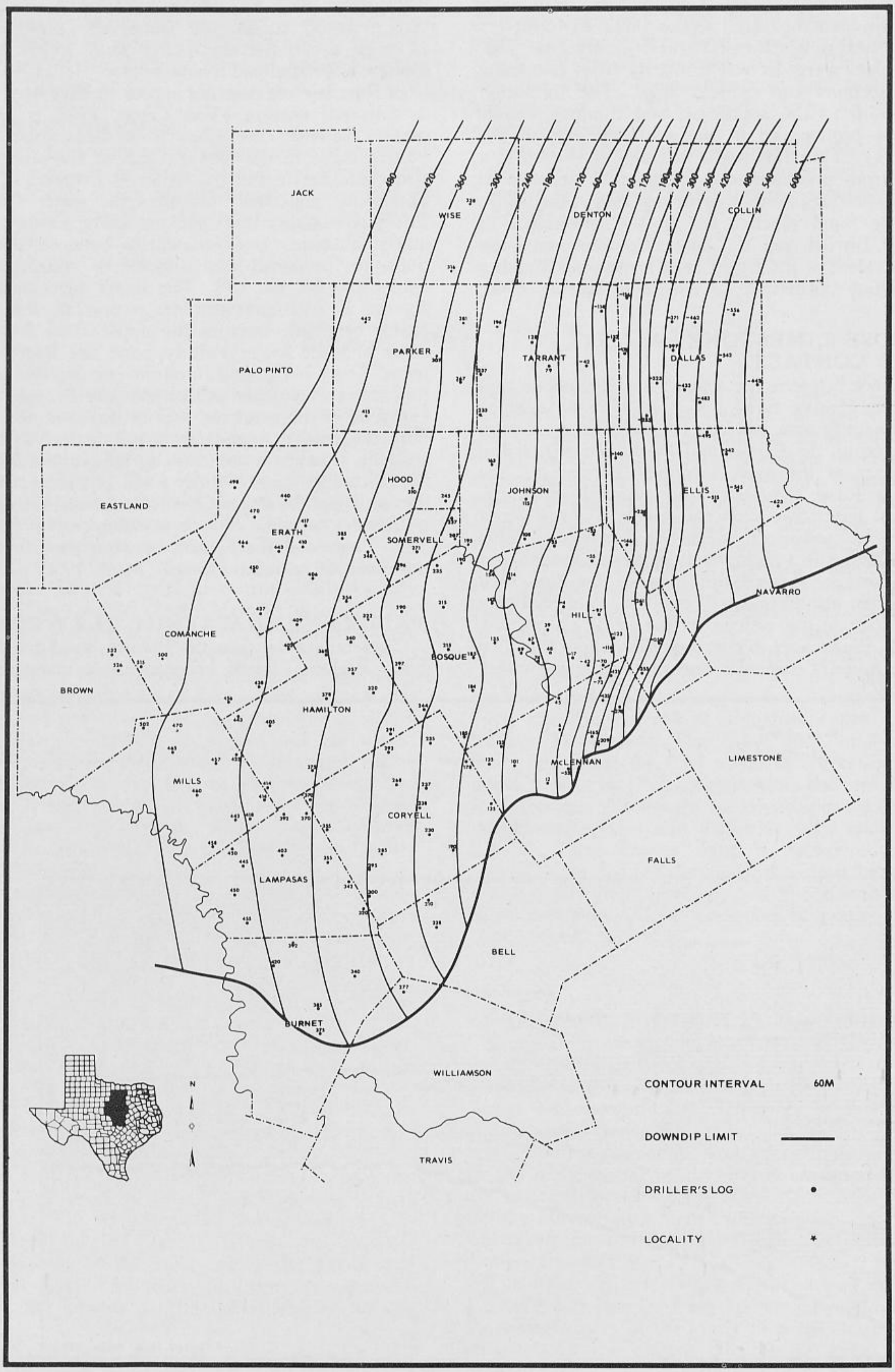

Fig. 3. Structure contour map of top of Paluxy Sand.

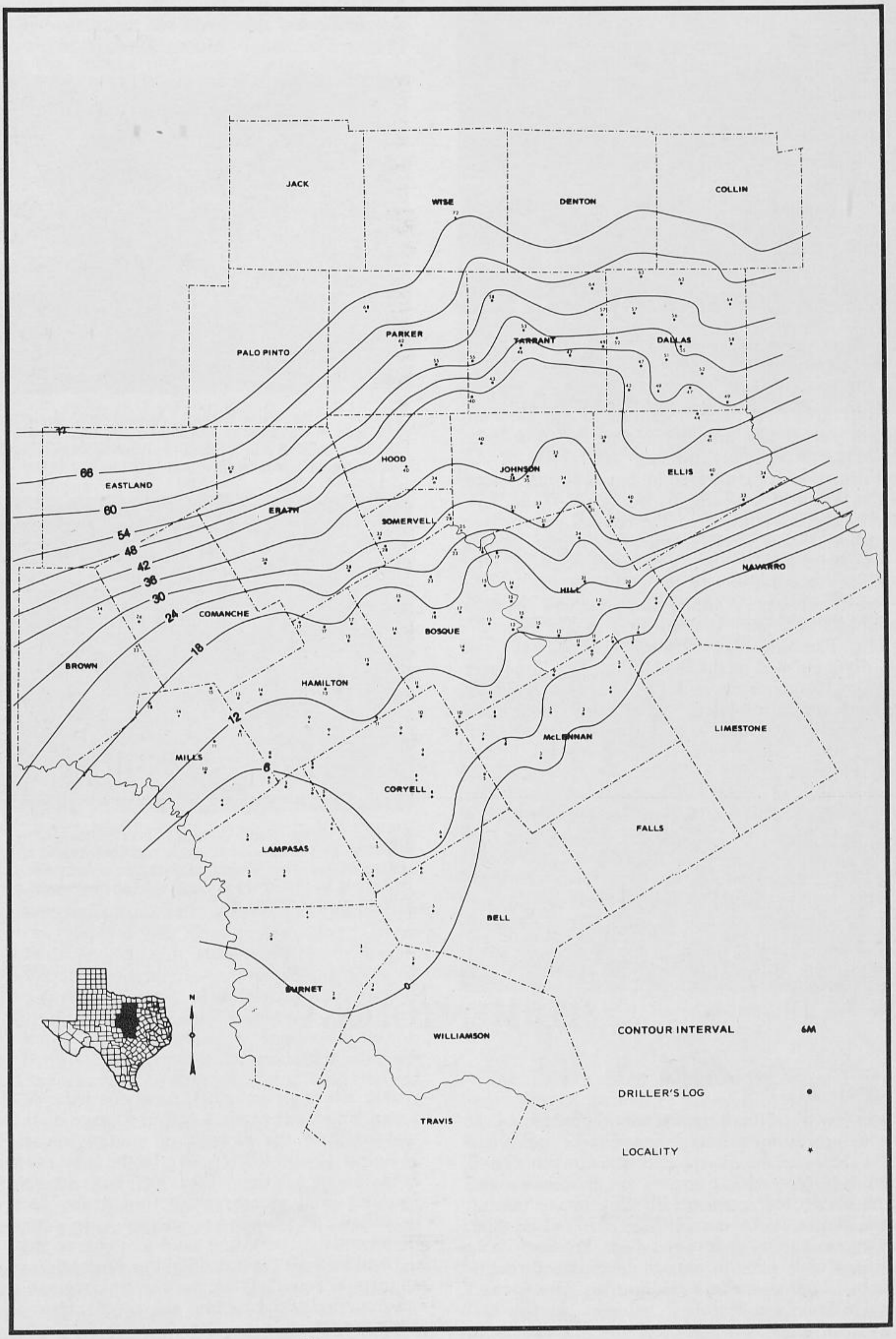

Fig. 4. Isopach map of the Paluxy Sand.

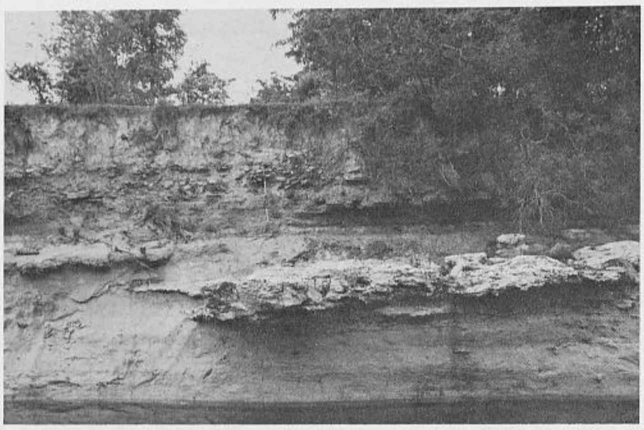

Fig. 5. Glen Rose Limestone-Paluxy Sand contact. The Glen Rose Limestone is discontinuous and interfingers with the Paluxy Sand. Note the abrupt nature of the contact. Locality 80.

of the study area. At many localities in the northern and central part of the area the contact is an angular unconformity. Moderately dipping sand beds of the Paluxy Formation are truncated by horizontal limestone beds of the Walnut Clay (Fig. 6; loc. 3, 16, 45, 52, 78). At other localities in this area the contact occurs in a clay sequence 15 centimeters below the initial fossiliferous limestone bed of the Walnut Formation. The upper Paluxy Sand consists of white, unfossiliferous shale, and the lower Walnut Clay consists of dark shale with characteristic Walnut Clay fauna (loc. 27, 38, 41, 42). The contact is sharp and erosional, and can be easily distinguished in the field (Fig. 7). The lower Walnut Clay contains exceedingly minor amounts of quartz sand indicating that the Paluxy Formation was not extensively reworked during initial Walnut Clay deposition. The Paluxy-Walnut contact in the southern part of the area of investigation is also unconformable and erosional. The basal Walnut Clay contains local concentrations of calcareous cemented sandstone pebbles derived from the Paluxy and the contact is interfingering (loc. 19, 34). The contact between these formations represents a relatively short hiatus with marine units of the Walnut Formation progressively onlapping periodically exposed, contemporaneous, nearshore, terrigenous deposits of the Paluxy Formation (Moore, 1966, p. 26).

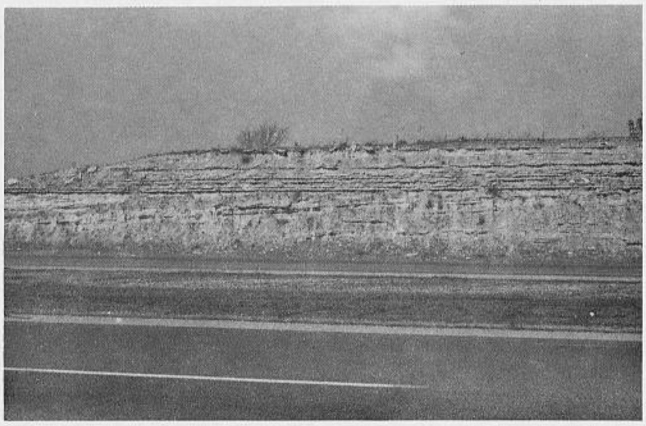

Fig. 6. Paluxy Sand-Walnut Clay contact. Moderately dipping sand beds of the Paluxy Formation are truncated by horizontal limestone beds of the Walnut Formation indicating an angular unconformity. Locality 20.

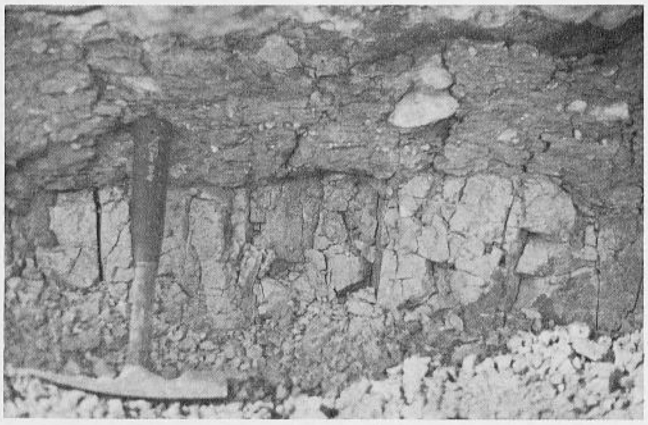

Fig. 7. Paluxy Sand-Walnut Clay contact. The contact is erosional and occurs in a shale sequence below the first limestone bed of the Walnut Formation. Note the white fossil fragments in the Walnut Clay and the absence of fossils in the Paluxy Sand. Locality 41.

SEDIMENTOLOGY

SAND AND SILT

The Paluxy Sand is a quartzarenite composed of homogenous, medium to very fine quartz sand and coarse silt. Most of the quartz grains are monocrystalline, because polycrystalline grains are less stable and tend to be eliminated more readily due to weathering (Pettijohn, Potter, and Siever, 1972, p. 216). Limonite, hematite, pyrite, and magnetite are common constituents of the Paluxy and occur in variable amounts throughout the area. Tourmaline and feldspar are also present but in insignificant quantities.

The average grain size of sediment ranges from fine to very fine sand.* However, medium sand and coarse silt are common throughout most of the study area. Grain sizes reflect the size range of the available material and the amount of energy imparted to the sediment (Folk, 1974, p. 4). In the northern part of the area, average grain sizes are larger, ranging from medium sand to coarse silt, but grain sizes decrease downdip. The southern outcrops are composed predominantly of very fine sand and coarse silt.

Sand and silt from the Paluxy Formation range from angular to rounded, but most grains are sub-angular to sub-rounded. Angular and sub-angular grains are more

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*All sample analyses can be obtained for reproduction costs from Baylor University, Department of Geology.

common in the northern and western parts of the area. Sand and silt grains in the south are generally sub-angular to sub-rounded.

Sands of the Paluxy Formation range from very poorly sorted to very well sorted. However, most sand is moderately to well sorted. The size range of the sediment, type of deposition, and duration of transport are all important factors in determining the sorting index of sediment (Folk, 1974, p. 4). Sand grains in the northern and western parts of the area are very poorly to well sorted, and sediment downdip to the south is well to very well sorted.

Most of the sand and silt in the Paluxy Formation is white, but yellow and red grains are evident at most localities. The yellow and red coloration is due to weathering of hematite and limonite that stain the surrounding quartz grains.

Since the Paluxy Sand is a quartzarenite composed primarily of fine and very fine, sub-angular to sub-rounded quartz sand, it is considered to be at a mature to super-mature textural stage (Folk, 1974, p. 111). These textural stages are indicative of deposits in an area of intense abrasion and sorting, and under quiescent tectonic conditions (Folk, 1974, p. 110). However, these characteristics may also have been inherited from the original source area.

CLAY

Clay is also an important constituent of the Paluxy Formation, especially in the northern part of the area. In parts of Hood, Parker, and Tarrant Counties, clay comprises as much as 50 percent of the Paluxy Formation (loc. 36, 41, 42, 83). Paluxy clays are gray, white, red, purple, brown, and green. The relative occurrence and abundance of the different colors varies locally. All colors are present in the northern part of the area but gray and white clays are prevalent to the south.

In Parker and Tarrant Counties, thick sections of purple, red, green, and brown clay occur in the Paluxy Formation (loc. 36, 41, 42). Color variation results from the presence of iron-bearing compounds at different oxidation states in the clay. Red and purple clays have a ferric/ferrous ratio greater than unity and contain ferric oxide in the form of hematite. Green clays are often found in conjunction with red or purple clays (loc. 36) and generally contain small quantities of large pyrite crystals (Blatt, Middleton, and Murray, 1972, p. 40). The green color is due to differential oxidation states and represents a lesser degree of oxidation. Brown clays are often the result of weathered siderite in the formation (Pettijohn, Potter, and Siever, 1972, p. 272).

Gray clay, which is the predominant color of Paluxy clays, occurs throughout the study area. It is usually represented by thin layers less that 0.5 meter thick (loc. 34, 55, 78, 81, 83). The color is due to the presence of organic matter and is closely related to the percentage of organic carbon (Blatt, Middleton, and Murray, 1972, p. 402).

Quartz, occurring in amounts varying from 40 to 50 percent, is the predominant coarse fraction constituent of the Paluxy clays. Feldspar is also present but usually in amounts ranging between 5 and 25 percent. Montmorillonite is the primary clay mineral in the Paluxy Formation and represents approximately 30 to 40 percent of the clay constituents. Illite and kaolinite are also present but in minor amounts generally comprising less than 10 percent of the clay.

