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BIOSTRATIGRAPHIC STUDIES IN THE COMANCHE (CRETACEOUS) SERIES OF NORTHERN MEXICO AND TEXAS

by
Bobby Frank Perkins

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BIOSTRATIGRAPHIC STUDIES IN THE COMANCHE (CRETACEOUS) SERIES OF NORTHERN MEXICO AND TEXAS

by Bobby Frank Perkins

This paper describes the biostratigraphic relationships of the Aurora limestone in the Sierra de Tlahualilo of southwestern Coahuila to the type Aurora near Ojinaga, Chihuahua and to the type Lower Cretaceous (Comanche) series of northern Texas.

Stratigraphic sections of the Fredericksburg and Washita groups in the Fort Worth-Weatherford area of north Texas are redescribed. The following stratigraphic nomenclatural revisions are proposed: (1) the division of the Goodland formation (Fredericksburg group) into two members of which the lower is designated the Marys Creek marl member (new name) and the upper the Benbrook limestone member (new name); and (2) the use of the name "Denison formation" to include the units previously referred to in the Fort Worth-Weatherford area as the Denton, Weno, Pawpaw, Main Street, and Grayson formations and here considered members. Based on the author's collections, faunal lists of the larger invertebrate fossils for each formation and member are given and the useful zonal guide fossils are indicated.

A fauna of 45 species of larger invertebrate fossils from the upper member of the Aurora limestone of the Sierra de Tlahualilo is described. Of this fauna (1), twenty-seven species are identified and (2), five are compared with species

known from the Texas Comanchean; (3), two are identified with species previously known from the Mexican Cretaceous; (4), six are described as new species; and (5), six are given generic assignments only. On the basis of the stratigraphic ranges of the Texan and Mexican species with which the Aurora forms are identified and the ranges of the Texan and Mexican species allied to the new species from the Aurora, it is concluded that the upper member of the Aurora limestone in the Sierra de Tlahualilo should be correlated with the Washita group of Texas. The lower part is correlated with the Fort Worth limestone and the upper part is correlated with the lowermost part of the Grayson marl. The lower part of the Aurora limestone is tentatively correlated with the Walnut marl.

This correlation indicates an upper Albian to possibly a lower Cenomanian age for the upper member of the Aurora limestone in the area studied. Elsewhere in northern Mexico the formation has been determined as ranging from lower to middle Albian in age and only at the type area has the upper part of the limestone been considered as young as uppermost Albian or possibly Cenomanian. On the basis of this correlation it appears that the environment responsible for the origin of the Aurora limestone did not appear everywhere in northern Mexico at the same time nor did it persist for an equally long period at every place in the region.

The Aurora limestone is interpreted as a formation of epineritic origin deposited far from a source of clastics as indicated by the fauna and by the almost complete absence of

terriginous material within this unit. This origin is in contrast to that of the Fredericksburg and Washita groups in north Texas where the strata of these groups are principally epi- and infraneritic in origin as shown by the faunas and the abundance of fine-grained clastics throughout the strata.

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BIOSTRATIGRAPHIC STUDIES IN THE COMANCHE (CRETACEOUS) SERIES OF NORTHERN MEXICO AND TEXAS

INTRODUCTION

At the beginning of Cretaceous time the sea from the Gulf of Mexico spread westward into the Mexican Geosyncline and northward across the Gulf Coast area, first depositing the Neocomian sediments in the deeper parts of the basins and then the Comanchean sediments over a much broader area. In the greatest invasion of the continent in early Upper Cretaceous time, it deposited the Benton sediments over the Great Plains and eastern Rocky Mountain region. The details of North American Cretaceous history are still being filled in by the study of geologic sections, the identification of faunas on which age determinations are based, and the correlation of formations of widely different lithologic character laid down in different parts of the continent. The present investigation is a study of certain Comanchean sections in northern Mexico and northern Texas and their correlation by means of the contained faunas. The Aurora limestone in Mexico and the Fredericksburg and Washita groups in Texas yielded the principal faunas.

The Aurora limestone of northern Mexico is a biohermal unit deposited on a shallow bottom, distant from sources of clastics. Conditions favorable for this type of deposition began earlier and persisted longer in some places than in others. Elsewhere sediments of different origin were being deposited at the same time in other environments. The age

of the base and top of the Aurora limestone varies to some extent from place to place and the correlation of this biohermal unit with other units laid down elsewhere in the same sea poses a problem of considerable scientific and economic importance.

The Aurora limestone was named by R. H. Burrows (1909, p. 324; 1910, p. 96-98) after the Aurora mine in the Sierra de la Aldea near Ojinaga (Fig. 45) in northeastern Chihuahua. This range is about 250 miles north-northwest of the Sierra de Tlahualilo, where the formation was studied by the author. Burrows considered the Aurora as probably the age equivalent of the Edwards limestone of Texas. Later studies by King and Adkins (1946) based on fossils identified by R. W. Imlay resulted in a revised correlation of the formation. In the type area along the Rio Conchos valley the Aurora limestone is reported to be about 5,000 feet thick (King and Adkins, 1946, p. 286). It consists of two thick rudistid-bearing limestone members and two thinner marly units, one above and one below the upper limestone member. The upper thinly-bedded marl and the upper part of the rudistid limestone member subjacent to it were determined to be of Washita age. The lower marl unit is of Fredericksburg age and the lower rudistid limestone is at least partly of Trinity (Glen Rose) age.

The purpose of the present study is to determine the age of the Aurora limestone in the central part of the Sierra de Tlahualilo and to show its correlation with the Aurora in

the type area and with the north Texas formations of other facies deposited in the Lower Cretaceous seas.

The Sierra de Tlahualilo is one of several northwest trending mountain ranges of Cretaceous rock in northeastern Mexico (Fig. 1) located on the site of the pre-Aptian landmass, the Coahuila Peninsula (Fig. 45). In general, the Comanchean strata in these ranges rest on a folded Paleozoic basement and consist of interbedded gypsum and dolomite and rudistid reef limestone of Upper Aptian to Lower Cenomanian age (Kellum, 1944, p. 321). These deposits were laid down in the shallow seas that submerged the Coahuila Peninsula. Subsequently, the rocks have been folded into a belt of broad, gentle anticlines now forming the mountains and shallow synclines now forming the intermontane basins (Kellum, Imlay and Kane, 1936, p. 992). In contrast to the type section in north Texas the Comanchean rocks laid down over the Coahuila Peninsula contain almost exclusively an epineritic fauna (zoogenic according to Scott, 1940, p. 318) consisting of miliolid foraminifers, rudistids, mud-burrowing clams, gastropods, and echinoids; the epineritic aspect of this fauna is emphasized by the absence of a varied cephalopod assemblage (Scott, 1940, pp. 301, 302, 309).

In order to determine the correlation of the Aurora limestone of Mexico with the type Comanchean section of north Texas, the author studied and mapped in detail a selected part of the area where R. T. Hill, the father of Texas geology, first recognized the proper sequence of Lower Cre-

