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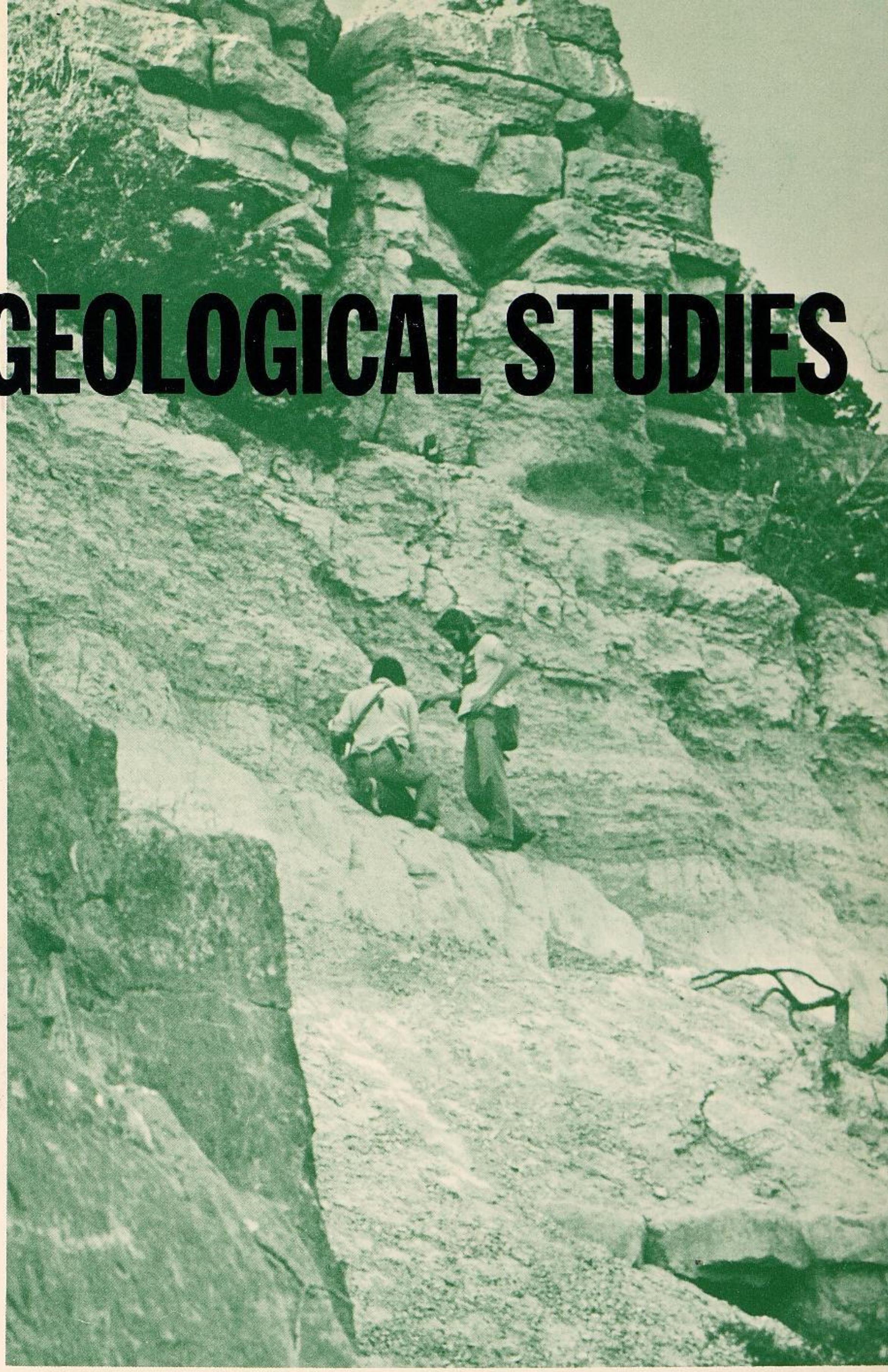

Stratigraphy of the Fredericksburg Group North of the Colorado River, Texas

LINDA WHIGHAM CORWIN

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

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

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Linda Whigham Corwin

BAYLOR UNIVERSITY
Department of Geology
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Linda Whigham Corwin

ABSTRACT

The Fredericksburg Group north of the Colorado River consists of a basal quartz sand (the Paluxy and the upper Antlers sands) and an overlying carbonate sequence (the Walnut Clay, the Comanche Peak Limestone, and the Edwards Limestone). These deposits represent a classical transgressive sequence and constitute a section of marginal marine deposits that has been preserved without significant alteration since deposition.

The Fredericksburg Group within the area of investigation was deposited in two major structural provinces: the western margin of the East Texas basin, a subsiding trough that does not appear to have been a significant control on the upper Fredericksburg sedimentation, and the Texas craton, a stable platform with several structural features that exhibited pronounced effects of the deposition of the Fredericksburg strata. The Concho arch, a broad Paleozoic structural high, represented one of the shallowest areas on the craton during Early Cretaceous time and is reflected in the Fredericksburg sediments by a thinning in the basal clastics over the arch and the loss of distinctive facies in the overlying limestones. The Llano uplift, an inlier of Precambrian granite and metamorphic rock, represented a structurally and topographically positive area during much of Early Cretaceous time, influenced the development of carbonate ramps and platforms to the east of the uplift, and is reflected by the loss of distinctive facies in the limestones to the northwest of the uplift.

The Fredericksburg Group within the area of investigation can be divided into seven stratigraphically distinct areas—Area One through Area Seven. It is necessary to divide the Fredericksburg strata into the seven areas because of large-scale facies changes and the nomenclature variations between the areas.

Deposition of the Fredericksburg Group was controlled by a single northwestward transgression of the Comanchean sea out of the East Texas basin, accompanied by minor regressions.

Deposition of the Paluxy Formation began on the Texas craton as the Glen Rose sea regressed into the East Texas basin. The basal Paluxy sands represent strandline and nearshore deposits of the regressing sea. With continued regression, braided streams deposited sands of the middle Paluxy Formation and, with further regression, the central portion of the study area was left exposed as a broad, low subaerial plain upon which a prominent soil horizon developed. After the regression of the Comanchean sea during the early and middle parts of Paluxy deposition, the sea transgressed to the northwest and the fluvial and nearshore deposits of the upper Paluxy Formation were laid down.

Northwestward transgression by the Comanchean sea continued across a broad, flat platform throughout deposition of the Walnut Formation. The basal Walnut units were deposited by an initially slow, then rapid transgression of the sea and represent nearshore deposits. The middle units of the Walnut Formation were deposited in low energy, shallow marine conditions with the later development of a large shallow bay in much of the eastern area. In the central and western portions of the study area, onlap of the deposits is indicated as the middle Walnut seas transgressed to the northwest. The upper Walnut sediments were deposited by the transgressing Comanchean sea in a normal marine environment in which water depth increased and turbulence decreased from the previous depositional environments of the Walnut Formation.

Deposition of the Comanche Peak Formation resulted from the continued northwestward transgression of the Comanchean sea. Environmental conditions alternated between slightly brackish to normal marine salinities as the basal Comanche Peak sediments were deposited. The slow accumulation of Comanche Peak sediments continued as the distance from the shoreline increased due to the transgression of the sea. A normal marine, clear water environment existed over the Texas craton. Deposition of the Callahan Complex, formed from Comanche Peak sediments in Nolan County, reflected the shallow water,

high energy environment that was coincident with the physiographic high of the structural Concho arch.

A single brief transgressive pulse, perhaps due to an eustatic rise in sea level, occurred in early Edwards time and resulted in the uniform deposition of Edwards sediments over the entire study area. As the lower Edwards sediments were deposited, the Comanchean sea was shallow, clear, and of normal marine to hypersaline conditions. Middle Edwards time brought the rapid transgression of abundant rudist populations into the study area, and conditions of shallow, marine waters continued to persist. Contemporaneous with the deposition of the rudist mounds, the highly agitated, shallow marine environment on the crest of the Concho arch in Nolan County continued to exist, and the Callahan Complex and related sediments were deposited. South and southeast of the Callahan Complex, a broad, flat, very shallow to emergent area existed, and the migration of tidal flat environments from south of the study area took place during middle and late Edwards time. The late Edwards depositional history is one of minor marine regression, which resulted in the development of a restricted, shallow, marine environment and eventual subaerial exposure of the upper Edwards surface.

After the upper Edwards Formation was subaerially exposed and the sediments lithified, an influx of terrigenous material from adjacent landmasses resulted in the deposition of the Kiamichi Formation over the area. Beyond the southern pinchout of the Kiamichi Formation, the Edwards Formation was somewhat later covered by the sediments of the Duck Creek Formation.

INTRODUCTION*

PURPOSE

The Lower Cretaceous Fredericksburg Group is considered one of the major rock units of Texas because of its wide areal extent and subsurface distribution. Several formations of the Fredericksburg Group are important for their aquifer and oil and gas potential. Therefore, it is important to understand the diverse physical character of the Fredericksburg Group and the wide variety of depositional environments that the rocks represent.

The Fredericksburg of west and central Texas consists of a basal quartz sand, the Paluxy and the Antlers sands, and an overlying carbonate sequence, the Walnut Clay, the Comanche Peak Limestone, and the Edwards Limestone. These deposits represent a classical transgressive sequence and constitute a section of marginal marine deposits, which has been preserved without significant alteration since deposition.

The Fredericksburg strata have been the subject of considerable research; however, individual studies have usually been limited to small sections generally without overlap in critical areas. Many interpretations have been based on assumptions concerning areas outside of the immediate study area, and environments of deposition have been selected to be "useful" to the interpretation for the area in question. This has led to a rather haphazard concept of the total Fredericksburg depositional system. Thus, the purpose of this study was to consider the stratigraphic sequence of Fredericksburg rocks and to develop models for the depositional history of the Fredericksburg Group on a regional scale.

The major objectives of the study were:

(1) To evaluate and synthesize the state of knowledge of rocks of the Fredericksburg Group.
(2) To field check existing descriptions and interpretations, and to add interpretations in those areas where suitable interpretations are lacking.
(3) Through electric log and outcrop analysis, to correlate facies patterns of the Fredericksburg Group, from the western margin of the East Texas basin, across the Texas craton, to the final exposures of the Fredericksburg rocks to the west in the Llano Estacado region.
(4) To develop a regional working model, based on modern clastic and carbonate depositional environments, for the Fredericksburg depositional period.

LOCATION†

The area of investigation includes the general regions of west and central Texas. The area is bounded on the north by Parker, Tarrant, and Dallas Counties; on the west by Lubbock, Lynn, and Dawson Counties; on the south by Burnet, Bell, and Milam Counties; and on the east by Kaufman, Henderson, Freestone, and Leon Counties (Figs. 1, 2). Geographically, the area lies south of a line joining Lubbock and Denton, east of Midland, north of Austin, and west of Tyler. The physiographic regions represented by the outcrop area of the Fredericksburg Group are the High Plains, the Lower Plains, the Edwards Plateau, the Cross Timbers, and the Grand Prairie (Fig. 3). Structurally, the area lies on the Texas craton and the western margin of the East Texas basin. The Balcones fault zone separates the Texas craton and the East Texas basin. The area lies north of the Llano uplift (Fig. 4).

The boundaries of the study are stratigraphically or structurally controlled. The northern boundary is controlled by the stratigraphic character of the uppermost unit of the Fredericksburg Group, the Edwards Formation. The Edwards thins northward, loses its characteris-

*A thesis submitted in partial fulfillment of the requirements for the M.S. degree in Geology, Baylor University, 1981.

†Thesis Plates Ia and Ib are comprehensive locality maps of described outcrops of the Fredericksburg Group. Information about them is available from the Department of Geology, Baylor University.—Editor.

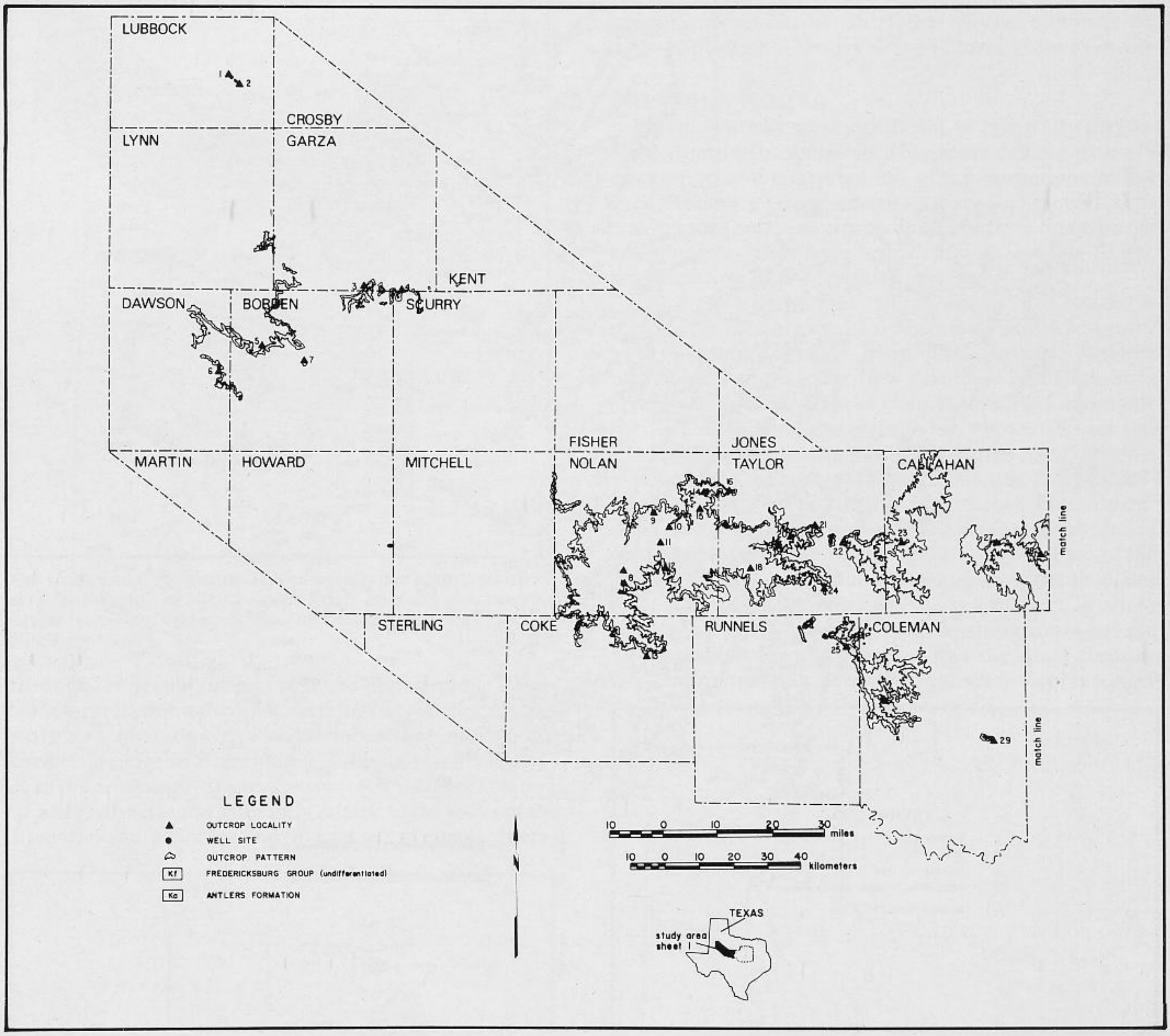

Fig. 1. Geologic and locality map, western section.

tic features, and is no longer recognizable as a distinct formation to the north of Hood County, where it and other limestones of the Fredericksburg Group are merged into the Goodland Formation. The study area extends northward to include the transition zone from Edwards to Goodland limestone (Fig. 2).

The western boundary is marked by the westernmost exposures of the Fredericksburg Group as it disappears beneath the High Plains of west Texas (Fig. 1).

The southern boundary is structurally controlled and is drawn along the northern margin of the San Marcos Platform (Fig. 2).

The eastern boundary is also structurally controlled and is drawn along the north-south trending Balcones fault zone, the hinge line between the Texas craton and the East Texas basin. Along the eastern margin, the study area is extended to include facies trends of the Fredericksburg Group characteristic of the western margin of the East Texas basin (Fig. 2).

The region of outcrop of Cretaceous strata is divided into three distinct areas, named for the physiographic regions in which they occur: (1) a western area along the eastern margin of the Llano Estacado; (2) a central area along the Callahan Divide; and (3) an eastern area coinciding with the Lampasas Cut Plain (Fig. 5).

In the Llano Estacado of northwest Texas, rocks of the Fredericksburg Group crop out along the eastern margins of the High Plains and in isolated outliers to the east. Dipping to the southeast at a rate of 7 to 8 feet per mile, the Fredericksburg strata average 105 feet in thickness.

The Callahan Divide is a series of mesas of Cretaceous rocks surrounded by lowlands in Triassic and Permian sediments, which together comprise the divide between the Colorado and the Brazos Rivers. Rocks of the Fred-

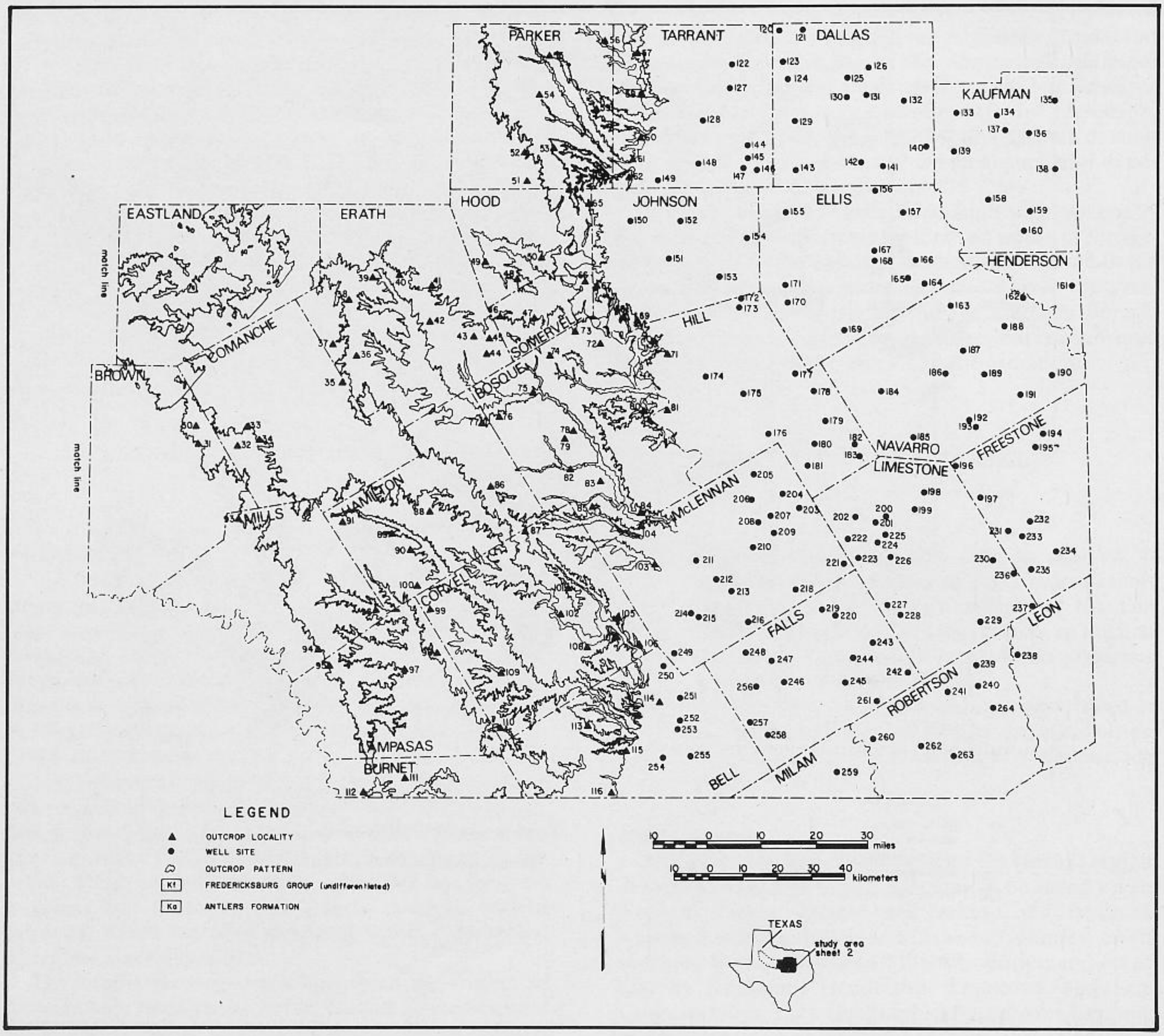

Fig. 2. Geologic and locality map, eastern section.

ericksburg Group average 180 feet in thickness along the divide, and the regional dip is to the east-southeast at a rate of about 10 feet per mile. The major structural control of the Callahan Divide sediments is the Concho arch.

The Lampasas Cut Plain, the northern extension of the Edwards Plateau, consists of a landscape of broad lowlands separated by mesas, which are capped by resistant Edwards Limestone. The less resistant Comanche Peak Limestone is exposed on the steep slopes, and the Walnut Clay and the Paluxy Sand form the valley floors. The Fredericksburg strata in the Lampasas Cut Plain average about 305 feet in thickness and dip east-southeast at about 10 feet per mile.

From the eastern margin of the outcrop belt, the Fredericksburg rocks dip gently to the east-southeast in the subsurface until they reach the Balcones fault zone, which trends through central McLennan and Hill Counties. East of this fault zone the rocks thicken abruptly, chiefly through thickening of the Walnut Clay, and increase in dip to the axis of the East Texas basin. Fredericksburg rocks average 350 feet in thickness in central McLennan County and increase to a thickness of over 600 feet in southern Freestone County (Fig. 47). The thickness increase in the Fredericksburg rocks can be attributed to the subsidence of the East Texas basin during parts of Comanchean time.

METHODS

The method of study included: (1) the compilation of a comprehensive index of localities described by previous workers in studies on the Fredericksburg Group from which the localities used in this study were drawn; (2) field reconnaissance to verify previous descriptions of the rock units; (3) laboratory analysis of selected samples

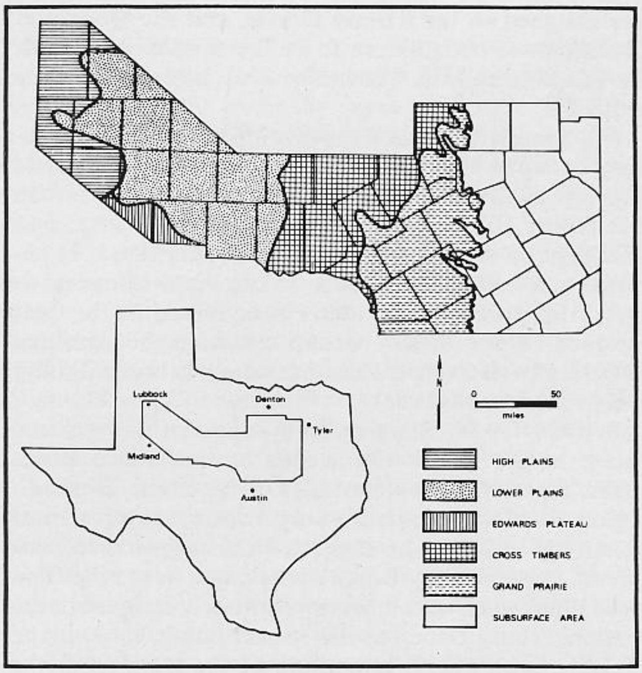

Fig. 3. Index map showing the area of investigation of the Fredericksburg Group north of the Colorado River, principal physiographic regions represented by the outcrop of the Fredericksburg rocks, and the geographic locality.

through the preparation of slab and petrographic slides; (4) interpretation of electric well logs across the eastern margin of the study area with the subsurface information used to prepare stratigraphic sections and isopach maps of each formation; (5) an extensive review and evaluation of works directly and indirectly related to the rocks of the Fredericksburg Group; and (6) a review of current literature pertaining to both ancient and modern clastic and carbonate depositional models that may have application to the depositional history of the Fredericksburg Group.

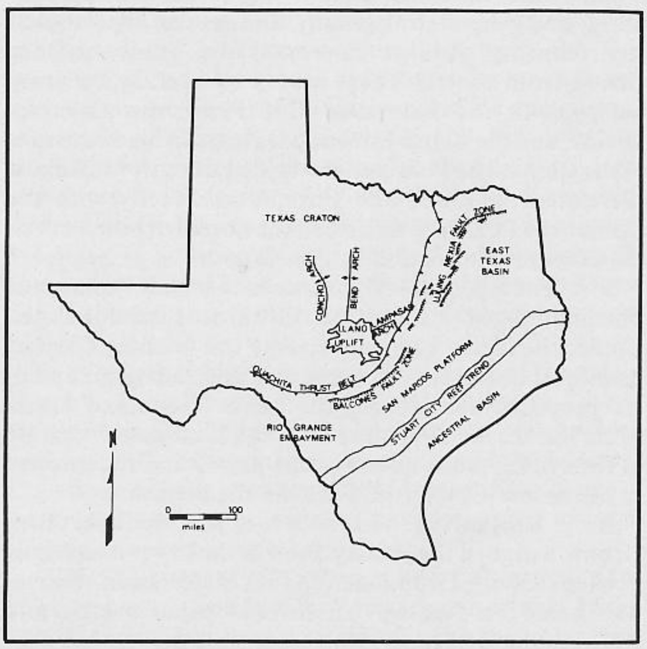

Fig 4. Structural and depositional features of the Texas craton and the East Texas basin with emphasis on those features that had a major influence on the distribution and character of the Fredericksburg Group.

PREVIOUS WORKS

Previous works most significant to this study may be divided into two categories: (1) papers dealing with the description and interpretation of the formations of the Fredericksburg Group and (2) papers dealing with general depositional sequences and systems in modern environments that have application as models to the interpretation of Fredericksburg deposition.

The first true geologic observations of Cretaceous rocks in Texas were made in the mid nineteenth century by a German geologist, Ferdinand Roemer. Roemer made observations in the New Braunfels-Fredericksburg area of south-central Texas from 1845 to 1847 and made the first significant geological observations of rocks of Fredericksburg age. Among his publications, that most significant to the current investigation was "Die Kreidebildungen von Texas und ihre organischen Einschlusse" published in 1852. Roemer grouped the Cretaceous strata into "Beds at the foot of the Highlands" and "Beds of the Highlands" in which what is now known as the Balcones fault scarp was the basis for the subdivision. Roemer mistakenly interpreted the Fredericksburg strata as Late Cretaceous in age and reported that the strata forming the escarpment (Fredericksburg rocks) were younger

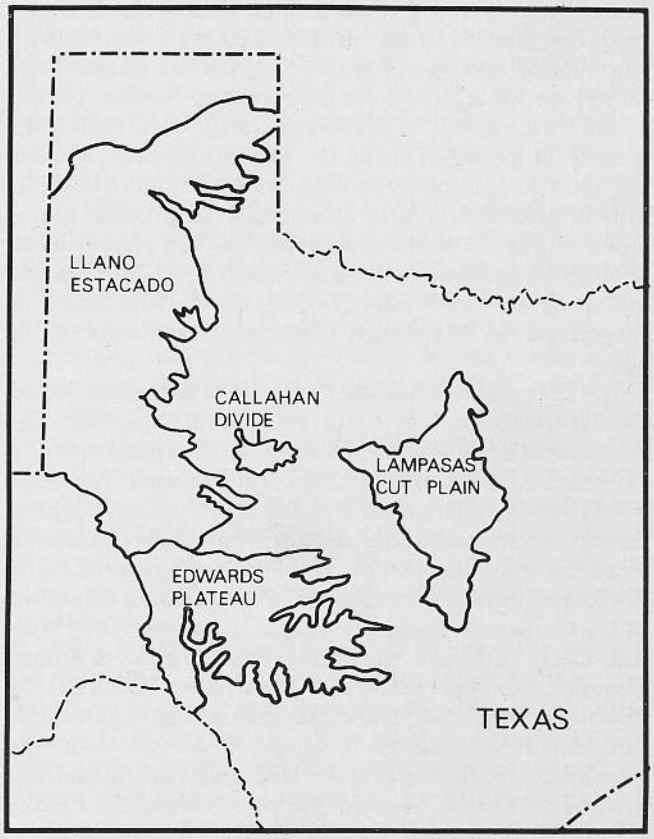

Fig. 5. The region of outcrop of the Cretaceous Fredericksburg Group of Texas is divided into four areas named for the physiographic regions in which they occur: the Lampasas Cut Plain, the Callahan Divide, the Llano Estacado, and the Edwards Plateau.

than those at the foot of the escarpment (Austin Chalk-Gulfian) (Thompson, 1935, p. 1508-1509).

G. G. Shumard described the Cretaceous of the Red River area in 1852 when he was attached to an expedition of the United States Army. He named the beds he mapped the Fort Washita Limestone and considered them Late Cretaceous in age (*idem*, p. 1509).

Jules Marcou was the first to recognize the strata of Texas and western Oklahoma as Neocomian or Early Cretaceous in age when he accompanied the "Thirty-Fifth Parallel Survey" expedition in 1855 (*idem*, p. 1509-1510).

In 1860, B. F. Shumard, in "Observations upon the Cretaceous strata of Texas," first described and assembled into a stratigraphic section the series of formations of the Cretaceous of Texas. In the publication, he named three formations: (1) the "Caprina" Limestone, a yellow-white limestone occurring in massive beds and capping the highest elevations; (2) the Comanche Peak Group, a soft, yellow to white, chalky limestone; and (3) the "Caprotina" Limestone, a light gray, fossiliferous, earthy limestone. His descriptions of the lithology and fossil content indicate Shumard was dealing with the formations now known as the Edwards, Comanche Peak and Walnut, and Glen Rose, respectively (*idem*, p. 1510).

The proper sequence of Cretaceous strata of Texas was first recognized by R. T. Hill in 1887. Hill established two subdivisions of rock, "the Gulf Series" and "the Comanche Series," and correctly identified the Comanche Series as Early Cretaceous in age. Hill studied the rocks west of Fort Worth and observed that they carried an identical faunal assemblage to those described by Roemer (1852) around the town of Fredericksburg. He, therefore, named the group of rocks the Fredericksburg Division and used the formation names given by Shumard in 1860. Hill originally included Shumard's "Caprotina Limestone" in the Fredericksburg Division. In a paper on the geology of southwestern Arkansas in 1888, Hill named and described the Trinity Division for the first time and recognized the "Caprotina Limestone" as late Trinity in age.

In 1891 in one of his most important contributions to Comanchean geology, Hill recognized the Kiamichi Formation as part of the Washita Series, considered the "Caprina Limestone" as the uppermost formation of the Fredericksburg Division, and, for the first time, used the name Comanche Peak Chalk for Shumard's Comanche Peak Group. However, in southern Oklahoma the name Goodland Limestone was given to the northern extension of the Comanche Peak type rocks. Hill named the "Walnut Clays" for the exposures near Walnut Springs, Bosque County, Texas, where "alternating strata of thin limestone flags and yellow clay marls, accompanied by inconceivable numbers of *Exogyra texana*" underlie Comanche Peak Limestone. Hill also named and described the Paluxy Sand for exposures along the Paluxy River near the town of Paluxy and tentatively assigned it to the Fredericksburg Division.

The name Edwards Limestone was substituted for "Caprina Limestone" in a joint paper by R. T. Hill and T. W. Vaughn in 1898. Also at this time, the Paluxy Sand was assigned to the Trinity Group, and the Goodland Limestone was considered to be the equivalent of both the Edwards and the Comanche Peak limestones to the south.

Hill summarized his classification of the Fredericksburg Group in 1901 in his report on the "Geography and Geology of the Black and Grand Prairies of Texas." In this report Hill described the extent, importance, and thickness of the Edwards and Comanche Peak Limestones and the Walnut Clay in Texas. At this time, however, Hill still believed the Paluxy Sand to be best assigned to the Trinity Group, although he admitted difficulty in devising a clear boundary between Trinity and Fredericksburg rocks.

In 1928, T. W. Stanton, in a paper on the regional extent of the Lower Cretaceous or Comanche Series rocks, correlated the limestones of the Llano Estacado region with the Fredericksburg limestones of central Texas. In addition, he suggested that sands then considered upper Trinity, north of the pinch out of the Glen Rose Limestone, were more appropriately assigned to the Fredericksburg Group as the Paluxy Sand.

Gayle Scott (1930) in a study of the stratigraphy of Parker County described the stratigraphic relationship between the Glen Rose Limestone and the Paluxy Sand. He recognized that the upper beds of the Glen Rose Limestone and the lower beds of the Paluxy Sand interfinger and that the Paluxy's southward thinning was due to the lensing out of successively lower beds in the main body of the Glen Rose Limestone. He interpreted the Paluxy sands as the shoreward sandy facies of the upper Glen Rose, deposited as the Glen Rose sea regressed.

In 1932, W. S. Adkins described the Cretaceous rocks of Texas and briefly reviewed the structural setting of the region, the areal distribution of the rocks, their paleontology and general stratigraphy, and general depositional environments. Adkins correlated the Fredericksburg Group from central Texas across to west Texas using outcrops in the Lampasas Cut Plain, the Callahan Divide, and the Llano Estacado regions. In his discussion of the Comanche Peak and Edwards Formations, Adkins correlated the Goodland Formation directly with the Comanche Peak and described the northern pinch out of the Edwards Formation at Fort Worth.

S. A. Thompson (1935) proposed the name "Gatesville Formation" to include the Edwards Limestone, the Comanche Peak Limestone, and the Walnut Clay as members; however, this term was not widely accepted. He proposed abandoning the name "Goodland Limestone" for the name "Comanche Peak Limestone" because of the synonymous nature of the names and the priority of the name "Comanche Peak" in the literature.

R. T. Hill, in 1937 in a review of the Fredericksburg Group, assigned the Paluxy Sand as the lower member of Fredericksburg Group stating that his decision reversal was based on "recently discovered paleontologic and stratigraphic evidences, which demonstrate the fact that the formation is the logical beginning of a cycle of sedimentation of the character which should be the true criteria for classification into groups, instead of solely paleontologic data."

F. E. Lozo (1949) studied the regional relationships of the Fredericksburg Group from the Brazos River valley area south into the Colorado River valley area. He substantiated Hill's (1937) assignment and recognized the Paluxy Sand as the lowermost formation in the Fredericksburg Group. In this study, Lozo divided the Walnut Clay into four unnamed members.

In 1953, J. P. Brand described the Cretaceous rocks of the Llano Estacado of Texas and considered the paleontologic, stratigraphic, and structural relationships of the formations. Brand noted that the formations of the Trinity Group (Antlers Sand) and the Fredericksburg Group (Walnut Clay, Comanche Peak Limestone, and Edwards Limestone) are similar lithologically and paleontologically to equivalent units of the Callahan Divide.

W. H. Matthews (1956) considered the Fredericksburg Group as a whole and divided it into three principal facies: (1) marginal or littoral facies; (2) neritic facies; and (3) biostromal facies. In the study, he concentrated on the biostromal facies of the Edwards Formation, describing the lithology and fauna varieties.

In 1959, the most comprehensive study of the Edwards Limestone to date was published by the Texas Bureau of Economic Geology. In this report, edited by F. E. Lozo, were papers by F. E. Lozo, H. F. Nelson, K. P. Young, and O.B. Shelburne.

F. E. Lozo (1959) (*idem*, p. 1-20) described the stratigraphic relationships of the Fredericksburg rocks in north-central Texas. He considered the Fredericksburg interval as a sedimentary cycle initiated by the deposition of terrigenous clastics, the Paluxy Sand, and terminated with the deposition of shallow and clear water carbonates, the Edwards Limestone.

In a detailed study of the Edwards Limestone in central Texas, H. F. Nelson (1959) (*idem*, p. 21-95) described and interpreted the gradational contact between the Comanche Peak and Edwards Limestones, the facies developed within the Edwards Limestone, and the unconformable contact between the Edwards and the overlying Kiamichi Formation. Nelson divided the Edwards Limestone into three facies: (1) rudist biohermal and biostromal reefs; (2) inter-reef sediments; and (3) primary dolomite. In addition, Nelson showed that the Edwards Formation throughout central Texas had been subaerially exposed and lithified prior to deposition of the overlying Kiamichi Formation.

K. P. Young (1959) (*idem*, p. 97-104) studied the paleoecology of the Edwards Limestone in Hill and Bosque Counties with emphasis on the fauna as water depth indicators. He interpreted the basal zone of the Edwards Limestone to have been deposited in about 20 to 25 feet of water and the upper zone to have occupied a depth slightly above mean low spring tide.

O. B. Shelburne (1959) (*idem*, p. 105-130) reviewed the stratigraphy of the Kiamichi Formation in central Texas. The Kiamichi had been considered to be the uppermost unit of the Fredericksburg Group, although it is separated from the underlying Edwards Formation by an unconformable corroded, pitted, and burrowed surface. Shelburne attributed the southern thinning of the Kiamichi to its southern onlap of the unconformable surface at the top of the Edwards Formation.

W. A. Atlee (1962) studied the facies relationships, lithologies, and economic importance of the Paluxy Sand in central Texas using both surface and subsurface data. He interpreted the depositional environments of the Paluxy as ranging from fluvial or fluviomarine to shallow marine.

J. G. Frost (1963) described the regional stratigraphy and depositional environments of the Edwards Limestone from Waco to Abilene. He interpreted three facies in the Edwards: (1) a reefal biohermal and biostrome facies; (2) a patch-reef dolomitic facies; and (3) a back-reef fine-grained dolomitic facies.

The Edwards Limestone of Coryell County was studied by G. L. King in 1963. He described the lithologies and thickness variations within the formation. In addition, King related the build-up of the Edwards Limestone and the pinch out of the Kiamichi Shale and the Paluxy Sand in Bosque County to the presence of a structural hinge that controlled deposition during Fredericksburg time.