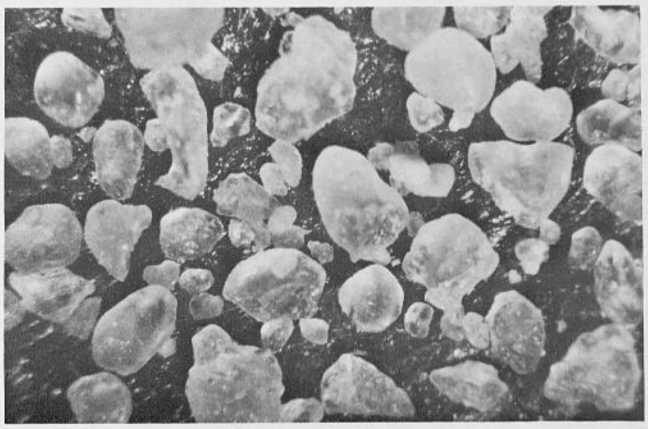

Fig. 8. Frosted, well-rounded sand grains occurring in conjunction with polished, angular sand grains. Locality 15.

PROVENANCE

Sand and silt from the Paluxy Formation have been derived from more than one source. This fact is indicated by the presence of frosted, well-rounded grains in conjunction with polished, angular grains (Fig. 8), bimodal grain size distribution (Fig. 9), and the occurrence of medium, well-rounded sand only in the eastern and northern part of the area.

Fig. 9. Bimodal grain size distribution, fine sand and coarse silt. Locality 41. (x 31.5)

The Paluxy Sand is a multicycle sand which has been derived primarily from the Antlers Sand that merges with it in the western and northern part of the area (Fig. 2). However, the original source area for the Paluxy Sand includes Pennslyvanian and older Paleozoic strata in central Texas and the Arbuckle-Ouachita uplifts in Arkansas and Oklahoma (Atlee, 1962, p. 18). Plutonic quartz, with scattered vacuoles, microlites, and straight to slightly undulose extinction is the predominant quartz type in the Paluxy Sand. Volcanic and vein quartz also occur but are less abundant in most samples. Plutonic quartz originates from granite batholiths or granitic-gneisses, and volcanic quartz is reworked from rhyolites (Folk, 1974, p. 71).

The Arbuckle Mountains contain large exposures of Precambrian granite and rhyolite and are the probable source for the plutonic and volcanic quartz of the Paluxy Formation. The Ouachita Mountains also probably contributed quartz to the Paluxy Sand but to a lesser degree.

PALEONTOLOGY

The paleontological content of the Paluxy Formation is highly restricted in abundance and occurrence, and varies locally with depositional environments. The fauna are most common in the eastern and southern part of the area, whereas the flora become increasingly significant to the west and north. These distributions are due to a transition from predominantly marine deposits to the east and south to fluvial deposits to the west and north.

Pelecypods are the dominant megafossils in the Paluxy Formation and have been reported throughout much of the area. *Exogyra texana* is one of the most common pelecypods and has been described in central Parker County (Hendricks, 1957, p. 35) and also in Burnet County (Moore and Martin, 1966, p. 985). Other pelecypods, including *Trigonia* (loc. 65, 81), *Cardium* (loc. 83), *Protocardia* (loc. 19, 60, 83), and *Ostrea* (loc. 44, 50), are present in the Paluxy Formation but are restricted in occurrence and abundance. Gastropods are also significant paleontological constituents of the Paluxy Sand. However, *Turritella* and *Tylostoma* (Fig. 10; loc. 24, 65), *Actaeonella* (Moore and Martin, 1966, p. 985), and *Vicarya* (Atlee, 1962, p. 17) are the only gastropod genera that have been identified. Their occurrence is limited to the eastern and southern parts of the area. Serpulid worm tubes are also present in the Paluxy Sand but are restricted in occurrence to southern Parker and northern Hood Counties (loc. 79, 81, 83). Microfossils from the Paluxy Formation include Foraminifera, Ostracoda, and Conchostraca. *Textularia* and *Globotruncana* are the only Foraminifers that have been identified and are present in the eastern part of the area (loc. 11). The only recognized ostracode, *Cypridea wyomingensis,* occurs in northern Mills County along State Highway 16 north of Priddy. However, other ostracodes have been reported from different localities within the area of investigation (Atlee, 1962, p. 14). Conchostracans or clam shrimps have been identified from four localities in the northern part of the area. Brackish water forms have been reported at Azle in Tarrant County and on the Lewis farm southeast of Decatur in Wise County. Fresh water forms were found at Kings Creek in Montague County and northwest of Decatur on the Butler farm in Wise County (Tasch, 1967, p. 257).

Fig. 10. Gastropods and pelecypods from the Paluxy Formation. Note the dominance of the gastropod *Turritella.* Locality 24.

Fossil turtle bones, gar teeth, and unidentified vertebrate teeth and plates are present in the Paluxy Sand in northern Mills County (Atlee, 1962, p. 17). Shark and ray teeth, frog and salamander bones, and several specimens of fish bones including *Pycnodontiae* occur in Parker and Wise Counties (Tasch, 1967, p. 257). Premolars and molars from the Cretaceous triconodont, *Astrocondodon denisoni* have also been reported in the study area. These mammals were semi-aquatic and lived around brackish water bays (Slaughter, 1969, p. 107).

Large concentrations of silicified, carbonized, and pyritized fossil wood are common throughout most of the area and are particularly abundant in the north and west. The wood occurs as large logs up to one meter long (loc. 36, 53) or as smaller fragments disseminated throughout the sand (loc. 36, 38, 41, 44, 82). Imprints of leaves from dicotyledonous flowering plants are present northwest of Stephenville in Erath County. The identified genera include *Cinnamomum, Sapindus, Aralia, Sassafras, Benzoin, Sterculia, Artocarpus,* and *Acer.* These fossil leaves represent one of the earliest known occurrences of angiosperms (Ball, 1937, p. 529). Gymnosperms have also been reported in the Paluxy. Specimens of *Cycadeoidae barti* and *Cycadeoidea johnstoni* are present north of Comanche in Comanche County and near Stephenville in Erath County (Wieland, 1931, p. 394).

DEPOSITIONAL ENVIRONMENT

LAKE MERRITT MEMBER

The Lake Merritt Member crops out throughout most of the area of investigation (Fig. 11) and is characterized by thin horizontal sand beds alternating with thin clay beds. Sand beds are generally less than 30 centimeters thick, and clay beds have an average thickness of 20 centimeters. In the northern part of the area this member has an average thickness of 5 meters. It thins slightly along strike (Fig. 12) and downdip but has a remarkably uniform thickness throughout most of the northern (Fig. 13) and central parts of the area (Fig. 14). In northeast Bosque County, the Lake Merritt Member consists of 4.6 meters of horizontally bedded sand (loc. 27), and in southwestern Coryell County it is represented by 3.1 meters of interbedded sand and clay (loc. 19). In the southern part of the area, it becomes indistinguishable from the other members of the Paluxy Formation (Fig. 15).

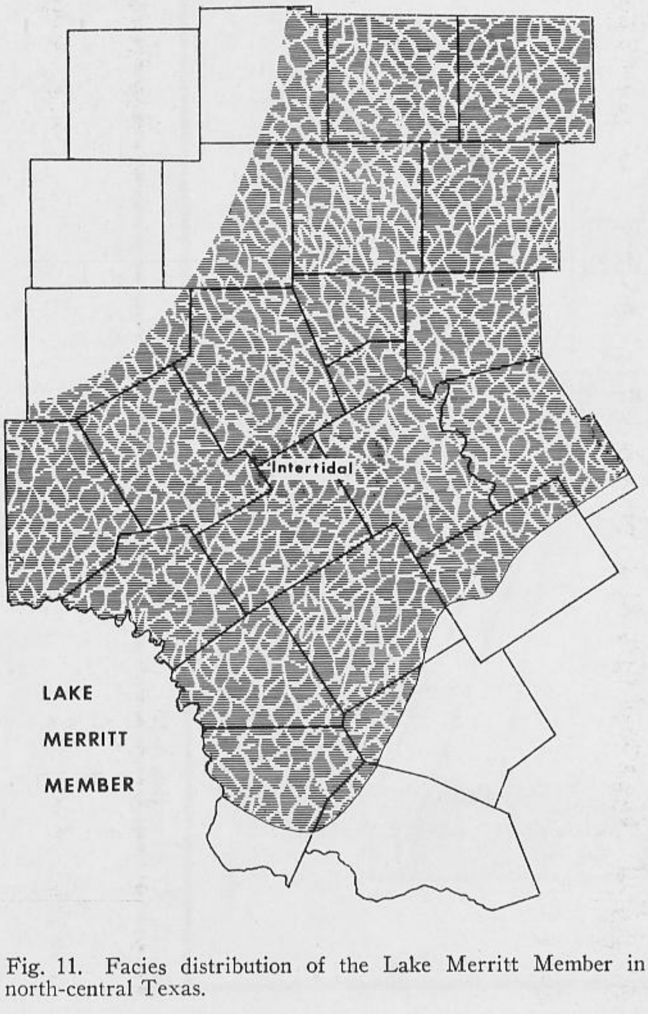

Fig. 11. Facies distribution of the Lake Merritt Member in north-central Texas.

Petrology

The Lake Merritt Member is composed predominantly of very fine sand and coarse silt. Fine sand also is present at several localities but is not characteristic of this member. Sediment is generally sub-angular to sub-rounded and well sorted to very well sorted (Fig. 16). Sand and silt in the western and northern part of the area tend to be slightly more angular due to proximity to the source area. Most of the sand and silt is loosely compacted but indurated beds with calcite cement locally are present. The uppermost bed of the Lake Merritt is typically an indurated sandstone with borings and ripple marks (loc. 15, 27, 37, 39, 55).

Limonite and hematite are present throughout the Lake Merritt Member in variable amounts. Magnetite is the most abundant heavy mineral and occurs at most localities. Near the base of the Lake Merritt, in the eastern part of the area, is a platy bed of pyrite occurring approximately 5 centimeters above the Glen Rose Limestone (loc. 11, 27, 76). The occurrence of pyrite indicates deposition under anaerobic conditions and is characteristic of fine-grained shallow marine sediments enriched in organic material (Berner, 1971). This pyrite bed could also be of secondary origin.

Clay is a common constituent of the Lake Merritt Member and is predominantly gray with large amounts of sand, silt, and organic material. It is usually well laminated and contains variable amounts of fossil and wood fragments. Shale, exhibiting similar characteristics, is also present but is not as common.

Depositional Environment

The Lake Merritt Member was deposited in an intertidal or tidal flat environment, indicated primarily by characteristic sedimentary structures. Tidal flat deposits are transported and deposited by tidal currents and are most extensive in areas with appreciable differences between low and high tide. Tidal flats develop along gently dipping coasts with marked tidal rhythms where sediment is available and wave action is weak (Reineck and Singh, 1975, p. 355). The intertidal environment of the Lake Merritt Member probably developed along an open sea where wave activity was reduced due to a long subtidal zone. This environment is indicated by the presence of planktonic foraminifera, such as *Textularia* and *Globotruncana*, in the member (loc. 11, 15). The thickness of the tidal flat sequence and the sedimentary structures suggest a moderate to large tidal range for the regressing Early Cretaceous Sea. The predominance of sand over silt and clay also indicates a large tidal range and strong current velocities. Deposition of this member probably occurred very rapidly because the present rates of sediment accumulation on modern tidal flats is very rapid (McKee, 1957, p. 1739).

Intertidal flats are traditionally divided into sand flats, mixed flats, and mud flats. Distribution of sediment on a tidal flat results from differences in energy and transporting mechanisms (Reineck and Singh,

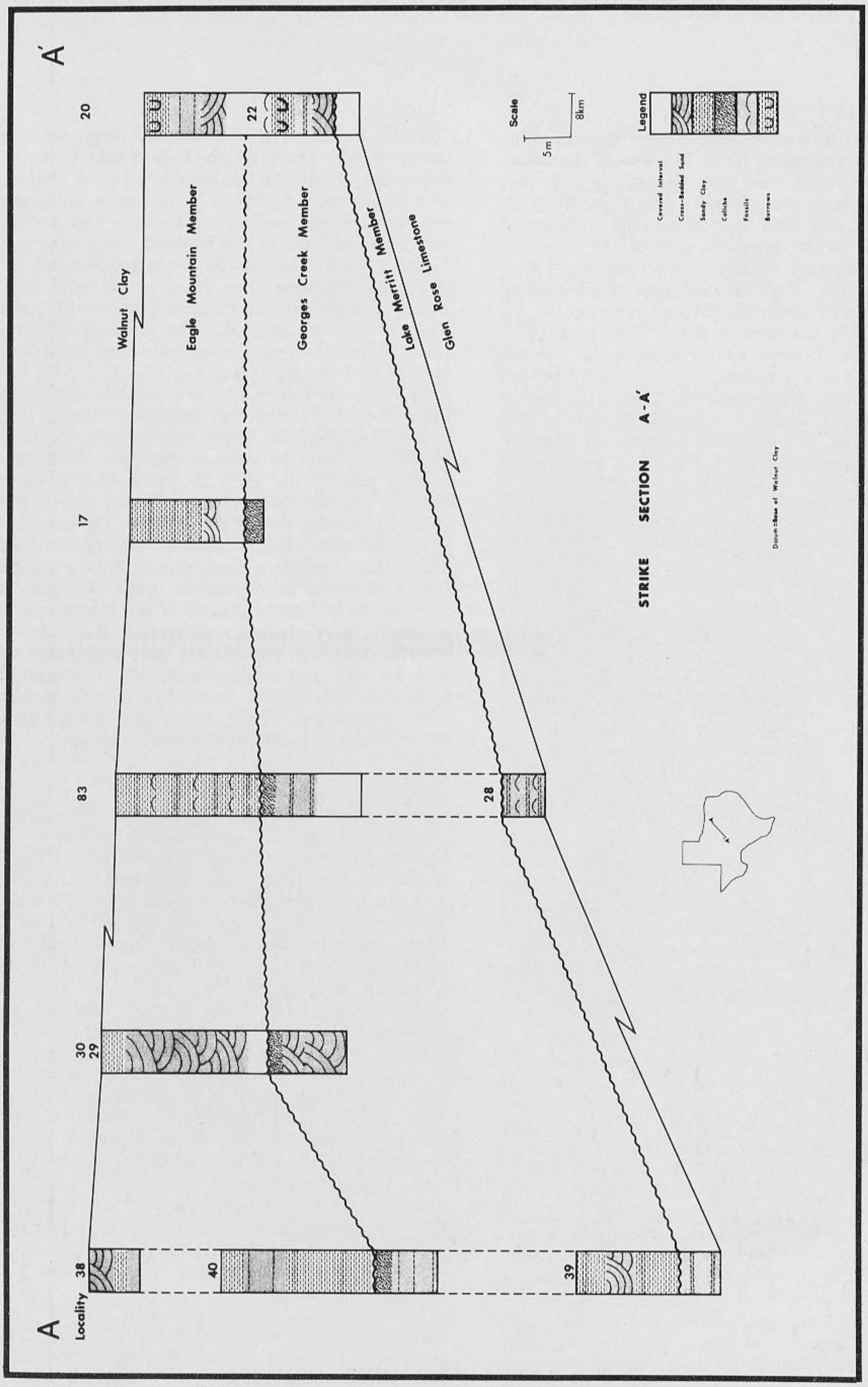

Fig. 12. Cross section A-A′.