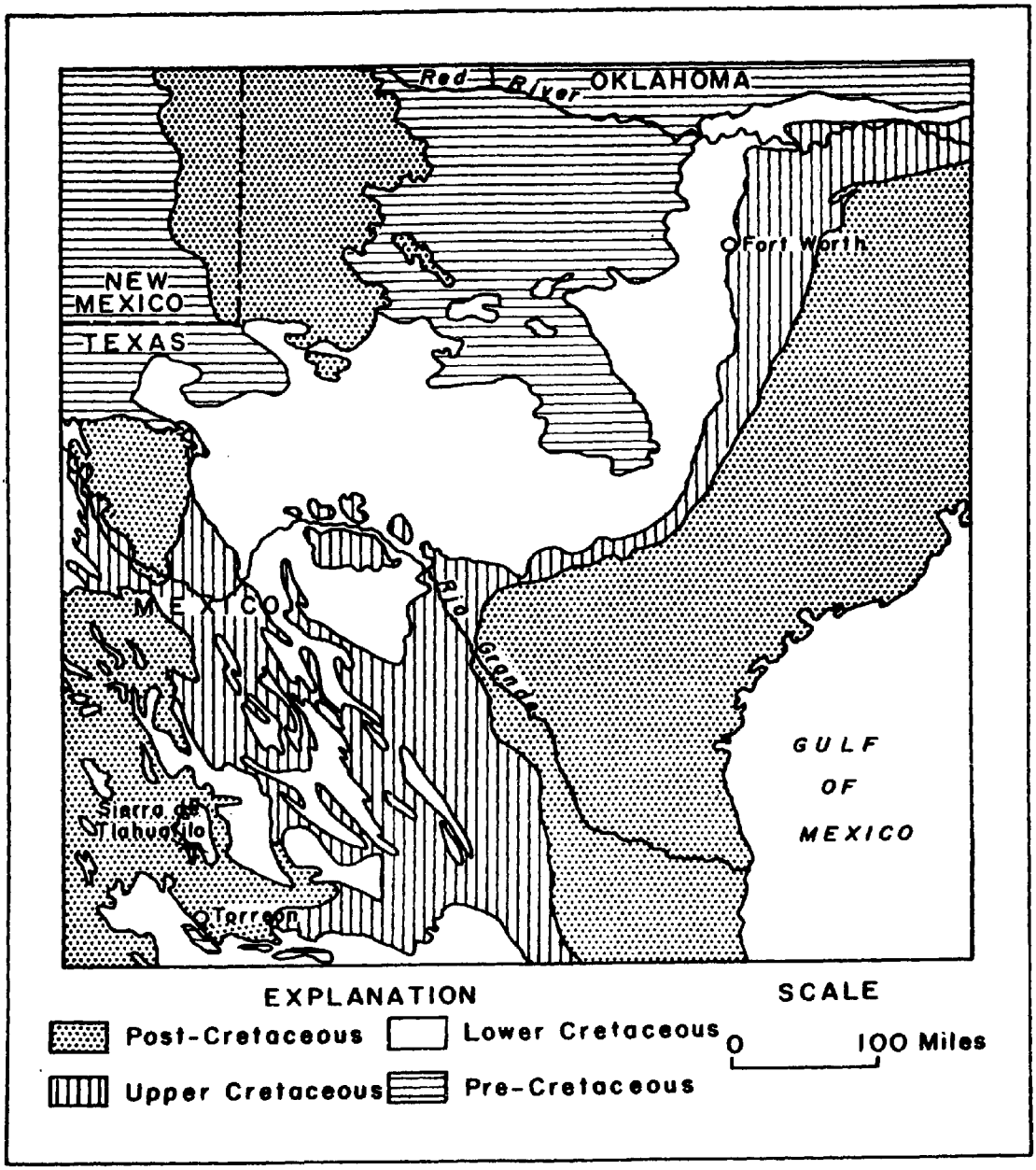


Figure 1. Generalized geologic map of portions of Texas and and Mexico. Data from "Geologic Map of North America" compiled by G. W. Stose, Geological Society of America, 1946.

taceous formations in Texas. The area is in the central parts of Tarrant and Parker counties.

The type Comanchean in north Texas is comprised of sandstones, marls, and limestones ranging in age from Middle Aptian through early Cenomanian. Laid down as shelf deposits on the northwestern side of the Cretaceous Gulf of Mexico they strike northeast and dip east-southeast at less than fifty feet per mile. Paleontologically, these strata are characterized by an abundant epi- and infraneritic fauna including many species of pelecypods, gastropods, nautiloids, ammonoids, and echinoids.

The field work in Mexico was done by the University of Michigan Museum of Paleontology 1952 Mexican Expedition comprised of Professor Lewis B. Kellum, Mr. Cecil C. Kersting and the author. During the 1952 field season, the map (Pl. 4) of part of the Sierra de Tlahualilo (the Ojo de Agua area) was constructed and most of the fossils from the Aurora herein described were collected. Additional mapping and collecting in the Sierra de Tlahualilo was done the following year by another University of Michigan expedition led by Professor Kellum. Many of the Aurora specimens collected by the second group have been generously made available for use in this report.

The field work in the north Texas area was done during the 1953-54 academic year and the summer of 1954. The fossils from both Mexico and Texas were studied in the Southern Methodist University Museum of Paleontology during the 1954-55 academic year.

ACKNOWLEDGMENTS

The author acknowledges a special debt of gratitude to Professor Lewis B. Kellum who has shown a kindly and active interest in the study throughout its duration. He made it possible for the author to participate in the 1952 Mexican Expedition and granted him permission to use the fossils collected and the map prepared by the field party. His criticism and advice both in the laboratory and in the field have been most important to the successful completion of the project.

The author has profited greatly from discussion and field conferences with Dean Claude C. Albritton, Jr. of Southern Methodist University. Dean Albritton made several field trips with the author in the north Texas area, and his advice and aid have been greatly valued.

Appreciation is also expressed to Mr. E. R. Leggatt of the United States Geological Survey. Mr. Leggatt was most generous with his time in the field in helping the author solve many of the stratigraphic problems of the Texas area.

To his wife, Patricia, the author is especially grateful for assistance given in this study. She has participated in all phases of the work with enthusiasm, but above all she has given the words and actions of encouragement necessary to bring the project to its conclusion.

The funds for the field work in Mexico were provided by the University of Michigan Museum of Paleontology and Department of Geology. To both divisions of the University the

author wishes to express his thanks.

Finally the author wishes to express his appreciation to the members of his doctoral committee for their constructive criticism and guidance throughout the preparation of the dissertation.

Field cars and equipment for study in the north Texas area and laboratory facilities for study of fossils were provided by the Southern Methodist University Department of Geology.

PART I. STRATIGRAPHY OF THE FREDERICKSBURG AND WASHITA GROUPS IN THE FORT WORTH-WEATHERFORD AREA, TEXAS

INTRODUCTION

Location and Accessibility

The Fort Worth-Weatherford area, which comprises about 100 square miles in middle Tarrant and middle eastern Parker counties, Texas, is bounded approximately by the meridians 97° 12' W. and 97° 43' W. and the parallels 32° 47' N. and 32° 41' N. in Parker County and 32° 38' N. and 32° 43' N. in Tarrant County. The mapped area extends through the southern part of the city of Fort Worth and westward along U. S. Highway 80-180 to a point about four miles east of the town of Weatherford (Fig. 2).

A network of hard-surfaced and gravel roads covers the area making all parts easily accessible under all weather conditions.

Previous Investigations

The early history of geological research in Texas through the year 1885 has been summarized by Robert T. Hill (1887). Of these early investigations none dealt directly with the geology of the Fort Worth-Weatherford area. However, two of these studies are notable since they deal with strata of Comanchean age in adjacent areas. The first of these is the work of Ferdinand Roemer (1849, 1852), who studied the central Texas Cretaceous geology giving particular emphasis to the paleontology. The other is the report of G. G. Shumard

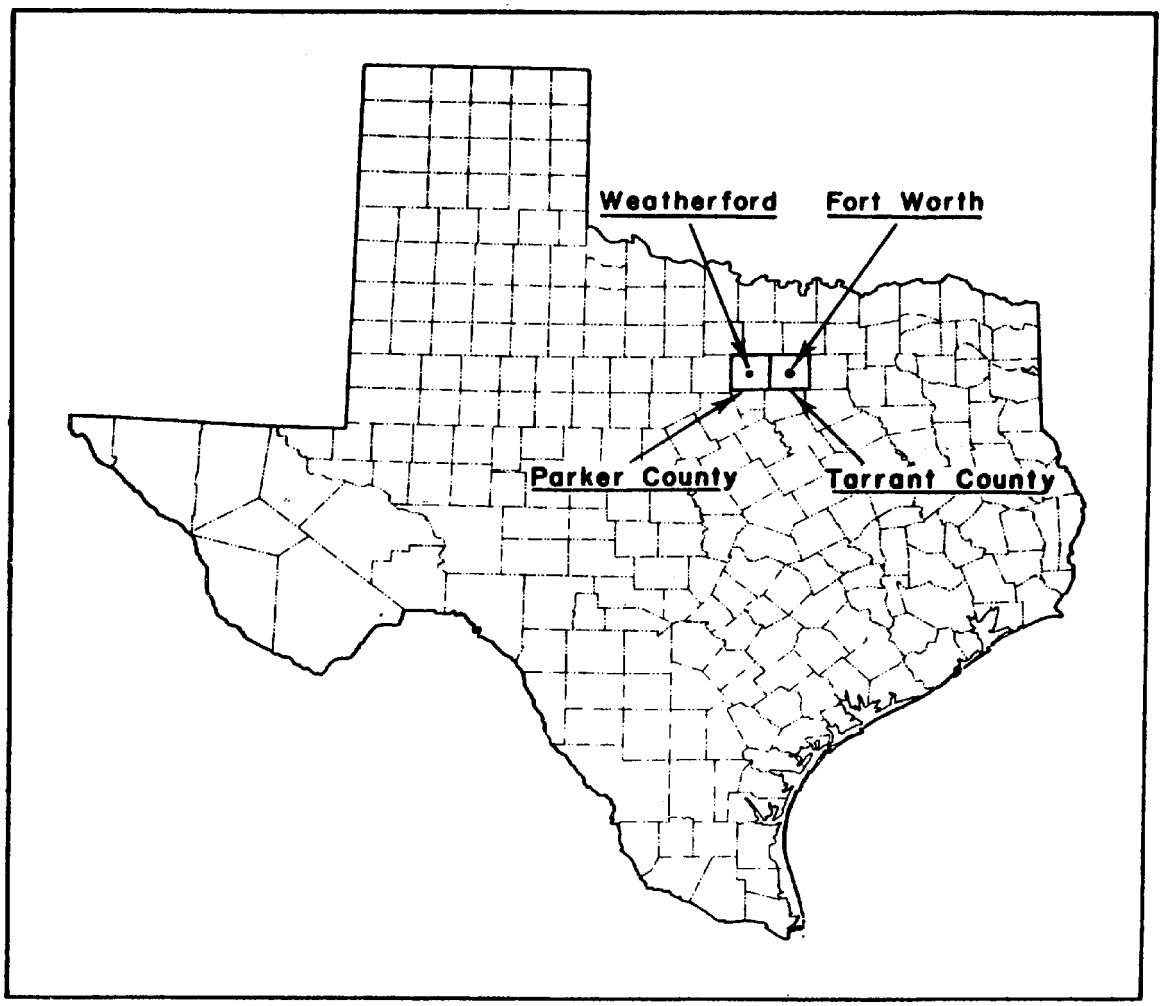


Figure 2. Map of Texas showing location of Fort Worth-Weatherford area.