The stratigraphic framework, facies distribution, and geologic history of the Fredericksburg Group in south-central Texas were described by C. H. Moore in 1964. He interpreted the southernmost exposures of the Paluxy Sand to represent a continental to nearshore terrigenous sequence and the overlying limestones, deposited in environments ranging from salt marsh to shallow marine, to have transgressed from south to north across the slowly subsiding west flank of the Tyler basin. Moore also described the development of an oolitic lentil, known as the Moffat mound, in the Comanche Peak and Edwards Formations in Bell County.

In 1966, C. H. Moore and K. G. Martin examined a southward trending tongue of the Paluxy Sand in Travis, Williamson, and Burnet Counties. They described the lithology, the facies relationships, and the depositional history of the sand. Moore and Martin recognized five facies and interpreted the Paluxy as the product of a coastal environment transitional between continental and marine environments.

J. O. Jones (1966) conducted a comprehensive study of the Walnut Formation in central and west-central Texas. In this study, he divided the Walnut into five members based on fossil content and lithology and interpreted their deposition as products of conditions ranging from quiet to turbulent in brackish to normal marine environments.

The stratigraphy and mineral and chemical properties of the Paluxy and Antlers Formations of north-central and west-central Texas were described by W. L. Fisher and P. U. Rodda in 1967. They recognized three facies in the Antlers Formation and tentatively correlated the upper sand unit with the sand of the Paluxy Formation.

In a second paper published in 1967, W. L. Fisher and P. U. Rodda described the Edwards Formation in terms of three facies: (1) a rudist-biohermal-biostromal facies; (2) a platform grainstone facies; and (3) a lagoonal facies. They suggested that the rudist bioherms of the Edwards

Limestone were deposited or grew on an extensive shallow-water platform bounded by deep-water basins in which chiefly lime muds were deposited. Fisher and Rodda designated the term "Kirschberg lagoon" for the area of restricted evaporite deposition on the Comanchean platform in central Texas. They also divided the dolomites in the Edwards into (1) stratal dolomite and (2) massive dolomite and judged them to be the "products of metasomatic replacement of calcium carbonate . . . resulting from contact with magnesium-enriched brine waters."

D. L. Amsbury (1967) studied Lower Cretaceous caliches in central Texas and interpreted them to represent ancient soil profiles. He stated that "one soil profile within the Paluxy Formation provides the basis for subdivision of the Paluxy into two members in Mills, Brown, Comanche, and Erath Counties." Amsbury also recommended the use of ancient soil profiles for dividing the Antlers Formation into two units.

In 1967, the Permian Basin Section of the Society of Economic Paleontologists and Mineralogists published the "Comanchean (Lower Cretaceous) Stratigraphy and Paleontology of Texas," which included studies dealing with the Fredericksburg Group and the underlying and overlying units, the Trinity and Washita Groups, respectively. Included in this report were papers by Keith Young, O. T. Hayward and L. F. Brown, Jr., and Leo Hendricks. Descriptions of the lithic units and summaries of the sedimentary history of the Lower Cretaceous rocks for portions of central Texas were included in each of the papers.

C. H. Moore (1967) studied the Cretaceous of west-central Texas in the Callahan Divide and the northern Edwards Plateau regions. In the Callahan Divide area, Moore distinguished Fredericksburg and Trinity equivalents in the Antlers Sand and proposed the term "Walnut-Comanche Peak undifferentiated" for the carbonate sequence that exhibits similarities to both formations as they are developed in the type sections in central Texas. Moore also extended an unnamed formation, a post-Edwards-pre-Washita ammonite-bearing marl, northward from the southern Edwards Plateau onto the Callahan Divide where it is represented by a thin veneer of residual soil.

The clastics and carbonates of west-central Texas, the Callahan Divide region, were studied in 1968 and 1969 by students under the direction of C. H. Moore. Related studies were conducted by J. B. Marcantel, E. L. Marcantel, A. L. Boutte, and R. A. Castle.

J. B. Marcantel (1968) examined the distribution, nature, and origin of the dolomites in the Edwards Formation. He interpreted the dolomites as products of deposition in supratidal, intertidal, and shallow subtidal environments and believed that they represent a regressive phase in the depositional history of the Fredericksburg sediments. Marcantel also related the dolomites in the Edwards to modern dolomites currently forming in similar environments.

E. L. Marcantel (1968) studied the paleoecology and diagenetic fabric of a rudist biostrome, the Skelly-Hobbs reef complex. She described the lithology and faunal variations in the biostrome and the underlying and overlying rocks and the sedimentary environment in which the biostrome developed. Marcantel interpreted the biostrome to have developed in very shallow marine water during a regressive phase of Fredericksburg deposition.

A. L. Boutte (1969) examined the stratigraphic facies relationships of the Fredericksburg limestones with emphasis on the geometry and depositional origin of a carbonate sand body, termed the Callahan Complex. Boutte determined the nature of the carbonate sand body and its relationship to the underlying structural feature of the Concho arch. He also examined the effect of the sand body on the development of the surrounding carbonate facies.

R. A. Castle (1969) correlated the Antlers Sand in the Callahan Divide area with the equivalent clastic units, the Trinity sands and the Paluxy sands, in the Lampasas Cut Plain area of central Texas. He recognized the presence of a caliche soil profile developed on progressively younger Paluxy Formation sediments from west to east. Castle interpreted the caliche layer as the boundary between the Trinity and Fredericksburg equivalent sands in the Antlers Sand of the Callahan Divide.

M. A. Mosteller (1970) examined the subsurface development of the Comanchean sediments from the eastern margin of the Texas craton into the East Texas basin. Through the correlation of isopach intervals with lithologic and environmental data, Mosteller interpreted the sedimentary history of the Comanchean Series and divided it into two major periods: (1) a deltaic period, the sands of the Trinity Group, and (2) a marine transgression period, the Glen Rose Formation of the Trinity Group, the Fredericksburg Group, and the Washita Group.

C. C. Smith (1971) analyzed the facies and depositional history of the Antlers Sand in the Callahan Divide area. Smith agreed with R. A. Castle (1969) concerning the presence of a caliche layer in the Antlers Sand, which indicates periods of weathering and soil formation. Smith interpreted the caliche zone to represent a meaningful boundary between Trinity and Fredericksburg deposition in the Callahan Divide-Lampasas Cut Plain area and suggested its use as the division between the two groups rather than the present placement of the boundary at the top of the Glen Rose Formation.

The Antlers Formation in west-central Texas was studied by P. A. Boone in 1972. He divided the Antlers into eight major sedimentary facies based on primary rock properties of composition, texture, sedimentary structures, and geometry. Boone's environmental facies of the Antlers include point bar, flood basin, delta, marine bar, bay-lagoon, terrigenous shallow shelf, and open marine platform carbonates.

W. A. Mudd (1972) studied the contact between the Comanche Peak and Edwards Formations in part of McLennan, Coryell, Hamilton, and Bosque Counties. He stated that in the initial deposition of the Edwards Limestone, the *Eoradiolites* spat attached to three types of substrate: (1) *Dictyoconus* mats; (2) *Cladophyllia* mats; and (3) burrow-solidified carbonate mud.

D. S. Roberson (1972) separated the reef province of the Edwards Limestone into three facies: (1) a reef facies; (2) an inter-reef-biohermal facies; and (3) a biohermal-mound facies. She conducted a detailed study of the distribution, paleoecology, and environments of deposition of the mound and biohermal facies of the upper Edwards in central Texas. Roberson interpreted the circular bioherms of the Edwards Limestone as the product of deposition in quiet waters behind a reef barrier where periodic influxes of clay or carbonate mud terminated the biohermal growth.

P. R. Rose (1972) described the "Edwards" as a group, consisting of two formations in south-central Texas, Kainer and Person, and two formations in the eastern Edwards Plateau, Fort Terett and Segovia. He described the stratigraphy and depositional history of these rocks in the surface and subsurface. Rose recognized nine major environments in the Edwards: open deep marine; open shelf; open shallow marine, moderate to high wave energy; open shelf, low wave energy; restricted shallow marine; tidal flat; euxinic evaporitic shelf basin; evaporite dominated supratidal flat; and coastal terrigenous.

S. A. Mizell (1973) recognized three petrographic facies in the Edwards Limestone of McLennan County: (1) a lime wackestone-boundstone facies; (2) a calcarenite facies; and (3) a coarse calcarenite facies. He interpreted the facies to represent environments of deposition ranging from reef to off-reef to tidal channel.

The Walnut Formation in central Texas was studied by C. D. Flatt in 1976 with special emphasis placed on the massive oyster banks that occur throughout the formation. He examined the distribution and nature of the oyster banks and determined their significance in the deposition of the Walnut Formation. Flatt interpreted the Walnut Clay to represent a time transgressive unit deposited in environments ranging from nearshore to restricted lagoonal to shallow marine.

Steven L. Keyes (1976) studied the upper Edwards Formation in central Texas and observed a laterally continuous, limonite-stained and bored, case-hardened upper surface indicative of subaerial exposure. He interpreted the surface as a regressive cycle of non-deposition.

The Paluxy Formation in northeast Texas was examined by C. A. Caughey (1977) with three major depositional systems established: (1) a delta system; (2) a fluvial system; and (3) a strandplain system.

Sue L. Keyes (1977) divided the Comanche Peak Formation in central Texas into three facies: (1) a lower unit of thin *Texigryphaea* beds and nodular limestone; (2) a middle unit of nodular limestone, thin-bedded limestone, and marl; and (3) an upper unit of chalky bioturbated limestone and marl. She interpreted the units to represent a transition of the Comanche Peak sea from "variable salinity conditions with some clay influx to normal marine conditions with only minor amounts of clay."

A. D. Jacka and J. P. Brand (1977) described the biofacies and porosity development in the Edwards Limestone exposed in a large quarry in Scurry County, Texas. The Edwards Limestone was found to consist of four tabular biostromes overlain by a progradational reef-forereef complex. Diagenetic features of the Edwards indicate that it was subaerially exposed soon after deposition.

M. E. Staples (1977) described the Goodland Formation of north-central Texas and recognized three lithologic members: (1) the lowermost Mary's Creek Member (massive beds of fossiliferous marl and thin beds of ripple-marked limestone); (2) the Benbrook Member (thick fossiliferous beds of limestone and interlaminated marl); and (3) the upper Cresson Member (massive beds of calcarenite). He interpreted three sedimentary environments from the lithology and faunal assemblages of the Goodland: (1) a brackish water bay or lagoonal environment; (2) a predominantly clear, open marine environment; and (3) a high energy, shoal environment. Staples also stated that "the Comanche Peak Formation appears to be the southern equivalent of the Goodland Formation," having identical stratigraphy and paleontology.

L. C. Whigham (1978) described the regional stratigraphy and depositional environments of the Trinity and Fredericksburg Groups in central Texas. Each group was interpreted as a transgressive sequence of marginal marine deposits beginning with the deposition of continental or nearshore sands and terminating with the deposition of marine carbonates. Holocene models were used to support the interpretation of the depositional history of the basal Cretaceous marginal marine deposits.

The Edwards Limestone in parts of Erath, Somervell, Johnson, Hill, Bosque, and Hamilton Counties was studied by G. B. Lambert in 1979. He divided the Edwards Limestone into five facies based on lithology and faunal assemblages. He interpreted the depositional history of the sequence as the result of facies offlap of nearshore, restricted marine sediments over offshore, open marine sediments. Lambert also interpreted the existence of an actual organic barrier reef in the Edwards Limestone in central Texas.

M. B. Weems (1979) divided the Edwards Limestone in central Texas into four facies: (1) rudist biohermal-biostromal facies; (2) flank bed facies; (3) interbank facies; and (4) dolomitic facies. Weems interpreted the facies characteristics to suggest that the limestone of the Edwards was not composed of wave resistant carbonate reefal material, but is instead composed of rudist bank deposits.

The Paluxy Formation of north-central Texas was divided into three members on the basis of depositional environment and petrologic and stratigraphic relationships by M. T. Owen in 1979. The lowermost Lake Merritt Member was interpreted as intertidal deposits, the Georges Creek Member was interpreted as channel bar and flood basin deposits of a braided stream system, and the uppermost Eagle Mountain Member was interpreted as point bar and floodplain deposits of a meandering river system.

Summary literature on general stratigraphic principles, carbonate and clastic sedimentation, and depositional environments was consulted in order to interpret the depositional history of the Fredericksburg Group. The references most useful in this study include those by

Ham (1962), Selley (1970), Blatt, Middleton, and Murry (1972), Laporte (1974), Reineck and Singh (1975), and Wilson (1975).

The interpretation of the depositional history of the Fredericksburg Group was also based to a large degree on its comparison to modern models. Descriptions of depositional environments in the modern carbonate provinces of Florida, the Bahamas, and the Persian Gulf provided useful information.

R. N. Ginsburg (1956) studied the environmental relationships of grain size and constituent particles in the carbonate sediments of southern Florida. A symposium, edited by Pray and Murray (1965) discussed dolomitization and limestone diagenesis. Topics most important to this study include those considering the stability relations of calcite and aragonite, the deposition of penecontemporaneous dolomite in the Persian Gulf, and the presence of supratidal dolomite from Andros Island, Bahamas. The sedimentary structures in modern carbonate sands of the Bahamas were examined by J. Imbrie and H. Buchanan (1965). M. M. Ball (1967) conducted a detailed discussion of the carbonate sand facies and their environments in the Florida and Bahama provinces.

J. M. C. Taylor and L. V. Illing (1969) described the Holocene intertidal calcium carbonate cementation surrounding the Qatar Peninsula, Persian Gulf. Carbonate sediments and their diagenesis were studied by R. G. C. Bathurst (1971) who included discussions concerning the recent carbonate environments of the Great Bahama Bank, Florida, and the Persian Gulf, as well as interpretations of recent carbonate algal stromatolites. B. H. Purser and E. Seibold (1973) and B. H. Purser (1973) examined Holocene carbonate sedimentation and diagenesis in the Persian Gulf province.

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REGIONAL GEOLOGY

STRUCTURE

The Lower Cretaceous rocks of Texas were deposited within three major structural provinces: (1) the East Texas basin, a subsiding trough marking the eastern margin of this study; (2) the Rio Grande embayment (or Maverick basin), a subsiding trough south of the area of interest of this investigation; and (3) the Texas craton, a stable platform that divided the two negative areas. Several structural or depositional features within these provinces exhibited pronounced effects on the deposition of the Fredericksburg strata. These features are the Concho arch, the Llano uplift, the Lampasas arch, the San Marcos arch, and the Stuart City reef trend (Fig. 4).

The Concho arch is a broad Paleozoic structural high described by Cheney and Goss (1952, p. 2262) as "extending northwest (from the Llano uplift) to the Texas Panhandle region, but has lost prominence as a result of subsidence beneath the Permian basin." This feature is the northwestern counterpart of the San Marcos arch of south-central Texas. The positive character of the Concho arch is reflected in the Fredericksburg sediments by a thinning in the basal clastics over the arch and the loss of distinctive facies in the overlying limestones (Boutte, 1969, p. 11-14). The limestones display facies characteristic of deposition under conditions of shallower water and higher energy than in the surrounding areas. Thus, the Concho arch region probably represents one of the shallowest areas on the craton during Early Cretaceous time (*idem*, p. 14).

The Llano uplift is an inlier of Precambrian granite and metamorphic rock and represented a structurally and topographically positive area during much of Early Cretaceous time. It was not until deposition of the upper Edwards Formation that the Llano area was completely covered by the Cretaceous seas. The Lampasas arch is a plunging anticline resulting from deformation on the margin of the Llano uplift. Both the Llano uplift and the Lampasas arch were sufficiently positive to influence development of carbonate ramps and platforms. The Lower Cretaceous carbonate facies of moderate subsidence built out from these positive areas exhibit irregular patterns and wide facies belts (Wilson, 1975, p. 32).

The San Marcos arch is a broad, gentle anticlinal nose or platform extending northeast from the Llano uplift. This feature marks the southern edge of the Texas craton. The positive character of the San Marcos arch is illustrated by the development of shallow water, high energy lime grainstone trends in the Fredericksburg carbonates along the axis of the arch (oral communication, C. H. Moore, Jr., 1979). This facies development is similar to that exhibited by the facies of the Fredericksburg sediments at the axis of the Concho arch.

The Stuart City reef is a sedimentary feature that extends from northern Mexico into central Texas and marks the shelf edge during Early Cretaceous time. The reef, a prominent barrier composed of rudists, corals, and algal debris, began to form during Early Cretaceous Trinity time and continued to be a topographic high during Fredericksburg time. However, due to the large expanse of the shelf behind the reef, normal marine conditions existed north of the Stuart City reef (*idem*).

The Lower Cretaceous Fredericksburg Group, therefore, was deposited on a broad shallow shelf bounded by deep water basins. Structurally positive features on the shelf exhibited pronounced effects on the deposition of the sediments, usually producing sites of shallow water deposition.

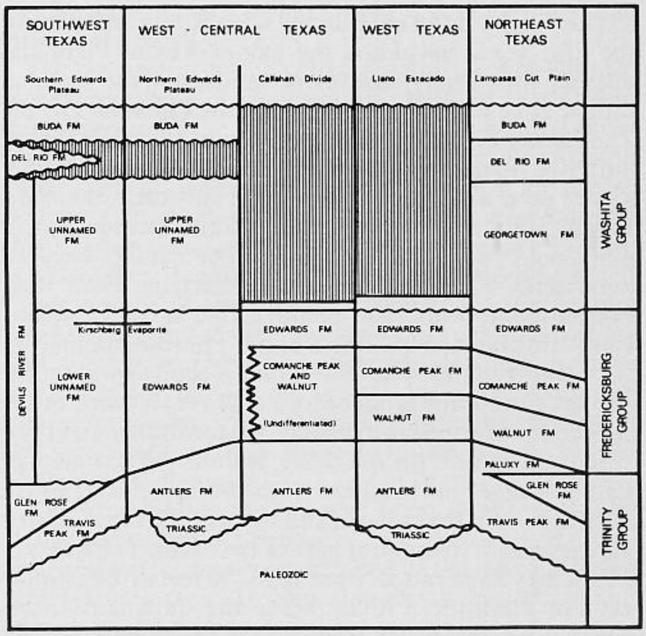

Fig. 6. Stratigraphic nomenclature and regional stratigraphic relationships of the Fredericksburg Group throughout Texas. Note particularly the Lampasas Cut Plain region, the Llano Estacado region, and the Callahan Divide region. (*Adapted from Moore, 1969, p. 7).*

STRATIGRAPHY

The Cretaceous System of Texas is traditionally divided into two series, the Comanchean Series and the overlying Gulfian Series. The Comanchean Series is divisible, in ascending order, into Trinity, Fredericksburg, and Washita Groups. This study encompasses the uppermost part of the Trinity Group, the Fredericksburg Group, and the lowermost part of the Washita Group.

The following section outlines the stratigraphic nomenclature and regional stratigraphic relationships of these rock units throughout Texas. Because of large scale facies changes and the resulting nomenclature variations between regions, it is necessary to divide the outcropping Cretaceous strata into four areas corresponding to the physiographic regions in which they occur (Fig. 6). The four regions include the Lampasas Cut Plain, the Callahan Divide, the Edwards Plateau, and the Llano Estacado.

The uppermost Trinity Group in the East Texas basin, the Lampasas Cut Plain, and the southern Edwards Plateau is represented by the Glen Rose Formation. The Glen Rose Formation is generally composed of beds of thin- to medium-bedded dense limestone alternating with marl and marly limestone. The contact between the Glen Rose Formation and the sands of the overlying Paluxy Formation appears to be conformable in the Lampasas Cut Plain where the lithologic change is considered gradational, abrupt, or interfingering (Owen, 1979, p. 9). The Glen Rose Formation thins westward and northward from the East Texas basin. It ranges in thickness from 3500 feet in the East Texas basin to 400 to 800 feet in the eastern Lampasas Cut Plain. The Glen Rose Formation pinches out to the west in Wise County.

In the Callahan Divide, the northern Edwards Plateau, and the Llano Estacado the uppermost Trinity unit is the Antlers Formation. The term Antlers was first used by R. T. Hill (1901) to designate the coalescence of the lower Trinity sands with the Fredericksburg Paluxy Sand where the Glen Rose Limestone is absent. The Antlers Formation is a fine- to medium-grained, poorly cemented to uncemented quartz sandstone with lenses of silt and clay in the upper portion and a pebble conglomerate of chert and quartz in the lower portion. A regional caliche zone, representative of a paleosoil, averages 2 feet in thickness and lies 15 to 25 feet below the overlying carbonates sequence in the Antlers Formation of the Callahan Divide. The regional caliche zone represents a hiatus separating the Antlers into the lower Trinity equivalent and the upper Fredericksburg equivalent (Castle, 1969, p. 47-50 and Smith, 1971, p. 35-37). The Antlers Formation unconformably overlies clastic sediments of Triassic and Paleozoic age in the Callahan Divide and the Llano Estacado. The upper contact between the Antlers Formation and the carbonate sequence of the Fredericksburg Group is gradational (Marcantel, 1968, p. 10). The Antlers Formation ranges in thickness from 60 to 180 feet in the Callahan Divide, is as much as 120 feet thick in the Edwards Plateau (Moore, 1967, p. 6), and is 22 to 26 feet thick in the Llano Estacado.

The Fredericksburg Group of Texas consists of a basal quartz sand, the Paluxy Formation and its equivalents in the Antlers Formation, and an overlying carbonate sequence, the Walnut Formation, the Comanche Peak Formation, and the Edwards Formation, and their stratigraphic equivalents.

The Paluxy Sand overlies the Glen Rose Limestone in the East Texas basin and the Lampasas Cut Plain and overlies the Trinity equivalent sands and the regional caliche zone of the Antlers Sand in the Callahan Divide. The Paluxy Formation consists of massive to thin beds of buff, fine- to medium-grained, relatively unconsolidated, quartz sand with lenses and beds of silty clay and shale. Fossils are rare in the Paluxy Sand and include gastropods, pelecypods, and ostracods. The contact between the Paluxy Formation and the underlying Glen Rose Formation appears to be conformable in the Lampasas Cut Plain and the East Texas basin. The lower contact of the Paluxy Sand with the Trinity equivalents in the Antlers Formation is unconformable as evidenced by the caliche zone formed in a regional paleosoil. The Paluxy is conformable with the overlying Walnut Formation. The Paluxy ranges in thickness from 200 to 400 feet in the northern East Texas basin and thins to the south until it pinches out in the central part of the basin. Thickness of the Paluxy Sand ranges from 20 to 190 feet in the Lampasas Cut Plain to 15 to 25 feet in the Callahan Divide, where it represents the upper part of the Antlers Formation, and it is not present to the west in the Llano Estacado.

The Walnut Formation varies in character and includes calcareous clay, bedded coquinoid and argillaceous limestone, fossiliferous nodular limestone, and thin ripple-marked limestone. The most prominent feature of the formation in the Lampasas Cut Plain is the accumulation of massive oyster banks of *Texigryphaea* and ammonite beds of *Oxytropidoceras*. West in the Callahan Divide and Llano Estacado, the absence of the prominent fossil beds and terrigenous material makes difficult the separation of the Walnut Formation from the overlying Comanche Peak Formation, and in that region it is recognized as a single unit, the Walnut-Comanche Peak Undifferentiated Formation (Moore, 1969, p. 9). The contact between the Walnut Formation and the Comanche Peak Formation is conformable and gradational. The Walnut Formation thins to the north in the East Texas basin and thickens southward to more than 400 feet in the central part of the basin. The Walnut Formation ranges in thickness from 20 to 180 feet in the Lampasas Cut Plain and thins progressively to the west where it ranges from 4 to 40 feet in the Llano Estacado.

The Comanche Peak Formation exhibits a characteristic lithology, consisting of chalky nodular limestone interbedded with occasional thin beds of marl. The faunal content is similar to that of the Walnut Formation, with the addition of more marine species; however, the number of individuals in a given species is considerably less. The Comanche Peak Formation and the overlying Edwards Formation are conformable across an abrupt contact. The Comanche Peak Formation traditionally is not separated into a distinct unit in the East Texas basin but is grouped together with the overlying Edwards age rocks in the Goodland Formation. However, in the areas where it is considered a distinct unit, the Comanche Peak Limestone ranges in thickness from 60 to 180 feet at the western margin of the basin and shows a general thinning to the north. Thicknesses in the Lampasas Cut Plain range from 40 to 120 feet, and, where it can be differentiated from the underlying Walnut Formation, it appears to remain a fairly consistent thickness of 70 feet from the Callahan Divide to the Llano Estacado.

The term "Walnut-Comanche Peak Undifferentiated" is used in the Callahan Divide for the marl-bearing, fossiliferous, nodular limestone that possesses characteristics of both the Walnut Formation and the Comanche Peak Formation. In this study, the term Walnut-Comanche Peak Formation is used for this unit. The Walnut-Comanche Peak Formation is not recognizable in the Edwards Plateau south of a zone where the entire unit is represented by a lime grainstone complex.

The Goodland Formation crops out from southern Parker County to the Red River and is the name traditionally used for the combined Comanche Peak and Edwards Formations in the subsurface of the East Texas basin. The Goodland Formation is a fossiliferous limestone and marl sequence that conformably overlies the Walnut Formation and conformably underlies the Kiamichi Formation of the Washita Group. Most recent workers (Keyes, 1977, p. 24 and Staples, 1977, p. 76) consider the Goodland Formation to be the northern equivalent of the Comanche Peak Formation for the stratigraphy and paleontology of the two formations are identical. The Goodland Formation thins westward and southward from 400 feet near the axis of the East Texas basin and ranges in thickness from 116 feet in central Tarrant County to 20 feet near the Texas-Oklahoma border.

The Edwards Formation exhibits a wide variety of lithologies, and major facies changes occur within the unit throughout Texas. In places, the Edwards is a nearly pure (less than one percent terrigenous material) rudist-bearing limestone. In other places, it consists of lime wackestones, packstones, and grainstones, dolomites, and biostromal, biohermal, and mound accumulations of rudist debris. In the Lampasas Cut Plain, the upper surface of the Edwards Formation is characterized by a laterally continuous, limonite-stained and bored, case-hardened surface indicative of subaerial exposure. Thus, the contact between the Edwards Formation and the overlying Kiamichi Formation is believed to be unconformable. The upper surface of the Edwards Formation has largely been removed in the Callahan Divide where the Edwards Formation is unconformably overlain by Quaternary deposits. Late Tertiary-Quaternary caliche unconformably overlies the Edwards Formation in the Llano Estacado. The Edwards Formation, like the Comanche Peak Formation, is not recognized as a distinct unit in the East Texas basin but is grouped with the Comanche Peak Formation into the Goodland Limestone. Where the Edwards is considered as a distinct unit, it thins and pinches out to the north and gradually thickens to the south on the western margin of the East Texas basin. The Edwards Formation exhibits a consistent thickness from the Lampasas Cut Plain to the Callahan Divide to the Llano Estacado, ranging from 20 to 50 feet in thickness and, over most of the area, it remains a near-uniform 30 to 35 feet thick.

Major stratigraphic relationships and facies changes occur in the Fredericksburg carbonates from the Callahan Divide through the Edwards Plateau. South of the Callahan Divide where the Walnut-Comanche Peak Formation is no longer recognizable, the entire Fredericksburg Group takes on characteristics of the Edwards Formation (massive bedding, dolomite, chert, and rudists) and is termed the Edwards Formation by Moore (1969, p. 11). In the southern Edwards Plateau, one formation, the "Unnamed Lower Unit," was recognized by Lozo and Smith (1964) and correlates with Moore's Edwards Formation. An evaporite facies is present near the top of the Edwards Formation and the "Unnamed Lower Unit" in an area extending east to Fredericksburg in Gillespie County, southwest to eastern Sutton County, and northwest to central Coke County (J. Marcantel, 1968, p. 16). The evaporite facies, informally named the Kirschberg Evaporite facies, contains gypsum with associated limestone, dolomite, and crystalline calcite. The Kirschberg evaporite averages 45 feet in thickness and is usually represented by evaporite solution collapse zones. The presence of this evaporite feature is important to the interpretation of the regional stratigraphy and the regional conditions existing during Fredericksburg time throughout much of Texas.

The lowermost Washita Group in north-central Texas, in the Lampasas Cut Plain, and into the East Texas basin is represented by the Kiamichi Formation. The Kiamichi is a black, fissle shale, which becomes calcareous in the upper portion of the unit. Although there is an abrupt change in lithology, the Kiamichi Formation conformably overlies the Goodland Formation (Staples, 1977, p. 41). However, due to the pitted, bored, and iron-stained upper surface of the Edwards Formation, the contact between the Edwards and Kiamichi Formations is considered unconformable. The Kiamichi Formation thins southward and pinches out in the subsurface in southern Limestone County. The Kiamichi Formation thins from 120 feet near the Red River to pinch out in central McLennan County.

The Fredericksburg Group of Texas is represented by clastic and carbonate deposits. The lithology and distribution of the facies were controlled by the regional structural features on the Texas craton and the rate and extent of transgression of the Comanchean sea.

STRATIGRAPHY

The major objective of the present investigation was to determine the stratigraphy and depositional history of the Fredericksburg Group; from base to top, the Paluxy, the Walnut, the Comanche Peak, and the Edwards Formations. The Antlers Formation, formed by the coalescence of the basal sands of the Trinity Group and the Paluxy Sand of the Fredericksburg Group where the Glen Rose Limestone is absent, received limited consideration. Only those sediments of the Antlers Formation laterally equivalent to the Paluxy Formation were considered in this investigation.

Rocks of the Fredericksburg Group are characterized as clastic deposits conformably overlain by carbonate deposits. They occur as a wedge of sediments that dip gently and thicken in a southeastward direction. North-south geologic sections (Fig. 7) and east-west geologic sections (Fig. 8) across the study area illustrate the thickening wedge of Fredericksburg rocks in the subsurface.

The Fredericksburg Group within the region of investigation can be divided into seven stratigraphically distinct areas (Fig. 9). Area One is in Lubbock, Garza, Dawson, and Borden Counties; Area Two consists of southwestern Nolan and northern Coke Counties; Area Three is in central Nolan County; Area Four is in northeastern Nolan, Taylor, Runnels, Callahan, and Coleman Counties; Area Five consists of Parker, Tarrant, and northeastern Hood Counties; and Area Six comprises Erath, Hood, Somervell, Johnson, Bosque, Hamilton, McLennan, Brown, Comanche, Mills, Coryell, Lampasas, northern Burnet, and northwestern Bell Counties. From the outcrop, the rocks of the Fredericksburg Group dip eastward along a line from central Bell County to western Tarrant County to enter the subsurface. This eastern subsurface portion of the area of investigation is considered as a distinct area and is designated Area Seven. Detailed stratigraphic relationships of the Fredericksburg rocks in each area are presented in the following discussion.

AREA ONE

The Fredericksburg Group of Area One (Fig. 9) consists of a thin Walnut Formation, a thick Comanche Peak section, and the Edwards Formation. Three measured sections illustrate the stratigraphic sequence in Area One: the Fluvanna section (locality 4) (Fig. 10), locality 5, and the Gail Mountain section (locality 6) (Appendix I).

The Walnut Formation, the lowermost unit of the Fredericksburg Group in Area One, disconformably overlies the Antlers Formation of the Trinity Group. In areas of southern Lubbock County, the basal portion of the Walnut Formation contains argillaceous sandstone (localities 2 and 4).

The Walnut Formation consists of from 10 to 20 feet of limestone, shale, and sandstone. Throughout Area One, the Walnut Formation can be divided into three informal zones (Brand, 1953, p. 8). The basal portion consists of dark yellowish orange to yellowish gray to light gray, loosely consolidated, massive, argillaceous sandstone (localities 2 and 4). At locality 2 in southern Lubbock County, the entire Walnut section is sandy and the upper portion is fossiliferous, containing the pelecypods *Ostrea, Exogyra texana,* and *Gryphaea mucronata*. The middle portion of the Walnut Formation contains light gray, massive to nodular, argillaceous lime wackestone and

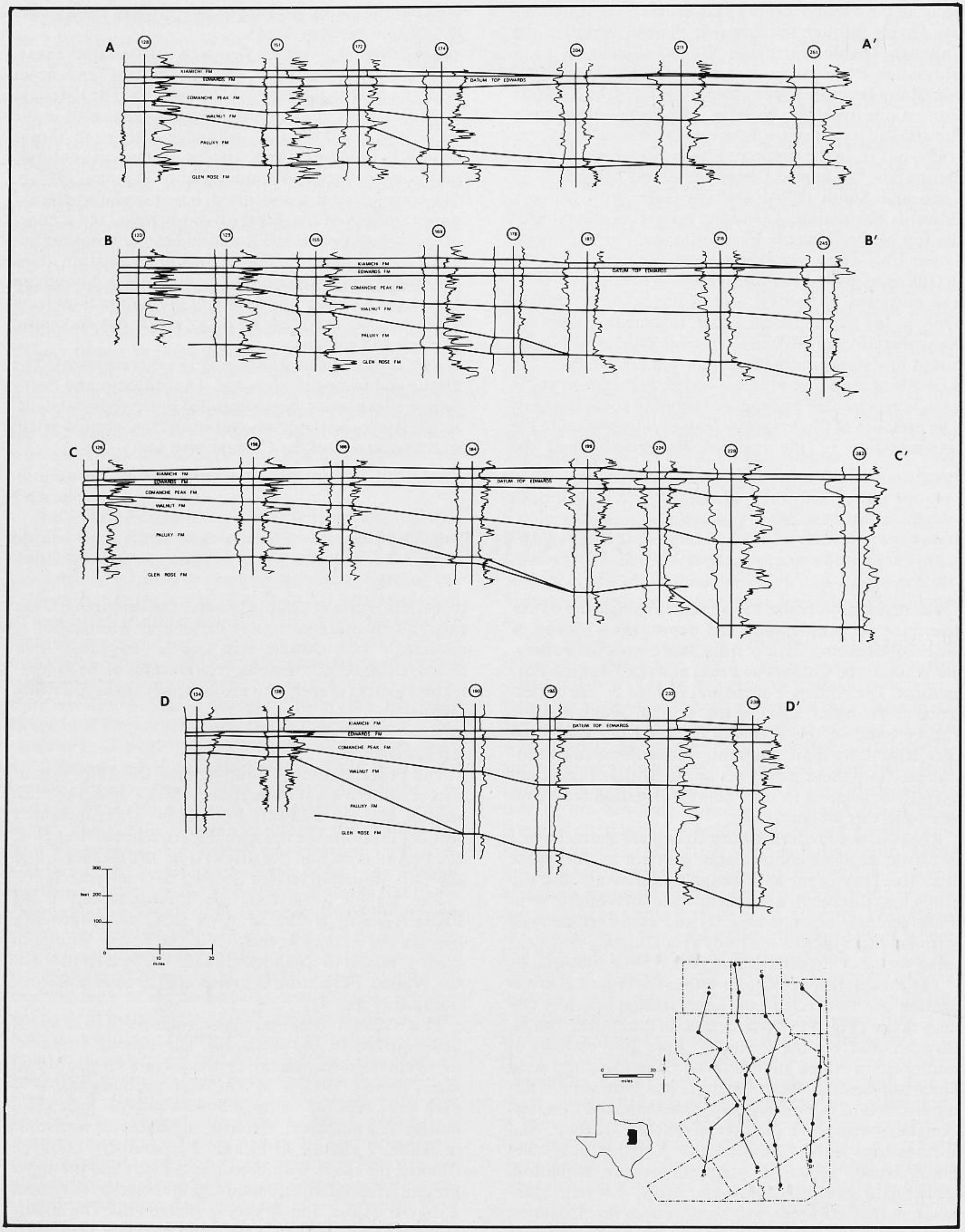

Fig. 7. North-south geologic cross sections.

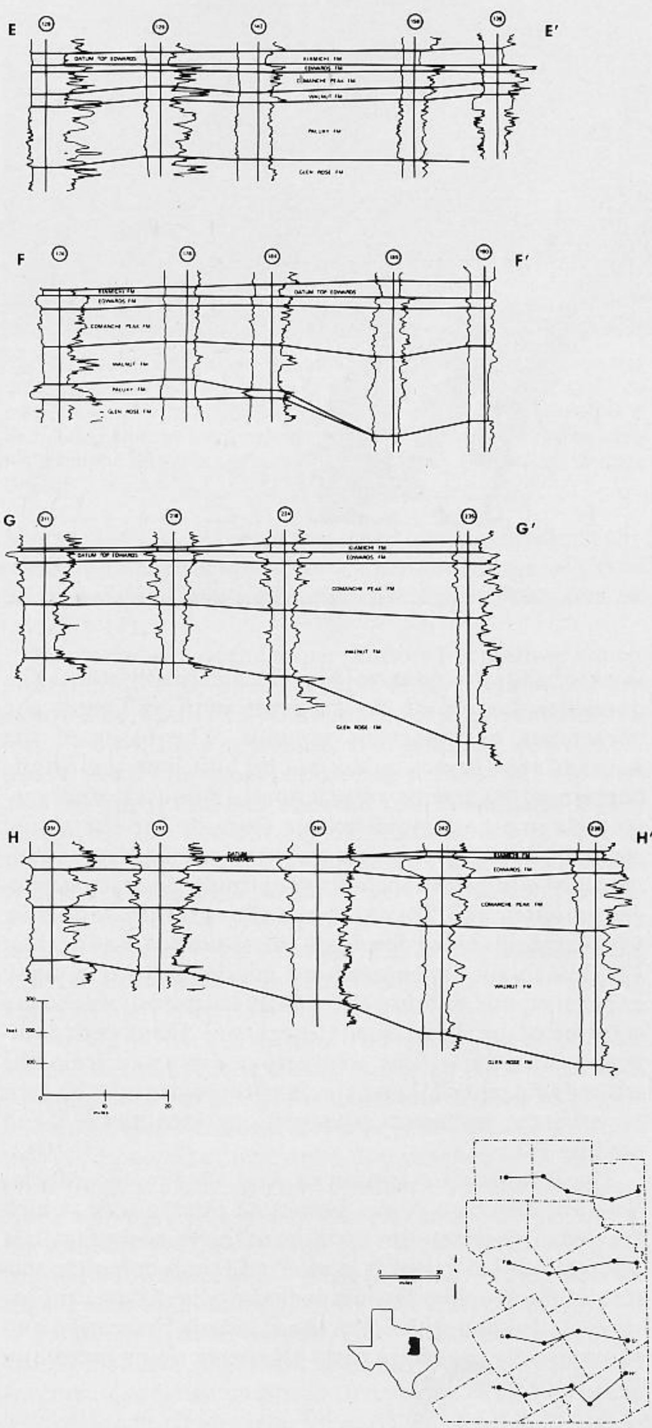

Fig. 8. East-west geologic cross sections.

yellowish brown to dark gray, thinly laminated, arenaceous, calcareous shale (localities 4, 6, and 7). Interbeds of blue-gray shale are also present in the limestones (locality 4). Both the limestones and shales are fossiliferous and contain a profusion of individuals of the oyster *Gryphaea mucronata,* and lesser numbers of the pelecypods *Ostrea, Exogyra texana,* and *Protocardia texana.* The upper portion consists of medium gray to olive gray, slightly calcareous shale and light gray, nodular, argillaceous lime wackestone (locality 4). The upper Walnut Formation has abundant specimens of the oyster *Exogyra texana.*

The upper contact of the Walnut Formation with the overlying Comanche Peak Formation is gradational and is characterized by slight lithologic and faunal variations. Three criteria were noted by Brand (1953, p. 8) as helpful in determining the contact:

(1) The upper Walnut is predominantly shale with interbeds of thin, nodular, argillaceous limestone; whereas the lower Comanche Peak is predominantly thick- to massive-bedded limestone with thin interbeds of shale (locality 4).