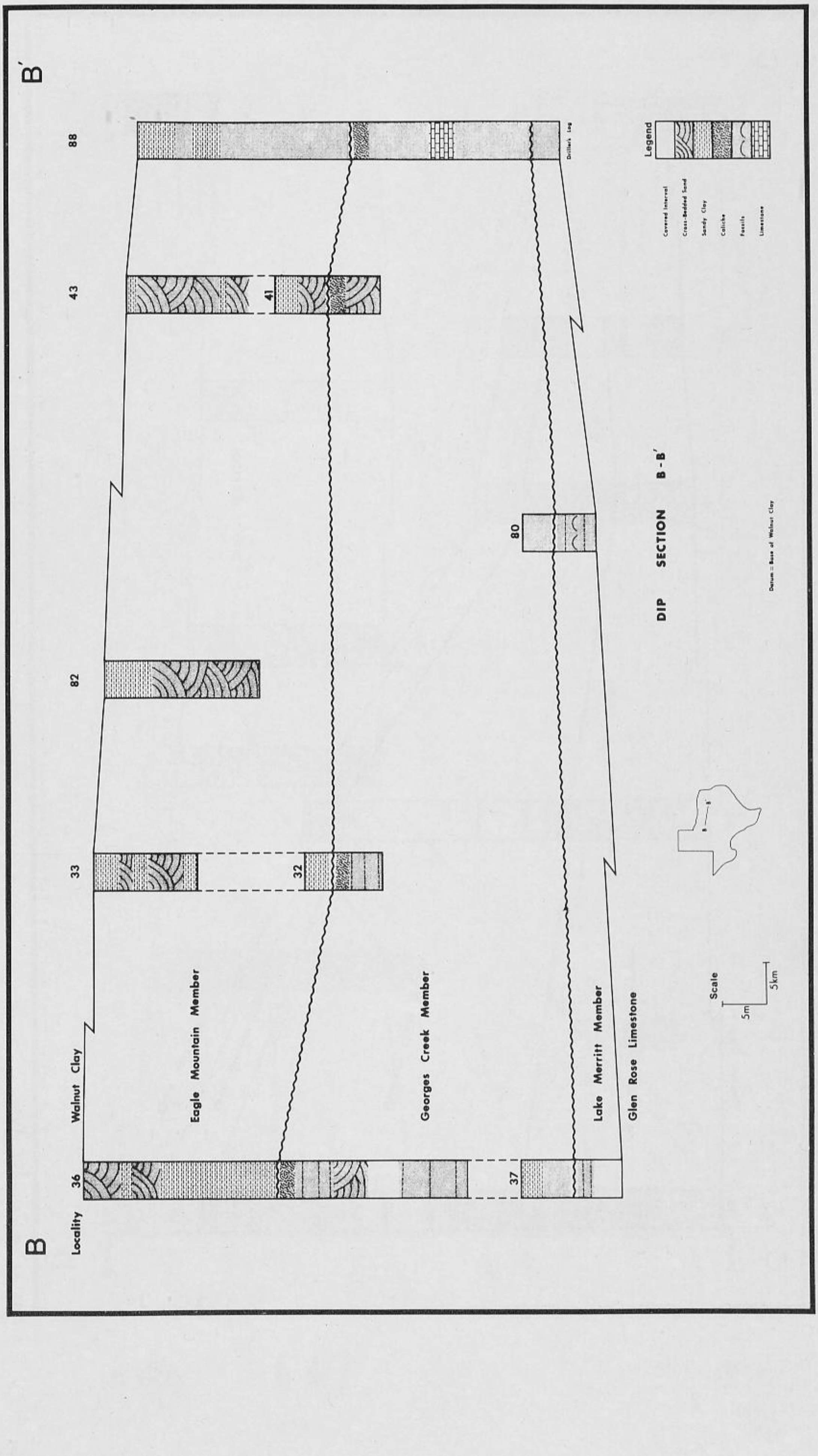

Fig. 13. Cross section B-B′.

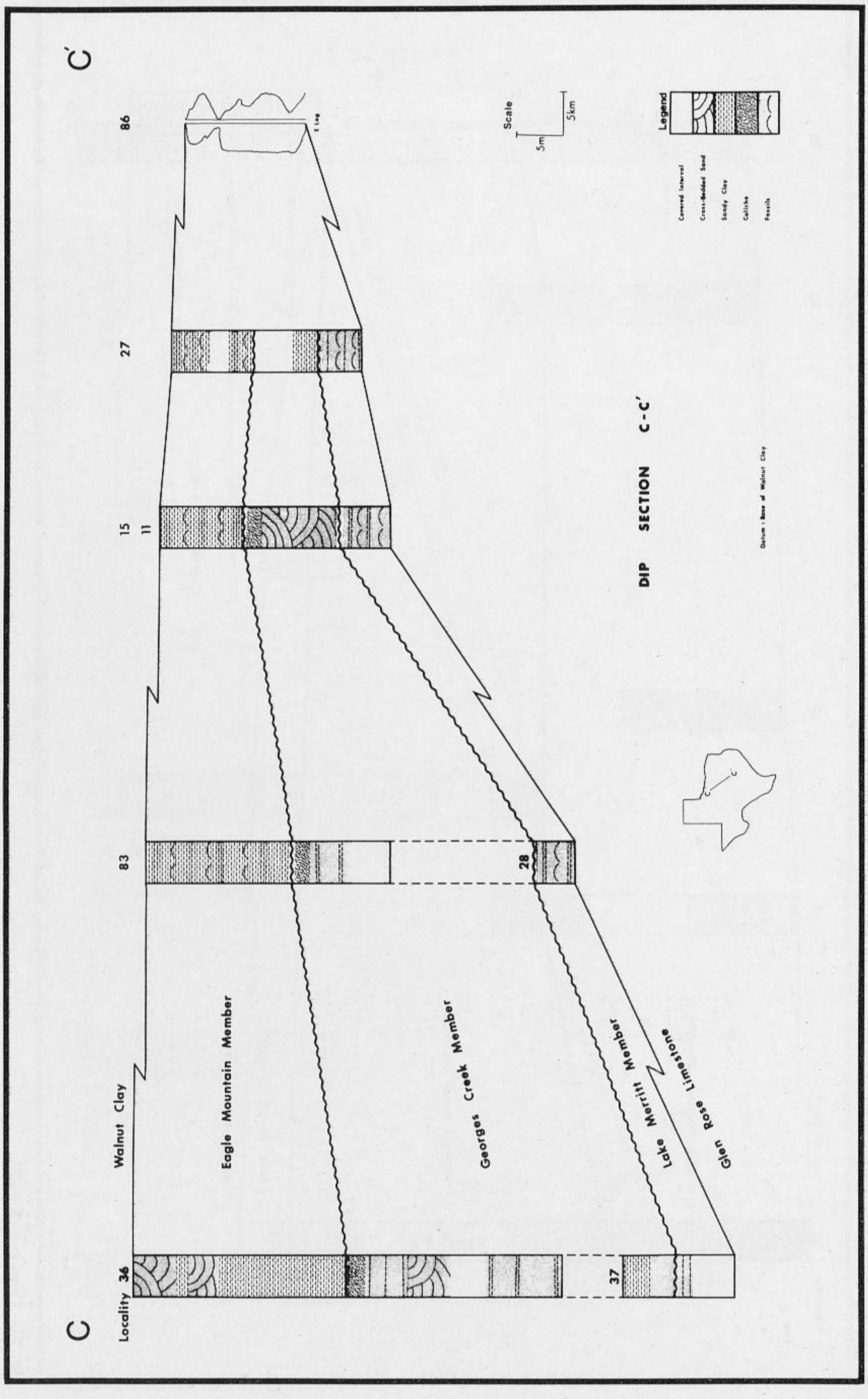

Fig. 14. Cross section C-C'.

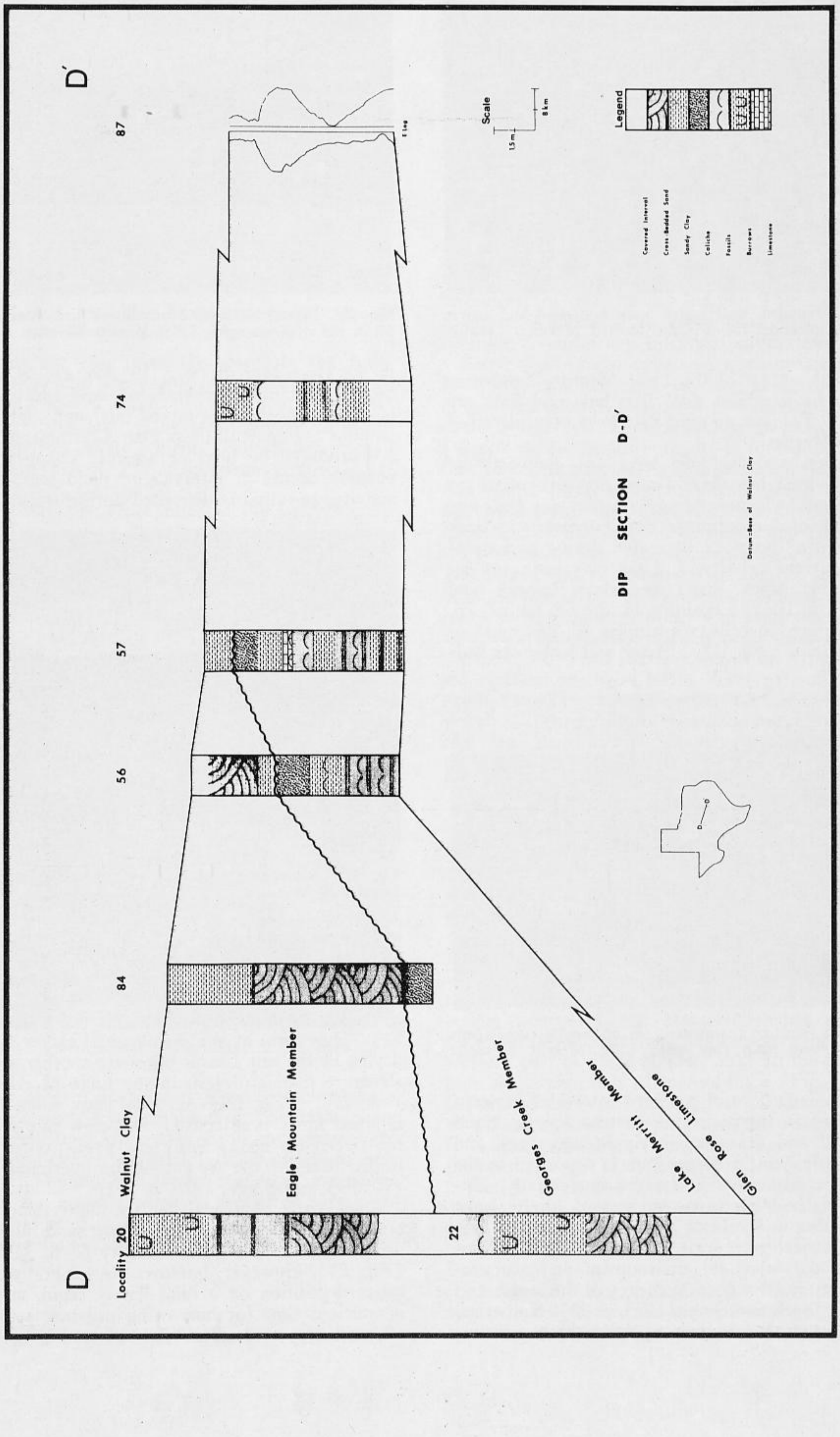

Fig. 15. Cross section D-D'.

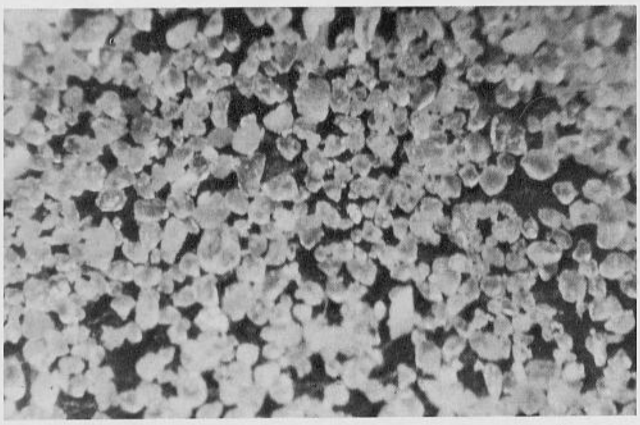

Fig. 16. Sub-rounded, well sorted very fine sand and coarse silt from the intertidal facies. Lake Merritt Member. Locality 19. (x 31.5)

1975, p. 358). Most of the Lake Merritt Member is represented by a mixed tidal flat, but mud flats are also evident. To date, no sand flats have been identified in the Lake Merritt.

Stratification and bedding form are diagnostic of mixed tidal flat deposits. These deposits occur as horizontal sand beds alternating with thin clay beds and are the result of alternation of tidal currents and slack water. The sand beds are deposited during periods of wave and current activity, and the clay beds are deposited during slack water periods (Reineck and Singh, 1975, p. 107). Localities 11, 39, 55, 64, 67, 76, and 80 exhibited excellent examples of this type of stratified bedding (Fig. 17). Flaser and lenticular bedding are also indicative of a mixed intertidal environment and form during periods of current activity. Sand is transported and deposited in ripple structures, and mud, previously held in suspension, is deposited in the ripple troughs during pauses in current activity. Examples of this bedding type are present in the Lake Merritt Member at localities 37, 39, 55, and 64 (Fig. 18). Asymmetrical wave-formed ripple marks are common to a mixed intertidal environment and are produced by different transporting energy of the swash and backwash (Reineck and Singh, 1975, p. 23). Numerous examples of asymmetrical wave ripple marks are present in the Lake Merritt (Fig. 19; loc. 11, 28, 37, 39, 55, 64, 67). Thinly interlaminated sand and mud bedding is also diagnostic of a mixed tidal flat. Sand and mud laminae are generally less than 3 centimeters thick and are produced by tidal or seasonal changes. Sand deposition occurs at intervals of flood and ebb current activity, and mud is deposited during stationary phases of high-water and low-water tides (Reineck and Singh, 1975, p. 108). Horizontal mud-filled laminae are well displayed at locality 67 (Fig. 20). Desiccation cracks are also common to an intertidal environment and occur at several localities in the Lake Merritt (loc. 15, 27, 49, 51). They form by the shrinkage of clayey beds due to drying by the sun. Clastic dikes are another sedimentary structure that is present in the Lake Merritt Member (loc. 27). They form on tidal flats when mud, in a liquified form, is injected from below into fractures in the overlying beds. Sufficient pressure for injection is produced by the weight of the overlying sediments (Reineck and Singh, 1975, p. 50).

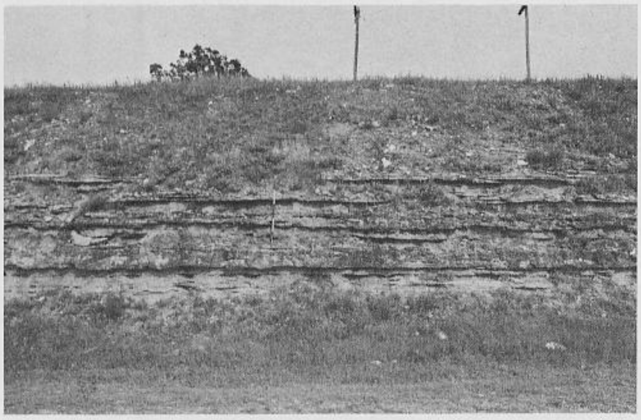

Fig. 17. Tidal bedding composed of horizontal sand beds alternating between thin clay beds. Lake Merritt Member. Locality 67.

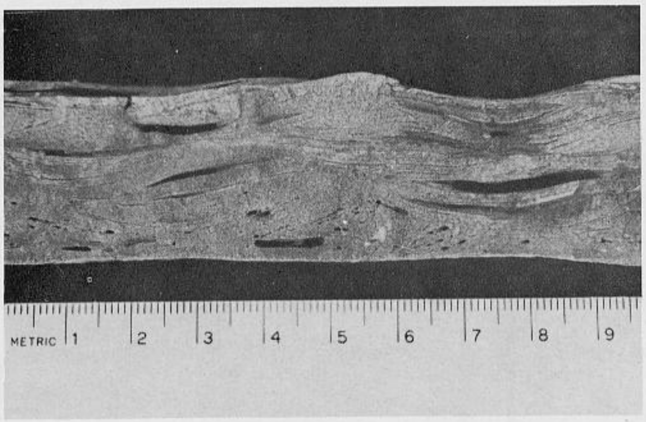

Fig. 18. Flaser bedding. Mud flasers are discontinuous and fill in the ripple troughs. Lake Merritt Member. Locality 39.

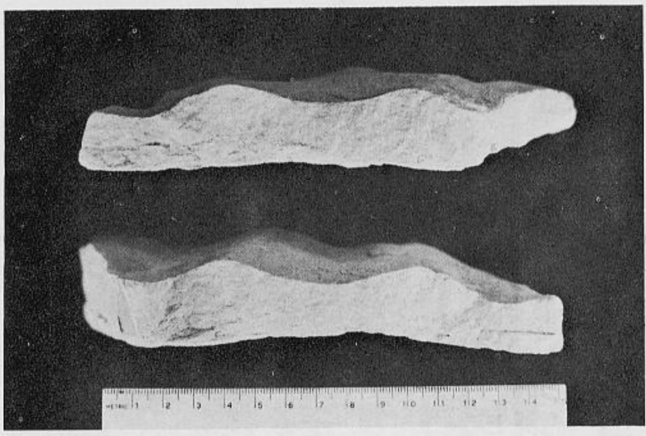

Fig. 19. Asymmetrical wave-formed ripple marks. Lake Merritt Member. Locality 56.

Many parts of a tidal flat are highly bioturbated by bottom dwelling organisms. Many sand-filled burrows occur in the clay units at locality 67 in Mills County (Fig. 21). However, burrows are generally scarce because deposition on a tidal flat is rapid, and there is insufficient time for burrowing organisms to establish a significant community (Reineck and Singh, 1975, p.