(1853), who first described the north Texas Cretaceous rocks at the Red River.

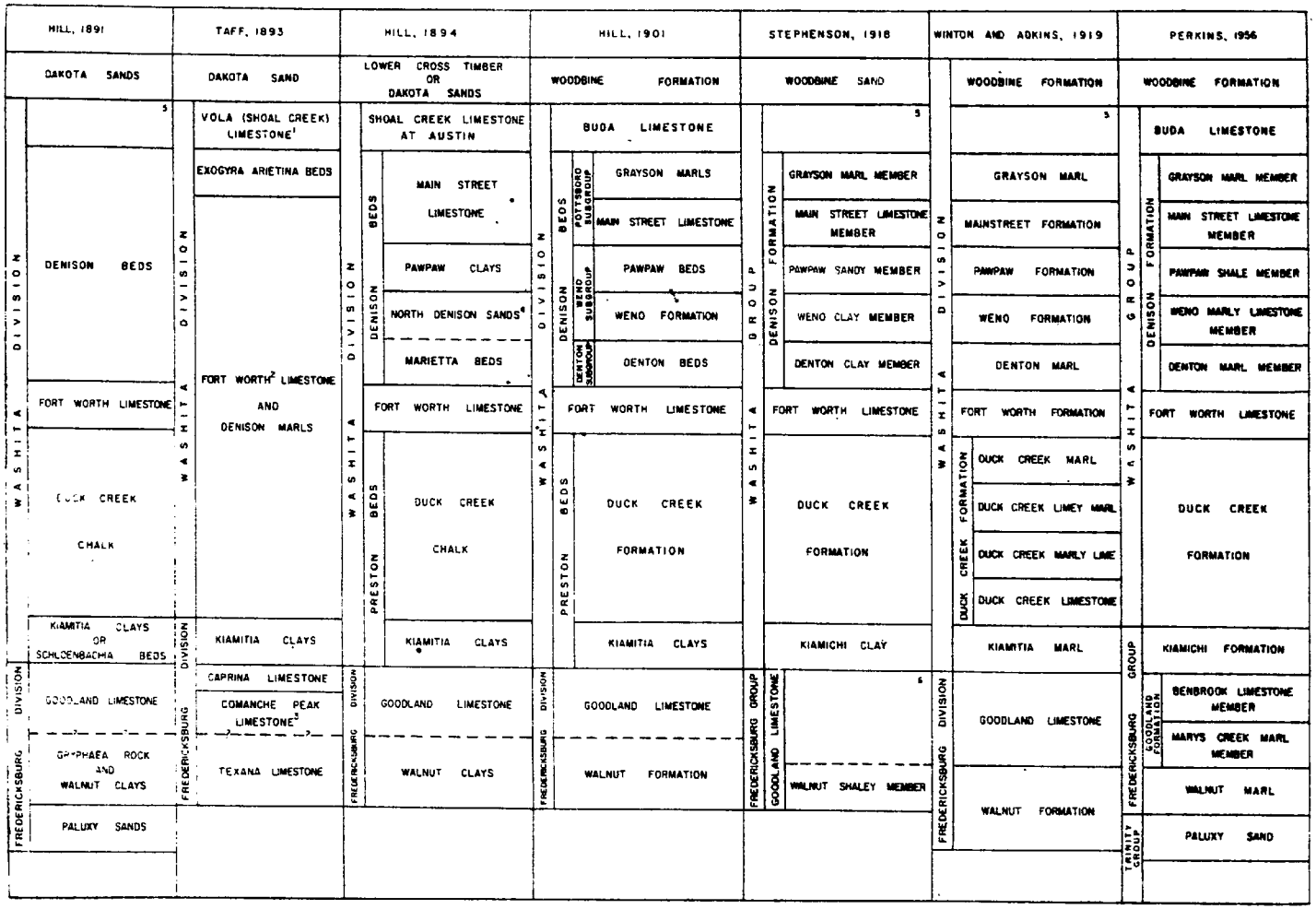
Robert T. Hill, in 1891, presented the first careful description and proper stratigraphic sequence of the Cretaceous formations of Texas. His report contains the framework of the classification now used for these strata. The classification proposed by Hill and those of later workers are shown in Figure 3.

In 1893, J. S. Taff prepared the first detailed description of the stratigraphic section of the Fort Worth-Weatherford area and compared this section with those of areas to the north and south. He (1893, pp. 245, 258-261) recognized the affinities of the Kiamichi formation with the Fredericksburg group and was the first to include that formation in that group.

In the following year Hill (1894) refined his earlier stratigraphic classifications of the Texas Cretaceous in his report on the geology of the Red River valley. He subdivided some of his larger units and replaced all paleontologic formational names with geographic designations.

The consumation of Hill's study of the Texas Cretaceous was realized in 1901 in the publication of his monumental work "Geography and Geology of the Black and Grand Prairies, Texas". As shown in Figure 3 the classification proposed by Hill is the one now used with only minor modifications.

Lloyd W. Stephenson, in 1918, published his observations on the geology of the Red River area in northern Texas and



1 Taff correlates this unit with the upper limey part of the Grayson marl.
2 See Hill, 1894, p. 327 footnote. Taff uses Fort Worth limestone for a type of lithology.
3 Taff does not indicate a definite lithologic boundary between the Comanche Peak and Texana limestones in Tarrant County (Taff, 1893, p. 254).
4 "North Denison sands" is very poorly defined and determination of the relationship between this unit and those in other classifications is difficult.
5 The Buda limestone or its equivalent was not recognized in the area of investigation.
6 Stephenson did not define an upper member for the Goodland limestone.

Figure 3. Chart showing terminology used by various workers for the Washita and Fredericksburg groups in north Texas.

southern Oklahoma. He proposed a simplification of Hill's divisions of the Washita group, which simplification is followed in the present paper.

In 1920, Winton and Adkins presented the first detailed study of the geology of the Fort Worth area in their "Geology of Tarrant County, Texas". Their report contains carefully prepared columnar sections, descriptions of the formations, and faunal lists as complete as could be compiled at that time. In the same year these authors (Adkins and Winton, 1920) also published an account of the fossil zones of the Fredericksburg and Washita groups of north Texas. This paper constitutes the foundation of our present understanding of the biostratigraphy of these strata in north Texas.

Gayle Scott (1926) made the first biostratigraphic report on the north Texas Cretaceous in which an attempt was made to demonstrate detailed relationships of the north Texas section with the standard European classification of the system.

Adkins' 1932 report on the Mesozoic stratigraphy of Texas summarized but did not greatly modify previous conclusions regarding north Texas Cretaceous stratigraphy.

More recent but less comprehensive contributions to the stratigraphy of the area have been made by Lozo (1944), Thompson (1935), Stephenson (1944), Albritton et al (1954), and Perkins and Albritton (1955).

In this report the author gives detailed stratigraphic descriptions of the Fredericksburg and Washita formations of

the area according to modern concepts of sedimentary rock classification and presents for these formations revised faunal lists which may serve as the basis for regional biostratigraphic studies.

Method of Investigation

The geologic maps (Pls. 1, 2) of the area were constructed with the aid of United States Department of Agriculture aerial photographs. The geologic contacts were located in the field and plotted on ten inch by ten inch stereo-paired aerial photographs. A base map was prepared from the photographs by the radial line method (Eardley, 1942, pp. 55-63a), and the geologic contacts were transferred from the photographs to the map by the same method.

Stratigraphic sections were measured by tape, Brunton compass, alidade, and plane table. Lithic determinations were made by the acid-insoluble residue method, and the stratigraphic sections were described according to the scheme of Barth, Correns and Eskola as given by Pettijohn (1949, p. 291, fig. 80) and as shown in Table 1.

Fossils were collected from each formation at numerous localities throughout the area. A list of the species found, their ranges, and localities of occurrence are given in Plate 3. New species of Cretaceous pelecypods from the area are described in the section on systematic paleontology. The type specimens are deposited in the University of Michigan Museum of Paleontology (U.M.M.P.).

Table 1.- Nomenclature and classification of clay-lime carbonate mixtures.

Rock Name	Per Cent Carbonate	Per Cent Clay
Limestone	95-100	0-5
Marly limestone	75-95	5-25
Marl	25-75	25-75
Marly clay or calcareous shale	5-25	75-95
Clay or shale	0-5	95-100

Note: The Pettijohn terms "limy marl" (25-35% clay) and "clayey marl" (65-75% clay) are not used in this report.

Geologic Setting

Physiography.- The Fort Worth-Weatherford area is almost entirely within the Grand Prairie (Hill, 1900), which is developed on the soft alternating marls and limestones of the Washita and Fredericksburg groups. The westernmost portion of the area lies within the eastern edge of a forested belt known as the Western Cross Timbers, which is developed on the Walnut marl and the underlying Trinity sands. The eastern limit of the area lies along the margin of a similar forested belt known as the Eastern Cross Timbers, which is developed on the Woodbine sandstone.