(2) Abundant specimens of the pelecypod *Exogyra texana* are present in the upper beds of the Walnut Formation but sporadic in the lower beds of the Comanche Peak Formation (localities 6 and 7).

(3) The echinoid *Enallaster texanus* is common in the lower beds of the Comanche Peak Formation but rare in the upper Walnut Formation (localities 4 and 7).

The Comanche Peak Formation consists of from 50 to 80 feet of limestone and interbedded shale and exhibits a general thickening trend to the east. The limestones in Area One are moderate yellow to light gray, predominantly nodular to thinly bedded to massive, argillaceous lime wackestone and lime mudstone. Dusty yellow to olive gray, thinly laminated shale interbeds occur throughout the section (localities 1, 2, 4, and 6). The basal Comanche Peak Formation contains arenaceous limestone and is characterized by scattered sand grains and quartz pebbles ranging in size from ¼ to one inch in diameter. Both the limestones and shales of the Comanche Peak Formation are fossiliferous. The fauna is dominated by pelecypods with *Gryphaea* and *Exogyra, Pecten, Protocardia, Lima,* and *Pinna* the most common. In addition, several species of gastropods, *Tylostoma* and *Turritella,* the ammonite *Oxytropidoceras,* and the irregular echinoid *Enallaster* are common components of the limestones and shales of the Comanche Peak Formation.

The contact between the Comanche Peak Formation and the overlying Edwards Formation is conformable and sharp. In weathered sections, the contact is easily recognized because of differential weathering and the typical Edwards overhang. Three criteria based on slight lithologic and faunal variations between the two units were noted by Brand (1953, p. 10) as an aid in determining the contact:

(1) The upper Comanche Peak Formation is predominately a fine-grained, argillaceous limestone; whereas the lower Edwards Formation is a coarse-grained limestone.

(2) Bedding planes are undulating in the Comanche Peak Formation but are regular in the Edwards Formation (Fig. 11).

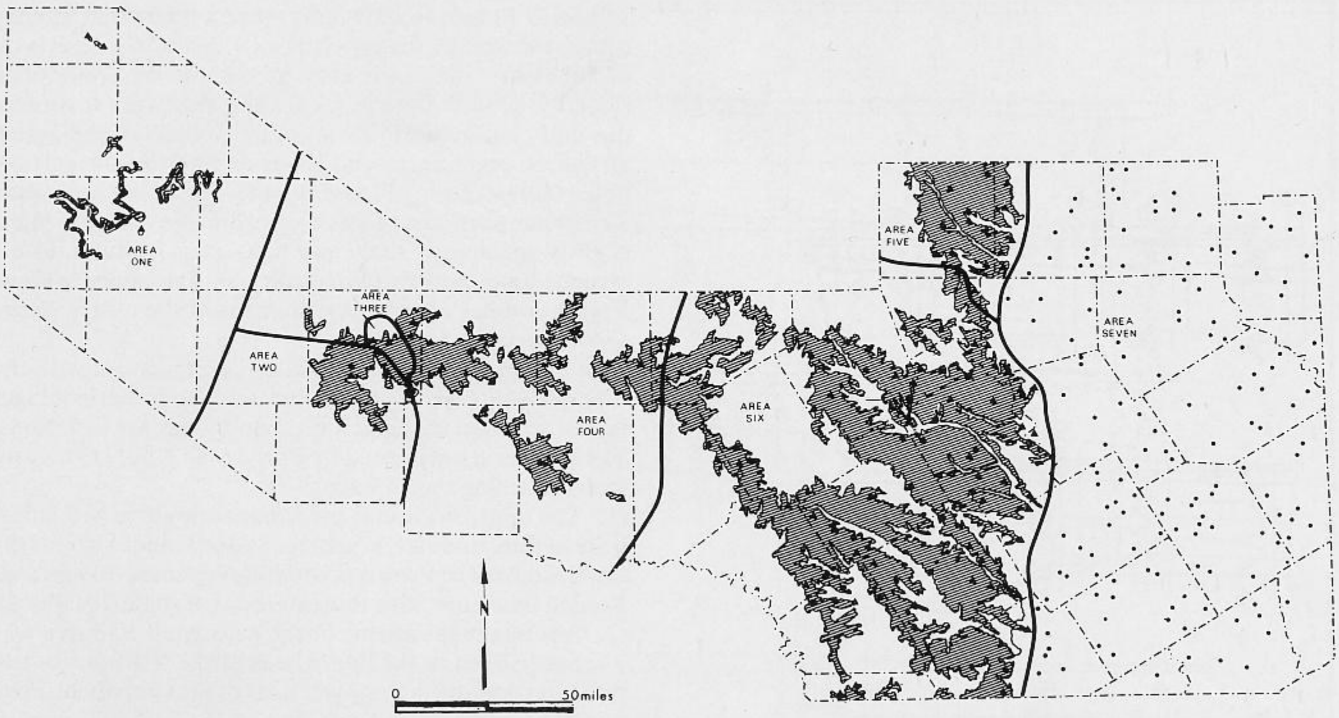

Fig. 9 The Fredericksburg Group within the area of investigation can be divided into seven stratigraphically distinct areas—Area One through Area Seven. ▵—outcrop locality, •—well site.

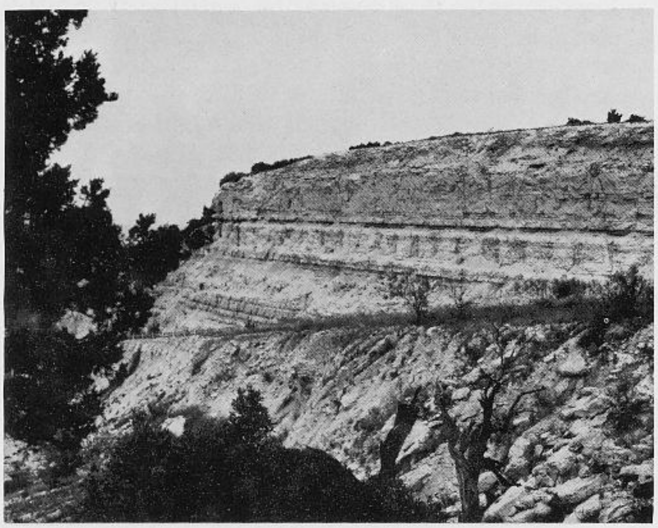

Fig. 10. Locality 4. A complete section of Fredericksburg rocks is exposed in Garza County. The contact between the Edwards Formation and the Comanche Peak Formation is marked at the upper, darkest receding marl break. Note the massive, thick-bedded character of the Edwards and the nodular limestones and interbedded shales of the Comanche Peak Formation.

(3) The basal Edwards Formation typically contains numerous rudists or is porous due to solution of rudist fossils.

(4) Shale interbeds are common in the Comanche Peak but are absent in the Edwards.

The Edwards Formation consists of from 18 to 35 feet of limestone, ranging from wackestones to packstones to grainstones. It is typically light gray to yellowish gray, thickly bedded to massive (Fig. 12), and fossiliferous. The dominant feature of the Edwards in Area One is the occurrence of numerous mounds. The bases of the mounds are distinct, underlain by buff lime grainstone containing fragments of echinoids, mollusks, and gastropods in a coquinoid texture (locality 5). The actual mounds, biohermal in nature, are composed predominantly of pelecypods including caprinids, *Chondrodonta, Eoradiolites,* and *Toucasia*, and the coral *Cladophyllia*, with caprinids being dominant (localities 4, 5, and 6) (Fig. 13). The fossils are encased in a micrite matrix. In many exposures, one or more of the beds are porous due to the solution of the rudist fossils (locality 6). Flank beds composed of nodular lime wackestone dip away from the mounds (locality 5), and similar lithologies may be seen covering the mounds at other sections (localities 4, 5, and 6) (Fig. 14).

The Edwards Formation in Area One is unconformably overlain by a dense, indurated caliche zone, which formed in clastic parent material of the Pliocene Ogallala Formation. However, it is inferred that a complete section of the Washita Group, including the Kiamichi Formation, was deposited over the Edwards Formation and subsequently eroded in early Cenozoic time (Jacka and Brand, 1977, p. 367).

AREA TWO

The Fredericksburg Group of Area Two (Fig. 9) consists of a thin sequence of sediments in the Antlers Formation, which is correlative with the Paluxy Formation, and a thick sequence of carbonate rocks characteristic of the Edwards, and thus termed Edwards Formation by

Fig. 11. Locality 6. The contact between the Edwards Formation and the Comanche Peak Formation is drawn at the marl break approximately even with the man's head. The bedding in the Comanche Peak is undulating and the limestones are nodular in character. The bedding planes in the Edwards are regular and the rocks are medium to thick bedded.

Moore (1969, p. 11). Two measured sections illustrate the stratigraphic sequence in Area Two: the Maryneal Composite section (locality 8) and the Nipple Peak section (locality 13).

The sediments of the upper Antlers Formation, which are laterally equivalent to the Paluxy Formation, are exposed at locality 13. They consist of approximately 12 feet of dark brown to buff, fine-grained, well-sorted, quartz sand. The sand is calcareous in the lower two feet, and the upper one and one-half feet of sand are highly burrowed. The nodular caliche facies, which represents the hiatus between the lower Trinity and upper Fredericksburg sediments in the Antlers Formation (Castle, 1969, p. 47-50 and Smith, 1971, p. 35-37), is not visible because of a covered interval. The upper sands of the Antlers Formation are transitional into the overlying marls of the Fredericksburg section.

The Edwards Formation, the entire carbonate sequence of the Fredericksburg Group in Area Two, consists of from 97 to 106 feet of massively bedded limestone and dolomite. The basal section of the Edwards Formation is composed of limestone. Interbedded buff, fossiliferous, marly limestone and fossiliferous, nodular limestone with oyster fragments and glauconite are present in the southern portion of Area Two (locality 13). Overlying the nodular limestone in the south (locality 13) and forming the base of the section to the north (localities 8 and 11) is a buff gray, thick-bedded, lime packstone with echinoids, mollusks, and algal remains. Coral and caprinid fragments are also common in the lime packstone unit. The major portion of the Edwards Formation throughout Area Two overlies the lime packstone and consists of dolomite. Two different dolomite facies with differing features can be distinguished (J. Marcantel, 1968, p. 44-59) in Area Two: laminated dolomite and fossil-mold dolomite. The laminated dolomite is a white to light gray, thin bedded or laminated, nonfossiliferous dolomite.

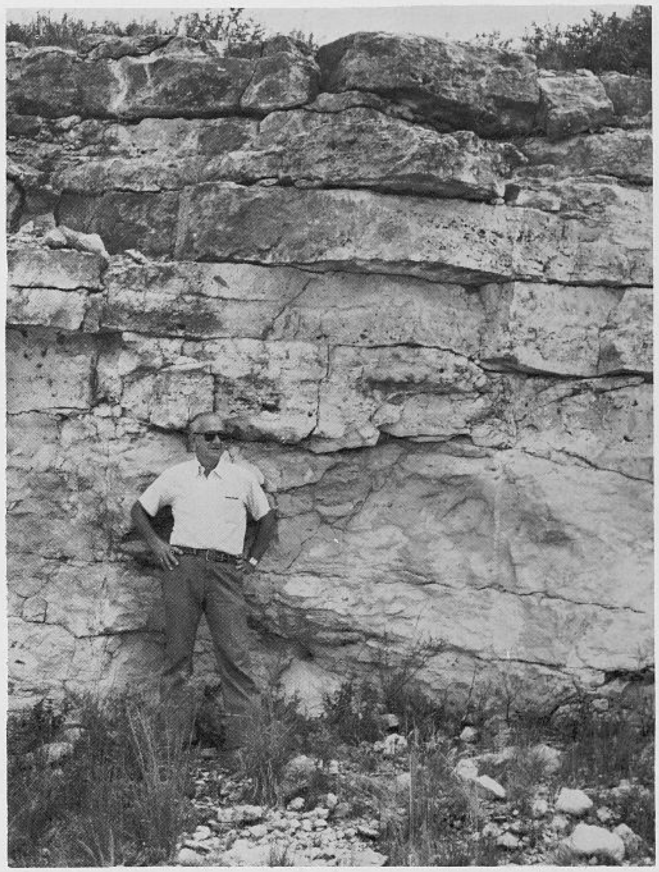

Fig. 12. Locality 6. The Edwards Formation of Area One is composed of light gray, medium to thick bedded to massive, lime wackestones to lime grainstones. Note the cavities formed from the solution of rudist fauna. These beda are located near an organic buildup or rudist mound.

Features of the laminated dolomite include desiccation cracks, calcite-filled vugs, and burrows (localities 8 and 11). The dolomite occurs as poorly defined crystals, usually less than 5 microns in size (J. Marcantel, 1968, p. 44). The fossil-mold dolomite is a buff gray to medium gray, medium to thick bedded, intensely burrowed dolomite containing abundant fossil molds. Most of the fossil molds are unidentified, but external molds of gastropods, the internal tubes of green algae, and clams are often preserved (localities 8 and 11). The fossil-mold dolomite is present in two crystal sizes: fine-grained dolomite with crystals approximately 5 microns in size and coarse-grained dolomite with crystals approximately 25 microns in size. The fine-grained dolomite is more abundant than the coarse-grained dolomite (J. Marcantel, 1968, p. 54). The laminated dolomite and the fossil-mold dolomite are found interstratified throughout Area Two.

The uppermost Edwards Formation exposed in Area Two overlies the dolomites in the northern portion of the area. It is a light gray to buff, thin to massively bedded lime packstone with abundant forams, especially miliolids, and rudist fragments, mainly of *Toucasia*, but fragments of caprinids and radiolites are also present (J. Marcantel, 1968, p. 37) (localities 8 and 11). The grains are supported by a mud matrix, and chert beds are characteristic of the lime packstone.

Much of the uppermost Fredericksburg Group, origi-

Fig. 13. Locality 5. This close-up of a rudist mound in the Edwards Formation shows the nature of the buildup. The mound is composed predominantly of pelecypods caprinids, radiolites, *Chondrodonta*, *Toucasia*, and the coral *Cladophyllia* in a micrite matrix. The fossils occur in a variety of orientations.

nally overlying the lime packstone containing the foraminifer miliolid and the pelecypod *Toucasia*, has been stripped by erosion (J. Marcantel, 1968, p. 65).

AREA THREE

The Fredericksburg Group of Area Three (Fig. 9) consists of an anomalously thick sequence of lime grainstones and packstones occupying an interval stratigraphically equivalent to the upper Walnut-Comanche Peak Formation and the lower Edwards Formation. Two measured sections illustrate the stratigraphic sequence in Area Three: the Sweetwater section (locality 9) and the Barton-Lambert Ranch section (locality 10). These sections are referred to collectively as the "Callahan Complex" by Boutte (1969, p. 21).

The thick sequence of grainstones and packstones comprising the Callahan Complex developed as an elongate carbonate-sand body. The shape and areal extent were determined by Boutte (1969, p. 23-26). The Complex has an asymmetrical, lenticular shape in a southwest-northeast direction, is approximately 5 miles wide, and reaches a maximum thickness of 60 feet at locality 9. The positioning of the Callahan Complex is coincident with the axis of the Concho arch structural feature.

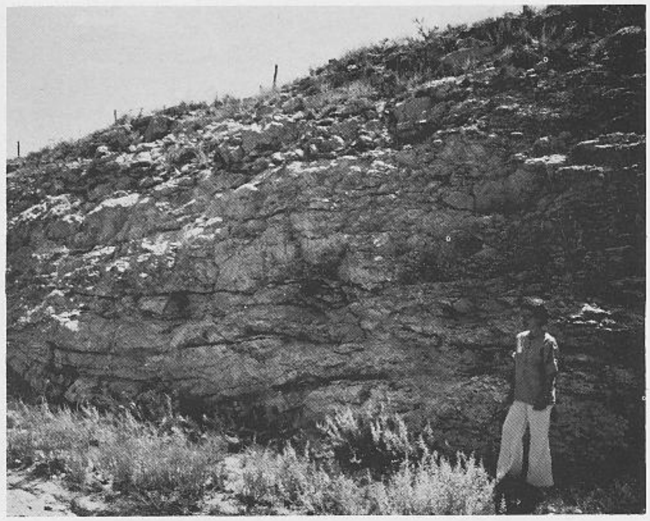

Fig. 14. Locality 5. A rudist mound and bounding flank beds are observed in the Edwards Formation of Area One. The main portion of the bioherm is behind the woman standing in the right side of the photo. Another mound is present outside of the photo on the far right side. Flank beds can be seen lapping up on the sides of the mounds. As the flank beds cover the relief on the mound, the beds return to being parallel as seen in the top of the section.

Numerous diastems occur at different stratigraphic levels within the Callahan Complex in Area Three. The diastems are represented by oxidized and iron-stained surfaces intensely burrowed by marine organisms (Fig. 15). The bored surfaces provide a basis of correlation within the Complex.

The basal section in Area Three consists of approximately 44 feet of buff to light gray, nodular to thin-bedded lime wackestone (localities 9 and 10). The wackestone is fossiliferous, containing both whole and fragmented fossils. The most common fauna include algae,

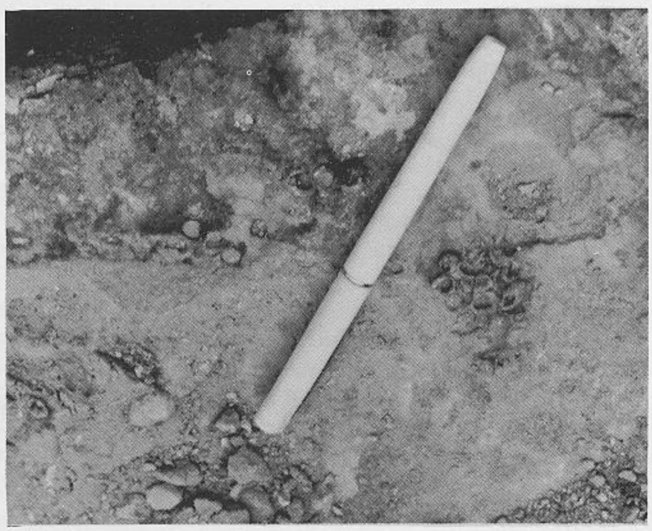

Fig. 15. Locality 10. Close view of bored surface. The borings by marine organisms on the right side of the photo have distinctive raised lips. To the left side of the photo, the boring-fill has weathered out leaving deep pits. The bored surface and other similar surfaces have been correlated throughout most of Area Three by Boutte (1969). The appearance of this bored surface is similar to the bored surface or hardground present at the top of the Edwards Formation of Area Six.

mollusks, gastropods, and echinoids. The oysters *Texigryphaea* and *Exogyra texana* are abundant in the lower portions of the section. Glauconite is also present. The most striking physical characteristics of the basal section of the Callahan Complex are marl zones, nodular bedding, and burrows. The burrows are commonly filled with a distinctive yellow, coarse-grained mud.

Boutte (1969, p. 28-33) divided the lime grainstones that form the remainder of the Callahan Complex into three facies: (1) well-sorted, oolitic lime grainstone; (2) well-sorted, bioclastic lime grainstone-packstone; and (3) poorly sorted, coarse-grained, bioclastic lime grainstone.

Overlying the nodular lime wackestones at both locality 9 and locality 10 is a 13- to 18-foot sequence of interbedded lime grainstones and lime packstones. The lime grainstones are light gray, intraclastic, well sorted, and fossiliferous. Oyster and mollusk fragments are common and glauconite is present in most of the units. Burrows are the most common sedimentary structures. The lime packstones are light gray, nodular, and contain mollusk, gastropod, and oyster fragments. Pellets are common in the packstone as is glauconite.

Major lithologic changes occur between the rocks exposed at locality 9 and the laterally equivalent rocks exposed at locality 10 throughout the remainder of the Fredericksburg sequence (Boutte, 1969, p. 44).

At locality 9, buff to light gray, poorly sorted, coarse-grained, bioclastic lime grainstone overlies the alternating lime grainstones and the lime packstones. Glauconite and algal material occur at the base of the unit along with large irregular "pods" of rudists. Laterally equivalent rocks exposed at locality 10 consist of buff, poorly sorted oolith lime grainstone at the base to well-sorted oolith lime grainstone at the top. The ooliths are well developed, large, averaging ¼ inch in diameter, round, and exhibit multiple coats on nuclei of foraminiferal tests, algal and mollusk fragments, glauconite, and other grains (Boutte, 1969, p. 28). Mollusk fragments and grapestone aggregates are common within the unit. The dominate feature of the oolith lime grainstone is the development of large-scale cross-bedding represented by large festoons (Fig. 16). The strata are inclined as much as 18 degrees and deep arcuate troughs are readily visible.

Overlying the poorly sorted lime grainstone at locality 9 is a 4-foot section of tan to blue-gray, argillaceous lime wackestone (Fig. 17). Fossils include oysters, gastropods, and occasional echinoids. This blue-gray wackestone represents the probable division between the underlying Walnut-Comanche Peak Formation and the overlying Edwards Formation. The basal unit of the Edwards Formation at locality 9 is composed of massive inclined accretion beds of light-gray limestone (Fig. 17). The accretion unit is approximately 9 feet thick and consists of individual cross-bed sets with less well-developed internal small-scale cross-bedding, which dips in the direction of accretion (Boutte, 1969, p. 71). The individual accretion beds vary in thickness from 2 inches to 2 feet and vary in length from 8 to 25 feet along the outcrop. The individual beds "pinch out" at the toe and become tangential to the underlying rock. The inclination at the crest of the beds ranges from 13 degrees to 25 degrees, and dip direction of the accretion beds ranges from S 10° E to S 28° W (Boutte, 1969, p. 71). Within the accretion beds, coarse-grained material is limited to the upper 3 feet of the unit and consists of poorly sorted fragments of rudists and other mollusks. This unit grades downward into finer material consisting of true oolith grains, and a micrite matrix forms the base of the accretion bed sequence.

Fig. 16. Locality 10. Large-scale festoon cross-bedding is developed in the oolith lime grainstone facies. The strata are inclined as much as 18 degrees, and deep arcuate troughs are clearly visible. The ooliths forming the lime grainstones are well developed, large, round, and exhibit multiple coats on nuclei of foraminiferal tests, algal and mollusk fragments, glauconite, and other grains.

Fig. 17. Locality 9. The basal portion of the Edwards Formation at this locality is composed of a nine-foot section of inclined accretion beds (center of photo). Underlying the accretion unit is a blue-gray lime wackestone, which represents the upper Comanche Peak Formation. Overlying the accretion unit is a 30-foot sequence of lime grainstone-packstone. The darker section of rock exposed at the top of the outcrop is a sequence of lime wackestone-mudstone with gastropods, mollusks, caprinids, and *Toucasia*.

Laterally equivalent rocks exposed at locality 10 consist of gray to buff, nodular lime wackestone with fauna including mollusk fragments and the pelecypods *Pecten, Monopleura, Toucasia*, and caprinids and an interbed of gray to tan, massive, fine-grained dolomite.

Overlying the accretion bed unit at locality 9 is a 30-foot sequence of buff gray, well-sorted, bioclastic lime grainstone-packstone with mollusk and caprinid fragments overlain by buff gray, nodular lime wackestone-mudstone with gastropods, mollusks, algae, and the pelecypods caprinid and *Toucasia* in the base of the unit (Fig. 17). Laterally equivalent rocks and rocks higher in the stratigraphic section exposed at locality 10 consist of alternating beds of lime grainstone and dolomite. The lime grainstones are light gray, well sorted, and include abundant gastropod, mollusk, and rudist fragments. The dolomite ranges from tan to gray, and thin to massive bedded. Much of the dolomite is laminated, and it is uniformly fine grained (Boutte, 1969, p. 9).

As observed in Area Two, much of the Fredericksburg Group, originally overlying the lime grainstones and dolomite, has been stripped by erosion (J. Marcantel, 1968, p. 65).

AREA FOUR

The Fredericksburg Group of Area Four (Fig. 9) consists of a thin sequence of sediments in the Antlers Formation that are laterally equivalent to the Paluxy Formation, a thick Walnut-Comanche Peak Formation, and the Edwards Formation. Five measured sections illustrate the stratigraphic sequence in Area Four: the Skelly Hobbs section (locality 14), the KTXS section (locality 16), the Mulberry Canyon section (locality 17), the Eagle Mountain section (locality 22), and the Santa Anna Mountain section (locality 29).

The regional caliche facies, which represents the hiatus between the lower Trinity and the upper Fredericksburg sediments in the Antlers Formation (Castle, 1969, p. 47-50; Smith, 1971, p. 35-37; and Owen, 1979, p. 24), can be observed at five localities in Area Four: localities 16, 19, 22, 27, and 29. The caliche of this regional facies is buff to gray, nodular, dense, and well developed. Chert nodules are visible at localities 19 and 22, and an "organ-pipe" outcrop appearance caused by vertical jointing characterizes the caliche at locality 22. The caliche facies ranges in thickness from 1.2 feet (locality 29) to 8.0 feet (locality 22) but averages about 2 feet in thickness. A sharp, irregular contact separates the caliche from the underlying and overlying sediments. Throughout the eastern and central portions of Area Four, the caliche facies lies 15 to 25 feet below the base of the Walnut-Comanche Peak Formation. However, in the western portion of Area Four at locality 29, the caliche facies lies 52 feet below the Walnut-Comanche Peak Formation. To the west, the caliche is better developed (more indurated) and lies deeper in the stratigraphic section.

In the northern portion of Area Four, the caliche facies is overlain by a tan to maroon, very fine-grained, silty sand (localities 16, 19, 22, and 27). The clay fraction of the silty sand is dominated by montmorillonite (Castle, 1969, p. 49 and Smith, 1971, p. 37). The caliche facies of the southern portion of Area Four (localities 25 and 29) is overlain by a thick section of buff, fine- to coarse-grained, cross-bedded sand, which contains numerous quartz pebbles in the lower portion.

The remainder of the Paluxy equivalent sediments in the Antlers consists of sandy silt, sand, and clayey silt. The sandy silts range from gray to maroon in color and usually contain lenses of fine sand or gray-green clays (Fig. 18) (locality 29). The sands generally overlie sandy silts and range from buff to brown to purple and are fine to medium grained. Small-scale cross-beds and ironstone concretions or ironstains are present at localities 16 and 25. The clayey silts are present at two localities: localities 19 and 22. The clayey silts are gray green to maroon, blocky, and noncalcareous at the base to calcareous in the top of the section (locality 22).

The sands and clayey silts grade upward to arenaceous, marly clay and silt containing oysters (*Exogyra texana*) and other marine fossils. The marly clay is transitional into the lime wackestones of the Walnut-Comanche Peak Formation above.

The Walnut-Comanche Peak Formation consists of from 75 to 110 feet of limestone and interbedded marl.

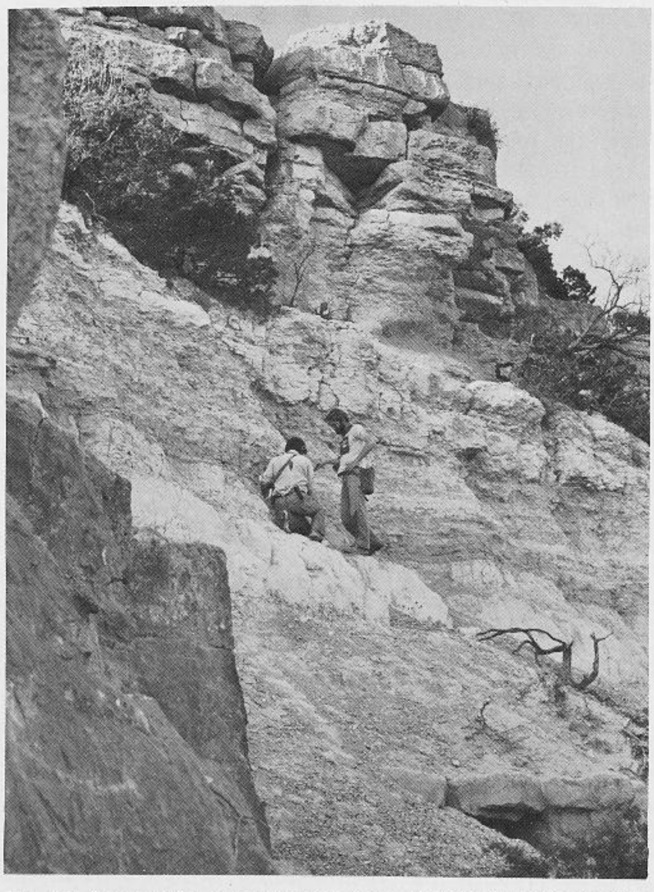

Fig. 18. Locality 29. A complete section of Fredericksburg rock is exposed at Santa Anna Mountain. The Edwards Formation caps the mountain (resistant ledges extending down to the dead tree in the right side of the photo). The Walnut-Comanche Peak Formation extends down to the feet of the men. The Paluxy equivalent sediments in the Antlers Formation form the remainder of the section.

Throughout Area Four, the basal section of the Walnut-Comanche Peak Formation is buff to light gray, nodular, arenaceous lime wackestone with clams, gastropods, echinoids, and the pelecypod *Exogyra texana* overlain by a buff, very fossiliferous marl with abundant echinoids and the pelecypod *Exogyra texana* (localities 14, 15, 20, 25, 27, and 29). The marl at locality 27 also contains the ammonite *Oxytropidoceras* in a key fossil bed useful in differentiation of Walnut and Comanche Peak Formations.

From east to west across Area Four, the sequence exhibits the gradual transition of the limestones from the Walnut-Comanche Peak Formation of the Callahan Divide area into the Walnut Formation and the Comanche Peak Formation of the Lampasas Cut Plain Area.

In the western portion of Area Four (localities 14, 15, 16, and 17), the fossiliferous marl is overlain by a thick sequence of buff to orange, nodular lime wackestones to lime packstones. Fossils are abundant in the section and include oysters (*Exogyra texana* and *Texigryphaea*), ammonites (*Metengonoceras*), echinoids (*Enallaster* and *Phymosoma*), gastropods (*Tylostoma*), and bivalves (*Homomya, Isocardia,* and *Lioistha*). Glauconite is present in the base of the sequence. Buff, fossiliferous, marly interbeds occur throughout the lime wackestone and lime packstone sequence. Overlying this sequence at locality 14 and locality 15 is a 5- to 7-foot thick unit of buff to gray-brown, well-rounded and well-sorted, mollusk fragment lime grainstone. The lime grainstone is a thin tongue of the much larger accumulation of grainstones, the Callahan Complex, found in Area Three (locality 9). The top of the Walnut-Comanche Peak Formation in the western part of Area Four is marked by a thin section of buff, algal lime packstone with glauconite and is conformable but in sharp contact with the overlying Edwards Formation.

In the central portion of Area Four (localities 20, 21, and 25), the basal fossiliferous marl is overlain by a thick sequence of gray to dark-brown, nodular lime wackestones to lime packstones with the oysters *Exogyra texana* and *Texigryphaea*, algae, and echinoids. Pellets are found at locality 20. Also at locality 20, the overlying unit is a thin, gray lime packstone-wackestone, which grades upward into a lime grainstone. This, in turn, is overlain by a thick sequence of buff to light gray, lime packstone-wackestone with mollusk fragments and caprinids in the base. The upper contact with the overlying Edwards Formation in the central portion of Area Four is covered.

The two localities in the eastern portion of Area Four, localites 27 and 29 (Fig. 18), illustrate the transition into the strata typical of the Lampasas Cut Plain area. The basal fossiliferous marl is overlain by a thin, buff, *Gryphaea* lime packstone (locality 27) and a thick sequence of buff to gray, marl and nodular lime wackestone. Fossils in this section include clams, echinoids, and the oysters *Gryphaea* and *Exogyra texana*. A thin interbed of gray to buff, thin-bedded lime grainstone is present at locality 27. The remainder of the section above the lime grainstone in the eastern portion of Area Four consists of strata characteristic of the Comanche Peak Formation: buff to light gray, nodular lime wackestone to mudstone with the oyster *Exogyra texana*, heart clams, and gastropods. The contact between the upper Walnut-Comanche Peak Formation and the lower Edwards Formation is conformable and sharp.

The Edwards Formation consists of from 30 to approximately 80 feet of limestone and dolomite. The base of the Edwards Formation in Area Four is marked by a distinctive buff lime packstone (localities 14, 15, 20, and 27). It is fossiliferous, containing algae, the miliolid foraminifer *Dictyoconus walnutensis*, and fragments of the pelecypods *Pecten, Toucasia,* and other bivalves, echinoids, and gastropods (E. Marcantel, 1968, p. 18-22).

A rudist sequence is developed upon the algal-*Dictyoconus* packstone and comprises the basal portion of the Edwards Formation in much of Area Four. A rudist mound complex has been described in detail by E. Marcantel (1968) (locality 14 and locality 15), and other rudist sequences are present at locality 24 and locality 29. A distinct faunal content and zonation can be observed in a typical mound sequence. The Skelly Hobbs mound com-

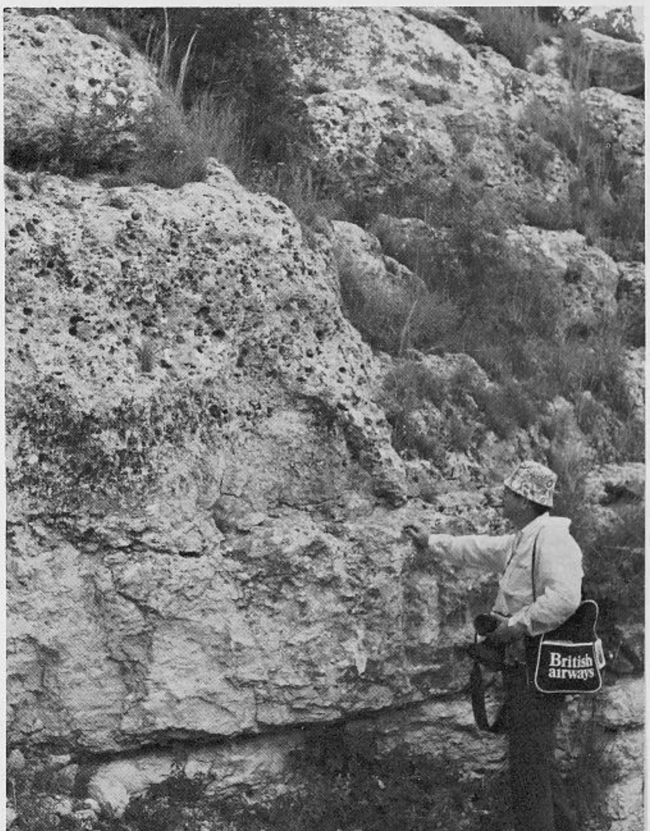

Fig. 19 Locality 14. A typical mound sequence is exposed at the Skelly Hobbs section. The rudist mound is developed upon an algal-*Dictyoconus* lime packstone (from man's hat down to his waist), which forms the basal portion of the Edwards Formation. The basal portion of the mound (center of the photo) is a lime packstone to wackestone composed of whole, large fossils of the rudist *Eoradiolites* and *Caprinuloidea* and numerous other pelecypods of *Chondrodonta*. Overlying this unit at the top of the photo is a lime packstone-wackestone with *Caprinuloidea* and *Chondrodonta* and less abundant radiolites and *Toucasia* fragments.

Fig. 20. Locality 14. Close view of the basal unit of the rudist-mound sequence in the Edwards Formation. The unit is lime packstone to wackestone composed of the pelecypods *Eoradiolites, Caprinuloidea*, and *Chondrodonta*. Note the large, whole fossils positioned in random orientations.

plex is divisible into four facies (including the algal-*Dictyoconus* packstone) (E. Marcantel, 1968, p. 25-30) (Fig. 19). The basal mound unit is 3 to 4 feet in thickness and consists of buff lime packstone to wackestone composed of large, whole fossils of the rudists *Eoradiolites* and *Caprinuloidea* and numerous pelecypod *Chondrodonta* (Fig. 20). The *Eoradiolites-Chondrodonta* unit is overlain by a massive 8- to 12-foot thick lime packstone-wackestone with the pelecypods *Caprinuloidea* and *Chondrodonta* and less abundant radiolites and *Toucasia* fragments. The *Chondrodonta* appear to have provided much of the mound framework (E. Marcantel, 1968, p. 28). Overlying the main portion of the rudist mound are limestone lenses of large caprinids ranging from 1 to 2 feet thick. Whole pelecypods of *Toucasia* and *Sellaea* occur in pockets between the caprinid clumps.