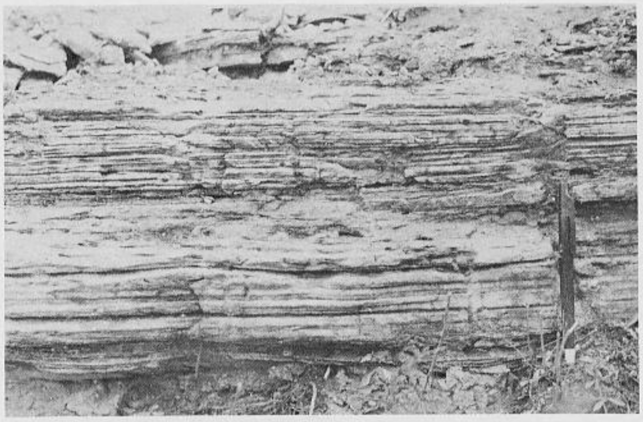

Fig. 20. Horizontal mud-filled laminae alternating between sand laminae. Lake Merritt Member. Locality 67.

150). Fossils are also relatively scarce in the Lake Merritt Member and are usually represented by fragments or void spaces. Many of the fossil fragments probably have been leached by secondary groundwater and redeposited as calcite cement. Limited quantities of fossil fragments are present in this member at localities 11, 15, 19, 27, 28, 60, and 65.

Mud tidal flats are represented in the Lake Merritt Member but are not as prevalent as mixed tidal flats. Mud flats are typically characterized by thick laminated mud with thin sandy intercalations (Reineck and Singh, 1975, p. 359). Localities 19, 60, and 65 are comprised of laminated, sandy clay with thin lenticular sand beds and represent mud flats of the Lake Merritt Member. Variable fossil concentrations and burrows are also common at these localities.

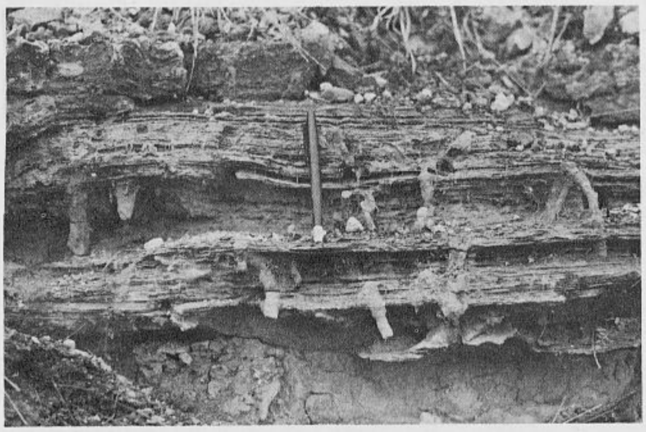

Fig. 21. Sand-filled burrows. Lake Merritt Member. Locality 67.

The Lake Merritt Member is also represented by a beach environment in several areas. The most characteristic sedimentary structures of this environment are large and small-scale, low-angle planar cross-bed sets (loc. 2, 51). The angle of inclination of the cross-bed sets reflects the original slope of the beach foreshore. Heavy mineral laminae and tidal channels with bimodal cross-bed orientation are also present in this environment (loc. 1, 2, 51).

ANALOG

Klein (1970) considers the Precambrian quartzite of Scotland to represent an intertidal and subtidal environment. It consists of a well-sorted orthoquartzite which is extensively cross-bedded. Thin laminae of mudstone, wavy flaser bedding, clay-filled ripple marks, mudcracks, and burrows are also common features of this environment. Klein (1971) also believes the lower member of the Wood Canyon Formation in Nevada was deposited in an intertidal environment. Diagnostic characteristics of this member include herringbone structure, current and interference ripple marks, and tidal bedding. These two examples of ancient intertidal deposits function as a depositional model for the Lake Merritt Member. Adequate examples of ancient tidal flats were infrequent in the literature surveyed, so two examples were needed to represent accurately the intertidal environment of the Paluxy Sand. The Lake Merritt Member is intended to serve as a well documented example of an ancient intertidal environment.

Some of the most extensive work on modern intertidal sedimentation has been done along the shorelines of the Netherlands, Germany, and England in the area of the North Sea. Reineck and Singh have constructed a hypothetical composite model of intertidal sedimentation based on previous investigations in this area. In this model three subenvironments are present: sand flat, mixed flat, and mud flat. Very fine sand with ripple marks, herringbone structure, and flaser bedding typify the sand flat (Reineck and Singh, 1975, p. 370). The mixed flat is composed of thinly interlaminated sand and mud, flaser and lenticular bedding, shell layers, and moderate bioturbation. The mud flat consists of mud with occasional lenticular sand lenses and strong bioturbation. Tidal flat deposits in the North Sea area are excellent analogies to the lower part of the Paluxy Formation. The Lake Merritt Member contains most of the sedimentary characteristics found in these deposits and was formed in a similar intertidal environment.

GEORGES CREEK MEMBER

The Georges Creek Member directly overlies the Lake Merritt Member and crops out throughout most of the area of investigation. It is composed of fluvial and subtidal facies (Fig. 22). The fluvial facies is present in the northern and central parts of the area and is characterized by thick sections of extensively cross-bedded sand, and red and white siltstone and clay. It grades downdip to the south into a subtidal facies which is composed of fossiliferous sandstone and limestone.

The Georges Creek Member reaches a maximum thickness of approximately 43 meters in the northwestern part of the area (loc. 36). In the northeastern part of the area it is 31 meters thick (Fig. 13), and in the central part thins downdip to 9.2 meters (Fig. 14). The Georges Creek Member also thins along strike and is 11 meters thick in Comanche County (Fig. 11). In the southern part of the area, the Georges Creek is only 2 meters thick and becomes increasingly difficult to differentiate from other members of the Paluxy Formation (Fig. 15).

PETROLOGY

The fluvial facies of the Georges Creek Member consists primarily of fine and medium sand (Fig. 23); however, very fine sand and coarse silt also occur in variable

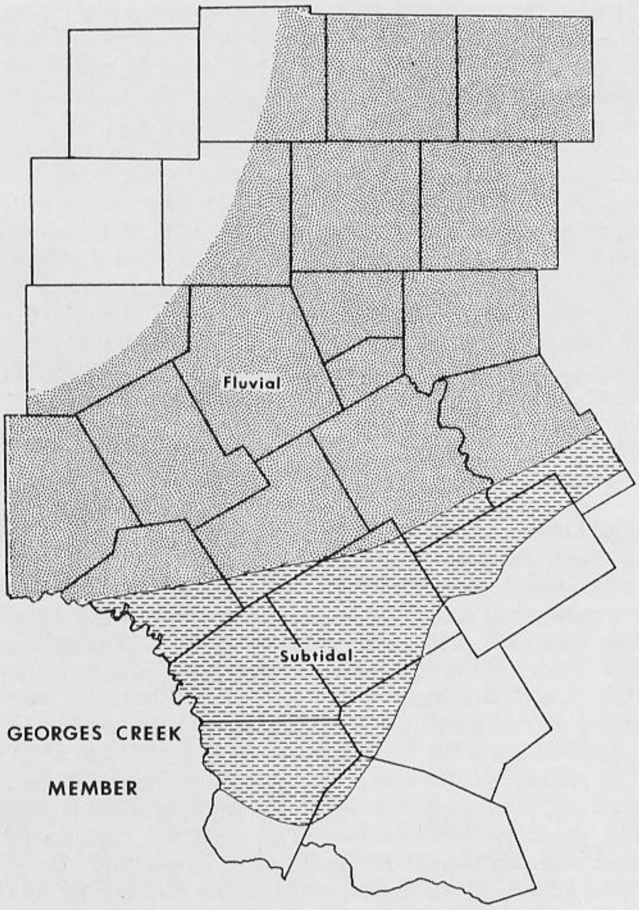

Fig. 22. Facies distribution of the Georges Creek Member in north-central Texas.

amounts. Sand and silt range from angular to well-rounded but most grains are sub-angular to sub-rounded. Well-rounded sand grains are more common in the eastern part of the area (loc. 15, 43). Sediment in this facies ranges from poorly sorted to well sorted, but moderately sorted sand and silt predominate. It is difficult to characterize sand and silt from the fluvial facies of the Georges Creek Member because the sediment is extremely variable within the outcrop.

Hematite and limonite are common minerals in the fluvial facies, particularly in the northern part of the area. In parts of Erath, Parker, and Wise Counties, thick sections of red, hematite-stained siltstone are typical of the Georges Creek Member. Iron concretions containing large amounts of pyrite, hematite, and limonite are also characteristic of this member. Feldspar is present but in minor amounts. Clay is typically red, but white and gray clay are also abundant at most localities. Most of the clay in this facies contains large amounts of sand and silt, wood fragments, and organic material.

Sediment in the subtidal facies of the Georges Creek Member is composed of well-sorted, very fine sand and coarse silt that is sub-angular to sub-rounded (Fig. 24). Clay and shale are predominantly gray with varying quantities of sand and silt, fossil fragments, and organic material.

Depositional Environment

Fluvial The fluvial facies of the Georges Creek Member was deposited in a braided stream system characterized by channel bars and floodbasin deposits. Braided stream systems consist of interconnecting networks of low sinuosity channels and are most common in arid or semiarid regions (Selley, 1970, p. 24). In these areas, erosion is rapid, discharge is large and sporadic, and vegetation is limited. Because of these factors, rivers become overloaded with sediment and cut channels which are immediately choked in their own detritus (Selley, 1970, p. 24). Channel bars are formed in this manner, dividing the channel into two new ones.

Longitudinal and transverse channel bars are the most common sedimentary features of a braided stream. Longitudinal bars form when the river is unable to carry its coarsest fraction. Deposition results and the coarse sediments trap finer particles and gradually build a ridge. By continued entrapment, the ridge builds upward and laterally, and becomes exposed during low water levels. This results in diversion of water flow around the channel bar. Longitudinal bars consist of poorly sorted, cross-bedded sand and are usually not preserved in the geologic record. Transverse bars form when sediment becomes deposited in depressions on the channel floor, and grow by downstream migration of foreset beds perpendicular to the current (Smith, 1970,

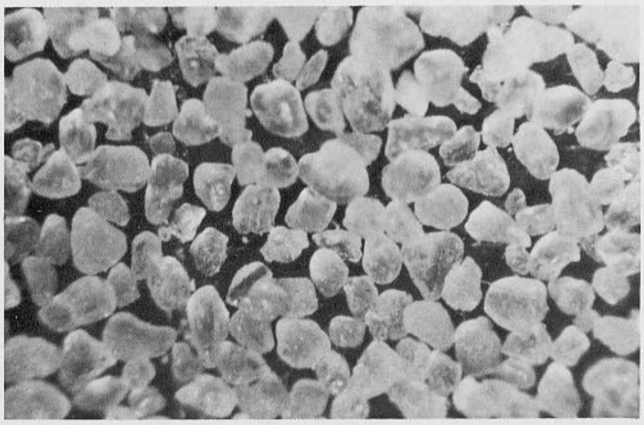

Fig. 23. Sub-angular, moderately sorted medium and fine sand from the fluvial facies. Georges Creek Member. Locality 43. (x 31.5)

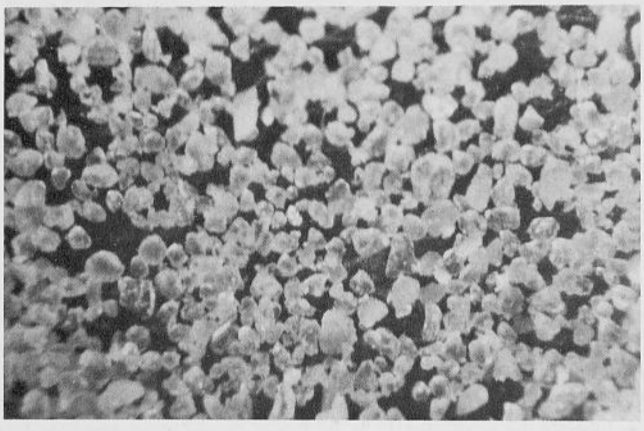

Fig. 24. Sub-angular, well sorted very fine sand and coarse silt from the intertidal facies. Georges Creek Member. Locality 22. (x 31.5)

p. 2994). These channel bars are better sorted than longitudinal bars and are composed of cross-bedded and horizontally stratified sand. Longitudinal and transverse bars are difficult to differentiate in ancient deposits. However, most of the channel deposits in the Georges Creek Member probably represent transverse bars as interpreted from the pronounced cross-bed sets and horizontal sand beds.

The most characteristic sedimentary structure of the channel bars in the fluvial facies of the Georges Creek Member is high-angle, unidirectional planar cross-bedding (Fig. 25; loc. 15, 43). This structure forms by the downcurrent migration of avalanche faces at the margins of transverse bars (Smith, 1972, p. 625). Foreset beds, with dip angles between 30 and 35 degrees, generally consist of alternating coarse and fine laminae and result from avalanching of previously sorted sediments (loc. 15, 36, 43). Variations in dip angles may result from changes in flow regime or by shifting strike direction or irregular bars (Smith, 1972, p. 628). Trough cross-stratification (Fig. 26; loc. 15) is also common on transverse bars and forms by the downstream migration of channel bars (Ore, 1964, p. 11). Channels eroding across bar tops are consequently filled with sediment and asymmetrical trough cross-bedding results (loc. 15). Trough cross-bedding is common at most localities in the Georges Creek Member. Tops of transverse bars often contain current or lingoid ripple marks with discontinuous crests and forward closure. Crests become lobate with increasing depositional energy (Reineck and Singh, 1975, p. 31). Locality 43 contains an excellent example of current ripple marks on top of a transverse bar (Fig. 27). Feeding trails and burrows along with ripple marks also occur on the tops of channel bars (loc. 81) and are formed during low-water periods when the top of the bar is periodically exposed (Fig. 28).

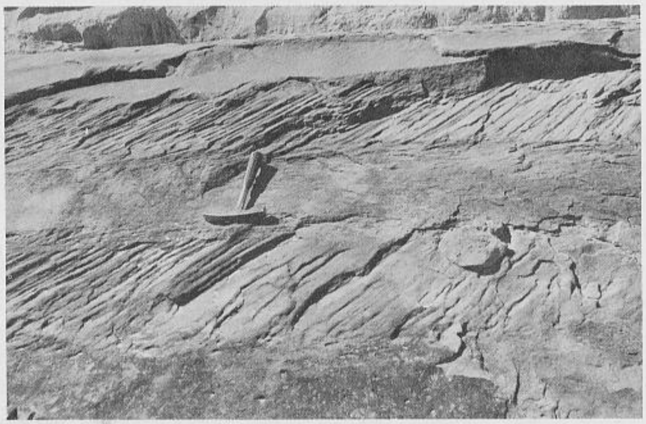

Fig. 25. High-angle, unidirectional planar cross-bedded sand. Georges Creek Member. Note the erosional bounding surface of the cross-bed sets. Locality 43.

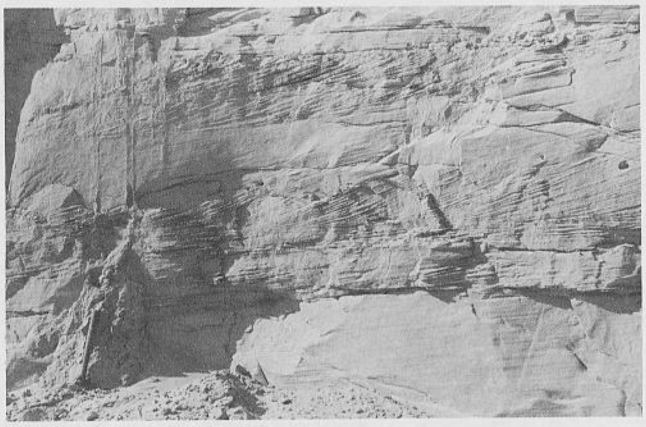

Fig. 26. Trough cross-bedded sand. Georges Creek Member. Note the asymmetry of the cross-bed sets. Locality 15.

Fig. 27. Lingoid ripple marks with discontinuous crests. Georges Creek Member. Current direction is toward the top of the figure. Locality 43.

Fig. 28. Feeding trails on the bottom of a sand bed. Georges Creek Member. Locality 81.