The area is drained by the Trinity River and its tributaries - the West Fork and the Clear Fork. Most of the smaller tributaries to these streams are ephemeral. Drainage is essentially from the northwest to the southeast with the major streams flowing down the gentle slope of the coastal plain. Cutting through the soft strata of marl and shale,

the small lateral streams flow in general southward.

The maximum relief of the area is approximately 400 feet. The highest elevations (approximately 1000 feet) are along the western edge of the area in Parker County. The surface slopes gently east-southeast, and the lowest portion (approximately 600 feet in elevation) is along Village Creek in eastern Tarrant County.

Structure.- Tarrant and eastern Parker counties lie in the western part of a broad band of Cretaceous outcrop which extends in an arc from the south flank of the Ouachita and Arbuckle mountains southward to central Texas and thence westward into northern Mexico (Fig. 1). In north Texas this Cretaceous bands defines the shelf area of the Cretaceous Gulf of Mexico and on the east is separated from the East Texas basin by the Luling-Mexia fault zone. On the west the Cretaceous outcrop is bounded by a broad area of Paleozoic rocks.

Overlying Paleozoic rock with angular unconformity, the Cretaceous strata in the Fort Worth-Weatherford area strike very slightly east of north (not more than N. 5° E.) and dip east at 42 feet to 52 feet per mile. As far as could be determined by use of the plane table and alidade, there is no significant change in the strike and dip of the beds throughout the area studied. Mr. E. R. Leggatt of the United States Geological Survey reports (oral communication) that from his studies of water well logs and samples throughout Tarrant County there is no marked departure from the strike and dip

determined from surface data by the author.

Several references have been made by previous writers to the Fort Worth syncline or basin (Adkins, 1918, p. 13; Adkins, 1933, p. 266; Eardley, 1951, p. 226). This syncline is described as being a northwest-southeast trending basin filled principally by pre-Comanchean deposits and having a very weak surface expression. Adkins (1933, p. 266) states that "the Cretaceous formations thicken toward its center, and are thinned over the adjacent highs". In the present investigation this thickening and thinning was not observed.

STRATIGRAPHIC GEOLOGY

General Stratigraphy

The sedimentary rocks of the Fort Worth-Weatherford area belong to the Cretaceous system, which in the larger valleys are covered by unconsolidated fluvial deposits of Cenozoic age. Three unconformities interrupt the sedimentary sequence: one between the Trinity and Fredericksburg groups, one between the Comanchean and Gulfian series of the Cretaceous, and one at the base of the Cenozoic.

The strata described in this report include only those of the Comanchean Fredericksburg and Washita groups. The Fredericksburg group includes the Walnut marl, the Goodland formation, and the Kiamichi formation; the Washita group includes the Duck Creek formation, the Fort Worth limestone, the Denison formation, and the Buda limestone.

Thicknesses and lithological characteristics of the formational units are summarized in Figure 4.

Fredericksburg Group

The name "Fredericksburg", derived from the central Texas town of that name, was first used by Hill (1887a) for the lowest division of the Comanche series. He defined the Fredericksburg group as the limestones overlying the Dinosaur sand (Travis Peak) and underlying the Washita division (group). In his later writing Hill (see Wilmarth, 1939, p. 775) variously modified this earlier classification and finally (1901) defined the group to include the Walnut formation and the Goodland limestone. The inclusion of the Kiamichi in the

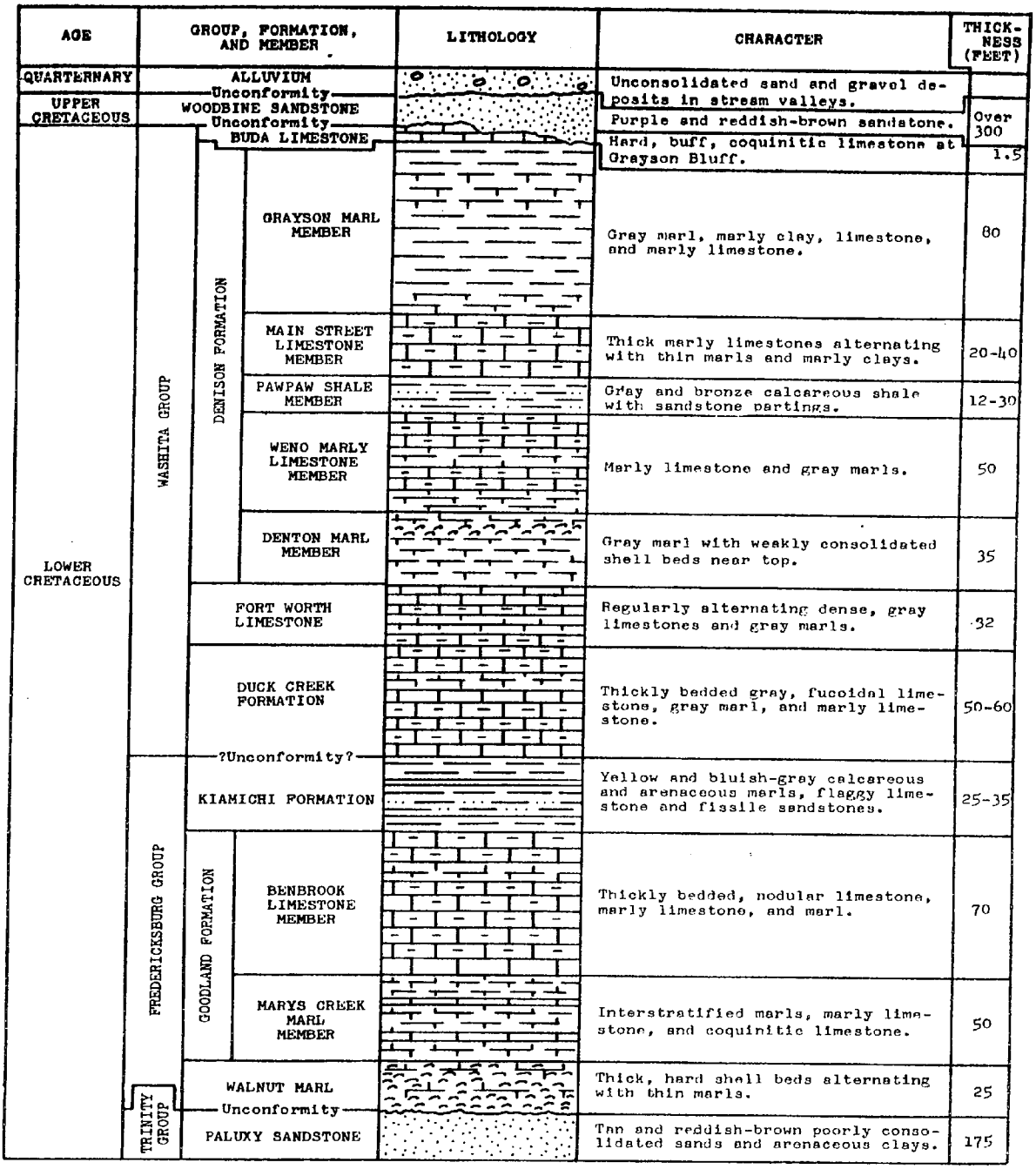


Figure 4. Generalized columnar section of the stratigraphic units outcropping in the Fort Worth-Weatherford area.

group was first suggested by Taff (1892, p. 245, 259-261) but has not been consistently followed by stratigraphers. It seems desirable, however, to include the Kiamichi in the Fredericksburg group because: (1), there is some evidence for an unconformity between the Kiamichi and the Duck Creek (Adkins, 1933, p. 360), whereas the Kiamichi-Goodland contact is apparently conformable; and (2), paleontologically (Plate 3) the Kiamichi is more closely allied to the Fredericksburg formations than to those of the Washita.

Wilmarth (1939, p. 775, 776) gives an excellent account of the usages of the terms "Fredericksburg Division" or "Group".

Walnut Marl

Name and type section.- Robert T. Hill (1891, p. 504, 512) applied the name Walnut to a sequence of "alternating strata of thin limestone flags and yellow clay marls, accompanied by inconceivable numbers of Exogyra texana..." exposed at Walnut Springs, Bosque County, Texas. As originally defined the name applied only to the Exogyra texana beds overlying and underlying the "Gryphaea rock" in the Texas and Arkansas region and not to the "Gryphaea rock" itself.

In 1892 J. A. Taff (p. 273, 274) considered these marls and the intervening "Gryphaea rock" as one unit to which he applied the name "Texana bed". He placed the lower boundary at the top of the Paluxy sand and the upper boundary at the "limit of occurrence of Exogyra texana".

In 1901 Hill (p. 205) revised his earlier definition

when he stated that the name "Walnut formation" was synonomous with "Exogyra texana beds" (Hill, 1887, p. 280), "Walnut beds" (Hill, 1890, p. 504, 512), and "Texana beds" (Taff, 1892, p. 273). He also indicated that "Walnut" was to apply to the Exogyra texana and Gryphaea mucronata shell beds and alternating marls.

In this report the name "Walnut marl" is used in reference to the yellow and gray shell-bed-bearing marls delimited below by the Paluxy sand and above by the basal blue marl of the Goodland formation.