The rudist-mound sequence is overlain by fine-grained dolomites (localities 15, 17, and 27), which comprise the middle portion of the Edwards Formation in much of Area Four (Fig. 21). Two distinct facies are present: laminated dolomite and fossil-mold dolomite (J. Marcantel, 1968, p. 44-59). The laminated dolomite is white to brown gray, thin bedded or laminated, and nonfossiliferous (Fig. 22). Sedimentary structures include mud cracks, root and animal burrows, current deposited "rip-up" clasts, and algal laminations (localities 15 and 17). The fossil-mold dolomite is buff gray to medium gray, medium to thick bedded, intensely burrowed, and contains abundant preserved external molds of mollusks (localities 15 and 17). Both the laminated dolomite and the fossil-mold dolomite have grain sizes of less than 10 microns (Moore, 1969, p. 132) and occur as repetitive couplets throughout the sections.

Much of the uppermost Edwards Formation has been stripped by erosion. However, lime packstones and grainstones containing many foraminifer miliolids and pelecypod *Toucasia* fragments are present in the upper sections of Area Four (localities 14, 17, and 27) and represent the uppermost Edwards Formation.

AREA FIVE

The Fredericksburg Group of Area Five (Fig. 9) consists of the Paluxy Formation, a thin Walnut Formation, and a thick section of the Goodland Formation. Four measured sections illustrate the stratigraphic sequence in Area Five: the Tin Top section (locality 51), and Eagle Mountain section (locality 57), the Lake Worth section (locality 58), and the Cresson section (locality 65).

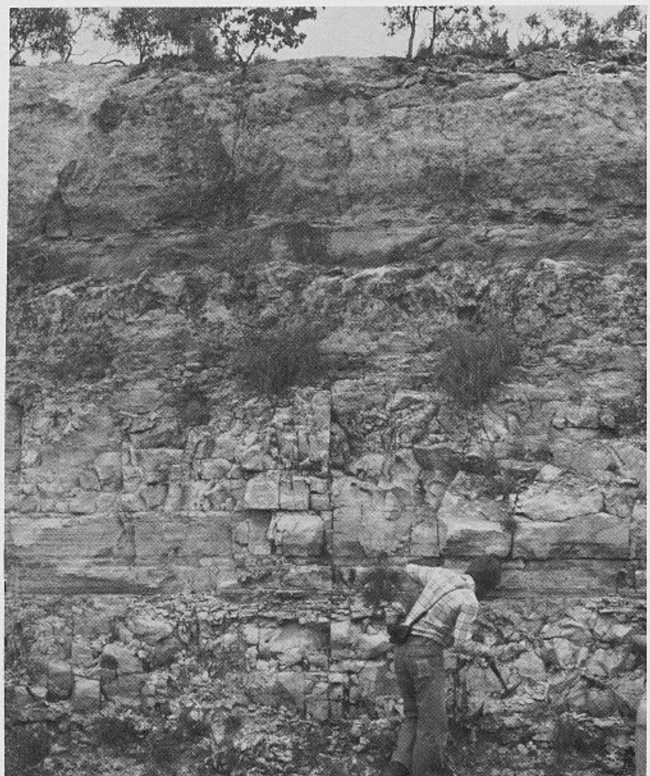

Fig. 21. Locality 17. Two distinct dolomite facies are present in the Edwards Formation at the Mulberry Canyon section: laminated dolomite and fossil-mold dolomite. The two dolomite facies comprise approximately 60 percent of the section and occur as repetitive couplets throughout the section.

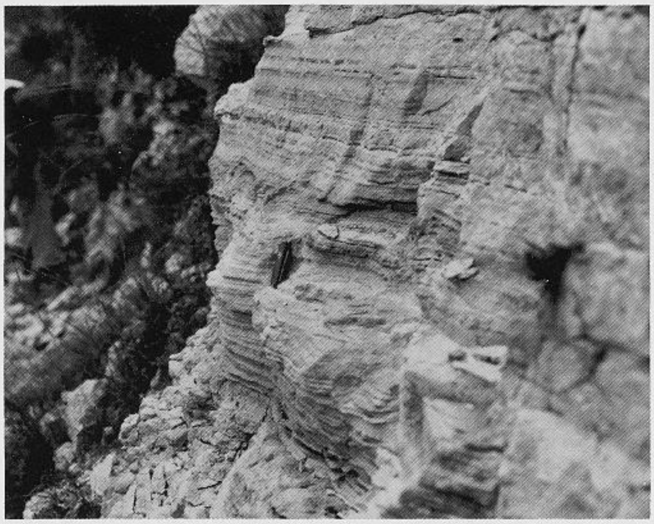

Fig. 22. Locality 17. Close view of laminated dolomite facies of the Edwards Formation. Note the fine-grained texture and the very thin laminations.

The Paluxy Formation consists of from 140 to 180 feet of sand, silt, clay, and caliche. Throughout Area Five, the Paluxy Formation can be divided into three members on the basis of petrologic and stratigraphic relationships and depositional environments: the lower Lake Merritt Member, the Georges Creek Member, and the upper Eagle Mountain Member (Owen, 1979, p. 8).

The basal portion of the Paluxy Formation, the Lake Merritt Member, consists of thin horizontal sand beds alternating with thin clay beds (Owen, 1979, p. 15) (locality 56). The sands are white, fine to very fine grained, subangular to subrounded, and are very well sorted. The sand beds range from loosely compacted to indurated with calcite cement. Clay is common in the Lake Merrit Member and generally occurs as horizontal laminae alternating between sand laminae (locality 56) (Fig. 23). Large- and small-scale, low-angle planar cross sets are also characteristic sedimentary structures (locality 56). 56).

Fig. 23. Locality 56. The basal portion of the Paluxy Formation, the Lake Merritt Member, is characterized by interfingering clay and sand laminae.

The Georges Creek Member of the Paluxy Formation directly overlies the Lake Merritt Member. It consists of thick sections of extensively cross-bedded sand, and red and white siltstone and clay (Owen, 1979, p. 21) (locality 51). The sand is white, primarily fine to medium grained, subangular to subrounded, and moderately sorted. Thin clay beds are present alternating between the sand beds. The clay is usually red, white, or gray, and clay clasts are common in the sand. Sedimentary structures in the Lake Merritt Member include horizontal and graded laminae, ripple marks, and small-scale, low-angle cross-beds (locality 51). Feeding trails and burrows occur in the Lake Merritt Member (locality 51).

The uppermost unit of the Georges Creek Member is a prominent caliche facies that separates it from the superjacent Eagle Mountain Member (Owen, 1979, p. 24). The caliche facies is white to brown, nodular, indurated, and well developed (locality 51). It is approximately ½-foot thick. The caliche facies of Area Five is laterally equivalent to the regional caliche facies in Area Two and Area Four, which separates the Trinity from the overlying Fredericksburg sediments in the Antlers Formation.

The Eagle Mountain Member is the uppermost unit of the Paluxy Formation in Area Five. It consists of cross-bedded sand with thick sections of clay (Owen, 1979, p. 25) (localities 51, 52, 54, 55, and 58). The sand is white, fine to medium grained, predominantly subangular, and poorly sorted to moderately sorted. Hematite, pyrite, and limonite (localities 54 and 55) are commonly present but in limited amounts. Sedimentary structures in the sands of the Eagle Mountain Member include a wide variety of cross-bedding. Horizontal laminae and graded laminae (locality 58) and massive discontinuous and ripple laminae (locality 55) are common. Large-scale trough and planar cross-bedding is present in the sands at locality 58. Clay clasts are common in the same unit. Small-scale trough and planar cross-bedding (Fig. 24) is abundant throughout the Eagle Mountain Member (localities 54, 55, and 58). Channel deposits characterized by an erosional base, lenticular shape, and other features such as small-scale ripple bedding, horizontal bedding, and laminae are also common in the Eagle Mountain Member of the Paluxy Formation (Fig. 25) (localities 55 and 58).

Clay is an important constituent of the Eagle Mountain Member in Area Five and is predominantly gray and white with large amounts of sand, silt, and carbonized wood (localities 51, 52, 54, 55, and 58). Serpulid worm tubes (localities 51 and 52) and large concentrations of silicified and pyritized fossil wood (localities 51, 55, and 58) are present in the Eagle Mountain Member of the Paluxy Formation.

The contact between the Paluxy Formation and the overlying Walnut Formation appears to be conformable and sharp. The Paluxy and Walnut Formations are in parallel beds in the sections where the contact is exposed in Area Five (localities 51, 52, 54, and 55).

The Walnut Formation consists of 25 feet of alternating fossiliferous limestone and marls. The lower 15 feet consist of buff to dark gray, thin-bedded lime wackestone with interbedded marls. The bed boundaries are indistinct giving the general appearance of nodular structure on the weathered outcrop (localities 51, 52, 54, and 55). The upper 10 feet of the Walnut Formation is composed of massive, hard ledges of lime packstone separated by beds of lime mudstone and marl (locality 58). The major components of the lime packstones are fragments of the oysters *Gryphaea mucronata* and *Exogyra texana*. The hard ledges stand out in marked relief in weathered sections. Other fossils are common in the Walnut Formation and include pelecypods (*Pecten* and *Protocardia*), cephalopods (*Oxytropidoceras*), and echinoids (*Holectypus, Salenia*, and *Enallaster*). The uppermost massive ledge of the Walnut Formation is conformable and gradational with the overlying beds of the Goodland Formation.

Fig. 24. Locality 54. Small-scale, high-angle, unidirectional planar cross-bedding is abundant throughout the Eagle Mountain Member of the Paluxy Formation. Note the erosional bounding surface of the cross-bed sets.

Fig. 25. Locality 55. Channel deposits characterized by an erosional base and lenticular shape are common in the Eagle Mountain Member of the Paluxy Formation. Other features such as small-scale ripple bedding, horizontal bedding, and laminae are common to the channel deposits.

The Goodland Formation in Area Five consists of approximately 120 feet of alternating thick beds of limestone, marly limestone, and marl. The Goodland Formation can be divided into three distinct members: the lower Mary's Creek Member, the Benbrook Member (Perkins, 1960, p. 15-19), and the upper Cresson Member (Staples, 1977, p. 17).

The basal portion of the Goodland Formation, the Mary's Creek Member, consists of approximately 40 feet of interstratified marls, marly limestones, and several hard fossiliferous limestones (Perkins, 1960, p. 15) (localities 57, 59, 63, and 65). The limestones of the Mary's Creek Member range from thin beds of buff, nodular, fossiliferous lime wackestone to lime mudstone to thin beds of buff, hard, fossiliferous lime packstone. Each of the limestone beds is separated from the next by units of buff, unfossiliferous marl (Fig. 26). The fauna of the Mary's Creek Member is highly varied. Pelecypods dominate the fauna of the Goodland Formation and include *Trigonia, Pecten, Inoceramus, Exogyra, Gryphaea, Lima, Isocardia, Protocardia,* and *Tapes* in the Mary's Creek

Fig. 26. Locality 63. The basal portion of the Goodland Formation, the Mary's Creek Member, is composed of marly limestones and interstratified marls. The limestones exposed at Bear Creek are buff, nodular, thin-bedded, fossiliferous lime wackestones, and the marls are buff and nonfossiliferous.

Member. Gastropods (*Tylostoma* and *Turritella*), cephalopods (*Oxytropidoceras* and *Metengonoceras*), and echinoids (*Salenia, Hemiaster,* and *Enallaster*) are also common throughout the member. A serpulid worm mat is present at locality 57 and consists of tubes oriented in random directions. Ripple marks are common on the upper surfaces of the thin limestones of the Mary's Creek Member (locality 63). Ripples tend to be symmetric with crests oriented in a northeast direction (Staples, 1977, p. 20). The contact between the Mary's Creek Member and the overlying Benbrook Member is gradational.

The Benbrook Member of the Goodland Formation is composed of approximately 70 feet of thick limestone and marly limestone alternating with thinner marls (Perkins, 1960, p. 19) (localities 53, 57, 61, 62, and 65). The Benbrook Member is composed largely of beds of buff, nodular, fossiliferous lime wackestone and buff, hard, fossiliferous lime packstone and grainstone. The beds are more resistant and thicker than those of the Mary's Creek Member, and the alternating marls are thinner and less abundant (Fig. 27). The greatest number and diversity of fauna in the Goodland Formation are in the Benbrook Member (Staples, 1977, p. 32). The faunal assemblage contains corals (*Parasmilia*), cephalopods (*Oxytropidoceras*), and echinoids (*Enallaster, Holectypus, Hemiaster,* and *Salenia*) as well as pelecypods (*Pecten, Inoceramus, Ostrea, Trigonia, Pinna, Exogyra, Lima, Isocardia, Gryphaea, Protocardia,* and *Tapes*) and gastropods (*Turritella, Tylostoma,* and *Cerithium*). Serpulid mats are present at locality 57 and locality 61 where they consist of tubes generally oriented in a northeast direction. Ripple marks have been reported in the lower Benbrook Member (Staples, 1977, p. 32-35) with the same size and orientation as those of the Mary's Creek Member; however, none are present in the sections observed for this study. The contact between the Benbrook Member and the overlying Cresson Member is gradational.

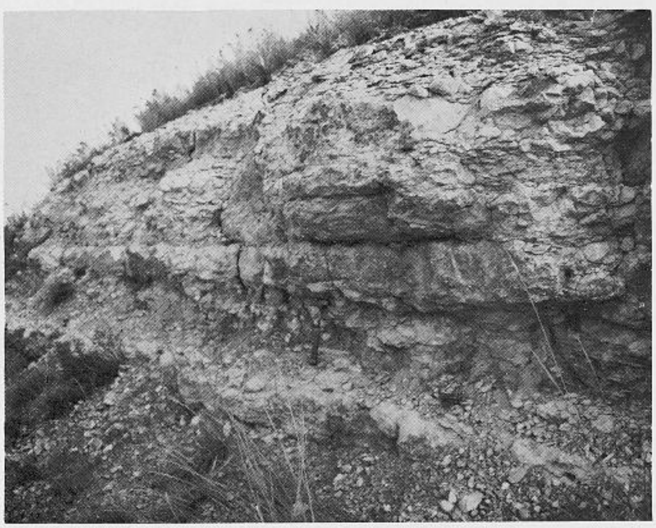

Fig. 27. Locality 62. The Benbrook Member of the Goodland Formation is composed of buff, nodular to dense, fossiliferous lime wackestones to lime packstones. The marl zones are thinner and less abundant than in the underlying Mary's Creek Member. Note the resemblance of the Goodland Formation to the Comanche Peak Formation.

The upper portion of the Goodland Formation exposed in the southern portion of Area Five, the Cresson Member, consists of dense lime packstone and grainstone (Staples, 1977, p. 35) (localities 62 and 65). The grains in the Cresson Member are comprised of coated shell fragments, pellets, foraminifers (*Dictyoconus* and *Quinqueloculina*), scattered oolites, and echinoid fragments. Most of the grains are less than ¼ inch in diameter (Stapes, 1977, p. 35). Pelecypods (*Pecten* and *Gryphaea*) and gastropods (*Turritella*) are also disseminated in the Cresson Member.

The Goodland Formation of Area Five is overlain by the Kiamichi Formation of the Washita Group. The contact is lithologically abrupt but appears to be conformable (Perkins, 1960, p. 19). The Kiamichi Formation consists of approximately 30 feet of yellow and bluish-gray, arenaceous, calcareous marl with a few beds of flaggy limestones and sandstones. The faunal assemblage of the Kiamichi Formation includes pelecypods, cephalopods, and echinoids (Perkins, 1960, p. 22-24).

AREA SIX

The Fredericksburg Group in Area Six (Fig. 9) is composed of a regionally thinning Paluxy Formation, the Walnut Formation, a thick section of the Comanche Peak Formation, and a lithologically consistent section of the Edwards Formation. Eight measured sections illustrate the stratigraphic sequence in Area Six: the Round Mountain Quarry section (locality 33), the Comanche section (locality 34), the Capital Silica section (locality 66), the Phillips Quarry section (locality 67), the Brazos Point I section (locality 72), the Cranfills Gap section (locality 86), the Jonesboro section (locality 87), and the Middle Bosque section (locality 103).

The Paluxy Formation consists of from 0 to 140 feet of sand, silt, clay, and caliche. The formation thins gradually down dip to the south-southeast as the sands interfinger with clays of the overlying Walnut Formation. The Paluxy Formation of Area Six is divisible into the three members described from Area Five: the lower Lake Merritt Member, the Georges Creek Member, and the upper Eagle Mountain Member (Owen, 1979, p. 8).

The basal portion of the Paluxy Formation, the Lake Merritt Member, consists of thin horizontal sand beds alternating with thin clay beds (Owen, 1979, p. 15) (localities 39, 45, 72, and 109). The Lake Merritt thins down dip to the south-southeast and exhibits a consistent character throughout Area Six. The sands are generally white, fine grained, subangular to subrounded, and are well sorted. The sand beds range from loosely compacted to indurated beds. Small-scale planar cross-beds (locality 39) and horizontal and ripple laminae (localities 39, 72, 77, and 109) are characteristic sedimentary structures in the sands of the Lake Merrit Member. Clastic dikes are present in the Lake Merritt Member at locality 72. Laminations of hematite and limonite are common (locality 109), and beds of pyrite occur in the lower portions of the member at several localities (localities 39, 72, and 77).

Clay is a common constituent of the Lake Merritt Member in Area Six. The clay is predominantly gray, silty, and well laminated. It occurs as thin beds alternating with horizontal sand beds. The alternating sand and clay beds also exhibit sedimentary structures of large- and small-scale, low-angle planar cross-bed sets with angles of inclination ranging from 20 to 45 degrees (Fig. 28) (localities 38 and 45).

Involute gastropods (Fig. 29) (localities 72 and 109), root mottles (locality 109), and silicified fossil wood fragments (locality 77) are present in limited quantities in the Lake Merritt Member.

The Georges Creek Member of the Paluxy Formation directly overlies the Lake Merritt Member. It is composed of thick sections of cross-bedded sand and red and white siltstone and clay in the northern and central portion of Area Six (localities 31, 34, 40, and 66) and is characterized as fossiliferous sandstone and limestone in the southern portion of Area Six (localities 90 and 96) (Owen, 1979, p. 21). The Georges Creek Member thins to the southeast as it changes facies characteristics and becomes indistinguishable from the other members of the Paluxy Formation.

Fig. 28. Locality 45. The Lake Merritt Member, the basal portion of the Paluxy Formation in Area Six, consists of alternating sand and clay beds that exhibit sedimentary structures of large- and small-scale, low-angle planar cross-bed sets with angles of inclination ranging from 20 to 45 degrees. The angular beds of the Lake Merritt Member are overlain by horizontal beds of the Bull Creek Member of the Walnut Formation.

Fig. 29. Locality 72. A hard ledge in the Lake Merritt Member of the Paluxy Formation (center of the section) is composed of cemented sand and involute gastropods. The ledge is underlain by white, very clean, fine-grained sands and overlain by clay and thin interbedded sands of the Georges Creek Member of the Paluxy Formation.

The sands and silts in the northern and central portions of Area Six range from white to brown, are predominantly fine to medium grained, subangular to subrounded, and moderately sorted. Thin clay beds interfinger with the sand beds (localities 31, 40, and 72). The clay is usually gray and contains large amounts of silt. Sedimentary structures in the Georges Creek Member in the northern and central portions of Area Six include high-angle, unidirectional planar cross-bedding with foresets at angles of inclinations ranging from 30 to 35 degrees, trough cross stratification (locality 66) (Owen, 1979, p. 23), and large-scale trough cross-bedding with foreset beds composed of sand and clay layers (locality 34) (Fig. 30). Burrows, bored surfaces, and root mottles are common features on the upper sand units of the Georges Creek Member (localities 40 and 66).

In the southern portion of Area Six, the Georges Creek Member is composed largely of fossiliferous sandstone and clay (localities 90 and 96). The sand is white, fine to very fine grained, and subangular to subrounded. The clay is yellow to gray and sandy. Both the sand and clay are fossiliferous and contain burrows and silicified wood fragments.

The uppermost Georges Creek Member is a prominent

Fig. 30. Locality 34. The Georges Creek Member of the Paluxy Formation exhibits sedimentary structures of large-scale trough cross-bedding with forset beds composed of sand and clay layers. The accretion units (center of the section) consist of buff quartz sand, which increases in grain size from very fine grained at the bottom to medium grained at the top. The average dip of the accretion beds is 15 degrees to the southwest, and individual beds are often separated by layers of green clay. The Walnut Formation is present at the top of the section and consists of alternating thin beds of ripple-marked, fossiliferous limestone and silty clay.

caliche facies that separates it from the superjacent Eagle Mountain Member (Owen, 1979, p. 24). The caliche facies is white to brown, nodular, indurated, and well developed (localities 31, 66, and 90). It is approximately 2.5 feet thick. The caliche facies is laterally equivalent to the caliche facies of Area Five and the regional caliche facies in Area Two and Area Four, which separates sands of Trinity age from sands of Fredericksburg age in the Antlers Formation.

The Eagle Mountain Member is the uppermost unit of the Paluxy Formation in Area Six. It consists of three facies that gradually grade into one another as the unit thins in a southeastward direction. In the northwestern part of Area Six, the Eagle Mountain Member consists of cross-bedded sand with thick sections of clay (localities 34, 40, and 48). These sediments grade into a facies characterized by horizontal alternating sand and clay beds and cross-bedded sand, which occupies the central portion of Area Six (localities 31, 66, 75, and 88). The southern and eastern portions of the area are composed of fossiliferous clay with thin, fossiliferous sand beds (localities 72 and 90) (Owen, 1979, p. 25).

The facies of the Eagle Mountain Member that occupy the northeastern portion of Area Six consist of cross-bedded sand and thick sections of clay (Owen, 1979, p. 25) (localities 34, 40, and 48). The sand is white to buff, fine to medium grained, subrounded to subangular, and poorly sorted to well sorted. Laminae of limonite and pyrite are present but in limited amounts (localities 40 and 48). Sedimentary structures in the sands of the Eagle Mountain Member include a wide variety of cross-bedding. Horizontal laminae, cross laminae, and small-scale trough cross-bedding (locality 34) are common. Moderately dipping cross-bed sets are also characteristic of this facies (locality 34) (Fig. 30).

The clay found in this facies of the Eagle Mountain Member is gray with large amounts of sand and carbonized wood. Sedimentary structures present in the clay include wavy and convolute laminae (locality 40). At locality 48, the clay occurs in a lenticular bed and exhibits distinct upper and lower contacts with the adjacent sands (Fig. 31).

The Eagle Mountain Member in the central portion of Area Six is characterized by horizontally bedded sand and clay and cross-bedded sand (Owen 1979, p. 25) (localities 31, 66, 75, and 85). The sand is white to gray, fine grained, subangular to subrounded, and well sorted. Thin beds of gray clay occur alternating with the sand beds throughout this facies of the Eagle Mountain Member. The clay is well laminated with organic material. The most common sedimentary feature of this facies is tidal bedding represented by horizontal sand beds alternating between thin clay beds (Owen, 1979, p. 28) (localities 31, 66, 75, and 88). Many sand-filled burrows and root mottles are common in this facies (locality 66). Longitudinal cross-bedded sand also characterizes the Eagle Mountain Member and is composed of moderately dipping sand beds alternating between clay beds (localities 31, 75, and 88) (Fig. 32).

The Eagle Mountain Member in the southern and eastern portions of Area Six is composed of fossiliferous clay with thin, fossiliferous sand beds (Owen, 1979, p. 25) (localities 72 and 90). The clay is gray, sandy, and laminated. Fossils, including involute gastropods, and carbonized plant remains are abundant in the clays. Thin beds of white, fine-grained, well-sorted sand occur within the clay units.

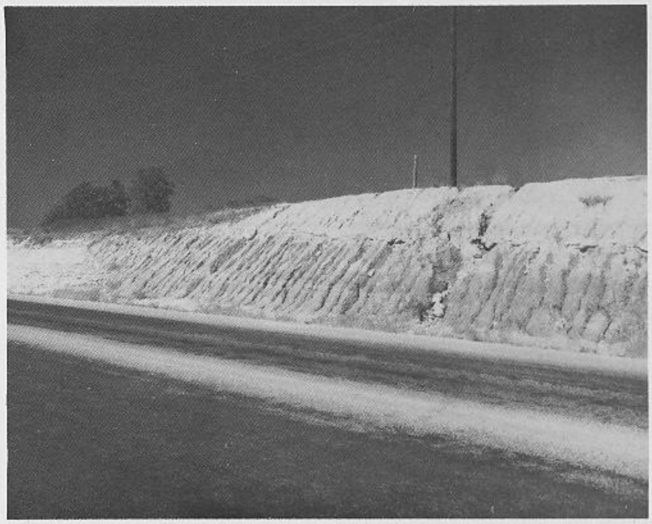

Fig. 31. Locality 48. A trough-shaped clay-filled channel is present in the Eagle Mountain Member of the Paluxy Formation. The channel appears trough shaped in cross section and exhibits distinct upper and lower contacts with the adjacent sands. Note the distinct color, bedding, and lithologic changes in the far left side of the photo. The clay that fills the channel is gray and contains large amounts of sand and carbonized plant remains. The adjacent sands are white, fine to medium grained, subrounded to subangular, and poorly to well sorted.

Fig. 32. Locality 75. Longitudinal cross-bedded sand also characterizes the Eagle Mountain Member of the Paluxy Formation and is composed of moderately dipping sand beds alternating between clay beds.

The contact between the Paluxy Formation and the overlying Walnut Formation is generally conformable throughout Area Six. This conformity of the contact is most apparent where the Paluxy and Walnut Formations are represented by parallel beds. However, there are several localities in the northern and central portions of Area Six where the contact is represented by an angular unconformity. The sand beds of the Paluxy Formation dip at relatively steep angles and are truncated at the top by the horizontal limestone beds of the Walnut Formation (localities 34, 44, 45, 75, and 88) (Figs. 28 and 33). The angular discordance probably represents a very short time value and involved the minimal stripping of bar sands of the Paluxy, later overlapped by deposits of the Walnut Formation (Flatt, 1976, p. 12). The contact between the Paluxy and the Walnut Formations represents a short break in sedimentation where marine units of the Walnut Formation "progressively overlapping periodically exposed, practically contemporaneous, nearshore terrigeneous deposits" (Moore, 1964, p. 26) of the Paluxy Formation.

The Walnut Formation is composed of from 55 to 180 feet of clay, limestone, and shell aggregate. The formation gradually thickens down dip to the south and east. The Walnut Formation of Area Six has been divided into five members on the basis of lithology and faunal content by Moore (1964) and Jones (1966).

The members have been classified as named units by Moore (1964) and have been given a numerical identification by Jones (1966). The members defined by both authors are near equivalents and, in ascending order, are the Bull Creek Member (Member One), the Bee Cave Member (Member Two), the Cedar Park Member (Member Three), the Keyes Valley Member (Member Four), and the Unnamed Marl Member (Member Five).

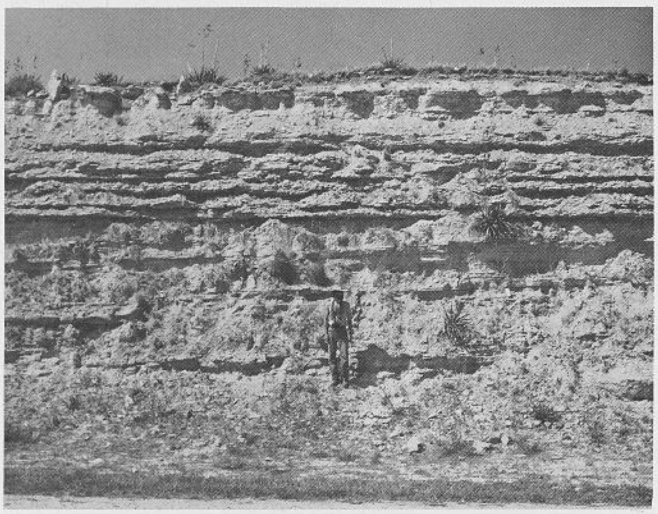

Fig. 33. Comanche section, Locality 34. The angular discordance that characterizes the contact between the Paluxy Formation and the Walnut Formation in the northern and central portions of Area Six is exhibited at the Comanche section. The contact is about two-thirds the way up the section approximately even with the yucca plant near the center.

The basal portion of the Walnut Formation, the Bull Creek Member or Member One, consists of argillaceous limestone beds (Jones, 1966, p. v.) (localities 34, 85, and 96). The Bull Creek Member thins from south to north and is present only in the south and southwestern portions of Area Six. The argillaceous limestone beds and the dark clay (locality 85) are limited in area of exposure and are confined to southern and western Coryell County and central Bosque County, respectively (Jones, 1966, p. v.). The alternating clay and flaggy limestone beds are more widely exposed (localities 34 and 96). The limestones are generally light tan to gray and range from mudstones to wackestones. They are thin bedded, argillaceous, and slightly fossiliferous. Jones (1966, p. 331) reported the following fauna from Member One: the pelecypods *Exogyra, Gryphaea, Ostrea, Protocardia,* and *Trigonia* and the gastropods *Actaceonella, Lunatia,* and *Turritella*. The most notable feature of the beds is the presence of well-developed ripple marks in the thin limestones. The clay, which alternates with the limestone beds, is dark tan to brown and contains scattered limestone nodules and few fossils (Fig. 33).

The Bee Cave Member or Member Two of the Walnut Formation is composed of alternating clay and thin ripple-marked limestone beds (Jones, 1966, p. vi.) (localities 33, 34, 42, and 47). It is more widespread than the Bull Creek Member and is present throughout Area Six as are the three overlying members. The limestone beds are white to gray to brown and range from lime wackestones to lime packstones. Many of the beds are nodular, but thin, dense limestones are also common. The dense limestones are often ripple marked on the upper surfaces (locality 34). The fauna of the limestones is varied, and Jones (1966, p. 331) reported the following genera: the pelecypods *Cyprimeria, Exogyra, Gryphaea,* and *Trigonia*, some horn corals, holothurians, the ammonite *Metengonoceras*, patelliform gastropods, and the gastropod *Tylostoma*. The pelecypods *Pecten* and *Protocardia* have also been found in the Bee Cave Member of the Walnut Formation. A small oyster bank composed of abundant *Exogyra, Trigonia*, and *Gryphaea* is present at locality 34. The clay beds of the Bee Cave Member are generally tan to brown, highly burrowed, and contain few fossils other than scattered small oyster *Gryphaea* and *Exogyra* valves.

The middle unit of the Walnut Formation, the Cedar Park Member or Member Three, is characterized by argillaceous, nodular limestone beds with a few thin beds of calcareous clay and ripple-marked limestone beds (Jones, 1966, p. vii.) (localities 33, 34, 36, 45, 96, and 102). The limestones, generally wackestones and scattered packstones, are white to buff, nodular to thin bedded, and argillaceous. Thin beds of calcareous clay and flaggy ripple-marked limestone beds are present at locality 102. The variety of fauna is greater in the Cedar Park Member than the preceding two members. However, the faunal abundance in the Cedar Park Member is less than in the lower two members. Jones (1966, p. 331) recorded the following faunal variety from Member Three: the pelecypods *Cyprimeria, Exogyra, Gryphaea, Inoceramus, Lima, Pecten, Pinna, Protocardia,* and *Trigonia*, the gastropod *Turritella*, the echinoids *Enallaster, Hemiaster,* and *Holectypus*, horn corals, and the ammonites *Metengonoceras* and *Oxytropidoceras*. The assemblage is notable for three reasons: (1) the appearance for the first time of the echinoids in the Walnut Formation; (2) the appearance of the ammonite *Oxytropidoceras*, a key fossil of the Walnut Formation; and (3) the development of larger and more common oyster banks. The oyster banks, described in detail by Flatt (1976), are composed largely of the pelecypods *Gryphaea, Pecten, Exogyra,* and *Protocardia*, the gastropods *Tylostoma* and *Turritella*, and the echinoid *Enallaster*. The oyster banks of Member Three are "scattered lenticular deposits with diverse but not abundant fauna" (Flatt, 1976, p. 18) and are easily distinguished from the surrounding sediments (Fig. 34) (localities 33, 45, 47, and 102).

The Keyes Valley Member or Member Four of the Walnut Formation consists of thin to thick beds of argillaceous limestone and calcareous clay (Jones, 1966, p. vii.) (localities 33, 47, and 108). The limestones are buff, nodular to thick bedded, argillaceous, and fossiliferous. They are dominantly lime packstones, but a thin bed of lime grainstone with pellets is present at locality 33. Large amounts of clay and marl with glauconite are inter-

Fig. 34. Locality 45. The oyster banks in the middle unit of the Walnut Formation, the Cedar Park Member or Member Three, are scattered lenticular deposits, which are easily distinguished from the surrounding sediments (the massive resistant ledge in the center of the section).

bedded with the limestones. Jones (1966, p. 331) reported the following fauna from Member Four: the pelecypods *Exogyra, Gryphaea, Pecten,* and *Protocardia*, the gastropods *Turritella* and *Tylostoma*, the echinoids *Enallaster* and *Phymosoma*, and the ammonite *Oxytropidoceras*. The oyster banks studied by Flatt (1976) reached a maximum in size and number in Member Four. The oyster banks are characterized by the pelecypod *Gryphaea* constituting 90 percent or more of a rock with an argillaceous matrix (Flatt, 1976, p. 19) (locality 108). The oyster banks occur most abundantly in Bosque and Coryell Counties.

The upper portion of the Walnut Formation, the Unnamed Marl Member or Member Five, is composed of calcareous clay and a few thin beds of argillaceous limestones (Jones, 1966, p. viii) (localities 33, 47, and 105). The calcareous clay is buff to light gray, porous, highly burrowed, and fossiliferous. The interbedded limestones are generally wackestones, nodular, argillaceous, and fossiliferous. The fossil assemblage of Member Five is extremely diverse, and Jones (1966, p. 331) reported the following fossils from the upper member of the Walnut: the pelecypods *Cyprimeria, Exogyra, Gryphaea, Inoceramus, Lima, Pecten, Protocardia,* and *Trigonia*, the gastropods *Turritella* and *Tylostoma*, holothurians, the echinoids *Phymosoma* and *Selenia*, and the ammonite *Oxytropidoceras*. The oyster banks of Member Five are less common than in Member Four and also thinner and less extensive (Flatt, 1976, p. 19). They occur in the thin argillaceous limestone beds between beds of calcareous clay.

The contact between the Wanut Formation and the overlying Comanche Peak Formation is conformable and gradational or interfingering. Generally, there is a gradual decrease in the abundance of the pelecypod *Gryphaea* and an increase in nodular-bedded limestone upward in the section.

The Comanche Peak Formation consists of from 60 to 125 feet of nodular limestone and chalky marl. It exhibits a gradual thinning trend to the west and retains a remarkable consistency in lithologic character throughout Area Six. The Comanche Peak Formation can be divided into three informal units: a lower unit of thin *Texigryphaea* beds and nodular limestone; a middle unit of nodular limestone, thin-bedded limestone, and marl; and an upper unit of bioturbated, chalky limestone and marl (Keyes, 1977, p. 19). The three units of the Comanche Peak Formation of Area Six are similar and grade laterally into the three members of the Goodland Formation of Area Five.

The basal portion of the Comanche Peak Formation, Unit One, consists of thin beds of the pelecypod *Texigryphaea* and nodular limestone (Keyes, 1977, p. 19) (localities 78, 80, 87, 101, and 112). The limestones of Unit One are typically wackestones with a section of mudstones at locality 80. They are white to buff, nodular, and sparsely fossiliferous. The interbedded marls are thin bedded and chalky. Thin-bedded limestones containing abundant oyster *Texigryphaea* are characteristic of the lower portion of Unit One. Other fossils found in Unit One are also common to the other units of the Comanche Peak Formation. These fossils include gastropods, mollusks, echinoids, pelecypods, and ammonites.

Unit Two, the middle portion of the Comanche Peak Formation, is characterized by nodular limestones, thin, evenly bedded limestones, and marls (Keyes, 1977, p. 19) (localities 71, 78, 86, 87, 101, and 105). The nodular limestones range from wackestones to mudstones, are white to buff to gray, highly burrowed, and fossiliferous. The thin, evenly bedded limestones are typically wackestones, buff to gray, dense, and fossiliferous. Thin beds of marl are present throughout Unit Two (Fig. 35). Fossils of Unit Two include those present in Unit One: pelecypods, gastropods, mollusks, echinoids, and ammonites.

The upper portion of the Comanche Peak Formation, Unit Three, is composed of bioturbated, chalky limestone and marl (Keyes, 1977, p. 19) (localities 44, 69, 70, 79, 81, 82, 86, 87, 99, 101, 103, and 105). The limestones of Unit Three are lime wackestones, buff, nodular, bioturbated, and fossiliferous. The marls are buff to bluish, thin bedded, laminated, and fossiliferous (Fig. 36). Fossils present in Unit Three are similar to those in the two lower units with the addition of coral and abundant foraminifers.

Fossils are abundant in the Comanche Peak Formation, particularly in the upper portions of the section. The oysters *Texigryphaea* and *Exogyra* are abundant in the lower unit of the Comanche Peak Formation. Gastropods are represented by *Tylostoma* and *Turritella*, and pelecypods are represented by *Cardium, Inoceramus, Ostrea, Pecten, Pinna,* and *Trigonia*. Echinoids and ammonites are common throughout the section but are most abundant in the upper portions of the unit. Burrows are evident at all localities and increase in abundance upward through the Comanche Peak section.