Horizontal, parallel stratification occurs in channel deposits of braided streams and is well represented in the fluvial facies of the Georges Creek Member (Fig. 29). Thin sand beds are deposited from intermediate currents of the upper-flow regime (Picard, 1973, p. 146). Horizontal laminae are present in the sand beds and result when coarse particles trap finer ones. Clay clasts are also prevalent in the sand beds. Mud layers, alternating between the sand beds, represent periods of quiet deposition in cut-off anabranches on bar tops during low-water stages (Smith, 1970, p. 3010). Discontinuous, horizontal stratification is common in braided stream deposits and is formed by high velocity currents of the upper-flow regime (Picard and High, 1973, p. 149). Bedding planes are usually irregular and wavy due to roughness of bed form and sediment trapping activity in poorly sorted sediments (Ore, 1964, p. 11). This stratification type is common at several

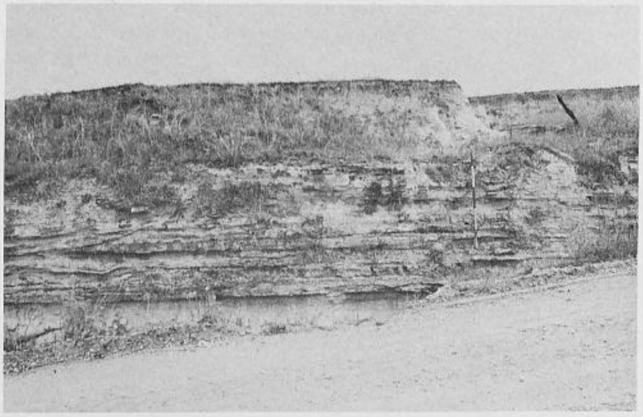

Fig. 29. Horizontal, parallel sand beds alternating between thin clay beds. Georges Creek Member. Locality 40.

localities in the northern part of the area (loc. 22, 36, 39, 40). Small and large channel-fill deposits and megaripple bedding are also present in the fluvial facies of the Georges Creek Member. The channel deposits are produced by scouring during flood stages and subsequent deposition as the velocity of the flood water decreases. Channel deposits range in thickness from less than one meter (Fig. 30; loc. 40) to more than 10 meters (loc. 15, 43). Megaripple bedding is common in fluvial deposits and is produced by downstream migration of megaripple currents (Reineck and Singh, 1975, p. 88). It is susceptible to erosion and is represented in the geologic record by large-scale trough cross-bedding (Reineck and Singh, 1975, p. 35). This bedding type was recognized at only one locality in the western part of the area (Fig. 31; loc. 22).

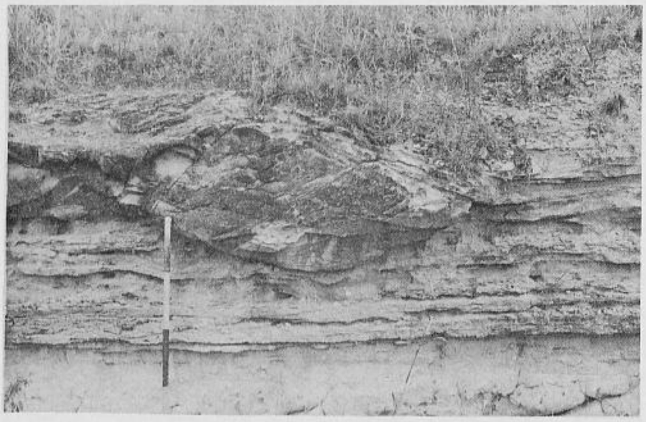

Fig. 30. Channel deposit, note symmetry and erosional base of the sand-filled channel. Georges Creek Member. Locality 40.

Floodbasin deposits of the Georges Creek Member are extensive in the northern part of the area. They are characterized by thick sections of red and white siltstone, and clay with abundant organic material (loc. 36, 37, 39, 40, 41). These deposits are usually structureless but occasionally contain thin horizontal sand beds, channel deposits, and laminations. Many of the laminations have probably been destroyed by compaction. The siltstone and clay were probably deposited on mudflats or in shallow, ephemeral lakes. The floodbasin deposits occur as alternating units of red siltstone, white siltstone, clay, and channel sand deposits. This sequence can be repeated several times within the outcrop. The cyclicity of the floodbasin and channel deposits is probably caused by rivers migrating across a floodplain under conditions of steady subsidence and sediment supply (Allen, 1964, p. 195).

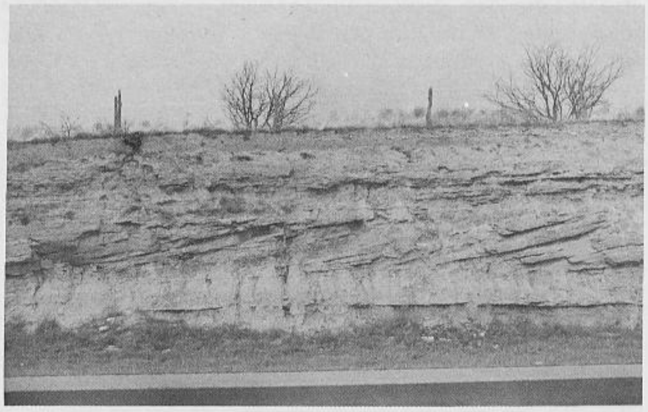

Fig. 31. Large-scale trough cross-bedding. Foreset beds are composed of sand and clay layers. Georges Creek Member. Locality 22.

The red coloration of the siltstone in this facies is of post-depositional origin. Sandy alluvium with no matrix accumulates in a desert basin and acquires hematite pigment by *in situ* alteration of iron-bearing silicates (Van Houten, 1968, p. 399). Several factors including warm temperatures, favorable EH-pH conditions, and occurrence of iron-bearing grains are needed for the alteration to take place (Walker, 1967, p. 366). The position of the water table and the permeability of the sediment are also critical factors controlling the coloration of the sediment (Glennie, 1970, p. 175). The red siltstone is generally more permeable than the white siltstone and clay. Desert climates with alternating wet and dry periods due to sporadic flooding meet most of these requirements. Therefore, most red bed deposits are associated with arid or semiarid environments (Glennie, 1970, p. 193). The red siltstone of the Georges Creek Member is also considered to have formed in a semiarid climate.

Subtidal The subtidal facies of the Georges Creek Member was deposited in a shallow marine environment and is only present in the southern part of the area. This facies is composed of thin fossiliferous sandstone and limestone beds alternating between thin layers of gray shale, clay, and sand (loc. 56, 59, 60). Exposures are inadequate in this area, and it is often difficult to distinguish this facies from the Lake Merritt Member (Fig. 15, p. 35).

The uppermost unit of the Georges Creek Member is a prominent caliche horizon that separates it from the overlying Eagle Mountain Member (Fig. 32). This horizon is present throughout most of the study area but is missing in the marine deposits to the southeast (loc. 15, 24, 32, 36, 40, 43, 56, 57, 84). The presence of caliche also indicates a semiarid climate during deposition of the Georges Creek Member. This type of climate is ideal for caliche formation because an arid climate allows for only superficial accumulations of calcium carbonate, and too much rainfall causes leaching of the soil solubles (Reeves, 1970, p. 353). Thick caliche profiles form under aggrading soil conditions

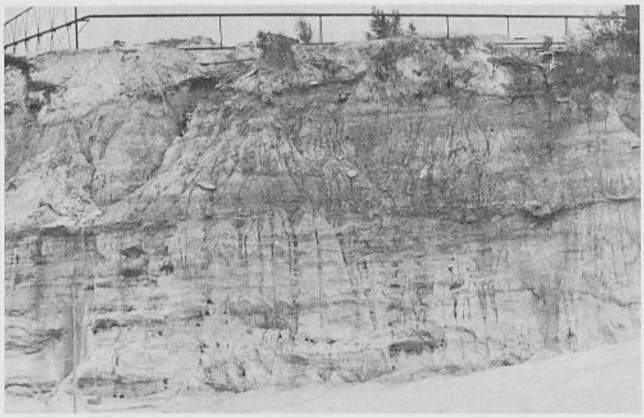

Fig. 32. A caliche horizon transects the center of the figure separating the underlying Georges Creek Member from the overlying Eagle Mountain Member. The Walnut Clay caps the section. Locality 15.

by downward percolation of soil water, causing solution and redeposition, and represent ancient soil horizons (Reeves, 1970, p. 355). The caliche horizon in the Georges Creek Member is primarily a mature caliche characterized by large and small brown, indurated, calcium carbonate nodules with sporadic lenses of Paluxy Sand (Fig. 33). Dendrites are also a common constituent of the caliche horizon. An immature caliche profile, made up of uncemented, white calcium carbonate, is present at several localities, but mature caliche predominates throughout the area. This caliche horizon, if it persisted farther north and west, would be a logical marker bed to subdivide the Antlers Formation into the Paluxy Formation and the Twin Mountains Formation. The exact regional extent of this horizon has not been yet determined.

Fig. 33. Caliche horizon. Note the nodular character of the bed. Georges Creek Member. Locality 15.

ANALOG

The sedimentary structures and depositional history of the Jurassic Westwater Canyon Member of the Morrison Formation in northwestern New Mexico closely resemble the fluvial facies of the Georges Creek Member. The Westwater Canyon Member is a multilateral sand body consisting of channel-fill deposits. Campbell, 1976, recognized two scales of channel-fill deposits and a distinct vertical sequence. This member was deposited in a braided stream system represented by longitudinal and transverse channel bars. The channel deposits consist of cross-bedded sand with erosional bases and ripple-laminated beds. Trough cross-bedding is dominant in the channels and often exhibits asymmetrical lateral filling. The Westwater Canyon Member has floodbasin and lake deposits downcurrent.

The Devonian Lower Old Red Sandstone in England, described by Allen in 1962 and 1964, also provides a depositional analog to the Georges Creek Member of the Paluxy Sand. It consists of channel deposits from braided and meandering streams, and floodplain deposits. The channel deposits are composed of planar and trough cross-bedded sandstone with cuspate ripple marks, scour-and-fill structure, and horizontal bedding. The floodplain deposits consist of red, structureless siltstone that was deposited on mudflats, backswamps, and shallow ephemeral lakes in an oxidizing environment.

Many examples of modern braided streams are described in the literature, and several depositional analogs for the Georges Creek Member are available. Smith, 1970, studied the channel bar deposits of the South Platte River in Nebraska and Colorado. He concluded that transverse bars contain predominantly planar cross-bed sets overlain by some trough cross-stratification. The longitudinal bars are characterized by internal, horizontal stratification, and trough and planar cross-bedding. The Brahmaputra River in Bangladesh, studied by Coleman in 1969, is an example of a braided river developed on a deltaic coastal plain. Channel bars consist of large and small-scale, cross-bedded sand with ripple marks, clay clasts and scour-and-fill structure. Horizontal bedding, lenticular sand units, mud, clay, and silt deposits are also common to this river. Channel bar deposits of the Cimarron River in Oklahoma contain many sedimentary structures similar to those in the Georges Creek Member. Horizontal bedding, medium-scale trough and planar cross-bedding, climbing ripples, and clay clasts are the most common features (Shelton and Noble, 1974, p. 743). The Red River in the semiarid panhandle of Texas is also a braided stream represented by longitudinal and transverse channel bars. The longitudinal bars are comprised of planar cross-bedding or horizontal stratification, and transverse bars consist of trough cross-bedded sand with scour-and-fill structure and ripple marks (Waechter, 1970, p. 713).

EAGLE MOUNTAIN MEMBER

The Eagle Mountain Member overlies the Georges Creek Member and consists of a fluvial facies, an intertidal facies, and a subtidal facies (Fig. 34). The fluvial facies, in the northern and central parts of the area, is composed of cross-bedded sand with thick sections of purple, brown, and white clay. This facies grades downdip into an intertidal facies, in the central part of the study area, characterized by tidal bedding and cross-bedded sand. The subtidal facies is present to the east and south and consists of fossiliferous clay with thin, fossiliferous sand beds.

The Eagle Mountain Member has a maximum thickness of 23 meters in northwest Parker County and thins downdip (loc. 36). It is 19 meters thick in western Tarrant County (Fig. 13) and thins to 11 meters in northeastern Somervell County (Fig. 14). In

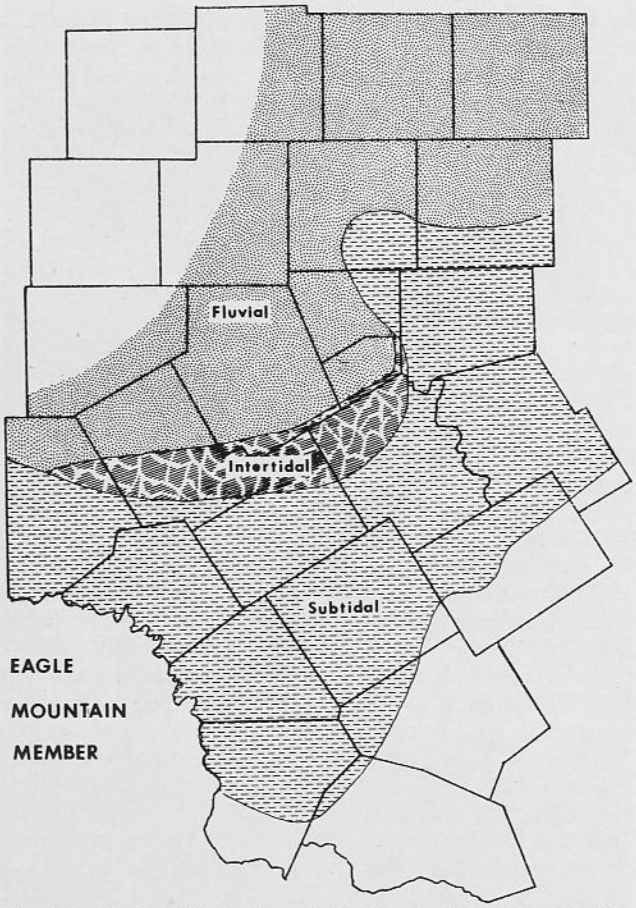

Fig. 34. Facies distribution of the Eagle Mountain Member in north-central Texas.

southern Hamilton County, the Eagle Mountain is 2 meters thick, and in the extreme southern part of the area it becomes indistinguishable from other members of the Paluxy Formation (Fig. 15). The Eagle Mountain also thins along strike (Fig. 12). In the northern part of the area it is 23 meters thick, and in the western part of the area in Comanche County it is 8 meters thick.

Petrology

The fluvial facies of the Eagle Mountain Member is composed primarily of fine and medium sand (Fig. 35), but very fine sand and coarse silt occur at most localities (Fig. 36). Bimodal grain size distribution characterizes the sediment of the Eagle Mountain. Angular as well as rounded sand grains are present but sub-angular sand grains predominate. Angular grains are prevalent in the western part of the area, and rounded grains occur more frequently in the east. Generally, medium sand tends to be frosted and better rounded than fine and very fine sand. Most of the sand from this facies is poorly sorted to moderately sorted. However, very poorly sorted and well-sorted populations occur in conjunction with moderately sorted sediment. Sand and silt grains vary in size and morphology from bed to bed within each locality, and it is difficult to characterize sediment from this facies.

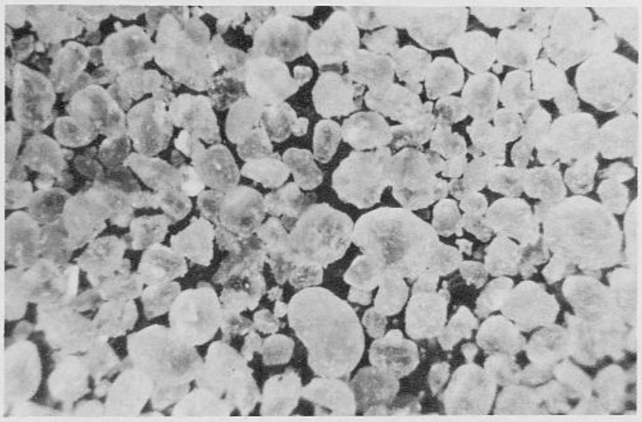

Fig. 35. Sub-rounded, moderately sorted medium and fine sand from the fluvial facies. Eagle Mountain Member. Locality 36. (x 20)

Hematite, pyrite, limonite, gypsum, and feldspar are present in the fluvial facies but in limited amounts. Hematite, limonite, and pyrite occur in concretions and laminae and are present at most localities. Gypsum occurs as bands near the Paluxy Sand-Walnut Clay contact and is probably of secondary origin (loc. 38, 63). Small angular pebbles of feldspar are occasionally present in channel-lag deposits but are limited to the northeastern part of the area (loc. 25, 30). Clay comprises a large part of the fluvial facies particularly in the northern part of the area. Thick sections of purple, brown, and white clay containing sand and silt laminae, and organic laminae occur at many localities. Green and gray clay are also common in many areas but in lesser amounts.

Very fine sand and coarse silt characterize sediment in the intertidal facies (Fig. 36). However, fine sand occasionally is present in fluvial channels which extend into the intertidal facies.