Lithology and thickness.- In the Fort Worth-Weatherford area the Walnut marl is about 25 feet thick and consists of beds of the shells of Gryphaea mucronata Gabb and Exogyra texana Roemer alternating with thin marl units (Figs. 5, 6). The matrix of the shell beds is of the same lithology as the alternating marls, which are bluish on fresh exposure and weather yellow or buff. The lower 15 feet of the formation consists of thinly bedded shelly and calcareous marls. These lower beds are two to six inches thick and the boundaries between them are indistinct so that on weathered outcrops ledges are not strongly developed. The upper ten feet of the formation is composed of massive, hard, blue shell beds ranging in thickness from one to five feet. These beds are separated by marl seams, and in weathered outcrops the shell beds stand out in marked relief.

Previous writers have placed the upper and lower contacts of the Walnut formation at various stratigraphic levels. As

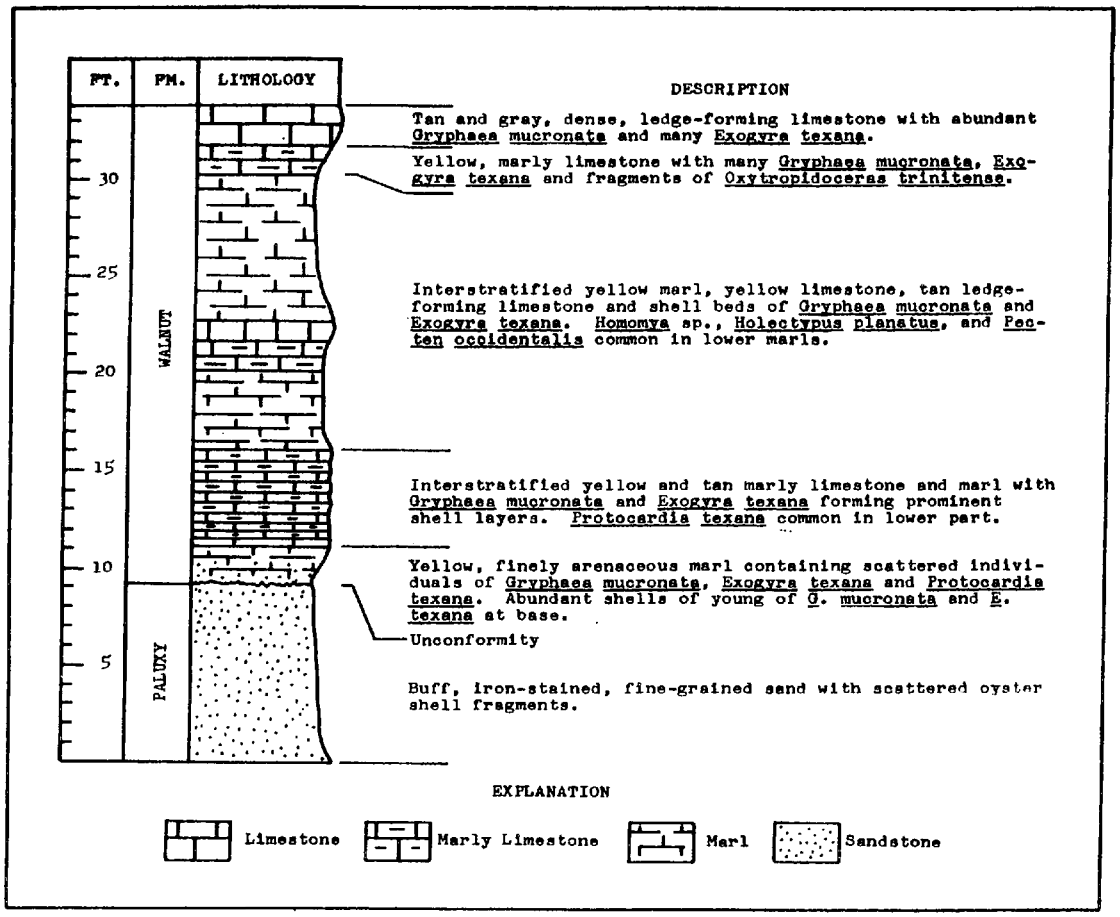


Figure 5. Graphic section of the Walnut marl in roadcut 4.5 miles east of Weatherford on U. S. Highway 80-180, Parker County (Locality T-12).



Figure 6. View of the Walnut marl in roadcut 4.5 miles east of Weatherford on U. S. Highway 80-180, Parker County (Locality T-12). Walnut-Paluxy contact indicated by black line in the area shaded by the lowermost resistant shell bed of the Walnut. See Figure 5 for graphic section.

a result reports of the thickness of the formation have ranged from 27 feet to 170 feet. J. A. Taff (1893, p. 252, 253), who assigned 170 feet to the formation (Texana limestone), included about 15 feet of arenaceous marl that in this report is considered Paluxy and about 130 feet of limestone and marly limestone in this report considered Goodland. Hill (1901, p. 124, 208, 221, pl. 19), who assigned 130 feet to the formation, included three feet of sand herein considered Paluxy and more than 90 feet of marly limestone herein considered Goodland.

Winton and Adkins (1920, p. 27) placed the upper contact of the Walnut at the top of the uppermost massive, hard Gryphaea mucronata ledge as is done in this report, but included in the formation 100 feet of marl, sand, and shell lenses considered Paluxy in this report. Scott and Hawley (in Adkins, 1933, p. 330; Hawley and Smith, 1933, p. 99-101) applied the name "Walnut" in the area west and northwest of Fort Worth to the "calcareous sediments, including the Gryphaea marcoui [G. mucronata] shell banks". This application is followed by Lozo (1944, p. 520).

Thompson (1935, p. 1530) included in his definition of the Walnut arenaceous marls presently assigned to the Goodland formation.

Distribution.- In the western part of the area the Walnut is the principal divide-former separating the drainage of the Clear Fork from that of the South Fork of the Trinity River (Pl. 1). It also caps numerous outliers located in

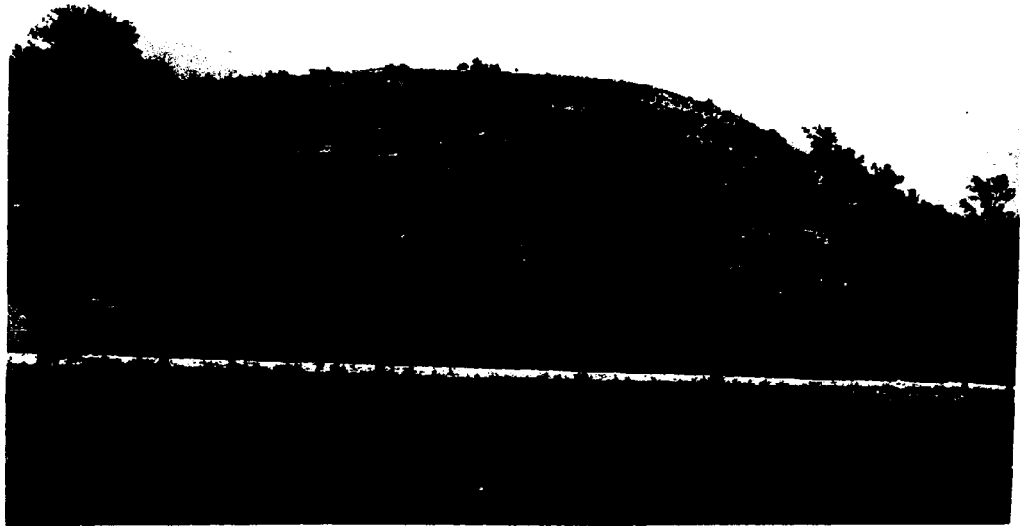


Figure 7. Outlier of Walnut marl capping a hill of Paluxy sandstone in eastern Parker County.



Figure 8. Paluxy sandstone-Walnut marl contact in roadcut 4.5 miles east of weatherford on U. S. Highway 80-180, Parker County (Locality T-12). See Figures 5, 6.

the valleys of these two tributaries (Fig. 7). Along the eastern margin of the Clear Fork floodplain the Walnut forms a low westward- and southwestward-facing escarpment. In western Tarrant County the Walnut forms the bed of Marys Creek at several points (Pl. 2), but at most places it is covered by river deposits.

Along the highly dendritic outcrop pattern of the Walnut in Parker County, numerous low waterfalls are developed along the headwaters of the small tributary streams. These waterfalls are typically developed on the upper massive shell beds of the formation, and the underlying softer marls are deeply undercut.

Structural relationships.- The Walnut rests with pronounced unconformity on the Paluxy sand. The lower unit of the Walnut is a yellow, sandy marl about eight to twelve inches thick. Its contact with the Paluxy is highly undulatory having a local relief of two to six inches (Fig. 8). It is not possible to measure differences which may exist in the dips of the two formations. The uppermost massive, hard, Gryphaea mucronata ledge of the Walnut is apparently conformable with the superjacent Goodland formation.

Faunal list.- The following fossils have been identified by the author from the Walnut marl in the Fort Worth-Weatherford area. Those species which appear to be limited to the Walnut marl on the basis of the author's collections are marked with an asterisk.