The upper 2 to 3 feet of the Comanche Peak Formation are dominated by the fossil coral *Cladophyllia* and the foraminifer *Dictyoconus walnutensis*. At many localities

Fig. 35. Locality 64. The middle portion of the Comanche Peak Formation is characterized by nodular limestone and thin marl. The nodular limestone beds range from wackestones to mudstones, are white to gray, highly burrowed, and fossiliferous.

(localities 33, 43, 44, 70, 79, 86, 87, 105, and 106), the coral *Cladophyllia* or the foraminifer *Dictyoconus walnutensis* is quite abundant and forms mats at the top of the Comanche Peak Formation (Mudd, 1972, p. 19).

The Comanche Peak Formation exhibits a consistency in lithologic and faunal characteristics throughout Area Six, and it varies only gradually upward through the section. However, two major changes occur from base to top of the formation: (1) terrigenous material, abundant in the lower facies, decreases upward, and (2) typical marine fauna increases into the middle facies and reaches maximum diversity and abundance in the upper facies of the Comanche Peak Formation.

The contact between the Comanche Peak Formation and the overlying Edwards Formation is conformable but, at most localities, the contact is abrupt. The upper Comanche Peak Formation is typically fine grained, argillaceous, and nodular; whereas the lower Edwards

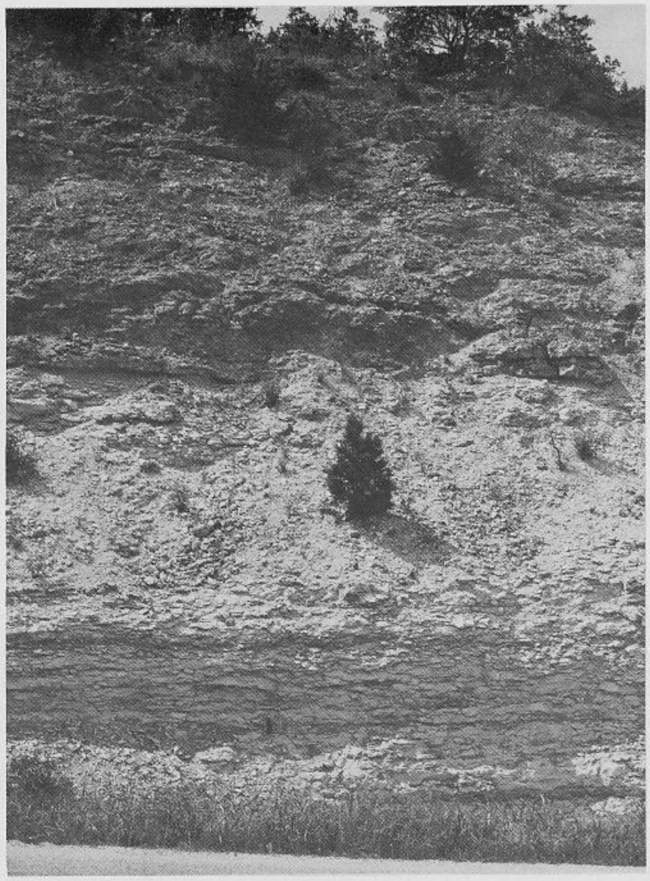

Fig. 36. Locality 86. The upper portion of the Comanche Peak Formation is composed of bioturbated, chalky limestone and marl. The contact between the Comanche Peak and the overlying Edwards Formation occurs midway up the section at the distinct color change. The limestones of the Comanche Peak Formation are wackestones, buff, nodular, and bioturbated. The upper two to three feet are dominated by the fossil coral *Cladophyllia* and the foraminifer *Dictyoconus walnutensis*. The base of the Edwards Formation is marked by a distinct lime packstone unit, which is overlain by a rudist-mound sequence.

Formation is coarse grained and thick, evenly bedded (Fig. 37). Shale interbeds are common in the upper Comanche Peak Formation but are absent in the lower Edwards Formation. Faunal variations are also apparent across the contact. The lower Edwards Formation often contains large accumulations of rudists, which are not found in the underlying Comanche Peak Formation.

The Edwards Formation of Area Six consists of from 5 to 80 feet of rudist limestone and dolomite. The Edwards Formation is characterized by a composition devoid of land-derived clastics and by a notable uniformity in thickness over much of Area Six. While thickness of the Edwards Formation varies from 5 to 80 feet in Area Six, it remains a near-uniform 30 to 35 feet over a major portion of the area. The thickness of the Edwards Formation begins to increase rapidly in Bell County. From this point southward, the Edwards Formation continues to thicken rapidly and changes character until it merges with the limestones of the Stuart City reef trend.

The Edwards Formation of Area Six can be divided into a number of facies on the basis of lithology and faunal characteristics. The facies are laterally correlative

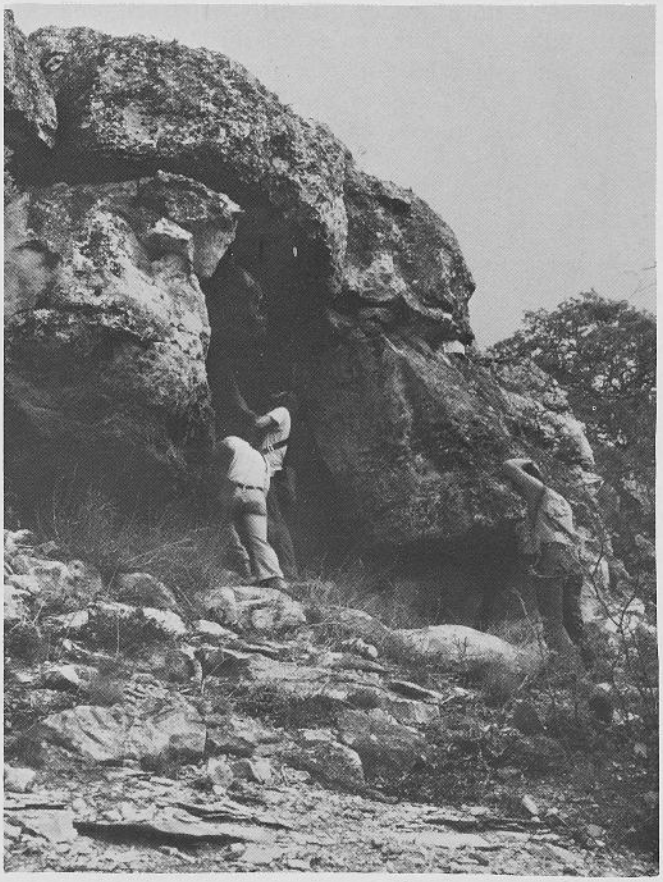

Fig. 37. Locality 30. The abrupt contact between the Comanche Peak and Edwards Formations is displayed at the Hog Mountain section. Note the nodular character of the Comanche Peak Formation and the thick-bedded, massive character of the Edwards Formation.

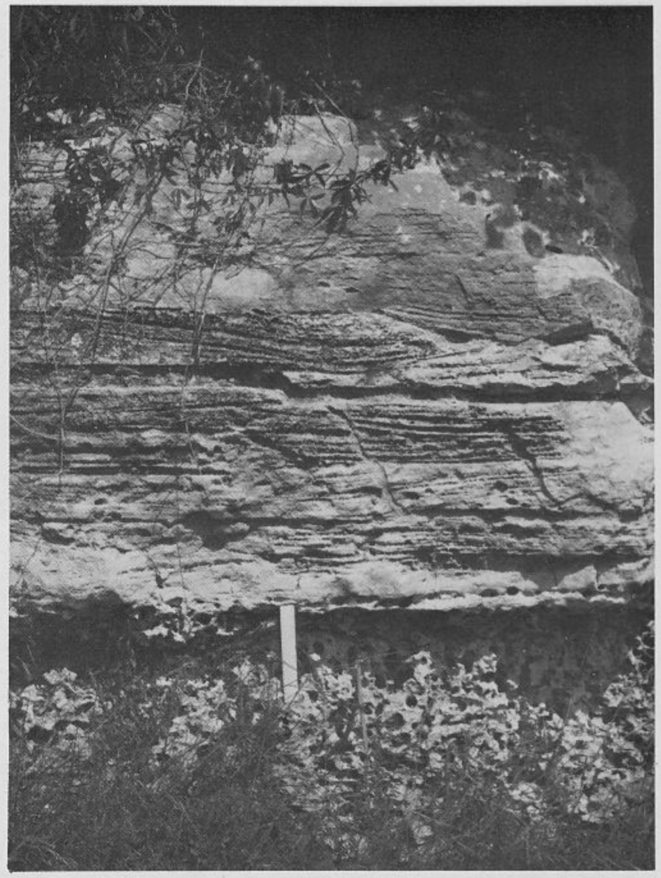

Fig. 38. Locality 33. The base of the Edwards Formation is marked by a distinctive lime packstone. The facies is massive to thick bedded, fossiliferous, and exhibits low-angle cross-bedding. Note the distinctive cross-bedding in the unit.

with those of the Edwards Formation in Area Four as described by E. Marcantel (1968) and in Area One as described by Brand (1953).

The base of the Edwards Formation in Area Six is marked by a distinctive buff lime packstone to lime grainstone (localities 33, 43, 44, 68, 69, 70, 79, 83, 86, 103, and 106). This basal bed is commonly a lime packstone, massive to thick bedded, and exhibits low-angle cross-bedding (Fig. 38) (locality 33) or intense burrowing. It is highly fossiliferous, containing algae, pellets, the miliolid foraminifera *Dictyoconus walnutensis*, the coral *Cladophyllia*, and fragments of rudists and other pelecypods. A unique feature of the lime packstone facies is the occurrence of algal oncolites (localities 69, 70, and 79). The oncolites have an average diameter of 5/8 inch, are elongate or oval, and have cores composed of rudist fragments or chalky nodules (Lambert, 1979, p. 27-39).

A rudist-mound sequence is developed upon the algal-*Dictyoconus* lime packstone and comprises the basal portion of the Edwards Formation throughout much of Area Six. The mound complex in Area Six has been described in detail by Nelson (1959) and Lambert (1979). A distinctive faunal content and zonation can be observed in the mound sequence.

The base of the mound sequence is dominated by a buff, massive to thick-bedded, lime wackestone to lime packstone with abundant fragmented and whole fossils of the pelecypods radiolitid and caprinid rudists, *Chondrodonta*, and the coral *Cladophyllia* (Fig. 39) (Lambert, 1979, p. 41, 51) (localities 33, 43, 44, 67, 69, 70, 76, 79, 83, 86, 99, 100, 103, 105, 106, 107, 113, and 114). The radiolitids dominate in the lower part of the section, whereas the caprinids increase in abundance and dominate the upper portions of the section. The coral *Cladophyllia* occurs with the radiolitids in the lower portions (Lambert, 1979, p. 50).

The caprinid-radiolitid-*Chondrodonta* lime wackestone facies is overlain by buff to light-gray, massive, lime wackestone packstone with abundant pelecypods with caprinid, *Toucasia*, and *Chondrodonta* (Lambert, 1979, p. 52, 53) (localities 33, 43, 44, 69, 70, 71, 79, 83, 86, 99, 100, 103, 105, 106, 107, 113, and 114). Bioturbation is extensive throughout this facies. Relief on the top of the mound sequence is obvious and greater than the relief on the lower mound facies (Fig. 40) (Lambert, 1979, p. 53).

The rudist-mound sequence is overlain by one of three facies: (1) a fine-grained dolomite facies; (2) a rudist grainstone facies; or (3) a mollusk-miliolid wackestone and marl facies. Each of these facies is in sharp contact with the mound sequence.

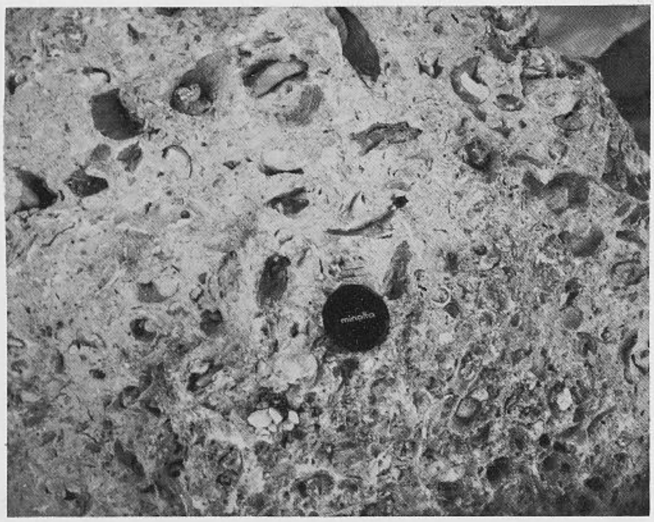

Fig. 39. Locality 67. Close view of the base of the rudist-mount sequence. The base of the sequence is dominated by a buff, massive to thick-bedded, wackestone to packstone with abundant fragmented and whole fossils of the pelecypods radiolites and caprinid rudists, *Chondrodonta*, and the coral *Cladophyllia*. Note the random orientation of the rudists.

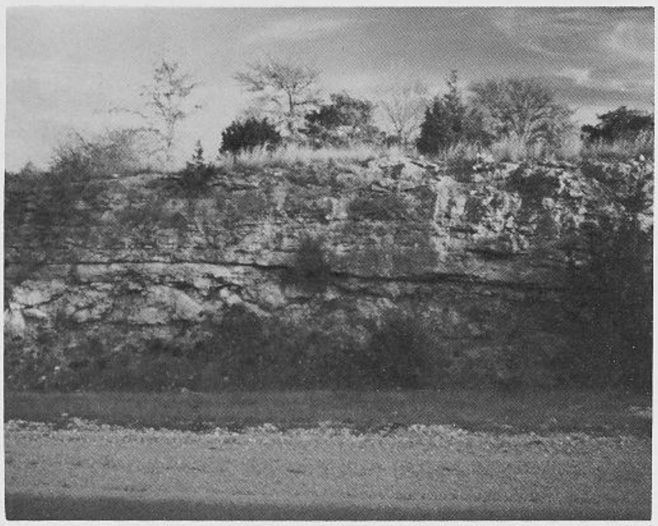

Fig. 40. Locality 79. The Edwards Formation is composed of a rudist-mound sequence, which consists of a lower caprinid-radiolitid-*Chondrodonta* facies and an upper caprinid-*Toucasia*-*Chondrodonta* facies. The relief on the top of the mound is obvious near the center of the section. The mound sequence is overlain by rudist grainstone composed of skeletal material of fragmented rudists and *Chondrodonta*.

The rudist-mound sequence is overlain by fine-grained dolomites that appear to be confined to the western and southern margins of Area Six (localities 33, 91, and 113). Two distinct dolomite facies are present: laminated dolomite and fossil-mold dolomite. The laminated dolomite is white to gray, thin bedded or laminated, and nonfossiliferous. Sedimentary structures include mud cracks, root and animal burrows, and algal laminations. The fossil-mold dolomite is buff gray to medium gray, medium to thick bedded, intensely burrowed, and contains abundant preserved external molds of mollusks. Both the laminated dolomite and the fossil-mold dolomite have grain sizes of less than 10 microns (Moore, 1969, p. 132) and occur as repetitive couplets throughout the section (Fig. 41).

The rudist grainstone facies overlies the rudist-mound sequence at localities 67, 69, 71, 76, 79, 86, and 104 and

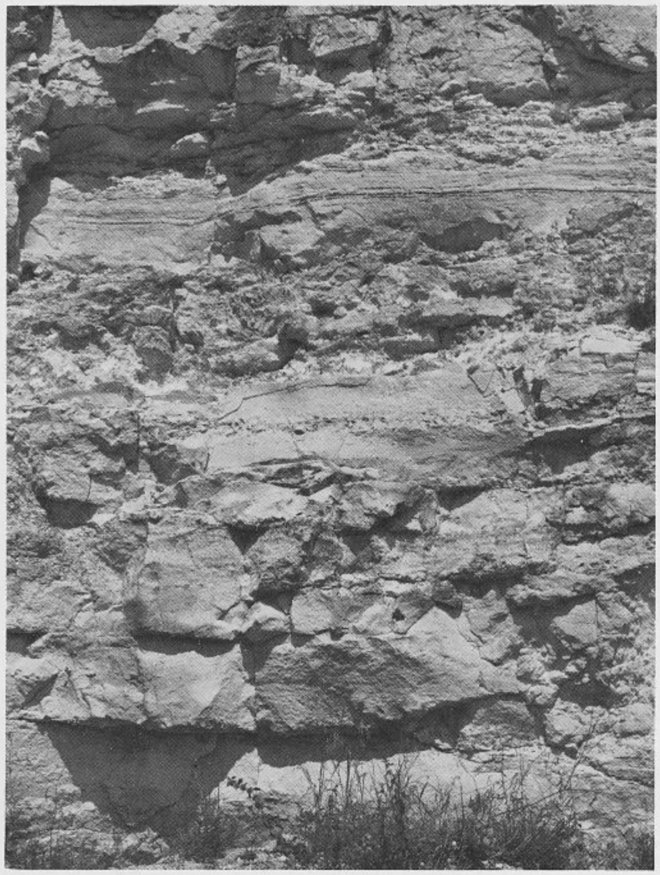

Fig. 41. Locality 33. The rudist mound sequence in the western portion of Area Six is overlain by fine-grained dolomites: laminated dolomite and fossil-mold dolomite. Note the laminations in the dolomite in the upper portion of the photo and the solution molds of fossils in the medium-bedded dolomite in the center of the photo.

overlies the fine-grained dolomite facies at locality 33. The grainstone is skeletal material composed almost entirely of fragmented rudists and the pelecypod *Chondrodonta* (Fig. 40) (Lambert, 1979, p. 56). The grainstones are buff, medium to thick bedded, and exhibit low-angle cross-bedding at several localities (localities 33, 67, and 104). Graded bedding within the grainstone facies usually consists of fining upward sequences (localities 76 and 79). Where the rudist grainstone facies comprises the upper portion of the Edwards Formation and directly underlies the Kiamichi Formation (localities 67, 79, 86, and 103), the upper surface of the Edwards Formation appears pitted and bored, iron stained, and pyritic. This surface appears to be well cemented and case hardened (Fig. 15).

The mollusk-miliolid wackestone and marl facies over-

Fig. 42. Isopach map of the Paluxy Formation.

lies the rudist-mound sequence at localities 44, 67, 70, 71, 83, 99, and 114 and overlies the fine-grained dolomite facies at locality 113. In addition, the lime wackestone and marl facies usually occurs between the rudist mound accumulations (Lambert, 1979, p. 63).

The lime wackestones and marls are characteristically interbedded and form a section of buff, well-bedded and nodular limestone. Bioturbation is extensive, and burrows are abundant throughout the facies. The fauna is limited to gastropods, pelecypod fragments, and miliolids. Chert beds of secondary origin are common within the marls (localities 44, 99, and 113). Where the wackestone and marl facies comprises the upper portion of the Edwards Formation and directly underlies the Kiamichi Formation (locality 70), the upper surface of the Edwards Formation appears pitted and bored, iron stained, and case hardened (Fig. 15).

The Edwards Formation exposed in Bell County differs in character from the Edwards Formation in the remainder of Area Six. A general thickening trend in the Edwards Formation begins in Bell County and continues to the south. The Edwards Formation averages 60 to 80 feet in thickness in Bell County and reaches a maximum of 125 feet at Moffat, near locality 114. At Moffat, the

Fig. 43. Isopach map of the Walnut Formation.

thick Edwards sequence is the result of the replacement of 30 feet of the Comanche Peak Formation and the addition of 60 feet above by strata that are lithologically similar to the Edwards Formation. This Moffat Lentil consists of lime grainstones composed of oolites and pellets. The Edwards Formation at other localities in Bell County (localities 115 and 116) is composed of alternating thick beds of limestone and dolomite. The limestones are buff, wackestones to mudstones, and fossiliferous with rudist fragments and pellets. The dolomites are brown, fine grained, and thin bedded. The sequence appears to resemble the alternating limestones and dolomites of the Edwards Formation in Area Two.

The Edwards Formation in Area Six is unconformably overlain by members of the Georgetown Formation. The Kiamichi Formation unconformably overlies the Edwards Formation in the northern and central portions of Area Six (localities 67, 68, 69, 70, 71, 74, 79, 81, 85, and 103). The following criteria were noted by Nelson (1959) and Shelburne (1959) as evidence for the unconformable contact:

(1) The upper Edwards Formation exhibits the effects of casehardening and oxidation;

(2) The top surface of the Edwards Formation contains

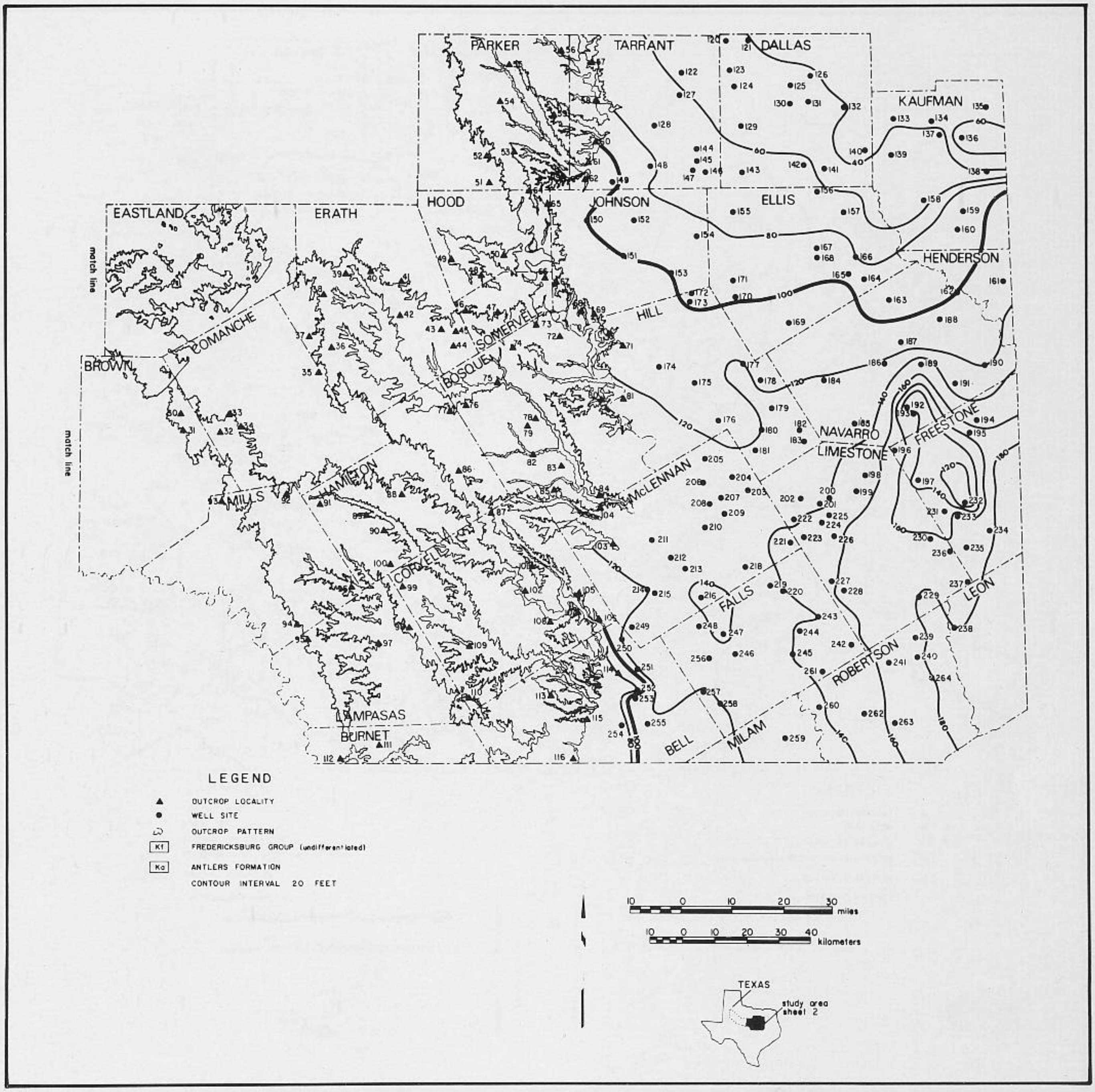

Fig. 44. Isopach map of the Comanche Peak Formation.

small bore holes and pits filled with Kiamichi clay;
(3) The lower Kiamichi Formation contains rounded pebbles of Edwards material; and
(4) The Kiamichi Formation onlaps the surface at the top of the Edwards as demonstrated by the pinch out of successively higher layers of the Kiamichi Formation.

The Kiamichi Formation is tan to brown to gray, calcareous, fossiliferous shale and clay. The most abundant fossil in the Kiamichi Formation is the oyster *Gryphaea*.

The Duck Creek Formation of the Georgetown Formation unconformably overlies the Edwards Formation in the southern portion of Area Six beyond the pinch out of the Kiamichi Formation. The basal Duck Creek Formation is composed of buff alternating marly chalky limestone and gray marl. The unconformity is marked by case hardening and oxidation and borings and pits of the upper surface of the Edwards Formation.

AREA SEVEN

The Fredericksburg Group of Area Seven (Fig. 9) is composed of a southwardly thinning wedge of the Paluxy Formation, a southwardly thickening wedge of the Wal-

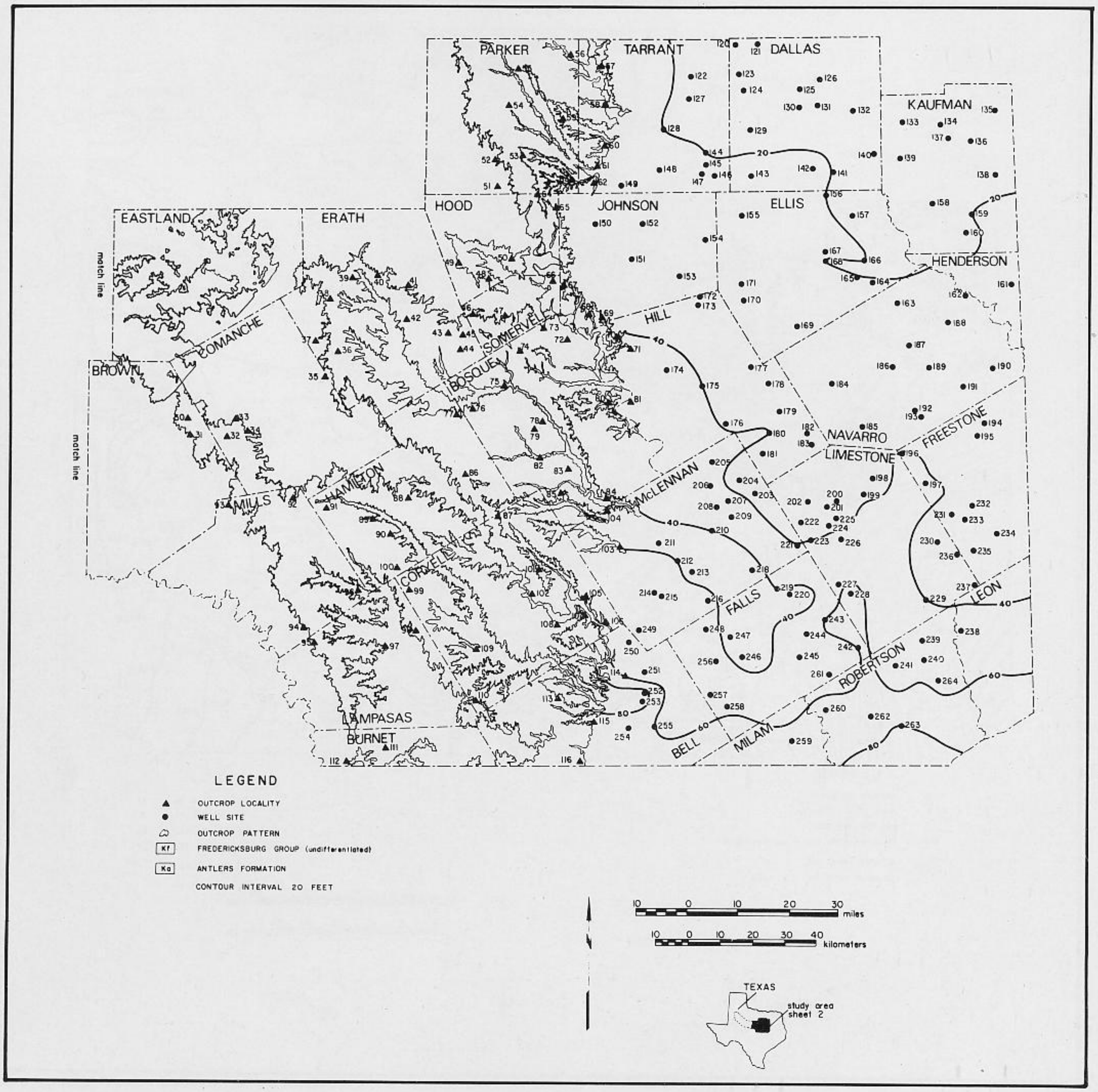

Fig. 45. Isopach map of the Edwards Formation.

nut Formation, and reasonably consistent sections of the Comanche Peak Formation and the Edwards Formation. Sedimentary strike in Area Six is N 45° E with regional thickening to the southeast in the lower formations and to the south in the upper formations. In general, the subsurface character of the Fredericksburg Group is one of consistent lithology and isopach consistency (Figs. 42-47).

The Paluxy Formation is a relatively thin unit composed of sandstone and shale, which forms a distinct lithic break between the carbonates of the underlying Glen Rose Formation and the overlying Walnut, Comanche Peak, and Edwards Formations. The Paluxy Formation ranges from 220 feet in northern Tarrant, Dallas, and Kaufman Counties to a basinward pinch out of the sandstone where it grades into the Walnut Formation (Caughey, 1977, p. 8) in central McLennan, southern Hill, and central Navarro, and Henderson Counties. This is illustrated in both north-south and east-west geologic sections (Figs. 7 and 8). The isopach map for the Paluxy interval (Fig. 42) illustrates the distribution and orientation of the sandstone accumulations. The distribution in Area Seven is uniform and characterized by evenly spaced contours, which extend irregularly along strike.

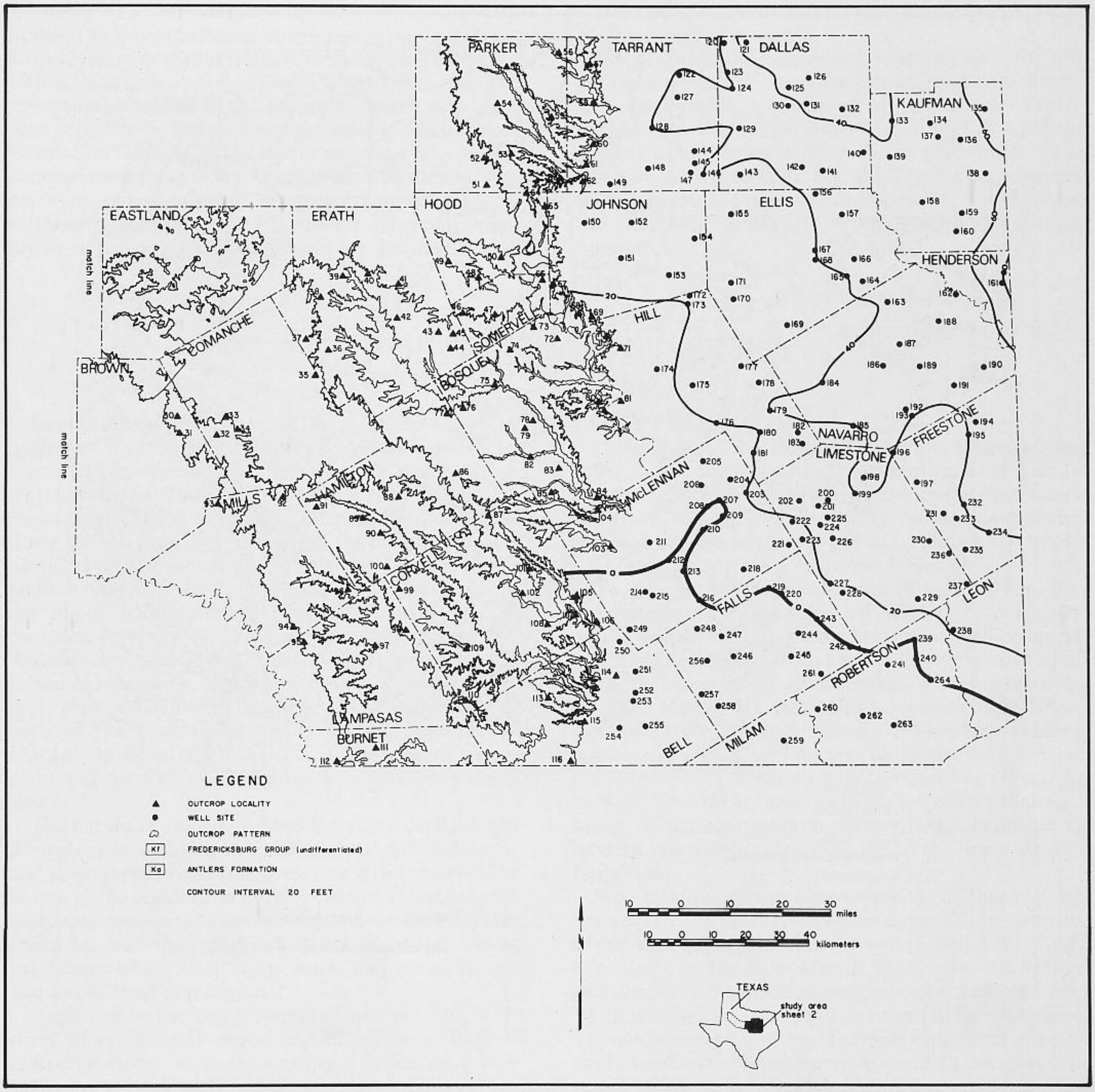

Fig. 46. Isopach map of the Kiamichi Formation.

At various levels within the Paluxy Formation characteristic log signatures illustrate the following sand-shale relationships: (1) thinly interbedded sands and shales; (2) upward coarsening profiles with abrupt upper sand-shale contacts; (3) uniform sands with abrupt upper and lower contacts; and (4) upward fining sand-shale sequences with abrupt bases.

The Walnut Formation of Area Seven is a regionally thickening wedge of calcareous clay and marly limestone. The Walnut ranges from 40 feet thick in Tarrant, Dallas, and Kaufman Counties to 460 feet thick in Robertson and Leon Counties (Fig. 43). The thickening trend is to the east and southeast and is well illustrated in the north-south and east-west geologic sections (Figs. 7 and 8). The log character and lithology remain consistent throughout Area Seven. The Walnut Formation is generally composed of thick upper and lower clay sequences separated by two limestone units. The dense limestones increase in abundance in the upper portion of the sequence as the Walnut thickens to the east into the East Texas basin.

The Comanche Peak Formation and the Edwards Formation traditionally are not separated into distinct units in the northern half of Area Seven and into the East Texas basin. They are grouped into a limestone and shale

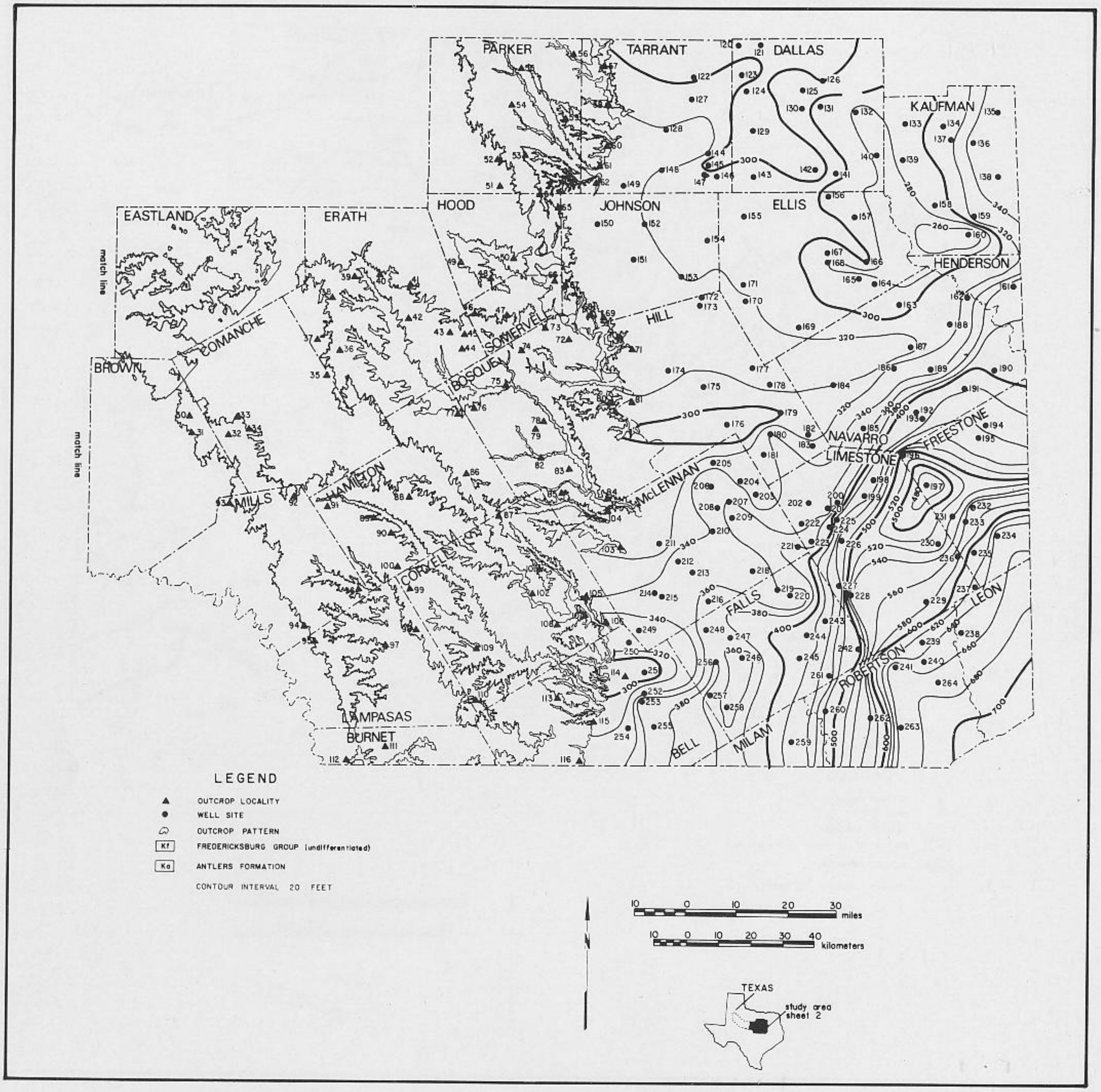

Fig. 47. Isopach map of the Fredericksburg Group.

sequence designated the Goodland Formation. However, for the purposes of this report, the Comanche Peak and Edwards Formations are considered as distinct units based on consistent and gradually changing log characters.