Fig. 36. Sub-angular, well sorted very fine sand and coarse silt from the intertidal facies. Eagle Mountain Member. Locality 44. (x 31.5)

The sand and silt particles are well sorted and sub-angular to sub-rounded. Channel deposits are usually moderately sorted to well sorted. Gray clay with sand, silt, and organic material occurs in thin beds throughout the area. White, structureless clay is also present in this facies but in limited amounts. Magnetite is abundant at most localities and occurs as horizontal laminations.

The subtidal facies of the Eagle Mountain Member is composed primarily of laminated gray clay. Fossils and organic material are also common. Thin beds of very fine sand and coarse silt are present within the clay at most localities. The sediment is well sorted and ranges from sub-angular to sub-rounded.

DEPOSITIONAL ENVIRONMENT

Fluvial The fluvial facies of the Eagle Mountain Member was deposited by a meandering river system characterized by channel and floodplain deposits. Channel or lateral accretion deposits result from channel migration which redistributes the available sediment. This is an active process on point bars. Floodplain or vertical accretion deposits form by deposition of sediment from suspension (Reineck and Singh, 1975, p. 230).

Point bars are the most prominent feature of a meandering river and form by lateral migration during flood stages. Deposition is periodic and extremely rapid (Reineck and Singh, 1975, p. 234). Partial point bar sequences are well represented in the fluvial facies of the Eagle Mountain Member. In an ideal point bar sequence large-scale trough and planar cross-bedding comprise the lowermost zone. This type of stratification is formed by the downstream migration of megaripples and indicates high current velocity probably during floods (Lane, 1963, p. 353). Basal point bar deposits in the Eagle Mountain Member consist of large-scale trough cross-bedded sand (Fig. 37). Planar cross-bedding is often present but is not prevalent (loc. 30, 36, 41, 82). Clay clasts are common in this zone and probably represent reworked bank material. Small scour-and-fill structures are also present (loc. 42). Most fluvial sediments in the Eagle Mountain represent lower point bar deposits. Above this initial point bar zone is a zone of small-scale cross-bedding and ripple laminae. Small-scale trough cross-bedding is abundant throughout the fluvial facies and is characteristically unidirectional (Fig. 38; loc. 30, 31, 36, 41, 42, 82). Such cross-bedding forms from moderate velocity currents in the lower-flow regime by migration of ripples (Picard and High, 1973, p. 191). This unit is typically overlain by a zone of horizontal bedding which is produced by deposition of suspension clouds due to a decrease in turbulence or fluctuations in current velocity (Reineck and Singh, 1975, p. 233). Horizontal sand beds are common in the Eagle Mountain Member and occasionally contain horizontal laminations (Fig. 39; loc. 20, 21, 31, 41, 42). Horizontal laminae are formed during the last phase of a receding flood when current velocity is reduced. This condition results in deposition of suspended sand in the form of horizontal and graded laminae (Fig. 40; Reineck and Singh, 1975, p. 233). The top of a point bar sequence is composed of silt and clay layers also deposited from suspension during waning flood stages. This zone is poorly represented in the Eagle Mountain fluvial facies probably because of erosion by subsequent flooding. This ideal point bar sequence does not occur at one locality but partial sequences are common throughout the area. Fluctua-


Fig. 37. Small scale trough cross-bedded sand. Eagle Mountain Member. Locality 82.


Fig. 38. Large scale trough cross-bedded sand. Eagle Mountain Member. Locality 82.

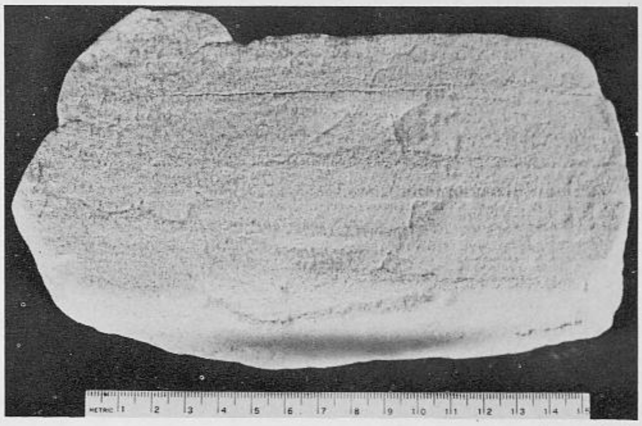
Fig. 39. Horizontal sand laminae. Each lamination is graded. Eagle Mountain Member. Locality 31.

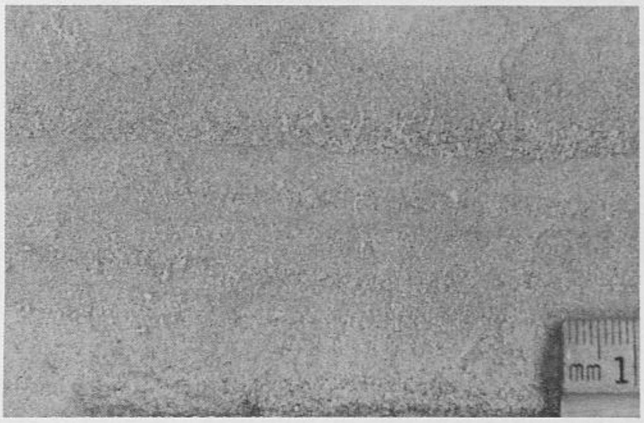

Fig. 40. Horizontal graded sand laminae. Eagle Mountain Member. Locality 31.

tions of depositional energy within a flood phase complicate the sequence and are responsible for incomplete profiles (Reineck and Singh, 1975, p. 233).

Channel-fill deposits as well as point bar deposits are well developed in the Eagle Mountain Member. Channel deposits range in thickness from several centimeters to several meters (Fig. 41). Many of the channels are asymmetrical in cross-section and consist of steeply inclined layers produced by currents (loc. 21, 41). Scour-and-fill structures are common along the channel base and form when water flowing over unconsolidated sediment scours out a shallow depression. Deposition then takes place as current velocity decreases (Reineck and Singh, 1975, p. 62). Cross-bedding in the channel-fill deposits is generally trough-shaped and conforms to the shape of the channel (loc. 30, 41). Minor lag concentrations occur at several localities, but are frequently indistinct due to uniformity of grain sizes. Other features present in these deposits include small-scale ripple bedding, horizontal bedding, laminae (loc. 21, 25, 30, 33), convolute bedding (loc. 21), and sole marks (Fig. 42; loc. 82). Channel-fill sequences in this member are interbedded with bar and floodplain deposits and record erosion by waxing flood and back-filling as flood decreases (Picard and High, 1973, p. 200). Lenticular sand beds are also common in the Eagle Mountain Member (loc. 26, 36, 41). These beds are produced by shifting depositional centers and record fluctuating flow regimes from bar to channel and back (Picard and High, 1973, p. 152).

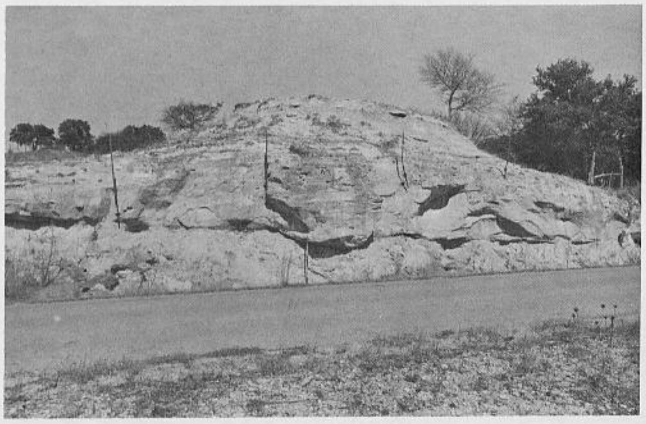

Fig. 41. Channel deposit. Note the erosional base and lenticular nature of the sand-filled channel. Eagle Mountain Member. Locality 33.

Fig. 42. Sole markings at the base of a sand bed. Note the orientation of the marks. Eagle Mountain Member. Locality 82.

Floodbasin deposits in the fluvial facies are extensive in Parker and Tarrant Counties. Thick deposits develop when rivers become fixed in position so extended periods of time are available for deposition. Sediment accumulation is slow, and deposition results primarily from suspension during overbank flow (Reineck and Singh, 1975, p. 250). Floodbasin deposits are typically divided into several different subenvironments; however, different subenvironments have not been recognized in the Eagle Mountain Member. Thick clay accumulations are characteristic of floodbasin deposits in the Eagle Mountain (Fig. 43). The clay contains large amounts of plant material, wood fragments, and ferrous iron nodules and is usually finely laminated. The laminae result from differences in color and grain size. Floodbasin deposits often have sharp lateral contacts with sand-filled channels. These deposits are best represented at localities 30, 36, 41, and 42.

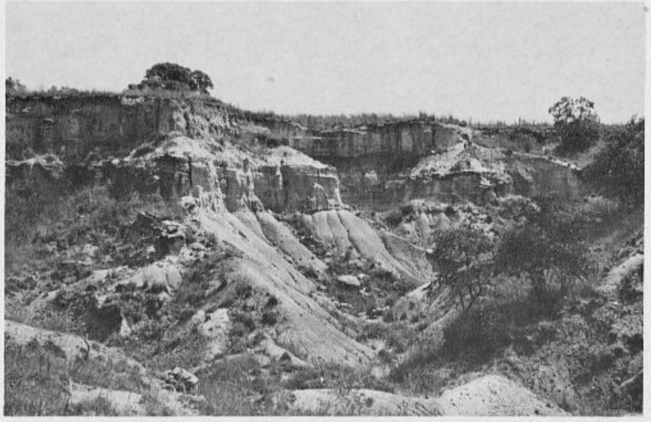

Fig. 43. Thick floodplain deposits composed of purple, brown, and white clay. Note the sharp contact between the clay and overlying sand bed. Eagle Mountain Member. Locality 36.

Intertidal The intertidal facies of the Eagle Mountain Member is represented only in the central part of the area of investigation (Fig. 34). It is similar to the intertidal facies of the Lake Merritt Member and contains many of the same sedimentary features. The most diagnostic feature of this facies is tidal bedding. Thin horizontal sand beds alternating between thin clay beds are common at many localities (loc. 9, 44, 50, 77). Sand and silt beds often contain horizontal laminae, ripple bedding, and small-scale planar cross-bedding (loc. 24, 50, 77). Burrows, root mottles, and various fossils are also contained in many of the sand and silt beds. Fossil concentrations vary locally and are highly restricted. In southwestern Johnson County, *Turritella* is the predominant fossil (loc. 24), but in northern Bosque County only *Ostrea* are present in this facies (loc. 44, 50). These fossil concentrations suggest deposition in a distinct environment because of the dominance of one fossil type at each locality.

Many fluvial channels transect the intertidal facies. These channels extend from the fluvial facies updip and have scoured out large sections of pre-existing intertidal deposits (Fig. 44). They are characterized by longitudinal cross-bedding produced by lateral shifting of

Fig. 44. To the right of the figure are horizontal sand and clay beds of the intertidal facies. To the left is the edge of a fluvial channel represented by moderately dipping cross-bed sets. Note the erosional nature of the contact between these deposits. Eagle Mountain Member. Locality 44.

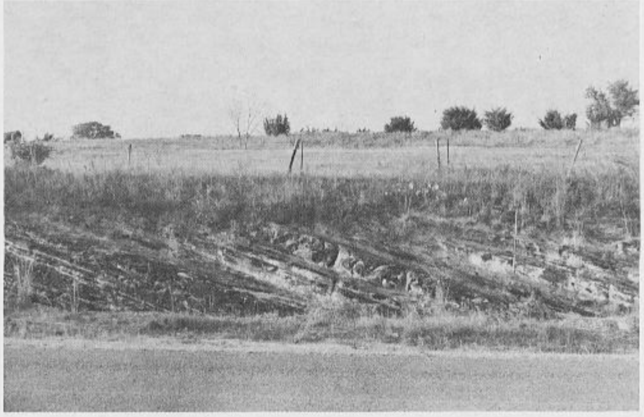

Fig. 45. Longitudinal cross-bedded sand composed of moderately dipping sand beds alternating between clay beds. Eagle Mountain Member. Locality 45.

the channel (Fig. 45). One side of the channel is eroded, and sedimentation takes place on the other side producing a series of inclined beds trending parallel to current direction (Reineck and Singh, 1975, p. 89). This type of cross-stratification is common in small river channels and is dominant throughout the central part of the area (loc. 44, 45, 49, 52, 64, 89). Longitudinal cross-bedding is also common in tidal channels, and the channel deposits of this facies possibly have an intertidal origin. However, the absence of fossils and glauconite and the presence of small-scale unidirectional trough and planar cross-bedding suggest a fluvial origin. Also, sediment in the channels is usually coarser than sediment from the intertidal facies and contains greater concentrations of fossil wood.

Subtidal The subtidal facies of the Eagle Mountain Member occurs in the northeastern and southern part of the area (Fig. 34). In southern Parker and northern Hood Counties, this facies is represented by a shallow, brackish water bay indicated by the presence of randomly oriented serpulid worm tubes (loc. 79, 81, 83). Studies by Andrews (1964) of serpulid reefs in Baffin Bay along the Gulf Coast of Texas suggest that randomly oriented serpulid worm tubes are due to the lack of constant current direction and indicative of a brackish environment. Concentrations of *Exogyra texana*, which generally inhabit shallow, brackish water environments, and the occurrence of brackish water forms of clam and shrimp together with frog and salamander bones in this area also suggest a restricted environment.

The subtidal facies consists of thin sand and silt beds alternating between thicker clay beds (Fig. 46). The clay contains large amounts of sand, silt, fossils, organic material, burrows, and occasional laminae. Most of the beds are structureless, probably reflecting intense burrowing by bottom-dwelling organisms. In the southern part of the area sand and silt become dominant in the section. These beds are usually highly bioturbated (Fig. 47) and contain variable amounts of fossil fragments and organic material. It is difficult to differentiate this member from other members of the Paluxy Formation in this area.

Fig. 46. Fossiliferous clay of the subtidal facies containing fossiliferous sand and silt beds. Eagle Mountain Member. Locality 83.

Fig. 47. Clay-filled burrows. Eagle Mountain Member. Locality 74.

ANALOG

The Lower Cretaceous Fall River Formation in Wyoming represents tidal flat deposits along a coastal plain drained by many small streams (Campbell and Oaks, 1973, p. 765). This formation was deposited in an environmental system similar to the Eagle Mountain Member. Landward the tidal flat deposits grade into a fluvial facies and seaward into shallow-shelf silt and claystone. The tidal flat deposits are composed of tidal bedding, ripple marks, horizontal and wavy laminae, and burrows. Channel deposits within the intertidal facies consist of high-angle, unidirectional cross-stratification bounded by parallel bedding surfaces. Large-scale planar cross-bedding is also common. An important criterion in identifying this complex was the seaward change from fluvial to intertidal to subtidal (Campbell and Oaks, 1973, p. 774). Similar criteria were used to establish the depositional complex of the Eagle Mountain Member.

Several modern examples of tide-dominated deltaic complexes serve as excellent depositional analogs to the Eagle Mountain Member. The Niger Delta, located on the west coast of Africa, is dominated by wave action and longshore currents (Oomkens, 1974, p. 196). The upper fluvial part of the delta includes braided and meandering streams composed of sand, gravel, and floodplain deposits. The lower deltaic plain is an intertidal mangrove swamp transected by numerous tidal channels (Oomkens, 1974, p. 198). These channel deposits consist of trough cross-bedded sand and are often topped by intensively burrowed marine silt and clay. Allen (1965) has also studied the Niger Delta complex in detail and arrived at similar conclusions. The Rhone Delta in southern France also closely resembles the Eagle Mountain Member. Morgan (1970) recognized fluvial, intertidal, and marine deposits. The fluvial sands consist of high and low-angle cross-bedding, horizontal bedding, and clay pebbles. Intertidal deposits consist of well-sorted sand with low-angle planar cross-bedding, thin shell layers, plant material, and thin clay beds. Homogeneous clay beds alternating between silt beds typify the marine deposits. Most beds are burrowed and contain fossils. Deltaic deposits of the Klang and Langat Rivers in the Malay Peninsula were also studied by Morgan (1970) and represent a tide-dominated delta. Fluvial deposits grade seaward into tidal flat deposits composed of tidal bedding, lenticular laminae, and shell fragments. These deposits then grade into shallow marine sand and clay.

DEPOSITIONAL HISTORY

The Lake Merritt Member of the Paluxy Formation represents strandline and very nearshore deposits of a regressing sea (Fig. 48). Regression was probably continuous because of the uniform character of the member. Deposition of the Lake Merritt terminated as the Early Cretaceous sea regressed to the southeast out of the area.