Pelecypoda

Cucullaea recedens Cragin

Pecten (Neithea) occidentalis (Conrad)

P. (Neithea) subalpinus (Böse)

Exogyra texana Roemer

Gryphaea mucronata Gabb

Protocardia texana (Conrad)

Cephalopoda

Oxytropidoceras acutocarinatum (Shumard)

*O. trinitense (Gabb)

Engonoceras pierdenale (von Buch)

Echinoidea

Tetragramma sp.

Holectypus (Caenholectypus) planatus Roemer

Salenia mexicana Schlüter

Enallaster mexicanus Cotteau

Goodland Formation

Name and type section.- The "Goodland limestone" named for Goodland, Oklahoma, was first described by Hill (1891, p. 504, 514) for the north Texas and southern Oklahoma attenuation of the central Texas Comanche Peak (Fredericksburg) group. He described the formation as a "single persistent layer" having the typical Comanche Peak fauna and the hardness of the Caprina limestone.

Various writers (for summary see Wilmarth, 1938, p. 837, 838) have questioned the desirability of using this name maintaining that since the Goodland is equivalent to the

Comanche Peak, the latter name, which has priority, should be used in north as well as central Texas. Since the identity of the Fredericksburg limestone of north Texas with the Comanche Peak limestone of central Texas is still open to question, the United States Geological Survey (Wilmarth, 1938, p. 838) and recent workers have retained the name "Goodland" in north Texas.

In this report the name "Goodland limestone" is replaced by "Goodland formation" as has been done by Lozo (1944) and others. The latter name applies, in the north Texas area, to the chalky limestone beds and alternating limestone and marl beds lying above the uppermost resistent bed of Gryphaea mucronata Gabb of the Walnut marl and below the Kiamichi formation.

Lithology and thickness.- In this area the Goodland formation consists of alternating thick beds of limestone, marly limestone, and marl (Figs. 9-11). The formation is approximately 120 feet thick and is herein divided into two members which are named and described as follows.

Marys Creek Marl Member (New Name)

Name and type section.- The name "Marys Creek marl member" is proposed here for the lower interstratified marls and marly limestones of the Goodland formation exposed in western Tarrant County, Texas. The type section is exposed along Marys Creek for a distance of 1.5 miles from the U. S. Highway 80-180 bridge (Loc. T-1) southeastward to the bluffs on the Rawl Ranch (Loc. T-2).

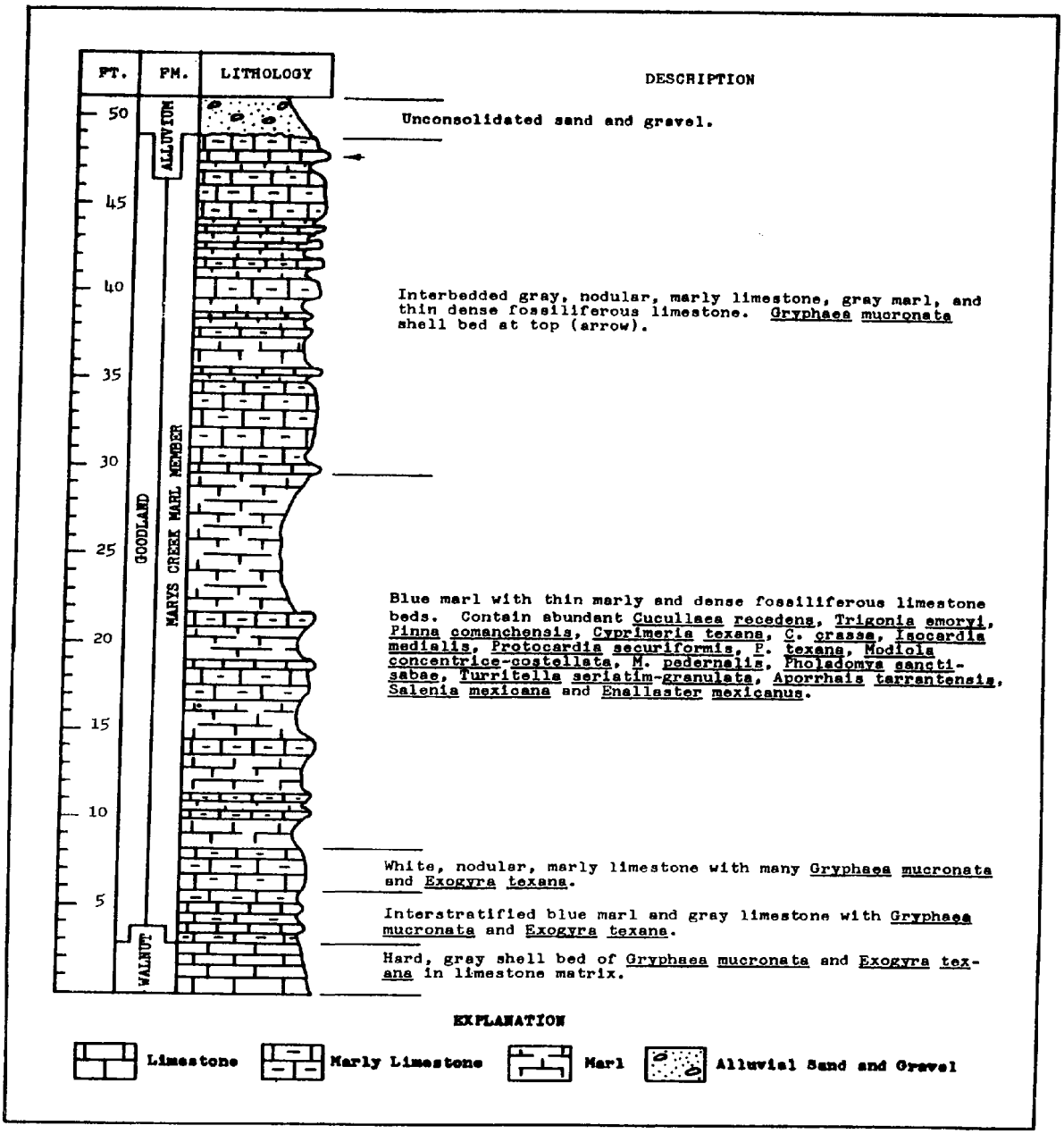


Figure 9. Graphic section of the Marys Creek marl member of the Goodland formation at the type locality on Marys Creek at U. S. Highway 80-180 bridge, Tarrant County (Locality T-1).

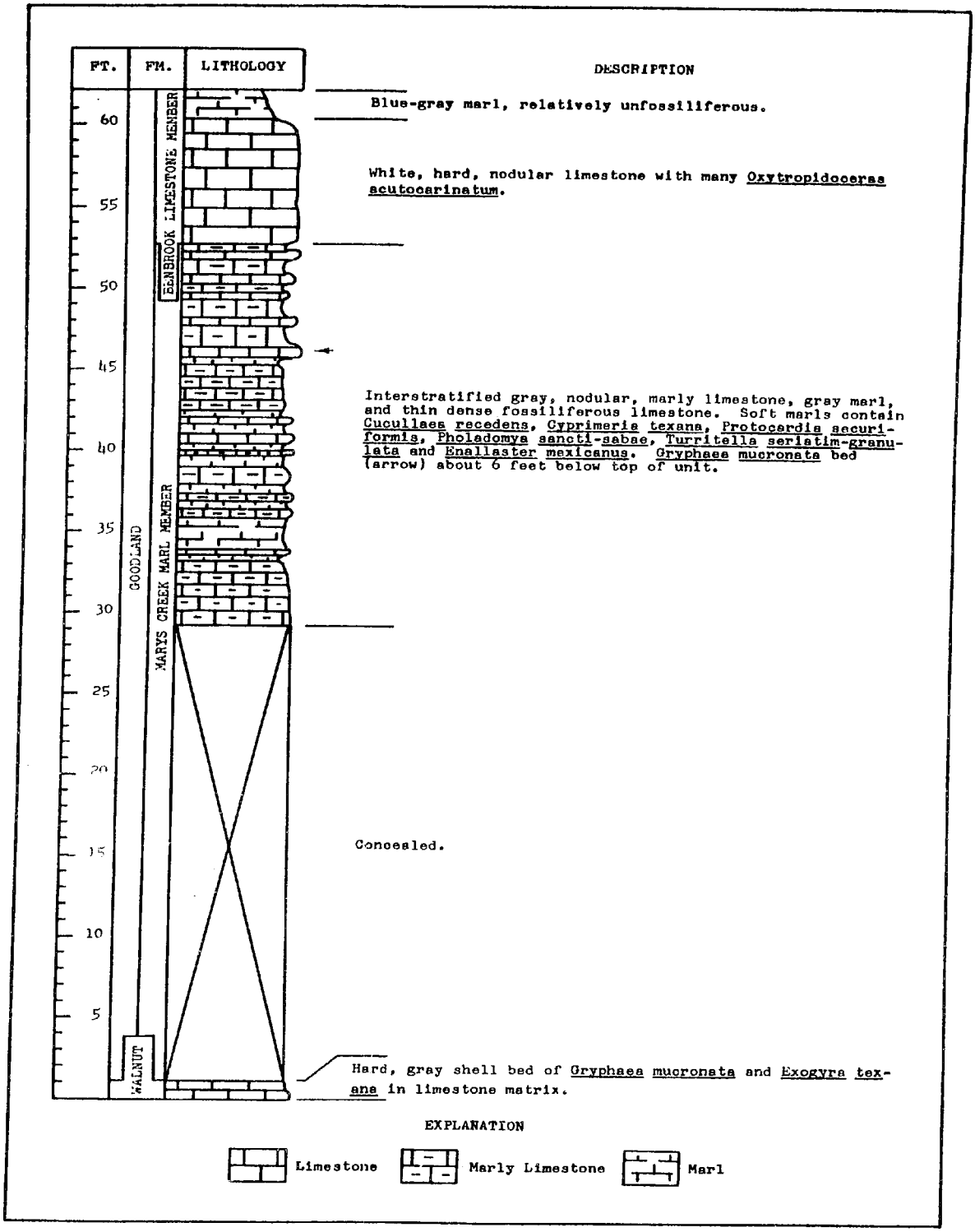


Figure 10. Graphic section of the upper part of the Marys Creek marl member and lower part of the Benbrook limestone member of the Goodland formation at the type locality of the Benbrook member in bluffs along Marys Creek on the Rawl Ranch, Tarrant County (Locality T-2). See Figure 11 for upper part of section.