The Comanche Peak Formation consists of limestones and interbedded shales, which exhibit a consistent thickness throughout much of Area Seven. The Comanche Peak Formation ranges from 40 feet thick in norhtern Dallas and Kaufman Counties to 180 feet thick in Freestone and Leon Counties (Fig. 44). As with the underlying Walnut Formation, the thickening trend is to the southeast, but the amount and rate of thickening are much less in the Comanche Peak Formation than in the underlying Walnut Formation. The north-south and east-west geologic sections (Figs. 7 and 8) illustrate the gradual thickening trend to the east and southeast. Two small anomalies are apparent in the Comanche Peak isopach (Fig. 44). A small circular thin is present in Freestone County, and a small thin is found in central Bell County. The depression in Bell County is located in the region of the Moffat Lentil, an area of anomalous Comanche Peak and Edwards Formations thicknesses in Area Six.

The Edwards Formation exhibits a consistent electric log signature and a consistent thickness throughout Area Seven. The Edwards Formation ranges in thickness from 10 to 15 feet in northern Dallas and Kaufman Counties to 80 feet thick in central Robertson County (Fig. 45). The most notable feature of the Edwards isopach map is the change of direction of sediment thickening. The Edwards Formation thickens in a southern direction with no evidence of thickening to the west. In addition, the contours are even and widespread, indicating gradual, uniform thickness variations (Figs. 7, 8, and 45). The small anomaly in Bell County coincides with the anomaly in the Comanche Peak Formation and is in the region of the Moffat Lentil of Area Six.

The Kiamichi Formation is a relatively thin clay unit with an interbedded limestone section, which overlies the Edwards Formation over much of Area Seven. The Kiamichi Formation ranges from 60 feet thick in Kaufman County to a basinward pinch out in McLennan, Falls, and Robertson Counties (Fig. 46). The Kiamichi Formation illustrates the same southern direction of thinning as the underlying Edwards Formation of the Fredericksburg Group.

DEPOSITIONAL HISTORY

Deposition of the Fredericksburg Group was controlled by a single northwestward transgression of the Comanchean sea, across the relatively stable Texas craton from the subsiding East Texas basin. During this major transgression there were a number of minor regressions, though the total effect was of the major transgression. The final phases of a late Trinity regressive cycle are recorded by the lower Paluxy Sand. The initial phase of the major transgression of Fredericksburg time is recorded by the upper Paluxy Sand, followed by the Walnut Clay, the Comanche Peak Limestone, and the Edwards Limestone, each characteristic of deeper water, more marine conditions. Evidence of an unconformity between the Trinity and Fredericksburg sequences is represented by a regional caliche zone present in the middle of the Paluxy Formation throughout the study area.

The nature of the lower Fredericksburg deposits was dependent upon the interactions of terrigenous sediments and the regressive and transgressive marine waters. The nature of the middle and upper Fredericksburg deposits was dependent on the major transgression of the Comanchean sea and the influences of tectonics, the rate of subsidence of the East Texas basin, and the structural features of the Texas craton.

Important to the interpretation of ancient strata is the study of present day processes and products. From a Holocene model, an understanding of sedimentary processes can be projected to an incompletely known ancient geologic example, and a far more accurate prediction of trends and facies can be obtained. The deposits of the Fredericksburg Group have modern analogs in a wide variety of environments. The characteristics of the modern models are applied to the interpretation of the depositional history of the deposits of the Fredericksburg Group.

The depositional history of the Fredericksburg Group, in chronological order, begins with the initial deposits of the Paluxy Formation and continues through deposition of the Kiamichi Formation of the overlying Washita Group. This history is presented here in a series of diagrammatic facies maps that illustrate the sequences of events that resulted in the Fredericksburg rocks.

EARLY PALUXY TIME

Deposition of the Paluxy Formation began on the Texas craton in the northeastern portion of the study area as the Glen Rose sea regressed into the East Texas basin (Fig. 48), and shoreline and fluvial sands and shales followed the retreating sea. The basal Paluxy sands, the Lake Merritt Member, represent strandline and nearshore deposits of the regressing sea (Owen, 1979, p. 30). Environments ranging from intertidal to tidal flat are represented by the alternating horizontal sand beds and thin clay beds, clastic dikes, and the limited quantities of fossil fragments. Beach environments are also present in the Lake Merritt Member and are represented by large- and small-scale, low-angle planar cross-bed sets. Modern intertidal environments present along the shorelines of the North Sea in areas such as German Bay (Reading, 1978, p. 174-175) are analogs to the lower Paluxy sands. Many of the sedimentary characteristics common to modern intertidal areas are found in the lower Paluxy Formation.

With continued regression of the Glen Rose sea, the braided streams that deposited the upper Trinity deposits of the Antlers Formation to the west (Smith, 1971, p. 52) extended over the Lake Merritt Member of the Paluxy and deposited the sands of the Georges Creek Member. The fluvial systems flowed across most of the study area and are represented by braided stream deposits of high-angle, unidirectional planar cross-bedding, trough cross stratification, and large-scale trough cross-bedding. The thick sections of red and white siltstone and clay are representative of flood-basin deposits of the fluvial systems (Owen, 1979, p. 22-24). Examples of braided streams in modern environments were described by Owen (1979) and included the deposits of the South Platte River in Nebraska and Colorado, the Brahmaputra River in Bangladesh, and the Red River in the panhandle of Texas. The deposits of these modern braided streams are depositional analogs for the Georges Creek Member of the Paluxy Formation.

MIDDLE PALUXY TIME

Southeastward regression and the migration of facies associated with the regression continued throughout

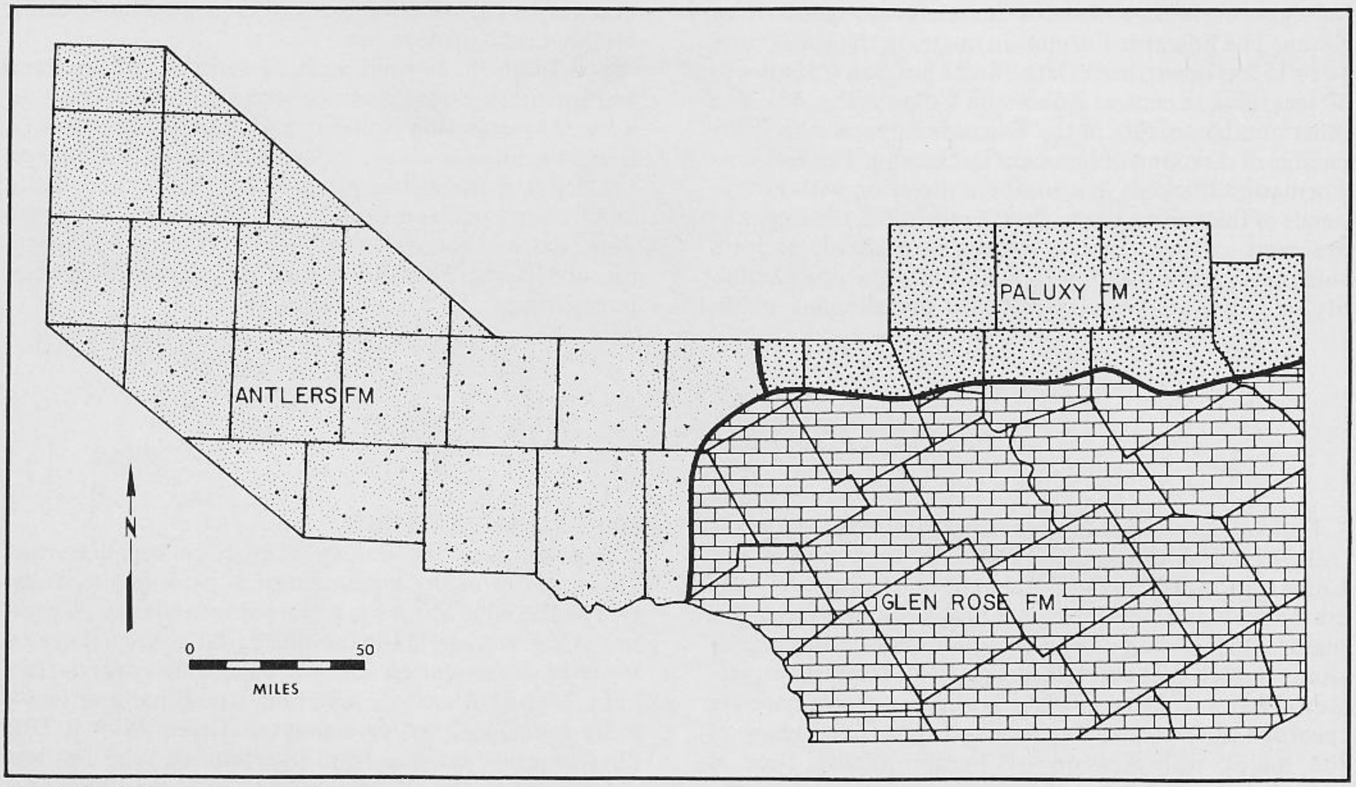

Fig. 48. Early Paluxy paleogeologic map.

deposition of the lower and middle Paluxy Sand. By middle Paluxy time, the regression left the central portion of the study area exposed as a broad, low subaerial plain (Castle, 1969, p. 78). Semiarid climatic conditions existed on the subaerial plain as evidenced by the development of a prominent caliche facies, the uppermost unit of the Georges Creek Member (Fig. 49). The caliche facies, characteristically brown, indurated, with well-developed calcium carbonate nodules, represents ancient soil horizons. This regional caliche zone also represents a hiatus separating the Antlers Formation into lower Trinity equivalents and the upper Fredericksburg equivalents (Castle, 1969, p. 47-50; Smith, 1971, p. 35-37; and Owen, 1979, p. 25) as well as separating the lower regressive deposits from the upper transgressive deposits of the Paluxy Formation.

As soil horizons developed on the subaerial plain in the central portion of the study area, the Paluxy Formation continued to be deposited by fluvial systems in the eastern portion of the study area (Fig. 49).

LATE PALUXY TIME

After regression of the Comanchean sea during the early and middle parts of Paluxy deposition, the sea again transgressed to the northwest. This was the beginning of the major Fredericksburg transgression, which culminated with the deposition of the limestones of the Edwards Formation.

Transgression of the Comanchean sea during Paluxy deposition reached its maximum extent during late Paluxy time, when the shoreline remained in Bosque, Brown, Comanche, and Hamilton Counties (Fig. 50) (Owen, 1979, p. 30). An intertidal environment existed along the shoreline and is represented by the fine-grained sand and gray clay of the Eagle Mountain Member with diagnostic tidal bedding and longitudinal cross-bedding.

In the central portion of the study area, north of the shoreline, rivers flowed from the north and northwest across the area and drained into the sea. These meandering streams were characterized by channel and flood-plain deposits recognized by distinctive cross-bedding, laminae, and channel-fill bed forms.

In the south-central portion of the study area, south of the shoreline in Bosque, Brown, Comanche, and Hamilton Counties, a shallow marine, subtidal environment is represented by fossiliferous clay with thin, fossiliferous sand beds.

The interlamination of the fluvial and marine deposits of the Eagle Mountain Member of the Paluxy Formation suggests the presence of a distructive delta sequence. Tidal and longshore currents of the transgressive sea reworked and redeposited much of the fluvial sediments (Owen, 1979, p. 30). Fluvial, intertidal, and marine deposits are recognized in modern tide dominated deltaic complexes such as the Niger Delta on the west coast of Africa (Oomkens, 1974, p. 195-222) and the Rhone Delta in southern France (Fisher *et al.*, 1969, p. 24).

In the southeastern portion of the study area beyond the margin of Paluxy Sand deposition, the lower Walnut Formation was contemporaneously deposited (Fig. 50).

EARLY WALNUT TIME

Northwestward transgression by the Comanchean sea continued across a broad, flat platform throughout

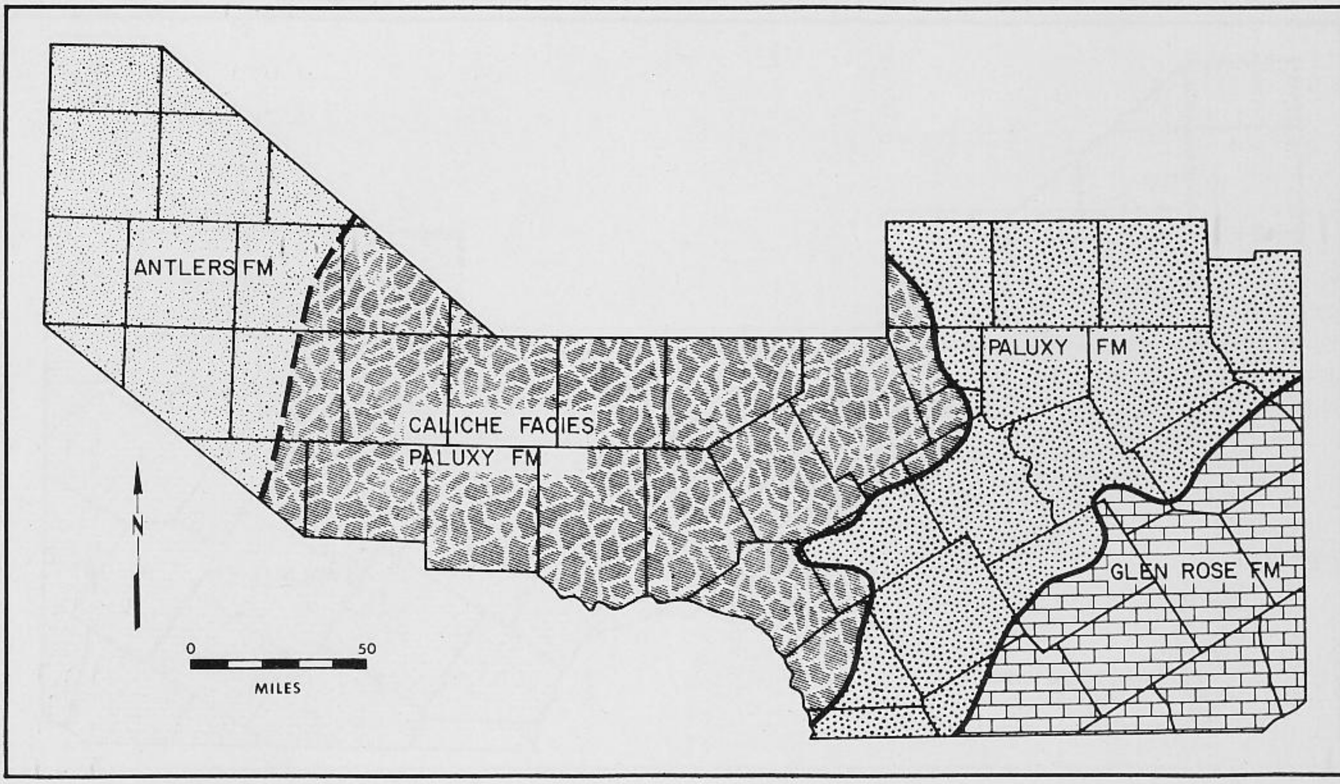

Fig. 49. Middle Paluxy paleogeologic map.

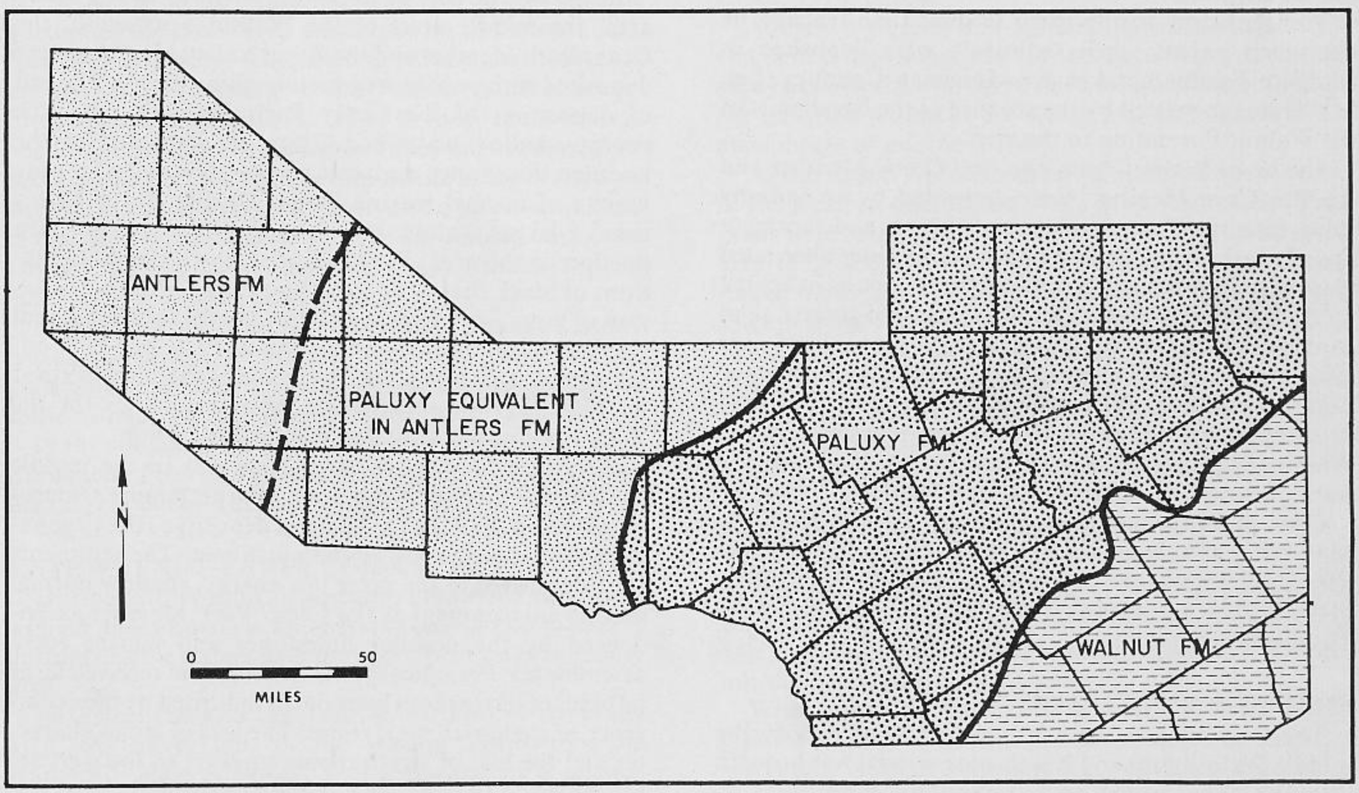

Fig. 50. Late Paluxy paleogeologic map.

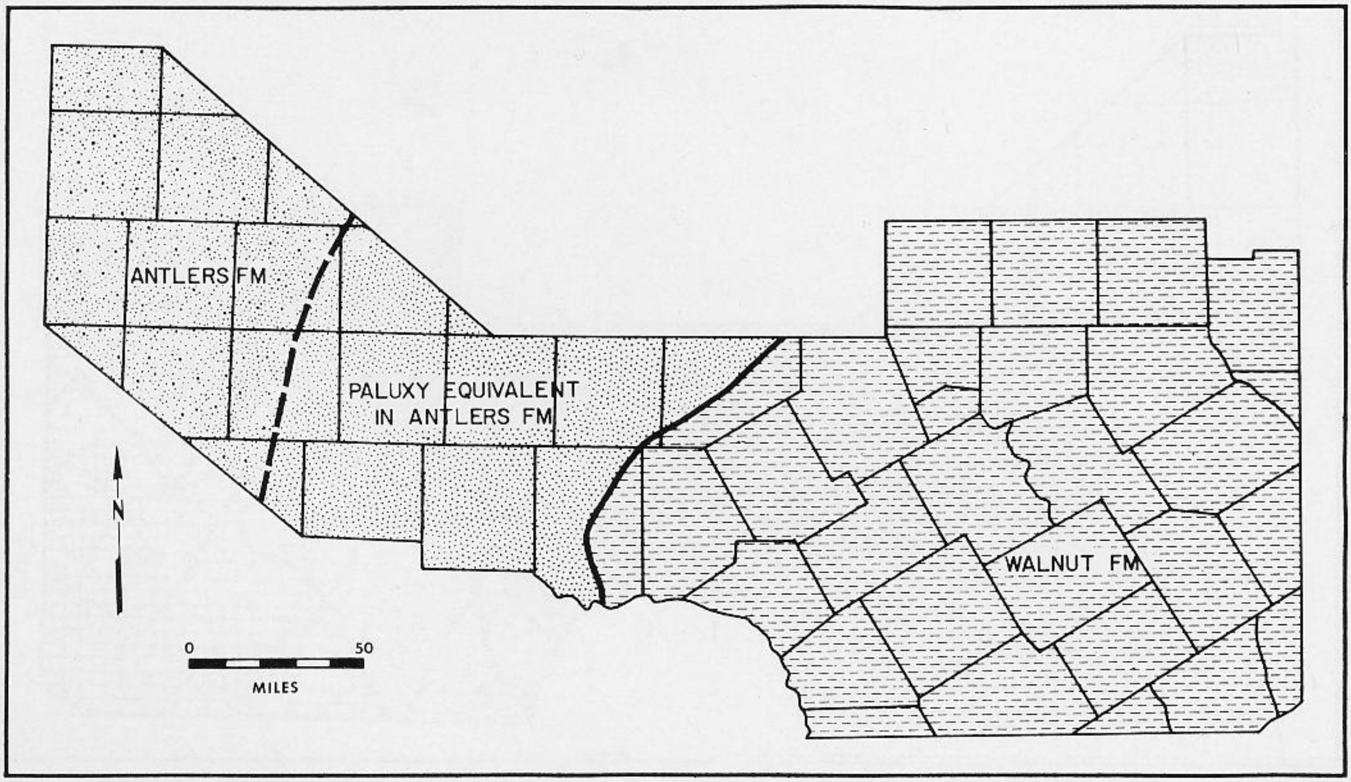

Fig. 51. Early Walnut paleogeologic map.

deposition of the Walnut Formation. Marine clay and limestone of the Walnut Formation were deposited on the Paluxy Sand.

Transgression during early Walnut time reached its maximum extent when sediments were deposited in southern Eastland and eastern Coleman Counties (Fig. 51). This is suggested by the absence of the basal units of the Walnut Formation to the west.

The basal Walnut units, the Bull Creek Member and the Bee Cave Member, were deposited by an initially slow, then rapid transgression of the sea and represent nearshore deposits. Environmental conditions alternated from slightly brackish to brackish to marine as indicated by faunal associations. The high clay and quartz sand content of the lower units indicates the presence of river influx or the action of longshore currents in the area of deposition (Owen, 1979, p. 32, 33). The presence of well-developed ripple marks in the thin limestones of the basal Walnut Formation suggests that water depths in the transgressing Comanchean sea were shallow.

Contemporaneous with the deposition of the Bee Cave Member near its maximum extent in Eastland and Coleman Counties was the deposition of the middle members of the Walnut Formation to the east on the margin of the Texas craton.

MIDDLE WALNUT TIME

The Comanchean sea continued to transgress during middle Walnut time and less clastic material was brought into the depositional area. Limestone deposition occurred over a large portion of the study area with marked thinning of the section to the north and northwest. (Fig. 52).

In the central and east-central portions of the study area, the middle units of the Walnut Formation, the Cedar Park Member and the Keyes Valley Member, were deposited with possible regression taking place at the end of deposition of the Cedar Park Member. The low energy, shallow water conditions are indicated by the nodular limestones and calcareous clay and the wide variety of normal marine fauna. During Keyes Valley time, a large, shallow bay formed in the northeastern portion of the area, as represented by the interlaminations of black shales, nodular limestones, the accumulation of large *Texigryphaea* banks, terrigenous sand, and ripple-marked limestone beds (Flatt, 1976, p. 33). Modern oyster reefs along the Texas Gulf coast as described by Flatt (1976) appear to be modern analogs for the *Texigryphaea* banks of the Walnut Formation.

Westward, key fossil beds pinch out in the middle Walnut, such as those containing the ammonite *Oxytropidoceras*, indicating the onlap of deposits as the Comanchean sea transgressed to the northwest. The sediments were deposited in the same low energy, shallow normal marine environment as the Cedar Park Member as evidenced by the nodular limestones and marine fossil assemblages. Periodically, the environment received large influxes of terrigenous material as indicated by the occurrence of shale-rich marl zones. The loss of facies character and the loss of stratigraphic markers to the west are attributed to the influence of the positive structural feature of the Concho arch.

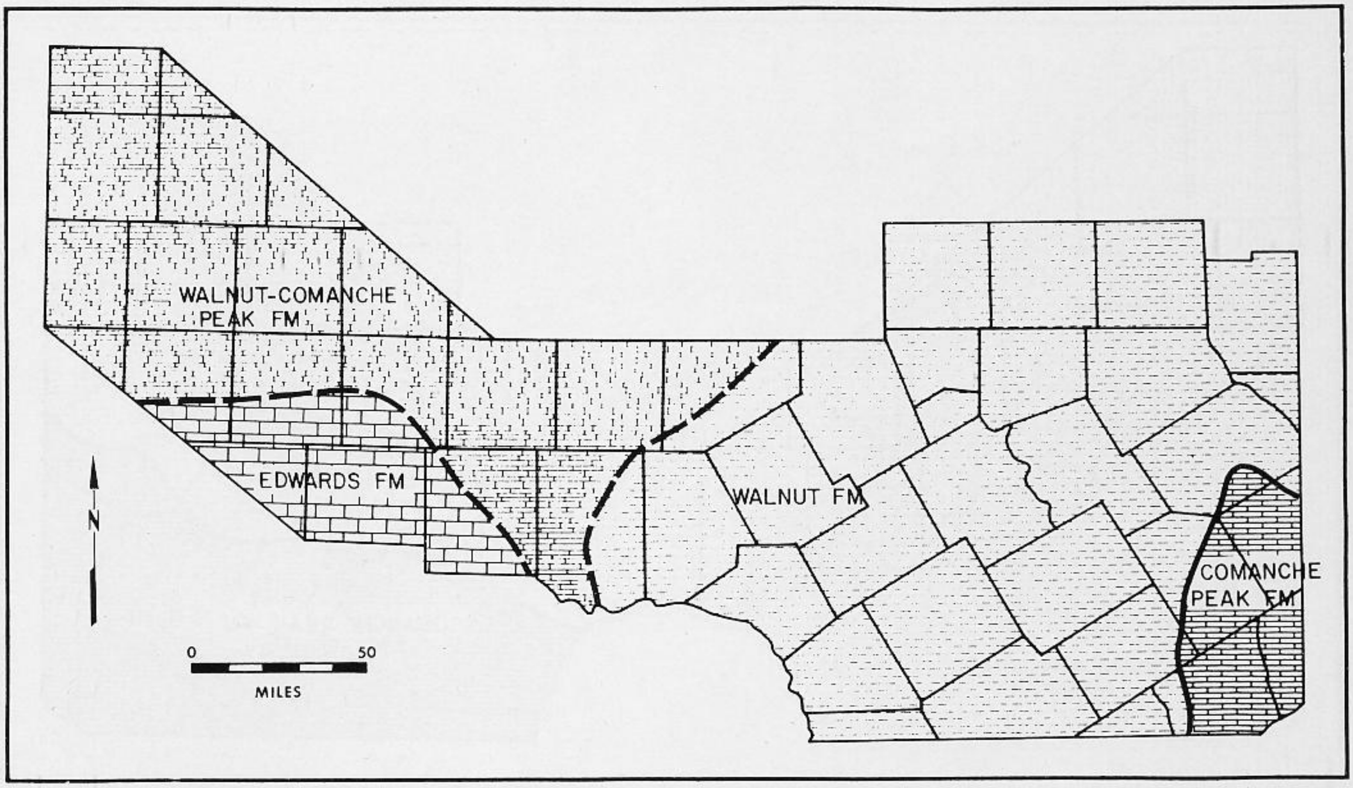

Fig. 52. Middle Walnut paleogeologic map.

In the west, the middle Walnut sediments deposited in the transgressing marine waters incorporated more of the underlying Antlers Sand than in other areas. The source of the marls of the Walnut Formation in the western portion of the study area appears to be in the west (i.e., New Mexico) rather than in the north and northeast as is the source of the marls of the Walnut in other areas. Environmental conditions similar to those in the central portion of the area during Keyes Valley depositional time occurred in the western portion of the area. A shallow bay, with slightly brackish waters and a paleo-strandline in the vicinity, is suggested by the accumulations of the oyster *Exogyra*, the nodular limestones, the interbedded marls, and the terrigenous sands.

In central Nolan County and western Runnels County and to the south, the Walnut sediments grade indistinguishably into the overlying sediments apparently because of relatively rapid uplift of the Llano region.

In the southeastern part of the area, deposition of the Comanche Peak Formation was beginning to occur on the margin of the Texas craton (Fig. 52).

LATE WALNUT-EARLY COMANCHE PEAK TIME

During late Walnut deposition, continued transgression of the Comanchean sea resulted in the influx of normal marine waters over the major portion of the study area.

In the central and east-central portions of the study area, the upper unit of the Walnut Formation, the Unnamed Marl Member, was deposited in a normal marine environment in which water depth increased and turbulence decreased from the previous depositional environments of the Walnut (Jones, 1966, p. 179) as evidenced by the appearance of planktonic foraminifera (Flatt, 1976, p. 35).

A relatively quiet, non-agitated, normal marine environment is also suggested for the western portion of the study area by the dominance of lime mud accumulation, the unsorted nature of the sediments, and the abundant assemblage of marine fossils.

As the upper Walnut sediments were being deposited in the western part of the study area, Comanche Peak muds were being deposited in the southeastern part of the area (Fig. 53). The Fredericksburg transgression continued uniformly and slowly as indicated by the uniform thickness of the sediments and the conformable and interfingering nature of the contact with the underlying Walnut Formation. Environmental conditions alternating between slightly brackish to normal marine salinities are represented by the occurrence of the oyster *Texigryphaea* beds in the lower Comanche Peak sediments.

LATE COMANCHE PEAK TIME

Northwestward transgression by the Comanchean sea during middle and late Comanche Peak time resulted in the westward migration of Comanche Peak deposits (Fig. 54). Similar environmental conditions existed throughout the study area during this time.

With transgression, the availability of land-derived clastics decreased as the distance from the shoreline increased. Normal marine salinity conditions prevailed as indicated by the abundant and diverse fauna and the

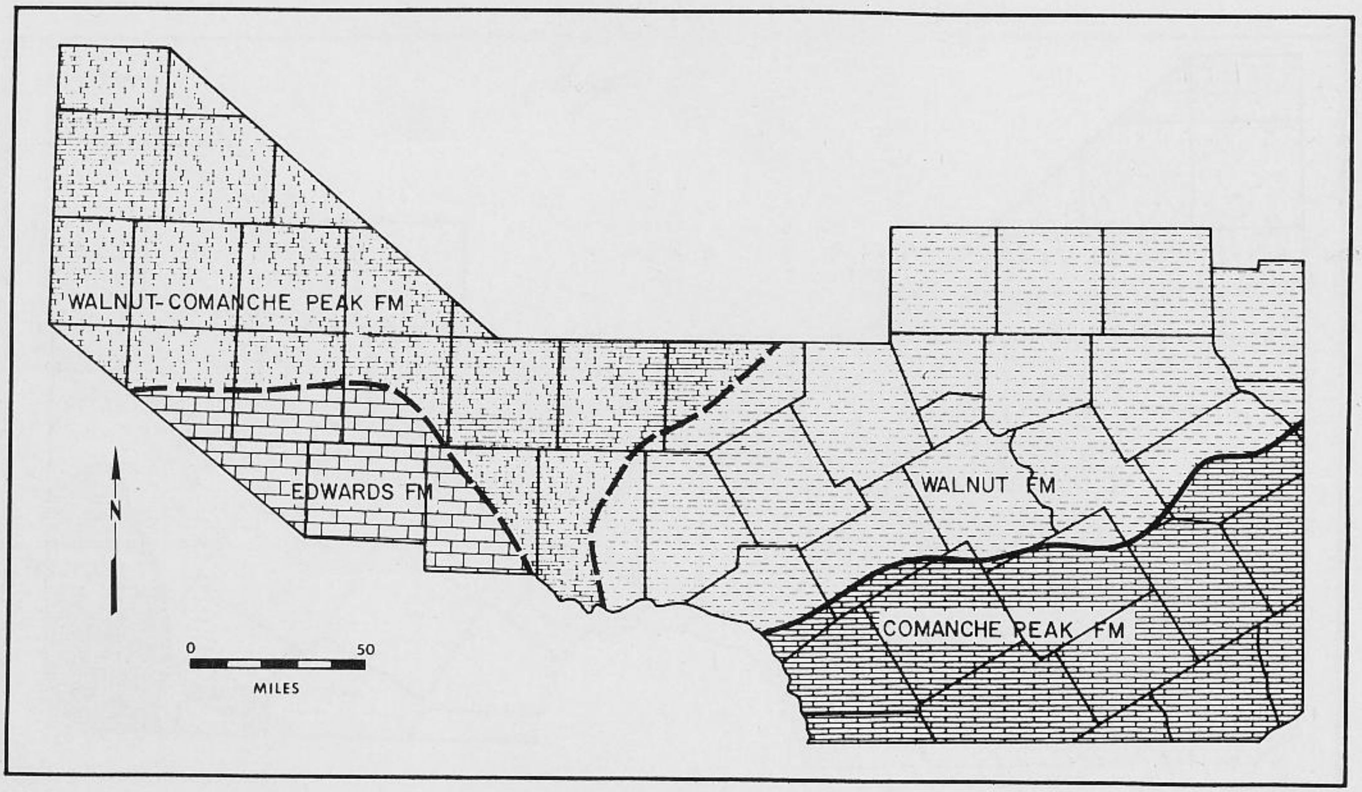

Fig. 53. Late Walnut—Early Comanche Peak paleogeologic map.

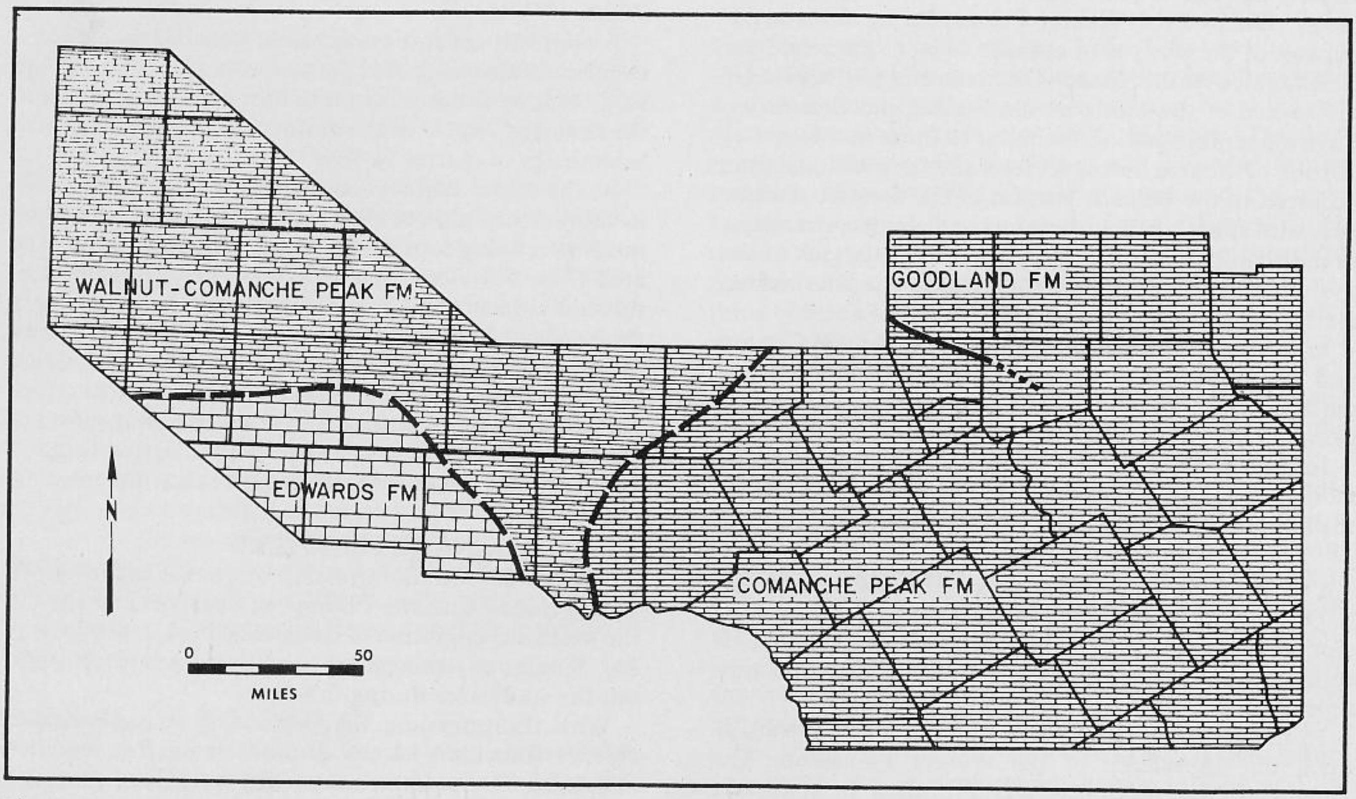

Fig. 54. Late Comanche Peak paleogeologic map.