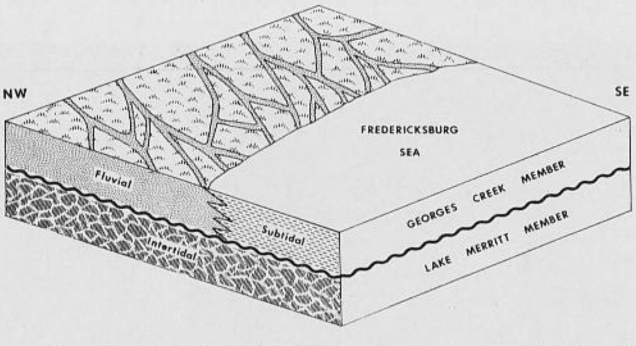

Fig. 48. Depositional model showing the facies distribution of the Lake Merritt and Georges Creek Members.

The Lake Merritt Member is separated from the overlying Georges Creek Member by a disconformity. Fluvial deposition of the Georges Creek Member probably began shortly after deposition of the Lake Merritt Member ceased. Braided streams that deposited the Antlers Formation to the north and northwest transected the area depositing the Georges Creek Member. A semiarid climate is suggested by the extensive braided stream deposits, abundance of red beds, and the presence of caliche. The fluvial systems flowed across most of the study area and emptied into the slowly transgressing Fredericksburg Sea to the south (Fig. 48). At the end of Georges Creek deposition, caliche covered most of the area. The caliche horizon occurs at a disconformity that separates the Georges Creek Member from the overlying Eagle Mountain Member. The hiatus was of sufficient duration for a thick, mature caliche profile to develop.

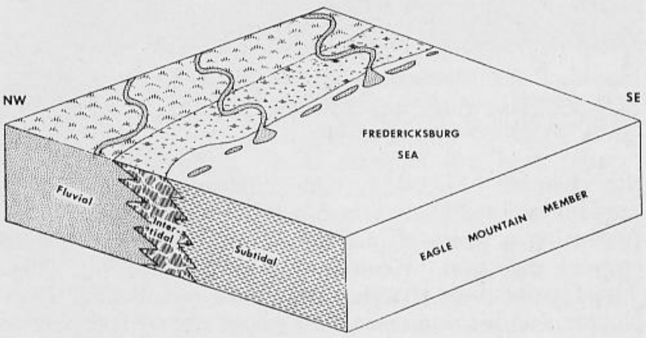

Fig. 49. Depositional model showing the facies distribution of the Eagle Mountain Member.

Subsequently, the Fredericksburg Sea transgressed into the central part of the area and Eagle Mountain deposition began (Fig. 49). In Bosque, Brown, Comanche, and Hamilton Counties basal Eagle Mountain deposits consist of intertidal and shallow marine sand and shale. The shoreline remained here during the rest of Eagle Mountain sedimentation, and meandering stream systems from the north and northwest began to drain into the sea. Fluvial and marine deposits interfinger in the central part of the area. From the transition area, the Eagle Mountain grades updip into fluvial deposits and downdip into marine deposits. A destructive delta sequence is suggested by the admixture of fluvial and marine deposits. Tidal and longshore currents of the Fredericksburg Sea reworked and redeposited much of the fluvial sediment in an intertidal and subtidal environment. In the northeastern part of the area a large shallow, brackish water bay formed, probably because it was protected from wave and current activity by a barrier island system (Fig. 49). This complex presumably extended across most of the central part of the area similar to the present Gulf Coast barrier island system. Brackish water fauna at several localities throughout the central part of the area suggest a partially protected coastline. However, no evidence for the postulated barrier island system presently exists. Paluxy deposition ended as the Fredericksburg Sea continued to transgress northward across the area depositing marine clay and limestone of the Walnut Formation on top of the lithified Paluxy Sand.

The climate probably became less arid during deposition of the Eagle Mountain Member. This is indicated by the development of meandering rivers with thick floodplain deposits that usually do not develop in semiarid regions. Fossil leaves, in detached concentrations, from the Paluxy Formation also indicate a subhumid to humid climate. The exact position of the loose concretions has not yet been determined. However, they are presumed to occur in iron concretions from the Eagle Mountain Member because the concretions are most abundant in the upper member.

CONCLUSIONS

1. The Paluxy Formation is a blanket sand that crops out throughout much of north-central Texas. It strikes northeast and dips southeast at a rate ranging from 1.3 meters per kilometer to 14.5 meters per kilometer. It has a maximum thickness of 240 meters and thins downdip.
2. The contact between the Glen Rose Limestone and the overlying Paluxy Sand is conformable and can be gradational, abrupt, or interfingering. The contact between the Paluxy Sand and the overlying Walnut Clay is unconformable and erosional throughout most of the area.
3. The Paluxy Sand is a quartzarenite composed of medium to very fine quartz sand and coarse silt. Most grains are sub-angular to sub-rounded and moderately sorted to well sorted. Clay comprises a large portion of the Paluxy Formation, especially in the northern part of the area. Colors include purple, brown, red, white, green, and gray. Montmorillinite is the primary clay mineral.
4. The Paluxy Formation is a multicycle sand that was derived primarily from the Antlers Formation in the northwestern part of the area. The original source area includes Pennsylvanian and other strata in central Texas as well as the Arbuckle-Ouachita uplifts in Arkansas and Oklahoma.
5. The paleontological content of the Paluxy Formation is extremely limited. Several genera of pelecypods, gastropods, and microfossils were identified from the Paluxy, but specimens are rare. Pyritized and silicified wood is the most abundant fossil in the Paluxy Sand.
6. The Paluxy Formation can be divided into three members on the basis of depositional environment, and petrologic and stratigraphic relationships. The Lake Merritt Member is the lowermost unit and is overlain by the Georges Creek Member. The Eagle Mountain Member is the uppermost unit of the Paluxy Formation.
7. The Lake Merrit Member consists primarily of horizontally bedded sand, silt, and clay deposited in an intertidal environment. The Georges Creek Member is characterized by channel bar and floodbasin deposits of a braided stream system that grades downdip into a subtidal facies. The Eagle Mountain Member is composed of point bar and floodplain deposits of a meandering river system. The Eagle Mountain fluvial facies grades downdip into an intertidal and subtidal facies.
8 The Lake Merritt Member is composed of strandline deposits of the regressing Early Cretaceous sea and represents the final phase of a regressive depositional cycle. Following a hiatus, deposition continued with the fluvial systems of the Georges Creek Member. Georges Creek deposition was terminated when an extensive caliche horizon blanketed the area. After another hiatus, the Eagle Mountain Member was deposited as fluvial and nearshore deposits of the transgressing Fredericksburg sea. Paluxy deposition ended as the sea transgressed across the area.

APPENDIX

LOCALITIES*

1. Southwest of Glen Rose 8 km on FM 203 at Ice Creek Branch in Somervell County. Lat 32° 10′ N. Long 97° 50′ W. Glen Rose Limestone and Paluxy Sand exposed.
2. West of Chalk Mountain 3.2 km on U.S. 67 at Lallah Branch in Erath County. Lat 32° 09′ N. Long 97° 75′ W. Paluxy Sand and Walnut Clay exposed.
3. Southwest of Glen Rose 12.8 km on U.S. 67 at Ice Branch Creek in Somervell County. Lat 32° 10′ N. Long 97° 51′ W. Glen Rose Limestone and Paluxy Sand exposed.
4. Southwest of Tolar 5.6 km on FM 2875 in Hood County. Lat 32° 22′ N. Long 98° 40′ W. Paluxy Sand exposed.
5. Northwest of Bluff Dale 6.4 km along a county road near the Paluxy River in Erath County. Lat 32° 21′ N. Long 97° 03′ W. Paluxy Sand exposed.
6. Southeast of Bluff Dale 8 km along a county road in Hood County. Lat 32° 18′ N. Long 97° 18′ W. Paluxy Sand and Walnut Clay exposed.
7. South of Granbury 8.8 km on State Highway 144 at Contrary Creek in Hood County. Lat 32° 21′ N. Long 97° 46′ W. Glen Rose Limestone and Paluxy Sand exposed.
8. South of Hill City 0.8 km on FM 201 in Hood County. Lat 32° 18′ N. Long 97° 50′ W. Paluxy Sand exposed.
9. Southwest of Glen Rose 11.2 km on U.S. 67 in Somervell County. Lat 32° 10′ N. Long 97° 52′ W. Paluxy Sand and Walnut Clay exposed.
10. South of Paluxy 8 km on FM 204 in Somervell County. Lat 32° 12′ N. Long 97° 54′ W. Paluxy Sand exposed.
11. East of Glen Rose 8 km on U.S. 67 near Brazos River in Somervell County. Lat 32° 16′ N. Long 97° 39′ W. Glen Rose Limestone and Paluxy Sand exposed.
12. South of Fort Spunky 1.6 km on FM 2174 in Hood County. Lat 32° 19′ N. Long 97° 43′ W. Paluxy Sand and Walnut Clay exposed.
13. Northeast of Granbury 8 km on FM 167 at Waples. Lat 32° 29′ N. Long 97° 43′ W. Paluxy Sand exposed.
14. East of Granbury 8 km on U.S. 377 at the junction of FM 208 in Hood County. Lat 32° 28′ N. Long 97° 42′ W. Paluxy Sand and Walnut Clay exposed.
15. East of Glen Rose 12.8 km on a county road at the Capitol Silica Quarry. Lat 32° 17′ N. Long 97° 38′ W. Paluxy Sand and Walnut Clay exposed.
16. Northeast of Stephenville 11.2 km on U.S. 377 in Erath County. Lat 32° 17″ N. Long 98° 07′ W. Paluxy Sand and Walnut Clay exposed.
17. North of Stephenville 12.8 km on FM 3025 in Erath County. Lat 32° 18′ N. Long 98° 15′ W. Paluxy Sand and Walnut Clay exposed.
18. Northwest of Dublin 3.2 km on FM 2156 in Erath County. Lat 32° 08′ N. Long 98° 26′ W. Paluxy Sand and Walnut Clay exposed.
19. Southwest of Gatesville 25.6 km on FM 116 at the junction of FM 116 and FM 580 in Coryell County. Lat 31° 16′ N. Long 97° 54′ W. Glen Rose Limestone, Paluxy Sand, and Walnut Clay exposed.
20. Southwest of Comanche 4.8 km on U.S. 67 in Comanche County. Lat 31° 52′ N. Long 98° 40′ W. Paluxy Sand and Walnut Clay exposed.
21. Northeast of Brownwood 17.6 km on U.S. 67 in Brown County. Lat 31° 51′ N. Long 98° 46′ W. Paluxy Sand and Walnut Clay exposed.
22. Southwest of Comanche 1.6 km on U.S. 67 in Comanche County. Lat 31° 53′ N. Long 98° 38′ W. Glen Rose Limestone and Paluxy Sand exposed.
23. Southeast of Glen Rose 12.8 km on FM 56 at Hill Creek in Bosque County. Lat 32° 10′ N. Long 97° 40′ W. Paluxy Sand and Walnut Clay exposed.
24. Southeast of Glen Rose 13.0 km on Park Road 21 at the Brazos River in Johnson County. Lat 32° 12′ N. Long 97° 42′ W. Paluxy Sand and Walnut Clay exposed.
25. West of the town of Lake Worth 0.8 km along Malaga Dr. at the eastern side of Lake Worth in Tarrant County. Lat 32° 47′ N. Long 97° 28′ W. Paluxy Sand and Walnut Clay exposed.
26. Southeast of Glen Rose 10.4 km on FM 56 in Somervell County. Lat 32° 10′ N. Long 97° 42′ W. Paluxy Sand and Walnut Clay exposed.
27. Southeast of Glen Rose 24.8 km on FM 56 at Spring Creek in Bosque County. Lat 32° 09′ N. Long 97° 40′ W. Glen Rose Limestone, Paluxy Sand, and Walnut Clay exposed.
28. South of Dennis 9.6 km on FM 1543 in Hood County. Lat 32° 33′ N. Long 97° 56′ W. Glen Rose Limestone and Paluxy Sand exposed.
29. East of Weatherford 9.6 km at Lake Weatherford Spillway in Parker County. Lat 32° 46′ N. Long 97° 41′ W. Paluxy Sand and Walnut Clay exposed.
30. East of Weatherford 9.6 km along southwest shore of Lake Weatherford in Parker County. Lat 32° 46′ N. Long 98° 42′ W. Paluxy Sand and Walnut Clay exposed.
31. Northeast of Weatherford 16 km at the townsite of Carter along Carter Creek in Parker County. Lat 32° 54′ N. Long 97° 44′ W. Paluxy Sand exposed.
32. West of Carter 2.9 km on a county road along Beene Creek in Parker County. Lat 32° 55′ N. Long 97° 47′ W. Paluxy Sand exposed.
33. West of Carter 1.3 km on a county road in Parker County. Lat 32° 54′ N. Long 97° 45′ W. Paluxy Sand and Walnut Clay exposed.
34. Southwest of Pidcoke 2.0 km on FM 116 in Coryell County. Lat 31° 13′ N. Long 97° 54′ W. Glen Rose Limestone, Paluxy Sand, and Walnut Clay exposed.
35. North of Weatherford 16.5 km on a county road near the junction of Gourneck Creek and FM 2421 in Parker County. Lat 32° 54′ N. Long 97° 49′ W. Paluxy Sand exposed.
36. Northwest of Weatherford 24 km on a county road along a branch of Cottonwood Creek at Slipdown Mountain in Parker County. Lat 32° 56′ N. Long 97° 54′ W. Paluxy Sand and Walnut Clay exposed.
37. Northeast of Adell 2.4 km on a county road along a branch of Cottonwood Creek in Parker County. Lat 32° 55′ N. Long 97° 54′ W. Paluxy Sand exposed.
38. South of Decatur 3.2 km on FM 730 in Wise County. Lat 33° 12′ N. Long 97° 35′ W. Paluxy Sand and Walnut Clay exposed.
39. South of Decatur 16 km on FM 730 in Parker County. Lat 33° 06′ N. Long 97° 34′ W. Glen Rose Limestone and Paluxy Sand exposed.
40. South of Keeter 0.5 km along a county road at Hog Branch in Wise County. Lat 33° 02′ N. Long 97° 37′ W. Paluxy Sand exposed.
41. Twin Points Resort at the east end of Eagle Mountain Lake Spillway in Tarrant County. Lat 32° 52′ N. Long 97° 30′ W. Paluxy Sand and Walnut Clay exposed.
42. West of Veale Station 0.8 km along Woody Creek in Parker County. Lat 32° 55′ N. Long 97° 42′ W. Paluxy Sand and Walnut Clay exposed.
43. Below Eagle Mountain Lake Spillway in Tarrant County. Lat 32° 52′ N. Long 97° 30′ W. Paluxy Sand exposed.
44. Spillway at Big Lake on Flat Top Ranch in Bosque County. Lat 32° 04′ N. Long 97° 51′ W. Paluxy Sand and Walnut Clay exposed.
45. East of Iradell 7.7 km on FM 927 in Bosque County. Lat 32° 01′ N. Long 97° 49′ W. Paluxy Sand and Walnut Clay exposed.
46. Northwest of Dublin 6.4 km on FM 2156 in Erath County. Lat 32° 08′ N. Long 98° 24′ W. Paluxy Sand and Walnut Clay exposed.
47. Northwest of Dublin 12.8 km on FM 2156 in Erath County. Lat 32° 07′ N. Long 98° 24′ W. Paluxy Sand exposed.
48. Southwest of Huckabay 3.7 km on FM 219 in Erath County. Lat 32° 18′ N. Long 98° 19′ W. Paluxy Sand and Walnut Clay exposed.
49. Southwest of Hico 8.8 km on FM 219 in Hamilton County. Lat 31° 55′ N. Long 98° 05′ W. Glen Rose Limestone, Paluxy Sand, and Walnut Clay exposed.

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*Detailed descriptions of localities (90 pages) can be obtained from the Department of Geology, Baylor University, for reproduction costs.