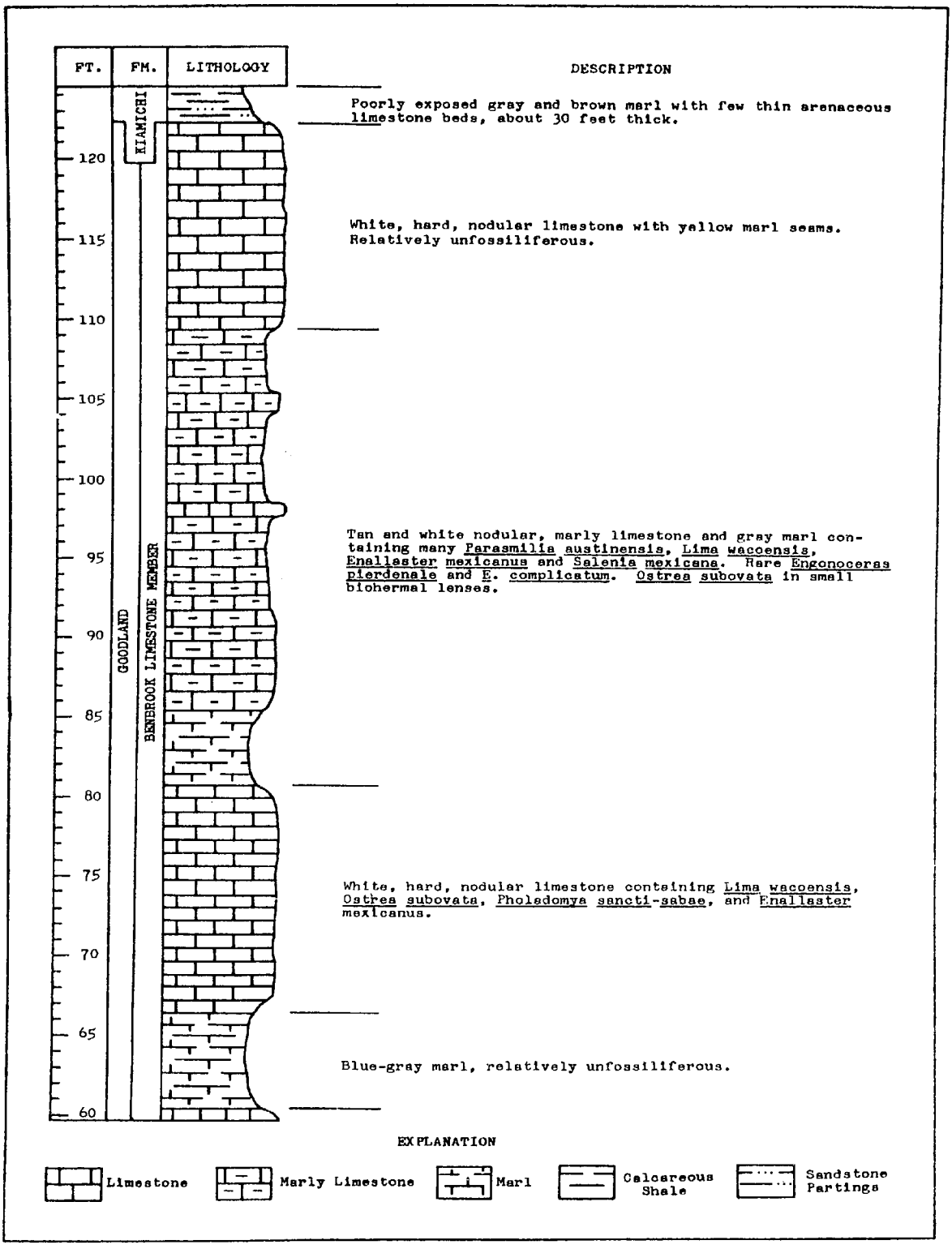


Figure 11. Graphic section of the upper part of the Benbrook limestone member of the Goodland formation at the type locality in bluffs along Marys Creek on the Rawl Ranch, Tarrant County (Locality T-2). See Figure 10 for lower part of section.

Lithology and thickness.- At the type locality the member consists of 51 feet of interstratified blue marls, marly limestones, and several hard, fossiliferous limestones (Figs. 9, 10, 12, 13). The lower 47 feet of the member is exposed in the east bank of Marys Creek immediately north of the U. S. Highway 80-180 bridge. Parts of the lower 40 to 45 feet of the member crop out at several points southeastward from the bridge along the creek to the Rawl Ranch bluffs where the upper 23 feet are exposed.

The basal part of the member is gradational from the Walnut marl; the contact between the two is arbitrarily placed at the top of the uppermost resistant shell bed of the Walnut (Figs. 9, 12). The upper limit of the member is placed at the top of the interstratified sequence of thin marls and limestones and at the base of the thick limestone and marly limestone sequence of the upper member. A widespread and easily recognized hard shell bed of Gryphaea mucronata Gabb in a limestone matrix occurring about six feet below the top of the member serves as a useful marker bed.

Benbrook Limestone Member (New Name)

Name and type section.- The name "Benbrook limestone member" is proposed here for the upper section of thick limestones and marly limestones of the Goodland formation as exposed in the bluffs along the south bank of Marys Creek on the Rawl Ranch 2.7 miles northwest of the town of Benbrook, Tarrant County, Texas (Loc. T-2; Figs. 10, 11, 13).



Figure 12. View of the lower part of the Marys Creek marl member of the Goodland formation at the type locality on Marys Creek (Locality T-1). See Figure 9 for graphic section.

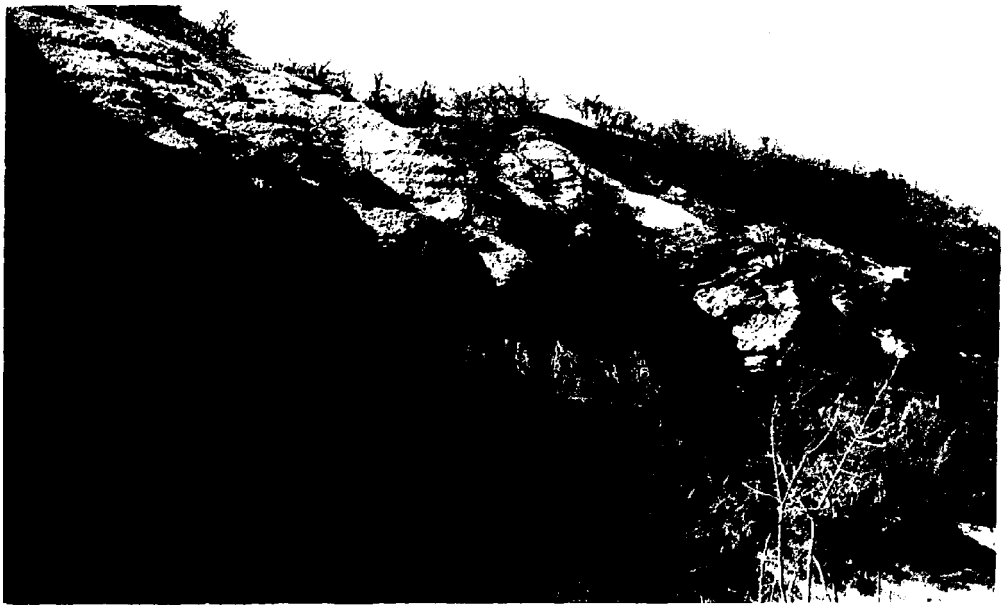


Figure 13. View of the Goodland formation at the type locality of the Benbrook member on the Rawl Ranch northwest of Benbrook (Locality T-2). A) Benbrook limestone-Marys Creek marl contact. B) Gryphaea mucronata marker bed. See Figures 10, 11 for graphic sections.

Lithology and thickness.- At the type locality (Loc. T-2) the member consists of 70 feet of thick limestone and marly limestone units alternating with thinner marls as described in Figures 10 and 11.