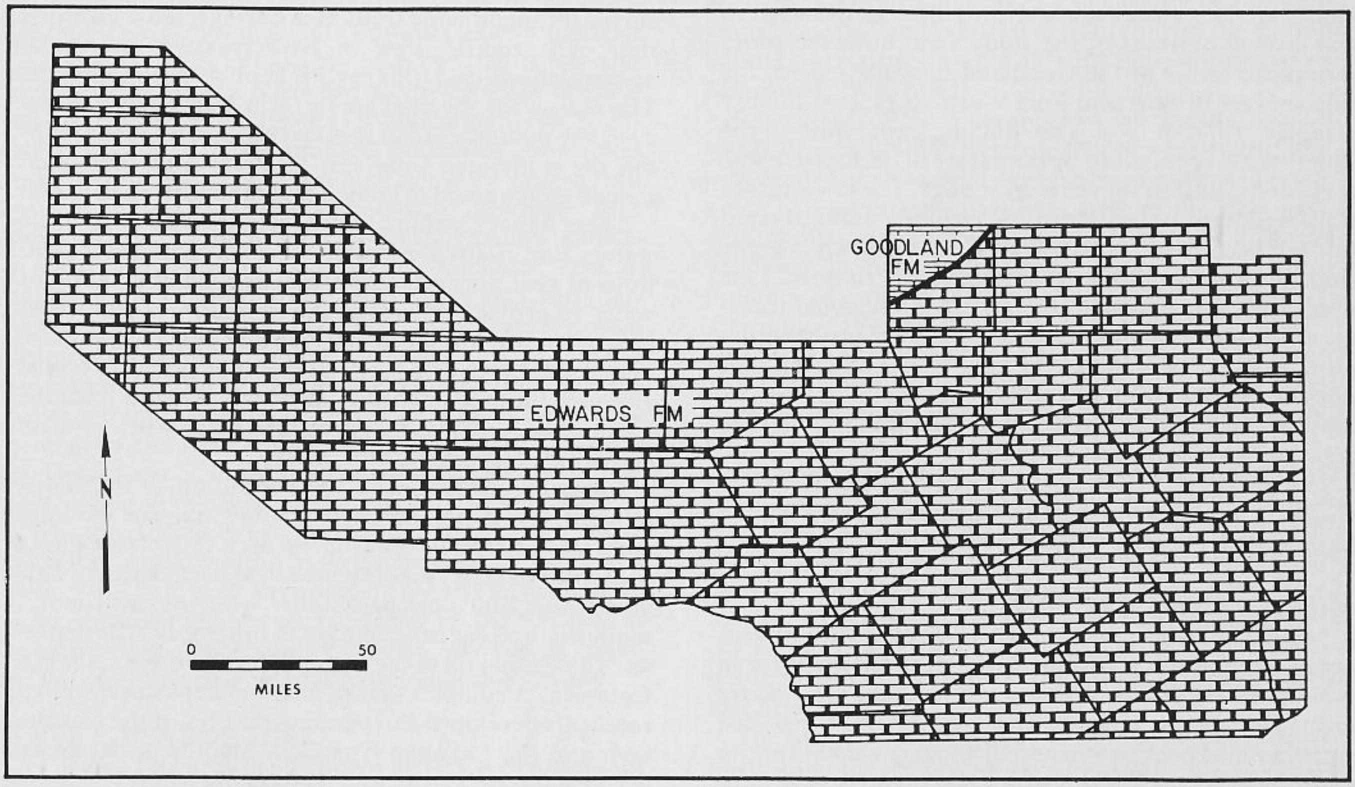

Fig. 55. Edwards paleogeologic map.

lack of terrigenous sediments. Slow sediment accumulation is indicated over most of the area by the extensive reworking of the substrate.

Toward the end of Comanche Peak time, the sedimentation rate decreased, and the waters cleared of terrigenous debris. This is indicated by the presence of calcareous algal plates, the increased abundance of fauna, and the increased percentage of calcium carbonate in the sediments (Keyes, 1977, p. 48). The widespread occurrence of the hermatypic coral *Cladophyllia* and the foraminifer *Dictyoconus walnutensis* in upper Comanche Peak sediments further suggests the clearing of the shallow water environment, which was then present throughout the study area at the close of Comanche Peak time.

In the northern part of the study area in Parker, Tarrant, and Johnson Counties, the sediments of the Goodland Formation, with the possible exception of the Cresson Member, were being deposited contemporaneously with those of the Comanche Peak Formation as is indicated by identical lithology and fauna.

As the Comanchean seas transgressed into the central portion of the study area, environmental conditions continued to be influenced by the Concho arch, which remained a broad structural high during Comanche Peak time and throughout deposition of the Edwards Formation and was consistently one of the shallowest areas on the Texas craton. The limestone facies of middle and late Comanche Peak time in Nolan County are characteristic of deposition under conditions of shallower water and higher energy than are the surrounding areas, which are represented by the presence of oolites and grapestones, the lack of mud, and the distribution of cross-bedding in the base of the Callahan Complex (Boutte, 1969, p. 45, 84).

In central Nolan County and western Runnels County and to the south, the Comanche Peak sediments continued to be affected by the relatively rapid uplift of the Llano region.

EARLY EDWARDS TIME

A single brief transgressive pulse, perhaps due to an eustatic rise in sea level, occurred in early Edwards time, and resulted in the uniform deposition of Edwards sediments over the entire study area (Fig. 55). This rapid transgression of the Fredericksburg sea is illustrated by the abrupt contact of the Edwards Formation with the underlying sediments. The similar thickness and similar lithologic features of the Edwards Formation over broad portions of the study area are also indicative of a single transgressive pulse. The lack of depositional thickening in the subsurface of the Edwards Formation, as indicated by the isopach map (Fig. 45), illustrates that there was no East Texas basin during Edwards time. In addition, the isopachs of both the Edwards Formation and the overlying Kiamichi Formation (Figs. 45 and 46) show no evidence for the North Texas lagoon as suggested by Lozo (1959). Instead, it appears that the sudden transgression at the beginning of Edwards time resulted in the uniform deposition of Edwards sediments over an immense area.

Transgression of the Comanchean sea during Edwards time resulted in the movement of the shorelines far westward, but only slightly northward from their positions of Comanche Peak time as indicated by the lack of terrigenous material in the Edwards deposits. Edwards limestones are 99 percent calcium carbonate in the western and central portions of the study area; however, more shoreward facies of the Goodland deposits replace the Edwards northward near Fort Worth in Tarrant County (Staples, 1977, p. 70). This oblique expansion of the shoreline was controlled by the nature of the topographic slope at the time of the sea level change. The low angle of slope westward across the Texas craton encouraged rapid transgression over a broad area. The slightly steeper slope toward the northern shoreline acted to restrict the northward transgression. In spite of the regional transgression, water depths remained shallow, probably no more than 10 to 30 feet. The seas remained clear, and normal marine to hypersaline conditions existed as represented by the initial Edwards packstone containing algae, foraminifera, and echinoids.

In central Nolan County, deposition of the Callahan Complex continued in a highly agitated, shallow marine environment (Boutte, 1969, p. 45-84).

MIDDLE EDWARDS TIME

Middle Edwards time brought far wider distribution of rudist populations across the study area. These appear to have been controlled by water circulation and water chemistry across a depositional region that included small isolated pockets where rudist spat could not survive and others where life was especially favored as is indicated by the increased thickness of the formation near Moffat in Bell County.

Mound-shaped accumulations of several groups of rudists, corals, and the pelecypod *Chondrodonta* occurred throughout the study area during middle Edwards time. The rudists grew in both massive biostromal accumulations and thinner biohermal accumulations. The reason for the changes in form is unknown. However, the mound growth is remarkably similar throughout the study area from east to west—each individual mound is composed of about the same zonation of fauna.

These rudist accumulations formed in shallow, marine water. For rudist development, environmental conditions of near normal salinity and enough circulation of water to provide nutrients and to remove wastes must have prevailed (J. Marcantel, 1968, p. 29). The presence of lime mud as matrix material implies low energy levels, although the mud deposition probably resulted from the trapping of sediment by the mound framework or algal activity (J. Marcantel, 1968, p. 29).

Contemporaneous with the deposition of the rudist mounds, the highly agitated, shallow, marine environment on the crest of the Concho arch in Nolan County continued to exist as represented by the sequences of lime grainstones and lime packstones with the gastropods, mollusks, and rudists common to other Edwards deposits. These units form the upper deposits of the Callahan Complex. A complex arrangement of depositional environments developed surrounding the area of the Concho arch and the Callahan Complex. Shallow shoal areas, deeper intershoal areas, and tidal channels developed as a result of the formation of the Callahan Complex of the positive structural high (Boutte, 1969, p. 85-88).

South and southeast of the Callahan Complex, a broad, flat, very shallow to emergent area existed, and

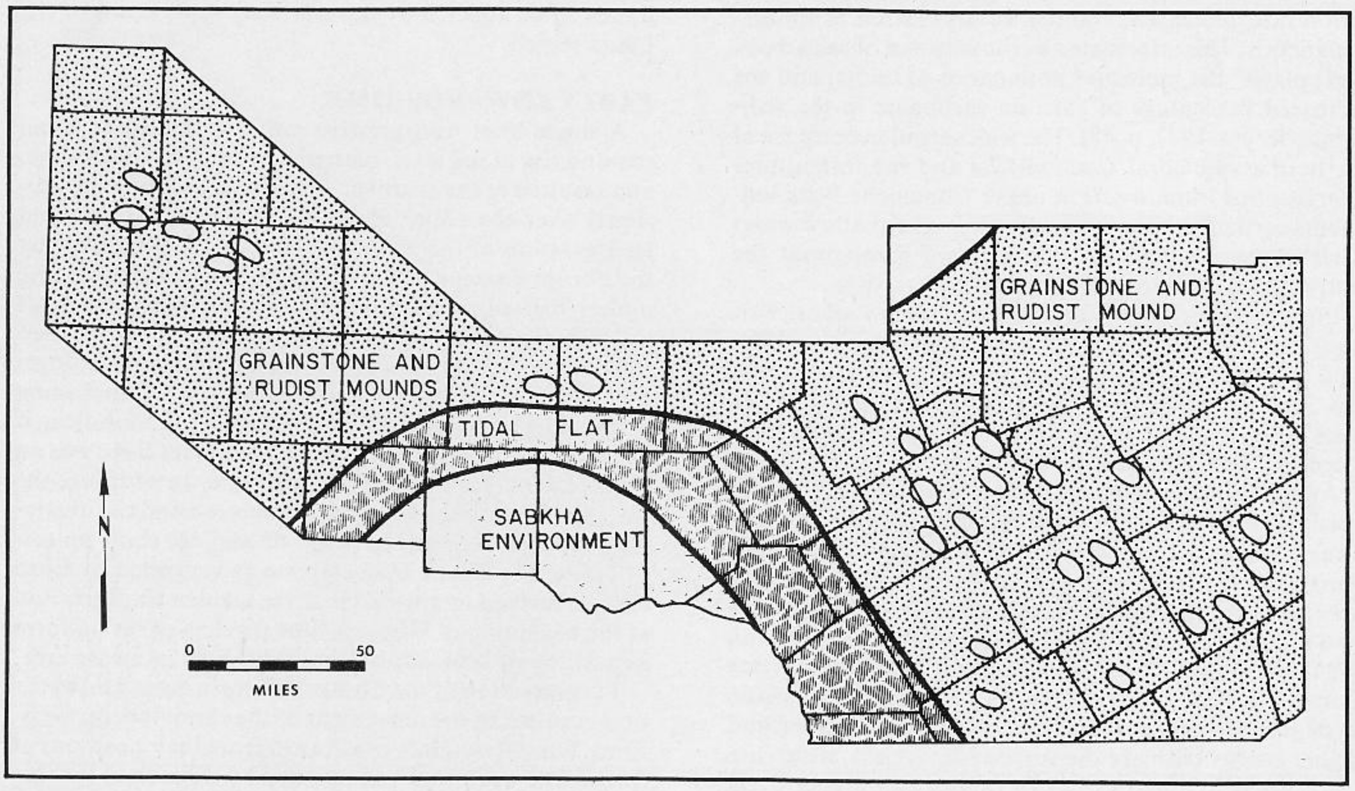

Fig. 56. Middle Edwards depositional environments.

the migration of environments from south of the study area took place during middle Edwards time. A tidal flat environment with conditions of poor circulation and high net evaporation is implied by the presence of dolomitized laminated mudstones (J. Marcantel, 1968, p. 76-84) (Fig. 56). The dolomitized laminated mudstones imply deposition at or above high tide level with overall low energy levels. Closely associated dolomite with abundant moldic fossils was deposited in shallow, subtidal waters with elevated salinities (J. Marcantel, 1968, p. 44-59). In the central portion of the study area, the alternation of the two dolomite facies resulted from the oscillation of the two environments within the major tidal flat environment. The laminated dolomites closely resemble penecontemporaneous Holocene dolomites that have been described from supratidal environments in Bonaire by Deffeyes *et al.* (1965), in the Bahamas by Shinn *et al.* (1965), and in the Persian Gulf by Illing *et al.* (1965).

The tidal flat environment was anterior to a large, broad, subaerially exposed region south of the study area (Fig. 57). The sebkha environment formed on the subaerially exposed region is characterized by the presence of evaporites, in all probability gypsum, and can be traced as far southeast as Fredericksburg, Gillespie County.

LATE EDWARDS TIME

The late Edwards depositional history is one of minor marine regression. In the central portion of the study area, the dolomite tidal flat spread from the southwest as the sea retreated. The tidal flat environment extended north to Nolan County and east to Comanche and Lampasas Counties, and tidal flat deposits buried the mound-building organisms over which the deposits spread (E. Marcantel, 1968, p. 43).

Regression of the Comanchean sea during late Edwards time resulted in development of a restricted, shallow, marine environment over the remainder of the study area. This environment is indicated by the lime packstones containing miliolids and the pelecypod *Toucasia*. Moderate to high energy conditions are implied by the presence of cross-bedding, the fragmental nature of the grains, and the absence of mud (J. Marcantel, 1968, p. 39). Areas in the east central portion of the region received sediments deposited under lower energy conditions as suggested by the greater amounts of mud as a matrix material.

In the eastern portion of the study area, deposition of the Edwards Formation was terminated as the Comanchean seas regressed, leaving the upper surfaces of the Edwards subaerially exposed. Subaerial exposure is indicated by the effects of case hardening and oxidation and the occurrence of bores and pits on the upper surfaces of the Edwards Formation. By the time the overlying formations were deposited on the Edwards Formation, it had been lithified.

The upper Edwards rocks in the central and western portions of the study area have been removed by erosion (Jacka and Brand, 1977, p. 367 and J. Marcantel, 1968, p. 65), and interpretations of the conditions of Edwards deposition there are speculative.

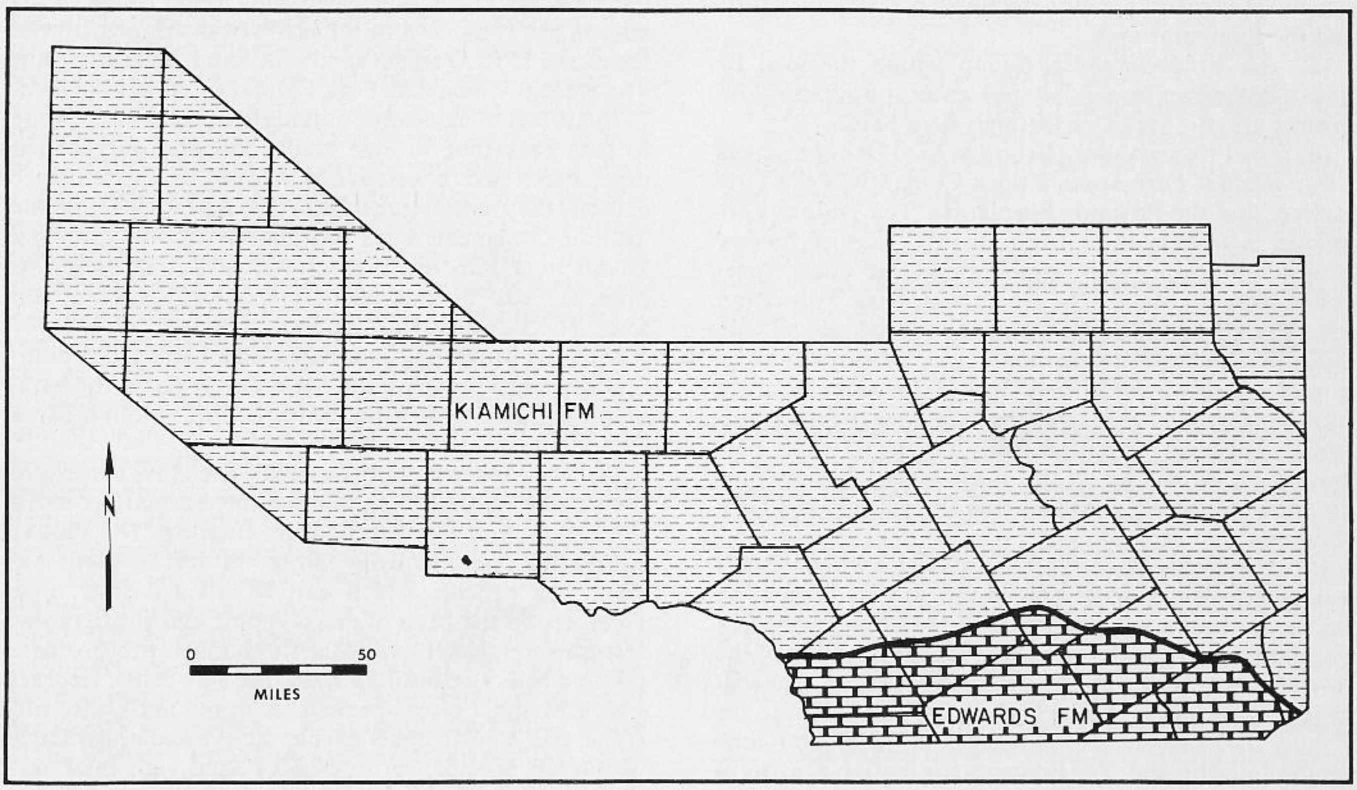

Fig. 57. Kiamichi paleogeologic map.

POST EDWARDS TIME

After the upper Edwards Formation was subaerially exposed and the sediments lithified, an influx of terrigenous material from a northern landmass resulted in the deposition of the Kiamichi Formation, which covers the Edwards Formation over much of the northern and central portions of the study area (Fig. 57). Although during Cenozoic time the Kiamichi Formation was eroded in the Llano Estacado region and the Callahan Divide region, a complete section of the Washita Group, including the Kiamichi Formation, was probably deposited in these regions (Jacka and Brand, 1977, p. 367).

In the eastern portion of the study area, the Kiamichi Formation is exposed on the outcrop. It was deposited unconformably on top of the Edwards Formation in shallow marine water as implied by the fauna, the ripple marks, and the thinly laminated black shales. The gradual thinning of the Kiamichi Formation to the south and the depositional trends of the subsurface, as illustrated by the isopach map (Fig. 46), imply that during Kiamichi time, as during Edwards time, the East Texas basin was not present. In addition, there is no evidence from the isopach map for the presence of a channel or seaway north of an Edwards reef trend as suggested by Lozo (1959) and Fisher and Rodda (1967b and 1969).

Beyond the southern pinch out of the Kiamichi Formation in southern McLennan and northern Falls, Robertson, and Leon Counties, the Edwards Formation was covered by the sediments of the Duck Creek Formation. The Duck Creek Formation was deposited by a transgressing Comanchean sea following deposition of the Kiamichi Formation.

SUMMARY AND CONCLUSIONS

(1) Fredericksburg rocks north of the Colorado River consist of a basal quartz sand (Paluxy and upper Antlers) and an overlying clay and carbonate sequence (Walnut Clay, Comanche Peak Limestone, and Edwards Limestone).

(2) The Fredericksburg Group was deposited in two major structural provinces: (a) the western margin of the East Texas basin and (b) the Texas craton. Several structural features within these provinces had pronounced effects on deposition of Fredericksburg strata. These structural elements are the Concho arch, the Llano uplift, and the Lampasas arch.

(3) The Fredericksburg Group within the area of investigation can be divided into seven stratigraphically distinct areas—Area One through Area Seven.

(4) The Fredericksburg Group of Area One consists of a thin Walnut Formation, a thick Comanche Peak Formation, and the Edwards Formation. The Walnut Formation is composed of from 10 to 20 feet of loosely consolidated sandstone, argillaceous lime wackestone, and calcareous shale. The Comanche Peak Formation consists of from 50 to 80 feet of lime wackestone and lime mudstone and interbedded shale. The Edwards Formation consists of from 18 to 35 feet of limestone, ranging from lime wackestones to lime packstones to lime grainstones. The most prominent feature of the Edwards Formation in Area One is the occurrence of numerous mounds composed of rudists and the pelecypod *Chondrodonta*.

(5) The Fredericksburg Group in Area Two consists of a thin sequence of sediments in the Antlers Formation that is correlative with the Paluxy Formation and a thick sequence of carbonate rocks that is characteristic of the Edwards, and thus termed Edwards Formation. The sediments of the upper Antlers, which are equivalent to the Paluxy Formation, are composed of 12 feet of fine-grained quartz sand. The Edwards Formation consists of 97 to 106 feet of massively bedded limestone and laminated and fossil-mold dolomite.

(6) The Fredericksburg Group of Area Three consists of an anomalously thick sequence of lime grainstones and packstones occupying an interval stratigraphically equivalent to the upper Walnut-Comanche Peak Formation and the Edwards Formation. This sequence is referred to collectively as the Callahan Complex.

(7) The Fredericksburg Group of Area Four consists of a thin sequence of sediments in the Antlers Formation, which are laterally equivalent with the Paluxy Formation, a thick Walnut-Comanche Peak Formation, and the Edwards Formation. Sediments in the Antlers Formation are composed of a basal well-developed caliche facies and 15 to 52 feet of sandy silt, sand, and clayey silt. The Walnut-Comanche Peak Formation consists of from 75 to 110 feet of limestone, ranging from lime wackestone to lime packstone to lime grainstone, and interbedded marl. From east to west across Area Four, the sequence exhibits the gradual transition of the limestones from the Walnut-Comanche Peak Formation of the Callahan Divide area into the Walnut Formation and the Comanche Peak Formation of the Lampasas Cut Plain area. The Edwards Formation is composed of 30 to 80 feet of limestone and laminated and fossil-mold dolomite. A rudist mound sequence is developed in the basal and middle portion of the Edwards Formation in Area Four.

(8) The Fredericksburg Group of Area Five consists of the Paluxy Formation, a thin Walnut Formation, and a thick section of the Goodland Formation. The Paluxy Formation contains from 140 to 180 feet of sand, silt, clay, and caliche, which can be divided into three members on the basis of petrographic and stratigraphic relationships: lower Lake Merritt Member (thin horizontal sand beds alternating within thin clay beds); Georges Creek Member (cross-bedded sand, red and white siltstone, clay, and an upper caliche facies); and upper Eagle Mountain Member (cross-bedded sand with thick sections of clay). The Walnut Formation consists of 25 feet of alternating fossiliferous limestone, with lime mud-

stone, lime wackestone, and lime packstone, and interbedded marls. The Goodland Formation is composed of 120 feet of alternating thick beds of limestone, marly limestone, and marl. The Goodland Formation can be divided into three members: lower Mary's Creek Member (interstratified marls, marly limestones, and several hard fossiliferous limestones); Benbrook Member (thick limestones and marly limestones alternating with thinner marls); and upper Cresson Member (dense lime packstone and lime grainstone).

(9) The Fredericksburg Group of Area Six is composed of a regionally thinning Paluxy Formation, the Walnut Formation, a thick section of the Comanche Peak Formation, and a lithologically consistent section of the Edwards Formation. The Paluxy Formation consists of from 0 to 140 feet of sand, silt, clay, and caliche divisible into the three members observed in Area Five: the lower Lake Merritt Member; the Georges Creek Member; and the upper Eagle Mountain Member. The Walnut Formation is composed of from 55 to 180 feet of clay, limestone and shell aggregate, which can be divided into five members on the basis of lithology and faunal content: Bull Creek Member or Member One (argillaceous limestone beds, dark clay, and alternating clay and thin flaggy limestone beds); Bee Cave Member or Member Two (alternating clay and thin ripple-marked limestone beds); Cedar Park Member or Member Three (argillaceous, nodular limestone with a few thin beds of calcareous clay and ripple-marked limestone beds); Keyes Valley Member or Member Four (thin to very thick beds of argillaceous limestone and calcareous clay); and the Unnamed Marl Member or Member Five (calcareous clay and a few thin beds of argillaceous limestones). The Comanche Peak Formation consists of from 60 to 125 feet of nodular limestone and chalky marl and can be divided into three informal units: a lower unit of thin *Texigryphaea* beds and nodular limestone; a middle unit of nodular limestone, thin-bedded limestone, and marl; and an upper unit of bioturbated, chalky limestone, and marl. The three members of the Comanche Peak Formation of Area Six are similar and grade laterally into the three members of the Goodland Formation of Area Five. The Edwards Formation consists of from 5 to 80 feet of rudist limestone and dolomite. The Edwards Formation can be divided into a number of facies on the basis of lithology and fauna. In Area Six, the Edwards Formation is composed of a distinctive lime packstone to lime grainstone in the base, an overlying rudist-mound sequence with distinctive faunal zonation in the middle, and an upper section of fine-grained dolomite, a rudist grainstone facies, or a lime wackestone and marl facies. The facies are laterally correlative with those of the Edwards Formation in Area Four and in Area One.

(10) The Fredericksburg Group of Area Seven, in the subsurface on the western margin of the East Texas basin, is comprised of a southwardly thinning wedge of the Paluxy Formation, a southwardly thickening wedge of the Walnut Formation, and consistent sections of the Comanche Peak and the Edwards Formations. In general, the subsurface character of the Fredericksburg Group is one of consistent lithology and thickness.

(11) The contact between the Trinity and Fredericksburg groups ranges from conformable to unconformable. In the western portion of the study area, where the Walnut Formation overlies the Antlers Formation, the contact is disconformable. Where the Fredericksburg equivalents of the Antlers Formation overlie the Trinity equivalents of the Antlers in the central portion of the study area, the contact is unconformable as represented by a regional caliche facies. In the eastern portion of the area, the contact between the Glen Rose and Paluxy Formations is conformable and can be gradational, abrupt, or interfingering.

(12) Each formation of the Fredericksburg Group is generally in conformable contact with the next overlying formation. The contact between the Paluxy Formation and the overlying Walnut Formation is generally conformable as is apparent where the Paluxy and Walnut are in parallel beds. Where the sand beds of the Paluxy Formation are moderately dipping and truncated by the horizontal limestone beds of the Walnut Formation, the contact is represented by an angular unconformity of little time significance. The contact between the Walnut Formation and the Comanche Peak Formation is conformable and gradational or interfingering. The contact between the Comanche Peak and the Edwards Formations is conformable but abrupt.

(13) The contact between the Edwards and Kiamichi Formations and the Edwards and Duck Creek Formations of the Washita Group is unconformable as indicated by the weathered surface at the top of the Edwards Formation. The contact between the Goodland Formation and the Kiamichi Formation is conformable.

(14) The distinctive lithologies of the sediments of the Fredericksburg Group can be explained by the environments of deposition of each formation.

(15) Deposition of the Fredericksburg Group was controlled by a single northwestward transgression of the Comanchean sea out of the East Texas basin, accompanied by minor regressions.

(16) The Paluxy Formation and its equivalents and the overlying carbonates of the Fredericksburg Group represent a classical transgressive sequence of alluvial sands through platform carbonates.

(17) Deposition of the Paluxy Formation began on the Texas craton as the Glen Rose sea regressed into the East Texas basin. The basal Paluxy sands represent strandline and nearshore deposits of the regressing sea. With continued regression, braided streams deposited sands of the middle Paluxy Formation and, with further regression, the central portion of the study area was left exposed as a broad, low subaerial plain upon which a prominent soil horizon developed. After the regression of the Comanchean sea during the early and middle parts of Paluxy deposition, the sea transgressed to the northwest and the fluvial and nearshore deposits of the upper Paluxy Formation were laid down.

(18) Northwestward transgression by the Comanchean sea continued across a broad, flat platform throughout deposition of the Walnut Formation. The basal Walnut units were deposited by an initially slow, then rapid transgression of the sea and represent nearshore deposits.

The middle units of the Walnut Formation were deposited in low energy, shallow marine conditions with the later development of a large shallow bay in much of the eastern area. In the central and western portions of the study area, onlap of the deposits is indicated as the middle Walnut seas transgressed to the northwest. The upper Walnut sediments were deposited by the transgressing Comanchean sea in a normal marine environment in which water depth increased and turbulence decreased from the previous depositional environments of the Walnut Formation.

(19) Deposition of the Comanche Peak Formation resulted from the continued northwestward transgression of the Comanchean sea. Environmental conditions alternated between slightly brackish to normal marine salinities as the basal Comanche Peak sediments were deposited. The slow accumulation of Comanche Peak sediments continued as the distance from the shoreline increased due to the transgression of the sea. A normal marine, clear water environment existed over the Texas craton. Deposition of the Callahan Complex, formed from Comanche Peak sediments in Nolan County, reflected the shallow water, high energy environment, which was coincident with the physiographic high of the structural Concho arch.

(20) A single brief transgressive pulse, perhaps due to an eustatic rise in sea level, occurred in early Edwards time and resulted in the uniform deposition of the Edwards sediments over the entire study area. As the lower Edwards sediments were deposited, the Comanchean sea was shallow, clear, and of normal to hypersaline salinity. Middle Edwards time brought the rapid transgression of abundant rudist populations into the study area, and conditions of shallow, marine waters continued to persist. Contemporaneous with the deposition of the rudist mounds, the highly agitated, shallow marine environment on the crest of the Concho arch in Nolan County continued to exist, and the Callahan Complex and related sediments were deposited. South and southeast of the Callahan Complex, a broad, flat, very shallow to emergent area existed, and the migration of tidal flat environments from south of the study area took place during middle and late Edwards time. The late Edwards depositional history is one of minor marine regression, which resulted in the development of a restricted, shallow marine environment and eventual subaerial exposure of the upper Edwards surface.

(21) After the upper Edwards Formation was subaerially exposed and the sediments lithified, an influx of terrigenous material from adjacent landmasses resulted in deposition of the Kiamichi Formation over the area. Beyond the southern pinch out of the Kiamichi Formation, the Edwards Formation was somewhat later covered by sediments of the Duck Creek Formation.

APPENDIX I

LOCALITIES*

1. (33°32′N, 101°41′W) Lubbock County. Comanche Peak Formation 500 yd (458 m) downstream from dam at east end of lower Buffalo Lake. (Brand, 1953, 29).
2. (33°30′N, 101°40′W) Lubbock County. Comanche Peak and Walnut Formations 2 mi (3 km) north and 2 mi (3 km) east of Posey along southwest wall of canyon of Double Mountain Fork of Brazos River. (Brand, 1953, 28).
3. (32°59′N, 101°17′W) Garza County. Edwards, Comanche Peak, Walnut, and Antlers Formations 5 mi (8 km) south and 5 mi (8 km) west of Justiceburg in north face of escarpment 1 mi (1.6 km) north of the Borden-Garza County line. (Brand, 1953, 16).
4. Fluvanna Section (32°58′N, 101°10′W) Garza County. Edwards, Comanche Peak, Walnut, and Antlers Formations 5.5 mi (8.9 km) south and 3.5 mi (5.6 km) east of Justiceburg in roadcut along Eppler-Fluvanna Road, 5 mi (8 km) north of Fluvanna on Farm Road 1269. (Brand, 1953, 15).
5. (32°48′N, 101°36′W) Borden County. Edwards and Comanche Peak Formations in roadcut on Farm Road 669, 3.7 mi (6 km) north of intersection with U.S. Highway 180. (Brand, 1953, 13).
6. Gail Mountain Section (32°46′N, 101°28′W) Borden County. Edwards, Comanche Peak, Walnut, and Antlers Formations 1 mi (1.6 km) west of Gail in roadcut along west side of Gail Mountain. (Brand, 1953, 14).
7. Key Section (32°45′N, 101°43′W) Dawson County. Edwards, Comanche Peak, Walnut, and Antlers Formations 4 mi (6.4 km) east of Key along U.S. Highway 180. (Brand, 1953, 10).
8. Maryneal Composite Section (32°11′N, 101°27′W) Nolan County. Edwards Formation in railroad cut of Panhandle and Santa Fe Railroad 2.5 mi (4 km) south-southeast of Maryneal. (Rodda et al., 1966, Nolan 3; Boutte, 1969, MC).
9. Sweetwater Section (32°22′N, 100°22′W) Nolan County. Edwards and Comanche Peak-Walnut Formations in roadcut on State Highway 70, 8 mi (12.9 km) south-southeast of Sweetwater. (Rodda et al., 1966, Nolan 2; Moore, 1967, S; Marcantel, 1968, S; Boutte, 1969, S; Smith, 1971, S).
10. Barton-Lambert Section (32°19′N, 100°18′W) Nolan County. Edwards-Comanche Peak-Walnut Formation 11 mi (18 km) south-southeast of Sweetwater on State Highway 70 and 1 mi (1.6 km) east across ranch field. (Boutte, 1969, BL).
11. Route 70 Composite Section (32°17′N, 100°20′W) Nolan County. Edwards-Comanche Peak-Walnut Formation in roadcut on State Highway 70, 15 mi (24 km) south-southeast of Sweetwater. (Boutte, 1969, R70C).
12. Blackwell Section (32°13′N, 100°19′W) Nolan County. Edwards-Comanche Peak Formations in roadcut on State Highway 70, 8.5 mi (13.7 km) north of Blackwell. (Rodda et al., 1966, Nolan 4).
13. Nipple Peak Section (31°59′N, 100°21′W) Coke County. Edwards-Comanche Peak-Walnut and Antlers Formations in roadcut 4 mi (6.4 km) west of U.S. Highway 277 on unnamed county road 6 mi (9.7 km) north of Bonte. (Moore, 1967, NP; Boutte, 1968, NP; Smith, 1971, NP).
14. Skelly Hobbs Section (32°24′N, 100°11′W) Nolan County. Edwards and Comanche Peak-Walnut Formations in roadcut on Dora Oil Field road, 2 mi (3.2 km) north of Farm Road 2035, 8.5 mi (13.7 km) east of Lake Sweetwater Municipal Park. (Moore, 1967, SH; Marcantel, 1968, SH; Boutte, 1969, SH; Smith, 1971, SH).
15. Skelly Hobbs III-IV Composite Section (32°22′N, 100°13′W) Nolan County. Edwards and Comanche Peak-Walnut Formations in roadcuts on Farm Road 2035, 7 mi (11.3 km) east of Lake Sweetwater Municipal Park. (Marcantel, 1968, SH III-IV; Boutte, 1969, SH III-IV).
16. KTXS Section (32°25′N, 100°06′W) Taylor County. Edwards, Comanche Peak-Walnut, and Antlers Formations in roadcut up mountain, 3.5 mi (5.6 km) west of Blair and 5 mi (8 km) south of Trent. (Jones, 1966, 1; Marcantel, 1968, KTXS; Boutte, 1968, KTXS; Smith, 1971, KTXS).
17. Mulberry Canyon Section (32°19′N, 100°08′W) Taylor County. Edwards and Comanche Peak-Walnut Formations in roadcut on Farm Road 126, 2 mi (3.2 km) north of the intersection with Farm Road 89. (Boutte, 1969, MC).
18. Happy Valley Section (32°13′N, 100°03′W) Taylor County. Edwards Formation in roadcut on U.S. Highway 277, 5.6 mi (9 km) south of intersection of U.S. Highway 277 and Farm Road 89. (Rodda et al., 1966, Taylor 3).
19. Steamboat Mountain Section (32°17′N, 99°57′W) Taylor County. Antlers Formation in roadcut on U.S. Highway 277, 7.5 mi (12 km) south of View. (Castle, 1969, SM I; Smith, 1969, SM I).
20. Zachary Quarry Section (32°18′N, 99°56′W) Taylor County. Edwards and Comanche Peak-Walnut Formations in quarry on west side of road, U.S. Highway 277, 4.5 mi (7.2 km) south of View. (Moore, 1967, Z; Boutte, 1969, Z).
21. (32°18′N, 99°51′W) Taylor County. Comanche Peak-Walnut and Antlers Formations in roadcut in quarry off Farm Road 1235, 4 mi (6.4 km) north-northwest of Buffalo Gap. (Jones, 1966, 2).
22. Eagle Mountain Section (32°16′N, 99°40′W) Taylor County. Antlers Formation in roadcut on U.S. Highway 84 and U.S. Highway 83, 5.5 mi (8.8 km) south of their intersection with Farm Road 707. (Castle, 1969, EM; Smith, 1969, EM).
23. Denton Section (32°16′N, 99°35′W) Callahan County. Edwards and Comanche Peak Formations in quarry on north side of State Highway 36, 3 mi (4.8 km) northwest of Denton. (Rodda et al., 1966, Callahan 1; Jones 1966, 22).
24. Ovalo Section (32°08′N, 99°49′W) Taylor County. Edwards and Comanche Peak Formations in quarry southeast of U.S. Highway 83, 1.7 mi (2.7 km) southwest of Ovalo. (Rodda et al., 1966, Taylor 1).
25. Table Mountain Composite Section (32°00′N, 99°45′W) Runnels County. Walnut-Comanche Peak and Antlers Formations in roadcut on Farm Road 382, 1.5 mi (2.4 km) north of its intersection with Farm Road 1770. (Castle, 1969, TMC; Smith, 1971, TMC).
26. Glen Cove Section (31°52′N, 99°38′W) Coleman County. Comanche Peak Formation in roadcut on Farm Road 2805, 1 mi (1.6 km) south of Glen Cove.
27. Spring Gap Section (32°16′N, 99°17′W) Callahan County. Edwards, Comanche Peak-Walnut, and Antlers Formations in west nose of Spring Mesa on the east side of the north-south gravel road, 9 mi (14.5 km) southwest of Putman. (Rodda et al., 1966, Callahan 4; Castle, 1969, SG; Smith, 1971, SG).
28. (32°13′N, 99°08′W) Callahan County. Edwards and Comanche Peak Formations in slope on west side of north-south gravel road, east of Farm Road 880, 7.2 mi (11.6 km) north-northeast of Cross Plains. (Rodda et al., 1966, Callahan 3; Jones, 1966, 25).
29. Santa Anna Mountain Section (31°45′N, 99°19′W) Coleman County. Edwards, Comanche Peak-Walnut, and Antlers Formations. Santa Anna Mountain on U.S. Highway 67, east side of Santa Anna. (Castle, 1971, SA; Whigham, 1978, 51).
30. Hog Mountain Section (31°55′N, 98°52′W) Brown County. Edwards, Comanche Peak, Walnut, and Paluxy Formations. Slope of Hog Mountain on unmarked county road, 1.5 mi (2.4 km) north of intersection of Farm Road 1457 and U.S. Highway 183, north of Brownwood. (Whigham, 1978, 49).
31. Salt Mountain Composite Section (31°53′N, 98°54′W) Brown County. Walnut and Paluxy Formations 7.2 mi (11.6 km) north and west of Blanket on Farm Road 1467. (Castle, 1969, SMC; Owen, 1977, 64; Whigham, 1978, 48).
32. (31°52′N, 98°45′W) Comanche County. Edwards and Comanche Peak Formations in roadcut and quarry, 7.2 mi (11.6 km) west of

*Sampling localities and measured sections (129 p.) are available from the Department of Geology, Baylor University, for reproduction costs.—Editor.