50. Southeast of Hico 5.6 km on State Highway 6 in Hamilton County. Lat 31° 58′ N. Long 97° 58′ W. Paluxy Sand and Walnut Clay exposed.
51. North of Jonesboro 3.2 km on FM 1602 in Hamilton County. Lat 31° 38′ N. Long 97° 58′ W. Glen Rose Limestone, Paluxy Sand, and Walnut Clay exposed.
52. South of Hamilton 0.8 km on U.S. 281 behind Ken's Shopping Center in Hamilton County. Lat 31° 42′ N. Long 98° 08′ W. Paluxy Sand and Walnut Clay exposed.
53. Southeast of Lankin 0.6 km on State Highway 36 in Comanche County. Lat 31° 48′ N. Long 98° 15′ W. Paluxy Sand exposed.
54. East of Hamilton 14.4 km on State Highway 22 in Hamilton County. Lat 31° 44′ N. Long 97° 59′ W. Glen Rose Limestone, Paluxy Sand, and Walnut Clay exposed.
55. Northwest of Shive 3.2 km on FM 221 near Collaras Creek in Hamilton County. Lat 31° 37′ N. Long 98° 15′ W. Glen Rose Limestone and Paluxy Sand exposed.
56. Southeast of Shive 8.8 km on FM 2414 at Hoffman Branch in Hamilton County. Lat 31° 35′ N. Long 98° 12′ W. Glen Rose Limestone and Paluxy Sand exposed.
57. Northwest of Ohio 1.6 km on FM 1241 near Cowhouse Creek in Hamilton County. Lat 31° 32′ N. Long 98° 05′ W. Glen Rose Limestone, Paluxy Sand, and Walnut Clay exposed.
58. Southeast of Evant 1.3 km on FM 183 at Langford Branch in Coryell County. Lat 31° 28′ N. Long 98° 08′ W. Paluxy Sand and Walnut Clay exposed.
59. East of Evant 2.4 km on U.S. 84 at Langford Branch in Coryell County. Lat 31° 29′ N. Long 98° 08′ W. Glen Rose Limestone and Paluxy Sand exposed.
60. North of Mullin 10.7 km on FM 573 at branch of Pompey Creek in Mills County. Lat 31° 39′ N. Long 98° 38′ W. Glen Rose Limestone, Paluxy Sand, and Walnut Clay exposed.
61. Northwest of Sidney 8.3 km on FM 1689 at Stagg Creek in Comanche County. Lat 31° 58′ N. Long 98° 47′ W. Paluxy Sand exposed.
62. East of May 4 km on FM 1689 in Brown County. Lat 31° 59′ N. Long 98° 53′ W. Paluxy Sand and Walnut Clay exposed.
63. South of May 8.8 km on U.S. 183 at the junction of FM 1467 in Brown County. Lat 31° 53′ N. Long 98° 55′ W. Paluxy Sand and Walnut Clay exposed.
64. Northwest of Blanket 10.9 km on FM 1467 along Salt Creek in Brown County. Lat 31° 53′ N. Long 98° 51′ W. Glen Rose Limestone, Paluxy Sand, and Walnut Clay exposed.
65. West of Comanche 7.4 km on FM 1689 in Comanche County. Lat 31° 55′ N. Long 98° 41′ W. Glen Rose Limestone and Paluxy Sand exposed.
66. Southeast of Goldthwaite 7.4 km east of U.S. 183 along A.T. & S.F. Railroad in Mills County. Lat 31° 24′ N. Long 98° 32′ W. Paluxy Sand and Walnut Clay exposed.
67. Northeast of Goldthwaite 8.2 km on State Highway 16 in Mills County. Lat 31° 32′ N. Long 98° 33′ W. Glen Rose Limestone, Paluxy Sand, and Walnut Clay exposed.
68. Southeast of Nix 1.6 km on FM 580 in Lampasas County. Lat 31° 06′ N. Long 98° 21′ W. Glen Rose Limestone, Paluxy Sand, and Walnut Clay exposed.
69. Northeast of Lometa 10.4 km on FM 581 in Lampasas County. Lat 31° 16′ N. Long 98° 22′ W. Paluxy Sand and Walnut Clay exposed.
70. East of Kemper 2.9 km on U.S. 190 in Lampasas County. Lat 31° 06′ N. Long 97° 58′ W. Glen Rose Limestone, Paluxy Sand, and Walnut Clay exposed.
71. South of Lampasas 8 km on U.S. 281 in Burnet County. Lat 30° 57′ N. Long 98° 13′ W. Glen Rose Limestone, Paluxy Sand, and Walnut Clay exposed.
72. Southeast of Burnet 7.2 km on a county road near South Fork of San Gabriel River in Burnet County. Lat 30° 43′ N. Long 98° 09′ W. Glen Rose Limestone, Paluxy Sand, and Walnut Clay exposed.
73. Northwest of Briggs 6.9 km on U.S. 183 in Burnet County. Lat 30° 55′ N. Long 97° 59′ W. Glen Rose Limestone, Paluxy Sand, and Walnut Clay exposed.
74. West of Gatesville 7.2 km on FM 2412 in Coryell County. Lat 31° 27′ N. Long 97° 48′ W. Glen Rose Limestone, Paluxy Sand, and Walnut Clay exposed.
75. North of Hazeldell Community 0.8 km on FM 1702 at Hazeldell Cemetery in Comanche County. Lat 31° 53′ N. Long 98° 20′ W. Paluxy Sand and Walnut Clay exposed.
76. Southeast of Hico 8 km on a county road at Bailey Branch in Hamilton County. Lat 31° 55′ N. Long 97° 58′ W. Glen Rose Limestone and Paluxy Sand exposed.
77. Northwest of Iradell 5.9 km on State Highway 6 in Bosque County. Lat 31° 58′ N. Long 97° 55′ W. Paluxy Sand and Walnut Clay exposed.
78. Northwest of Meridian 14.9 km on a county road at a branch of the North Bosque River in Bosque County. Lat 31° 58′ N. Long 97° 47′ W. Paluxy Sand and Walnut Clay exposed.
79. North of Tin Top 8 km on FM 1886 in Parker County. Lat 32° 39′ N. Long 97° 48′ W. Paluxy Sand and Walnut Clay exposed.
80. Southeast of Springtown 14.4 km on a county road along Ash Creek, 3.2 km north of Smith in Parker County. Lat 32° 54′ N. Long 97° 36′ W. Glen Rose Limestone and Paluxy Sand exposed.
81. South of Tin Top 4.8 km on FM 1884 at the Brazos River in Parker County. Lat 32° 34′ N. Long 97° 49′ W. Paluxy Sand and Walnut Clay exposed.
82. North of Ragle 4 km on a county road along a branch of Silver Creek in Parker County. Lat 32° 51′ N. Long 97° 39′ W. Paluxy Sand and Walnut Clay.
83. North of Thorp Springs 4 km on FM 2580 in Hood County. Lat 32° 30′ N. Long 97° 52′ W. Paluxy Sand and Walnut Clay exposed.
84. West of Indian Gap 3.7 km on FM 218 along Cowhouse Creek in Hamilton County. Lat 31° 41′ N. Long 98° 27′ W. Paluxy Sand and Walnut Clay exposed.
85. South of Lampasas 12.8 km on U.S. 281 in Burnet County. Lat 30° 59′ N. Long 98° 12′ W. Glen Rose Limestone, Paluxy Sand and Walnut Clay exposed.
86. Hill County. J. L. Myers & Sons, No. 1 E. Mixon. Electric Log. Lat 31° 53′ N. Long 97° 21′ W.
87. McLennan County. Meadows & Son, No. 2 City of McGregor. Electric Log. Lat 31° 27′ N. Long 97° 24′ W.
88. Tarrant County. T. J. Millican & Sons, E-12. Drillers' Log. 32° 49′ N. Long 97° 23′ W.
89. Northeast of Weatherford 5.6 km on FM 51 in Parker County. Lat 32° 48′ N. Long 97° 47′ W. Paluxy Sand and Walnut Clay exposed.
90. South of Star 5.6 km on FM 1047 along Brushy Creek in Mills County. Lat 31° 25′ N. Long 98° 18′ W. Glen Rose Limestone, Paluxy Sand, and Walnut Clay exposed.

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INDEX

Africa 30
Anabranches 23
Angiosperms 14
Antlers Fm. 25, 30
Antlers Sand 8, 13
Arbuckle Mts. 14
Arbuckle uplift 13
Arkansas 13
Austin, Tex. 5
Azle, Tex. 14

Baffin Bay 29
Balcones Research Center 5
Bangladesh 25
Bar deposits 28
Barrier island 31
Batholiths 13
Beach foreshore 21
Bell Co. 9
Bioturbation 21
Bones 14, 29
Borings 8, 15
Bosque Co. 5, 8, 15, 28, 30
Brackish water 29, 30, 31
Brahmputra R. 25
Braided stream(s) 22, 23, 25, 30
Brown Co. 5, 7, 9, 30
Bull Crk. Ls. Mbr. 9
Burnet Co. 5, 7, 9, 14
Burrows 20, 21, 23, 28, 29, 30
Butler farm 14

Calcite 8, 15, 21
Calcium carbonate 24, 25
Caliche 7, 8, 24, 25, 30
Carbon 13
Channel bars 22, 23, 25
Channel deposits 24, 25, 27, 30
Channel-fill deposits 25, 28
Cimarron R. 25
Clam shrimps 14, 29
Clay 8, 13, 15, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30
Clay clasts 25, 27
Claystone 29
Climate(s) 24, 31
Colorado 25
Comanche Co. 5, 7, 8, 9, 14, 21, 26, 30
Comanche Peak Fm. 8
Comanche, Tex. 14
Comanchean Series 8
Conchostraca 14
Concretions 22, 26, 31
Coryell Co. 5, 7, 8, 9, 15
Counties
    Bell 9
    Bosque 5, 8, 15, 28, 30
    Brown 5, 7, 9, 30
    Burnet 5, 7, 9, 14
    Comanche 5, 7, 8, 9, 14, 21, 26, 30
    Coryell 5, 7, 8, 9, 15
    Eastland 5
    Erath 5, 7, 8, 9, 14, 22
    Hamilton 5, 7, 8, 26, 30
    Hood 5, 7, 8, 9, 13, 29
    Jack 5
    Johnson 5, 28
    Lampasas 5, 7, 9
    McLennan 9
    Mills 5, 7, 8, 9, 14, 20
    Montague 14
    Parker 5, 7, 8, 9, 13, 14, 22, 25, 28, 29
    Somervell 7, 8, 9, 25
    Tarrant 5, 8, 13, 14, 25, 28
    Travis 5, 7
    Williamson 5
    Wise 5, 8, 9, 14, 22
Cretaceous 29
Cretaceous Sea 8
Current velocity 27, 28

Decatur, Tex. 8, 14
Delta 25, 30
Dendrites 25
Desiccation cracks 20
Devonian 25
Dikes 20
Disconformity 30

Eagle Mt. Lake 8
Eagle Mt. Mbr. 8, 24, 25, 26, 27, 28, 30, 31
Eastland Co. 5
East Texas Basin 5
Edwards Fm. 8
England 21, 25
Erath Co. 5, 7, 8, 9, 14, 22

Fall R. Fm. 29
Feeding trails 23
Feldspar 12, 13, 22, 26
Fish 14
Flaser bedding 20, 21
Floodplain deposits 22, 24, 30, 31
Fluvial deposits 8, 24, 30
Fluvial environ. 7
Fluvial facies 21, 22, 23, 25, 27, 28, 29
Foraminifera 14, 15
Fossils 9, 12, 14, 15, 21, 22, 26, 28, 29, 30, 31
France 30
Fredericksburg Group 5, 7, 8
Fredericksburg Sea 30, 31
Frogs 14, 29

Gar 14
Gastropods 14
Georges Crk. 8
Georges Crk. Mbr. 8, 21, 22, 23, 24, 25, 30
Germany 21
Glauconite 29
Glen Rose contact 9
Glen Rose Ls. 9, 15
Granite 13, 14
Granitic-gneises 13
Gravel 30
Gulf Coast 31
Gymnosperms 14
Gypsum 26

Hamilton Co. 5, 7, 8, 26, 30
Hematite 12, 13, 15, 22, 24, 26
Herringbone structure 21
Hood Co. 5, 7, 8, 9, 13, 29

Illite 13
Intertidal 30
Intertidal environ. 20, 21, 30
Intertidal facies 26
Intertidal flats 15
Iron 13, 22, 24, 28, 31

Jack Co. 5
Johnson Co. 5, 28
Jurassic 25

Kolinite 13
King Crk. 14
Klang R. 30

Lake Merritt 8
Lake Merritt Mbr. 8, 15, 20, 21, 24, 28, 30
Laminations 24, 29, 30
Lampasas Co. 5, 7, 9
Langat R. 30
Lewis farm 14
Limestone 9, 12, 21, 24
Limonite 12, 13, 15, 22, 26
Louisiana 8
Magnetite 12, 15, 26
Malay Penin. 30
Mangrove swamp 30
Marine deposits 30
Marine environ. 7
Marl 9
McLennan Co. 9
Meandering strms. 25, 27, 30, 31
Megaripples 24, 27
Microfossils 14, 15, 22
Mills Co. 5, 7, 8, 9, 14, 20
Mixed flat 15, 21
Montmorillonite 13
Montague Co. 14
Morrison Fm. 25
Mud 20, 21, 24, 25
Mud cracks 21
Mud flat 15, 20, 21, 24, 25
Mudstone 21

Nearshore deposits 9
Nebraska 25
Netherlands 21
Nevada 21
New Mexico 25
Niger Delta 30
Nodules 25, 28
North Sea 21

Oklahoma 13, 25
Old Red Ss. 25
Organic laminae 26
Organic matter 15, 22, 24, 29
Orthoquartzite 21
Ostracoda 14
Ouachita Mts. 14
Ouachita uplift 13

Paleozoic 13
Paluxy contacts 7, 8
Paluxy R. 7
Paluxy, Tex. 7
Parker Co. 5, 7, 8, 9, 13, 14, 22, 25, 28, 29
Pelecypods 14
Pennsylvanian 13
Plants 28, 30
Point bars 27, 28
Precambrian 14, 21
Priddy, Tex. 14
Pyrite 12, 13, 15, 22, 26

Quartz 9, 13, 14
Quartz arenite 12, 13
Quartzite 21

Rainfall 24
Ray teeth 14
Red R. 25
Reefs 29
Rhone Delta 30
Rhyolite 13, 14
Ripple marks 8, 15, 21, 23, 25, 30
Ripple structures 20, 27, 28
Ripple troughs 20
Rivers
    Brahmputra 25
    Cimarron 25
    Klang 30
    Langat 30
    Niger 30
    Paluxy 7
    Red 25
    Rhone 30
    South Platte 25

Creeks
    Georges 8
    King 14
Root mottles 28

Salamander 14, 29
Sand 8, 9, 13, 15, 20, 21, 23, 24, 25, 26, 27, 28, 29, 30
Sand flats 15, 20, 21
Sandstone 8, 9, 12, 21, 24
Scour-and-fill structure 25, 27, 28
Scotland 21
Serpulids 14, 29
Shale 12, 15, 22
Shark teeth 14
Shell layers 21, 30
Siderite 13
Silicates 24
Silt 12, 13, 15, 22, 25, 26, 27, 28, 29
Siltstone 9, 21, 22, 24, 25
Somervell Co. 7, 8, 9, 25
South Platte R. 25
Stephenville, Tex. 14
Strandline deposits 8, 9, 30
Stratigraphic units
    Antlers Fm. 8, 13, 25, 30
    Bull Crk. Ls. Mbr. 9
    Butler Fm. 14
    Comanche Peak Fm. 8
    Eagle Mr. Mbr. 8, 24, 25, 26, 27, 28, 30, 31
    Edwards Fm. 8
    Fall R. Fm. 29
    Fredericksburg Group 5, 7, 8
    Georges Crk. Mbr. 8, 21, 22, 23, 24, 25, 30
    Glen Rose Ls. 9, 15
    Lake Merritt Mbr. 8, 15, 20, 21, 24, 28, 30
    Morrison Fm. 25
    Old Red Ss. 25
    Trinity Group 5, 7, 8
    Walnut Fm. 8, 9, 12, 26, 31
    Westwater Canyon Mbr. 25
    Wood Canyon Fm. 21
Subtidal environ. 21, 30
Subtidal facies 21, 24, 25, 29
Swamp 30

Tarrant Co. 5, 8, 13, 14, 25, 28
Teeth 14
Texas Gulf Coast 29
Tidal bedding 21, 30
Tidal channels 21
Tidal currents 15, 20
Tidal flats 15, 20, 29, 30
Tourmaline 12
Towns
    Austin 5
    Azle 14
    Comanche 14
    Decatur 8, 14
    Priddy 14
    Stephenville 14
Trails 23
Travis Co., 5, 7
Trinity Group 5, 7, 8
Turtle bones 14

Vertebrate plates 14
Vertebrate teeth 14

Walnut Fm. 8, 9, 12, 26, 31
Westwater Canyon Mbr. 25
Williamson Co. 5
Wise Co. 5, 8, 9, 14, 22
Wood 14, 15, 28, 29
Wood Canyon Fm. 21
Wyoming 29

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