Comanche on U.S. Highway 67. (Rodda et al., 1966, Comanche 1; Whigham, 1978, 45).

33. Round Mountain Quarry (31°55′N, 98°41′W) Comanche County. Edwards, Comanche Peak, Walnut, and Paluxy Formations in dimension stone quarry northeast of mesa, 5.8 mi (9.3 km) north-northwest of Comanche off Farm Road 1689. (Rodda et al., 1966, Comanche 2; Jones, 1966, 6; Castle, 1969, RME; Flatt, 1976, 140).
34. Comanche Section (31°52′N, 98°40′W) Comanche County. Walnut and Paluxy Formations 2 mi (3.2 km) southwest of Comanche on U.S. Highway 67. (Jones, 1966, 7; Castle, 1969, CC; Flatt, 1976, 141; Owen, 1977, 20; Whigham, 1978, 46).
35. (32°03′N, 98°24′W) Comanche County. Paluxy Formation 4.1 mi (6.6 km) south of Dublin on U.S. Highway 67. (Whigham, 1978, 36).
36. (32°07′N, 98°21′W) Comanche County. Walnut Formation in roadcut 1.6 mi (2.6 km) north of Dublin on Farm Road 219 from its intersection with U.S. Highways 377 and 67. (Jones, 1966, 32).
37. (32°08′N, 98°26′W) Erath County. Paluxy Formation on Farm Road 2156, 4.7 mi (7.6 km) northwest of its intersection with Farm Road 219 and 2 mi (3.2 km) northwest of Dublin. (Whigham, 1978, 37).
38. Lingleville Section (32°15′N, 98°22′W) Erath County. Walnut and Paluxy Formations in roadcut 0.5 mi (0.8 km) north of Lingleville on Farm Road 219. (Jones, 1966, 34).
39. Huckabay Section (32°18′N, 98°19′W) Erath County. Walnut and Paluxy Formations in roadcut southwest of Huckabay, 2.3 mi (3.7 km) on Farm Road 219. (Owen, 1977, 48).
40. (32°18′N, 98°15′W) Erath County. Walnut and Paluxy Formations in roadcut on Farm Road 3025, 1.8 mi (2.9 km) east of intersection with State Highway 108. (Owen, 1975, 17; Owen, 1977, 17).
41. (32°17′N, 98°07′W) Erath County. Walnut and Paluxy Formations in roadcut on U.S. Highway 377, 5.5 mi (8.9 km) from intersection with Farm Road 1188. (Owen, 1977, 16).
42. (32°12′N, 98°07′W) Erath County. Walnut and Paluxy Formations in roadcut just south of Indian Creek, 3.6 mi (5.8 km) southeast on U.S. Highway 67 from its intersection with U.S. Highway 281 at Stevenville. (Jones, 1966, 36; Flatt, 1976, 176).
43. Chalk Mountain Section (32°09′N, 97°59′W) Erath County. Edwards and Comanche Peak Formations in abandoned quarry and roadcut 0.5 mi (0.8 km) north of U.S. Highway 67 and 5.1 mi (8.2 km) due west of Chalk Mountain community. (Lambert, 1979, 31).
44. (32°06′N, 97°57′W) Erath County. Edwards and Comanche Peak Formations in roadcut on State Highway 220, 4.1 mi (6.6 km) northwest of U.S. Highway 67. (Lambert, 1979, 30).
45. (32°09′N, 97°57′W) Erath County. Walnut and Paluxy Formations in roadcut on U.S. Highway 67, 1.6 mi (2.6 km) from its junction with State Highway 220. (Owen, 1977, 2).
46. (32°12′N, 97°54′W) Somervell County. Paluxy Formation, south of Paluxy, 5 mi (8 km) on Farm Road 204. (Owen, 1975, 10; Owen, 1977, 10).
47. (32°12′N, 97°48′W) Somervell County. Walnut Formation in roadcut on U.S. Highway 67, 1.3 mi (2 km) east of junction with Farm Road 203. (Flatt, 1976, 173).
48. Hood-Somervell Line Section (32°17′N, 97°50′W) Hood County. Paluxy Formation in roadcut on Farm Road 201, 1.6 mi (2.6 km) from intersection with State Highway 51.
49. Tolar Section (32°22′N, 98°40′W) Hood County. Paluxy Formation in roadcut southwest of Tolar 3.5 mi (5.6 km) on Farm Road 2875 or 3 mi (4.8 km) from intersection with U.S. Highway 377. (Owen, 1975, 4).
50. (32°21′N, 97°46′W) Hood County. Paluxy Formation south of Granbury 5.5 mi (8.9 km) on State Highway 144 at Contrary Creek. (Owen, 1975, 7).
51. Tin Top Section (32°34′N, 97°49′W) Parker County. Walnut and Paluxy Formation in roadcut south of Tin Top 3 mi (4.8 km) on Farm Road 1884 at the Brazos River. (Owen, 1977, 81).
52. (32°39′N, 97°48′W) Parker County. Walnut and Paluxy Formations 5 mi (8 km) north of Tin Top on Farm Road 1886. (Owen, 1977, 79).
53. (32°40′N, 97°44′W) Parker County. Goodland Formation in roadcut on State Highway 171, 13.5 mi (21.7 km) north of intersection with U.S. Highway 377 in Cresson. (Staples, 1977, 28).
54. (32°48′N, 97°47′W) Parker County. Walnut and Paluxy Formations in roadcut on Farm Road 51, 3.5 mi (5.6 km) northeast of Weatherford. (Owen, 1977, 89).
55. Carter Section (32°54′N, 97°45′W) Parker County. Walnut and Paluxy Formations in roadcut 0.8 mi (1.3 km) west of Carter on a county road north of Weatherford. (Owen, 1977, 33).
56. Reno Section (32°57′N, 97°35′W) Parker County. Paluxy Formation in roadcut on north side of Farm Road 1542 immediately east of Walnut Creek at west limits of Reno. (Fisher and Rodda, 1967, Parker 9).
57. Eagle Mountain Section (32°55′N, 97°28′W) Tarrant County. Goodland Formation in roadcut and quarry near Eagle Mountain power station on Farm Road 1220, 8.7 mi (14 km) north of its intersection with State Highway 199. (Staples, 1977, 15).
58. Lake Worth Section (32°47′N, 97°28′W) Tarrant County. Walnut and Paluxy Formations. West of the town of Lake Worth at the corner of Maglaga Drive and Hiawatha at the eastern side of Lake Worth. (Owen, 1977, 25).
59. Mary's Creek Section (32°45′N, 97°34′W) Parker County. Goodland Formation located on the banks of Mary's Creek where it goes under State Highway 5, 2.6 mi (4.2 km) north of its intersection with Interstate Highway 20. (Staples, 1977, 19).
60. Walnut Creek Section (32°42′N, 97°28′W) Tarrant County. Goodland Formation exposed in Walnut Creek west of U.S. Highway 377 bridge at Benbrook. (Rodda et al., 1966, Tarrant 1).
61. Benbrook Lake Section (32°38′N, 97°29′W) Tarrant County. Goodland Formation in roadcut on Steven Drive near the shores of Benbrook Lake, 0.7 mi (1.1 km) east of junction with U.S. Highway 377. (Staples, 1977, 23).
62. (32°36′N, 97°32′W) Tarrant County. Goodland Formation in roadcut on Farm Road 1187, 2.7 mi (4.3 km) east of its intersection with U.S. Highway 377. (Staples, 1977, 25).
63. Bear Creek Section (32°36′N, 97°34′W) Parker County. Goodland Formation in southern bank of Bear Creek under bridge on U.S. Highway 377, 2.8 mi (4.5 km) south of intersection with Farm Road 1187. (Staples, 1977, 27).
64. (32°34′N, 97°41′W) Hood County. Edwards and Comanche Peak Formations in small scarp in field south of gravel road between Farm Road 51 and State Highway 171, 4.2 mi (6.8 km) west-northwest of Cresson. (Rodda et al., 1966, Hood 5).
65. Cresson Section (32°30′N, 97°40′W) Hood County. Goodland Formation in roadcut on U.S. Highway 377, 3.5 mi (5.6 km) north of its intersection with Farm Road 208, south of Cresson. (Staples, 1977, 31).
66. Capital Silica Section (32°17′N, 97°38′W) Somervell County. Paluxy Formation 8 mi (12.9 km) east of Glen Rose on a county road at the Capital Silica Quarry. (Owen, 1977, 15).
67. Phillips Quarry Section (32°17′N, 97°36′W) Johnson County. Kiamichi and Edwards Formations in cut in C. Phillips Crushed Stone Quarry just north of U.S. Highway 67, 0.3 mi (0.5 km) east of the Johnson-Somervell County line. (Lambert, 1979, 1).
68. (32°12′N, 97°32′W) Johnson County. Kiamichi, Edwards, and Comanche Peak Formations in roadcut on Farm Road 1434, 4 mi (6.4 km) south-southeast of the Cleburne State Park entrance. (Lambert, 1979, 3).
69. Fishermans Paradise Section (32°11′N, 97°29′W) Johnson County. Kiamichi, Edwards, and Comanche Peak Formations in roadcut on a private road leading to the Fishermans Paradise community, just off Farm Road 916 and near Ham Creek Park. (Lambert, 1979, 4).
70. Round Rock Quarry Section (32°07′N, 97°27′W) Hill County. Kiamichi, Edwards, and Comanche Peak Formations in Atchison, Topeka, and Santa Fe Railroad cut, adjacent to the Round Rock Lime Company quarry, 3.5 mi (5.6 km) due west-southwest of Blum. (Lambert, 1979, 6).
71. Rock Creek Section (32°07′N, 97°23′W) Hill County. Kiamichi, Edwards, and Comanche Peak Formations in exposure on a tributary of Rock Creek approximately 300 ft (91.5 m) east of Farm Road 933 and 2 mi (3.2 km) south of Blum. (Lambert, 1979, 5; Keyes, 1977, 2).
72. Brazos Point I Section (32°09′N, 97°40′W) Bosque County. Walnut and Paluxy Formations in roadcut on Farm Road 56, 4 mi (6.4 km) south of Brazos Point. (Jones, 1966, 118; Owen, 1977, 27).

73. Brazos Point II Section (32°10'N, 97°40'W) Brazos County. Paluxy Formation in roadcut on Farm Road 56, 3.7 mi (6 km) due west of Brazos Point.
74. Walnut Springs Section (32°08'N, 97°45'W) Bosque County. Kiamichi and Edwards Formations 3 mi (4.8 km) northeast of Walnut Springs on State Highway 144. (Keyes, 1976, 5; Whigham, 1978, 10).
75. (32°02'N, 97°47'W) Bosque County. Walnut and Paluxy Formations in roadcut on Farm Road 927, 5.7 mi (9.2 km) east of the intersection with Farm Road 216. (Atlee, 1962, 9; Flatt, 1976, 139; Owen, 1977, 45; Whigham, 1978, 9).
76. Spring Creek Gap Section (31°54'N, 97°54'W) Bosque County. Edwards Formation in roadcut on Farm Road 1238 at Spring Creek Gap. 5.4 mi (8.7 km) south-southeast of Iredell. (Lambert, 1979, 24).
77. Bailey Branch Section (31°55'N, 97°58'W) Hamilton County. Paluxy Formation in roadcut on a county road at Bailey Branch, 5 mi (8 km) southeast of Hico. (Owen, 1977, 76).
78. (31°54'N, 97°41'W) Bosque County. Comanche Peak Formation on State Highway 22, 0.5 mi (0.8 km) southwest of the intersection with State Highway 6, south of Meridian. (Keyes, 1977, 4; Whigham, 1978, 7).
79. Meridian State Park Section (31°53'N, 97°42'W) Bosque County. Kiamichi, Edwards, and Comanche Peak Formations in roadcut on State Highway 6, 0.9 mi (1.4 km) southwest of the Meridian State Park entrance. (Payne, 1960, 6; Davis, 1976, 2; Molina, 1977, 10; Lambert, 1979, 22).
80. Kopperl Section (32°03'N, 97°32'W) Bosque County. Comanche Peak Formation 0.2 mi (0.3 km) south of Cedron Creek on State Highway 56, 1.5 mi (2.4 km) from the intersection with Farm Road 1713. (Keyes, 1977, 3; Whigham, 1978, 1).
81. Lake Whitney Section (31°57'N, 97°24'W) Hill County. Kiamichi, Edwards, and Comanche Peak Formations in exposure below bridge where Farm Road 1713 crosses Lake Whitney approximately 4.3 mi (6.9 km) due west of Whitney. (Lambert, 1979, 10).
82. Lanes Chappel Section (31°42'N, 97°37'W) Bosque County. Edwards and Comanche Peak Formations in roadcut 0.5 mi (0.8 km) northwest of Farm Road 2602 on an unmarked county road, 3 mi (4.8 km) northwest of the intersection of Farm Road 2602 and Farm Road 217.
83. Clifton Section (31°47'N, 97°36'W) Bosque County. Edwards and Comanche Peak Formations in roadcut on Farm Road 219, 4.9 mi (7.9 km) east of the intersection with Farm Road 182 west of Clifton. (Rodda et al., 1966, Bosque 8; Molina, 1977, 8; Whigham, 1978, 6).
84. Valley Mills Section (31°40'N, 97°28'W) Bosque County. Edwards Formation in roadcut on State Highway 56, 1 mi (1.6 km) north of Valley Mills. (Geno, 1976, 2; Molina, 1977, 3; Whigham, 1978, 2).
85. Meridian Creek Section (31°48'N, 97°43'W) Bosque County. Walnut and Paluxy Formations in roadcut on Meridian Creek on unnamed county road 2 mi (3.2 km) southwest of Farm Road 2136, 4 mi (6.4 km) west of State Highway 6.
86. Cranfills Gap Section (31°46'N, 97°56'W) Hamilton County. Kiamichi, Edwards, and Comanche Peak Formations in roadcut on State Highway 22, 6 mi (9.7 km) west of Cranfills Gap. (Jameson, 1959, 1; Rodda et al., 1966, Hamilton 9; Mudd, 1972, 7; Keyes, 1976, 5; Keyes, 1977, 7; Whigham, 1978, 13; Weems, 1978, 2; Lambert, 1979, 20).
87. Jonesboro Section (31°38'N, 97°50'W) Coryell County. Edwards and Comanche Peak Formations in roadcut 2.4 mi (3.9 km) east of Jonesboro on Farm Road 217. (Keyes, 1977, 8; Whigham, 1978, 17).
88. (31°42'N, 98°08'W) Hamilton County. Walnut and Paluxy Formations 0.5 mi (0.8 km) south of Hamilton on U.S. Highway 281 behind Ken's Shopping Center. (Owen, 1977, 52).
89. Shive Section (31°38'N, 98°16'W) Hamilton County. Paluxy Formation in roadcut on Farm Road 221, 0.5 mi (0.8 km) south of the intersection with Farm Road 2005. (Whigham, 1978, 33).
90. Hoffman Section (31°35'N, 98°12'W) Hamilton County. Paluxy and Glen Rose Formations in roadcut on Farm Road 2414, 6 mi (9.7 km) southeast of Shive at Hoffman Branch. (Owen, 1977, 56).
91. Indian Gap Section (31°40'N, 98°24'W) Hamilton County. Edwards and Comanche Peak Formations in bluff 75 yd (68.8 m) south of Farm Road 218 at Indian Gap. (Rodda et al., 1966, Hamilton 3; Frost, 1967, 99; Whigham, 1978, 41).
92. Priddy Section (31°41'N, 98°32'W) Mills County. Comanche Peak Formation in roadcut on State Highway 16, 1.3 mi (2 km) north of the intersection with Farm Road 218 north of Priddy. (Whigham, 1978, 42).
93. Zyphyr Section (31°40'N, 98°45'W) Mills County. Paluxy Formation in roadcut on Farm Road 218, 3.6 mi (5.8 km) east of Zyphyr. (Whigham, 1978, 44).
94. Scallorn Section (31°19'N, 98°28'W) Mills County. Walnut and Paluxy Formations in roadcut on unmarked county road, 1 mi (1.6 km) southwest of Scallorn, 150 ft (45.7 m) east of U.S. Highway 183. (Whigham, 1978, 27).
95. (31°17'N, 98°27'W) Lampasas County. Edwards and Comanche Peak Formations in bluff 200 yd (183.5 m) east of U.S. Highway 183, 5 mi (8 km) north of Lometa. (Whigham, 1978, 26).
96. Brushy Creek Section (31°25'N, 98°18'W) Mills County. Walnut, Paluxy, and Glen Rose Formations on Farm Road 1047, 3.2 mi (5.1 km) south of Star along Brushy Creek. (Owen, 1977, 90; Whigham, 1978, 30).
97. Onion Top Section (31°18'N, 98°17'W) Lampasas County. Comanche Peak and Paluxy Formations in roadcuts on an unmarked county road, 3 mi (4.8 km) south of Farm Road 581 south of Onion Top. (Whigham, 1978, 28).
98. Izoro Section (31°18'N, 98°04'W) Lampasas County. Edwards Formation in Butte on east side of gravel road 2 mi (3 km) west-northwest of Izoro. (Rodda et al., 1966, Lampasas 2).
99. (31°26'N, 98°07'W) Coryell County. Edwards and Comanche Peak Formations in roadcut on Farm Road 183, 4 mi (6.4 km) southeast of Evant. (King, 1963, 42; Geno, 1976, 10).
100. Evant Section (31°31'N, 98°11'W) Hamilton County. Edwards and Comanche Peak Formations in roadcut on U.S. Highway 84, 0.4 mi (0.6 km) east of the intersection with Farm Road 2414 west of Evant. (Whigham, 1978, 31; Weems, 1979, 20).
101. Gatesville Section (31°28'N, 97°42'W) Coryell County. Edwards and Comanche Peak Formations in roadcut on Farm Road 929, 2.9 mi (4.7 km) northeast of Gatesville. (Geno, 1976, 14; Keyes, 1977, 10; Whigham, 1978, 5).
102. Fort Hood Section (31°24'N, 97°43'W) Coryell County. Walnut Formation in roadcut on unmarked road, 1.8 mi (2.9 km) west of South Fork entrance of Fort Hood on State Highway 36. (Whigham, 1978, 4).
103. Middle Bosque Section (31°33'N, 97°27'W) McLennan County. Kiamichi, Edwards, and Comanche Peak Formations in roadcut on south side of bridge on Farm Road 317 over Middle Bosque River, 1.2 mi (1.9 km) north of Crawford. (Jameson, 1959, 16; Rodda et al., 1966, McLennan 2; Mudd, 1972, 3; Robertson, 1972, 4.2; Nelson, 1973, 2; Mizell, 1977, MBC; Davis, 1976, 7; Geno, 1976, 1; Lambert, 1976, 6; Keyes, 1977, 1).
104. Valley Mills Section (31°39'N, 97°38'W) McLennan County. Edwards Formation in Santa Fe Railroad cut on southeast side of Valley Mills. (Jameson, 1959, 10; Robertson, 1972, 2.6; Mudd, 1972, 4; Mizell, 1973, VMR; Nelson, 1973, 1; Keyes, 1976, 2).
105. Cavitt Section (31°23'N, 97°32'W) Coryell County. Edwards, Comanche Peak, and Walnut Formations in roadcut on Farm Road 107, 2 mi (3.2 km) west of the intersection with Farm Road 1996, northwest of Cavitt.
106. Mother Neff Park Section (31°20'N, 97°28'W) Coryell County. Edwards and Comanche Peak Formations in roadcut on State Park Road 14 at Mother Neff State Park.
107. Leon Junction Section (31°20'N, 97°36'W) Coryell County. Edwards and Comanche Peak Formations in roadcut on a gravel surface road, 1 mi (1.6 km) southwest of Leon Junction off Farm Road 931. (Weems, 1979, 15).
108. Flat Section (31°19'N, 97°39'W) Coryell County. Walnut Formation exposed in a ditch at the intersection of State Highway 36 and Farm Road 1829, 1.6 mi (2.6 km) northwest of Flat. (King, 1963, 33; Jones, 1966, 92; Flatt, 1976, 167).
109. (31°16'N, 97°54'W) Coryell County. Walnut and Paluxy Formations in roadcut on Farm Road 116, 0.2 mi (0.3 km) south of the intersection with Farm Road 580. (Whigham, 1978, 19).
110. Copperas Cove Section (31°06'N, 97°55'W) Coryell County. Comanche Peak Formation in roadcut on U.S. Highway 190, 1 mi (1.6 km) southwest of Copperas Cove. (Keyes, 1977, 11).

111. (30°51′N, 98°12′W) Burnet County. Walnut, Paluxy, and Glen Rose Formations in roadcut on U.S. Highway 281, 5.9 mi (9.5 km) south of Lampasas. (Whigham, 1978, 21).
112. Perry Triangulation Section (31°56′N, 98°23′W) Burnet County. Comanche Peak-Walnut Formation and Paleozoic rock in bluff 300 ft (91.5 m) from Farm Road 1478, 12.1 mi (19.5 km) west of Lampasas. (Whigham, 1978, 23).
113. Bandis Quarry Section (31°05′N, 97°35′W) Bell County. Edwards Formation in northwest end of Bandis Stone Quarry, 0.3 mi (0.5 km) west of Farm Road 3219 on Farm Road 439, north side of road near Nolanville. (Geno, 1976, 7; Davis, 1976, 11).
114. (31°10′N, 97°25′W) Bell County. Edwards and Comanche Peak Formations in roadcut at the junction of State Highway 36 and State Highway 317. (Davis, 1976, 12; Geno, 1976, 8; Weems, 1979, 3).
115. Stillhouse Hollow Section (31°02′N, 97°32′W) Bell County. Edwards Formation at Stillhouse Hollow Lake Spillway on Farm Road 1670, 1 mi (1.6 km) south of Farm Road 190. (Rodda et al., 1966, Bell 5; Nelson, 1973, 5; Geno, 1976, 6).
116. Salado Creek Section (30°55′N, 97°35′W) Bell County. Edwards Formation in roadcut on Farm Road 2843 at Salado Creek, 4.5 mi (7.2 km) southwest of Salado. (Geno, 1976, 4; Lambert, 1976, 1; Weems, 1979, 8).

APPENDIX II

SUBSURFACE LOCATIONS

The following abbreviations are used in this section:
Ki—Kiamichi Formation
Ed—Edwards Formation
CP—Comanche Peak Formation
Wa—Walnut Formation
Pa—Paluxy Formation
IC—Incomplete Section
ND—Not Determined

The following data are listed for the subsurface localities used in this study: company, operator, structural top of the Edwards Formation, thickness values for the Kiamichi Formation, the Edwards Formation, the Comanche Peak Formation, the Walnut Formation, and the Paluxy Formation.

Well #	Company/ Operator	Ed(top)	Ki	Ed	CP	Wa	Pa
	Bell County						
250	A. B. Johnson Howard #1	+540	0	50	120	150	15
251	Wes Tex Tool Co. Pendleton Deep	+410	0	42	120	210	0
252	Texas Water Well Ralph Plastics W W #1	+160	0	82	80	178	0
253	J. L. Meyers & Sons City of Temple #4	+109	0	85	108	180	0
254	Wes Tex Tool Co. Taylors Valley Deep	-122	0	68	70	185	0
255	J. L. Meyers Bell D. I. #1	-346	0	60	118	195	0
	Dallas County						
120	J. L. Meyers & Sons City of Coppell #2	-270	41	14	48	30	IC
121	J. L. Meyers & Sons City of Dallas W W #46	-542	35	16	42	25	225
123	Magnolia Pet. Trigg Est. 1	-312	42	16	50	34	206
124	Layne Tex Co. Whalen Corp. City of Irving	ND	40	18	50	40	185
125	Layne Tex Co. The Ruberard Co. #1	ND	38	18	50	44	200
126	Layne Tex Co. City of Dallas W W #43	ND	37	18	42	35	205
129	Layne Tex Co. City of Irving Trinity #3	-455	41	17	50	48	170
130	Texas Water Wells City of Dallas #40	-967	41	14	48	50	200
131	Layne Tex Co. Test #1 Dallas P&L	-1270	38	13	47	30	200
132	J. L. Meyers & Sons City of Mesquite W W #3	-1765	35	15	41	49	170
140	J. L. Meyers & Sons City of Seagoville #2	ND	54	16	34	24	ND
141	J. L. Meyers City of Wilmer	-1455	45	20	55	35	175
142	Layne Tex Co. City of Lancaster W W #3	-1155	43	23	62	35	175
143	J. L. Meyers & Sons City of Cedar Hill W W #2	ND	34	23	75	40	170
	Ellis County						
155	J. L. Meyers Midlothian #3	-319	35	29	76	60	140
156	Faulds-Whitehead Curtis-Hill	-1410	42	20	65	70	135
157	Amer. Liberty Oil Co. McClair #1	-1793	45	17	70	68	135
164	J. B. Stoddard W. E. Smith #1	-2090	45	22	93	65	105
165	Austex Drlg. Co. J. L. Champian	-1750	40	20	98	52	120
166	L. O. Cain E. W. Patak	-1820	47	20	80	85	115
167	T. W. Nowlin Christian #1	-1559	26	22	85	55	135
168	H. H. Coefield Christian #1	-1559	40	20	85	45	130
169	Hughey and Carpender McFeaster #1	-1237	27	30	110	93	75
170	Lesco Inc. LeSage	-368	22	35	99	58	130
171	J. Hickey Oil Co. Medford	-339	25	33	94	68	120
	Falls County						
219	J. L. Meyers Perry W W Corp.	-1155	0	40	135	185	0

Well #	Company/ Operator	Ed(top)	Ki	Ed	CP	Wa	Pa
220	Jackson and Hays Herman Waiting #1	-1411	0	30	140	180	0
242	Seaboard Oil Co. J. E. Green #1	-3340	0	60	155	290	0
243	McAlester Fuel Condy Nichols #A-1	-2529	0	60	140	230	0
244	Cockburn and Zephyr N. D. Buie #1	-2258	0	48	142	220	0
245	Goodson & J. L. Meyers J. B. Barguiner #1	-2222	0	47	140	231	0
246	A. H. Bell for Hughes C. L. Trice Land 2	-1053	0	33	137	185	0
247	Chitton W W Co. Chilton #2	-815	0	38	142	195	0
248	Wes Tex Tool Service Mooresville Water Supply #1	-567	0	42	138	190	0
256	Key Drilling Co. Durango-Lego W W Corp. W W #1	-742	0	47	128	205	0
257	A. Delcambre D. V. Deskocil #1	-994	0	42	118	205	0
258	Humble Oil & Ref. Co. Elenanor Carrol #1	-1053	0	57	120	180	0
261	Hinton Producing Co. N. J. Snider	-3367	0	48	144	263	0
	Freestone County						
188	The Texas Co. William White #1	-5033	45	29	196	330	0
194	Jack L. Phillips Monia Edens #1	-4759	46	30	150	247	0
195	Cardinal Drlg. Co. #1 Miller Sneed Unit	-4533	45	30	170	245	0
196	Douglas #1 Moody	-4490	40	40	175	295	0
197	C. W. Perryman Beulah Jackson #1	-4285	ND	43	137	285	0
231	R. E. Smith & Byrd Oil McAdams #1	-4741	32	25	155	330	0
232	Union Producing #1 Jordan	-5046	40	33	107	430	0
233	Continental Oil Co. H. C. Brown #1	-5038	35	30	170	360	0
234	Travis Ward Drlg. Co. W. D. Davidson #1	-5422	40	35	179	430	0
235	Humble Oil & Ref. Co. McWaters #1	-5291	35	34	175	400	0
	Henderson County						
161	Pan Amer. Pet. Corp. Emil E. Renberg #1	-5299	80	30	110	225	0
	Hill County						
172	Humble Oil Co. #1 Freeman	+50	24	35	93	66	110
173	Hunt Oil Co. #1 Wright	+60	20	32	98	100	95
174	Stubblefield #1 Sumner	+250	15	45	115	120	45
175	Texas Water Well Co. City of Hillsboro #16	-58	25	40	112	124	36
176	J. L. Meyers City of Abbott	-108	20	38	64	188	0
177	J. L. Meyers Brandon-Irene #1	-500	30	25	120	130	50

Well #	Company/ Operator	Ed(top)	Ki	Ed	CP	Wa	Pa
178	Phillips Pet. Co. Posey #1	-575	31	31	111	119	60
179	J. L. Meyers City of Malone #1	-935	40	30	135	135	0
180	J. L. Meyers #1 Penelope	-881	20	40	120	150	30
181	Well Tex Tool City of Birome	-1068	20	30	130	175	0
182	J. L. Meyers & Sons City of Hubbard W W #2	-1276	33	32	125	160	0
183	Shell Dev. Co. E. W. Barret #1	-1370	30	30	130	170	0
	Johnson County						
150	Warren Pet. Co. H. D. Hanna	+724	22	33	100	70	130
151	Layne Tex Co. City of Cleburne W W #12	+572	28	33	100	65	130
152	Sunray DX Oil Co. S. B. Findley #1	+450	30	30	95	76	120
153	Shell Oil Co. B. W. Goodwin	+110	24	35	100	60	125
154	Humble Oil Co. Haskell Dean #1	-25	25	35	90	65	120
	Kaufman County						
133	H. L. Hunt J. B. Smith #1	-2589	40	15	39	26	210
134	H. B. Ownby Drlg. Co. W. W. Lechner #1	-3453	47	15	35	30	230
135	W. C. Partee Plunkett #1	-4166	73	10	32	70	IC
136	Hughes Tool Co. Billings #1	-4059	40	15	75	80	180
137	D. G. Lake E. J. Fox #1	-4610	50	17	43	27	ND
138	Delphi Oil Co. Miller Hugh #1	-4410	53	17	40	32	IC
139	J. L. Meyers Crandell W W #2	-2637	55	17	50	28	190
158	Sulvester #1 NASH	-3182	45	15	52	38	190
159	Humble Oil & Ref. Co. Guy #1	-3968	45	20	95	40	167
160	Tenneco Oil Co. Clark #1	-3910	50	15	90	60	80
	Leon County						
238	Humble Oil Co. Martin #1	-5902	22	45	180	430	0
	Limestone County						
198	Zephyr Oil Co. C. Peoples #2	-2934	48	32	151	254	0
199	Hunt Oil Co. Guy Yelverton	-2905	22	38	154	243	0
200	Texas Oil Co. Keeling #1	-2079	30	30	140	200	0
201	Hunt Oil Co. Union Cent. Life Inc. Co. #1	-1835	28	27	138	190	0
202	J. L. Meyers & Sons City of Prairie Hill #1	-1480	25	30	135	185	0

Well #	Company/ Operator	Ed(top)	Ki	Ed	CP	Wa	Pa
222	Balcones Jackson #1	-1425	ND	35	138	185	0
223	Farrell Drlg. Co. J. R. Gillam #1	-1679	10	40	145	190	0
224	M. M. Miller J. C. Rogers #1	-2144	28	35	145	210	0
225	O. W. Killiam W. D. Stone	-2155	29	32	143	260	0
226	Gulf Oil & F. Bryant Beeville Est. #1	-2844	ND	52	158	265	0
227	Lone Star Prod. Co. Billy Criswell #1	-2680	20	57	159	241	0
228	W. H. Foster & Zephyr E. P. Wilson	-3722	19	63	175	310	0
229	Key Prod. Co. C. E. Roberts #1	-4658	30	40	180	358	0
230	H. L. Hunt Co. James Gibson Heirs #1	-4704	30	34	164	316	0
237	Sundancer Oil & Rebpel I. V. Carpenter #1	-5580	30	36	172	415	0

McLennan County

Well #	Company/ Operator	Ed(top)	Ki	Ed	CP	Wa	Pa
203	Simon Korshoj R. W. Ferguson #1	-909	20	31	130	170	0
204	Layne Tex Co. Leroy-Toors-Gerald W W #1	-697	2	30	128	153	22
205	C. M. Stoner Bold Springs Water Supply Co. #1	+78	2	47	125	128	30
206	H. R. Glass Ross Water Supply Co. #1	-304	2	48	125	155	30
207	J. L. Meyers & Sons J. B. Patterson #1	-555	0	55	132	158	15
208	J. L. Meyers & Sons Youngblood and Flowers	-400	0	50	130	155	15
209	J. L. Meyers Tiery #1	-620	0	45	137	183	0
210	Pure Milk Co. Garrison #1	-355	0	40	127	173	0
211	Chalk Bluff Water Supply Corp. Chalk Bluff #1	-260	6	37	128	148	0
212	C. M. Stoner Midway Water Co. #3	+75	0	40	133	142	0
213	J. L. Meyers & Sons Dr. Barnes W W #1	-105	0	35	135	145	0
214	J. L. Meyers Tilton #2	+372	0	45	120	180	0
215	C. M. Stoner Spring Valley Water Supply #1	+380	0	52	133	170	0
216	Wes Tex Tool Levi Water Supply	-500	0	53	142	180	0
218	Layne Tex Co. Texas P & L #2	-797	15	30	133	182	0
221	Mae Belcher Smyth #1	ND	5	40	145	195	0
249	J. L. Meyers Moody #2	+485	0	42	124	164	0

Milam County

Well #	Company/ Operator	Ed(top)	Ki	Ed	CP	Wa	Pa
259	Rimrock Tide Lands W. F. Crawford #1	-2628	ND	ND	ND	200	0

Navarro County

Well #	Company/ Operator	Ed(top)	Ki	Ed	CP	Wa	Pa
162	Humble Oil Co. Sarah B. Trammel #1	-3955	54	30	100	200	0
163	Hunt Oil Co. Fortson #1	-2391	35	30	95	65	105
184	Coffield-Guthrie Clark #1	-1585	40	30	122	148	20
185	Falcon Oil Co. Keitt #1	-2314	40	30	130	190	0
186	Benz Oil Co. Strain #1	-2430	47	30	121	174	0
187	J. L. Hunt E. Hamilton #1	-2568	50	30	110	177	0
189	Texas Oil Co. Edens #1	-5055	50	35	155	245	0
190	Humble Oil & Ref. Co. 1st Natl. Bank Corsicana #1	-4476	54	31	120	235	0
191	Carter-Gregg Oil Co. I. T. Kent #A-1	-4479	55	25	135	335	0
192	Temple-Hargrove Wallace #2	-4096	41	34	135	ND	ND
193	Temple-Hargrove Wallace #1	ND	40	32	141	237	0

Robertson County

Well #	Company/ Operator	Ed(top)	Ki	Ed	CP	Wa	Pa
239	Mobil Oil Co. Reagan #1	-5023	0	55	175	400	0
240	Humble Oil Co. Blair #1	-5535	0	52	177	415	0
241	Skelley Oil Co. Williams #1	-4764	0	45	170	460	0
260	Continental Oil Co. Cambell #1	-3746	0	65	138	277	0
262	Union Prod. Co. Gibson #1	-4945	10	70	150	340	0
263	Shell Oil Co. #1 Hamilton	-6057	0	80	170	420	0
264	Tx. Gas Explor. & W. C. Dunlap Jr. Mozelle Kellogg #1	-5893	0	50	180	440	0

Tarrant County

Well #	Company/ Operator	Ed(top)	Ki	Ed	CP	Wa	Pa
122	Texas Water Well Inc. City of Bedford #5	ND	42	18	54	40	186
128	Layne Tex Co. Texas Elec. Co. #6	+240	40	20	70	40	190
144	Layne Tex Co. City of Pantogo Trinity #4	+125	35	20	75	45	180
145	Layne Tex Co. Kee Branch Water Supply Corp. #1	ND	35	23	74	46	154
146	Shell Oil Co. Lowe 1	+12	40	28	72	50	155
148	Gearhart-Owen Testwell #4	+461	30	25	82	63	150
149	C. M. Stoner Town of Crowley #3	+525	25	28	102	68	132

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