Distribution of the Goodland formation.- The Goodland formation is the most widely distributed formation in the area mapped (Pls. 1, 2). Its outcrop forms a wide band in western Tarrant and eastern Parker counties. The Marys Creek marl member is poorly exposed throughout the area and occurs typically as a gentle slope or wide prairie leading up from the hard shell beds of the Walnut to the basal hard limestone of the upper member of the Goodland formation. The limestones of the Benbrook member are more resistant and thickner than those of the Marys Creek marl member and form steep and gererally barren slopes separating terraces developed on the softer marls. The brilliant white slopes on the limestones are a conspicuous feature of the landscape wherever the upper member occurs (Fig. 14).

Good exposures of the lower member of limited to stream beds, whereas the upper member is preserved in resistant hills and slopes high above stream level in most parts of the region.

Structural relationships of the Goodland formation.- The boundary between the Goodland formation and the subjacent Walnut is conformable and gradational. The contact with the superjacent Kiamichi is lithologically very abrupt and appears



Figure 14. White limestone slopes of the Benbrook member of the Goodland formation in pastures northwest of Benbrook, Tarrant County.

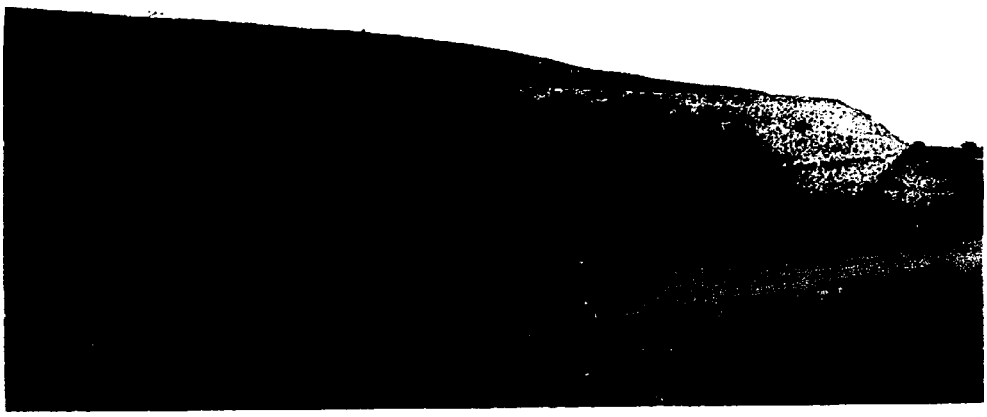


Figure 15. View of Cragin Knobs showing the Goodland-Kiamichi contact (line at top of trees) on Old Stove Foundry Road, Tarrant County (Locality T-11).

to be conformable. The upper contact is particularly distinctive, since the upper unit of the Goodland is a thick, hard, white limestone, and the lower unit of the Kiamichi is a soft, blue, arenaceous marl (Fig. 11). The limestone forms a steep, resistant, barren slope, and above the Kiamichi forms a gentle, receding, grassy slope (Fig. 15).

Faunal list.- The following fossils hve been identified by the author from the Goodland formation in the Fort Worth-Weatherford area. Those species which appear to be limited to the Goodland formation on the basis of the author's collections are marked with an asterisk.

Marys Creek Marl Member

Mollusca

Pelecypoda

Cucullaea recedens Cragin

*Barbatia subquadrata Perkins, sp. nov.

Trigonia emoryi Conrad

Plicatula subgurgitis Böse

Pecten (Neithea) occidentalis (Conrad)

P. (Neithea) subalpinus (Böse)

*Inoceramus sp. aff. I. concentricus Parkinson

*Pinna comancheana Cragin

Exogyra texana Roemer

Gryphaea mucronata Gabb

Lima (Mantellum) wacoensis Roemer

*Trapezium microsolen Perkins, sp. nov.

*T. texanum (Roemer)

*Cyprimeria crassa Meek

C. texana (Roemer)

C. sp.

*Cardium subcongestum Böse

*Isocardia medialis (Conrad)

*Protocardia securiformis (Cragin)

P. texana (Conrad)

*Modiola concentrice-costillata Roemer

*M. pedernalis Roemer

*Homomya cymbiformis Perkins, sp. nov.

*H. tarrantensis Perkins, sp. nov.

Pholadomya sancti-sabae Roemer

*Meretrix burkhardti Böse

*Tapes whitei Böse

*Leptosolen striatula Perkins, sp. nov.

Gastropoda

*Gyroides? sp.

*Tylostoma elevatum (Shumard)

*T.? formosum (Cragin)

*T. tumidum (Shumard)

*Turritella seriatim-granulata Roemer

*Aporrhais tarrantensis Stanton

*A. sp. A

*A. sp. B

Cephalopoda

Oxytropidoceras acutocarinatum (Shumard)

*Engonoceras complicatum Hyatt

Engonoceras pierdenale (von Buch)

*E. stolleyi Böhm

*Metengonoceras inscriptum? Hyatt

Echinodermata

Echinoidea

Salenia mexicana Schlüter

*Hemiaster whitei (Clark)

Enallaster mexicanus Cotteau

Benbrook Limestone Member

Coelenterata

*Parasmilia austinensis Roemer

Mollusca

Pelecypoda

Trigonia emoryi Conrad

Plicatula subgurgitis Böse

*Pteria pedernalis (Roemer)

Pecten (Neithea) occidentalis (Conrad)

P. (Neithea) texanus Roemer

*Inoceramus sp. aff. I. concentricus Parkinson

*Pinna comancheana Cragin

Ostrea subovata Shumard

*Exogyra plexa Cragin

E. texana Roemer

Gryphaea mucronata Gabb

*Lima pecosensis Stanton

L. (Mantellum) wacoensis Roemer

*Cyprimeria crassa Meek

Cyprimeria texana (Roemer)

C. sp.

*Cardium subcongestum Böse

*Isocardia medialis (Conrad)

*Protocardia securiformis (Cragin)

P. texana (Conrad)

*Anatina texana Cragin

Pholadomya sancti-sabae Roemer

*Tapes aldamensis Böse

*T. chihuahuensis Böse

T. gabbi Böse

*T. guadalupae Böse

*T. whitei Böse

Gastropoda

*Turbo? benbrookensis Stanton

*Calliostoma (Eutrochus) serratum Stanton

*Tylostoma chihuahuense Böse

*T. elevatum (Shumard)

*T.? formosum (Cragin)

*T. tumidum (Shumard)

*Turritella seriatim-granulata Roemer

*Cerithium bosquense Shumard

*Aporrhais kentensis Stanton

*A.? subfusiformis (Shumard)

*A. tarrantensis Stanton

*A. sp. B

Cephalopoda

Oxytropidoceras acutocarinatum (Shumard)

O. supani (Laşswitz)

**Engonoceras complicatum* Hyatt

E. pierdenale (von Buch)

**E. stolleyi* Böhm

Echinodermata

Echinoidea

Salenia mexicana Schlüter

Tetragramma sp.

Holectypus (*Caenholectypus*) *planatus* Roemer

**Hemiaster whitei* (Clark)

Enallaster mexicanus Cotteau

Kiamichi Formation

Name and type section.- Robert T. Hill (1891, p. 504, 515) applied the name "Kiamitia clays or *Schloenbachia* Beds" to a thick sequence of "marly clays, often stiff and black before oxidation, and accompanied by thousands of individuals of the variety of *Gryphaea pitcheri* [*G. navia*] so accurately figured by Marcou and White..." overlying the Goodland formation. The type locality is the plains of the Kiamichi River near Fort Towson, Choctaw County, Oklahoma.

In this report the name "Kiamichi" (changed from "Kiamitia" by the Board of Geographic Names, Adkins, 1933, p. 348) is used as originally defined by Hill, but because of the lithologic heterogeniety of the formation, the term "clays" is replaced with "formation".

Lithology and thickness.- In Tarrant County the Kiamichi formation consists principally of yellow and bluish-gray calcareous marls and a few thin, flaggy limestones and sandstones (Figs. 16, 17). The formation thins from about 35 feet in the northern part of the county (Loc. T-44) to about 27 feet in the southern part (Loc. T-16).

The Kiamichi is the most highly arenaceous formation of the Fredericksburg and Washita groups in the Fort Worth-Weatherford area. In the lower 15 feet there are numerous layers of fissile sandstones, many of them ripple-marked and containing iron minerals (Fig. 18). Interbedded with the sandstones are layers of black, waxy shale and hard, fossiliferous limestones. The middle part of the formation is much less arenaceous than the lower and upper parts and consists of marls and marly limestones with shell beds of Gryphaea navia Hall which occur at several levels. Most of the uppermost five feet consists of arenaceous marl.

Distribution.- In eastern Parker and western Tarrant counties the Kiamichi occurs in a narrow slope lying above the Goodland formation and leading up to the wide crests formed by the basal Duck Creek limestone (Pls. 1, 2). Although the formation is generally missing when not protected by a cap of Duck Creek limestone, several Kiamichi knobs without limestone caps may be seen about two miles north of U. S. Highway 80-180 east of Texas Farm Road 5 in Parker County. Typically the Kiamichi is deeply weathered, and the soil supports a heavy grass cover.

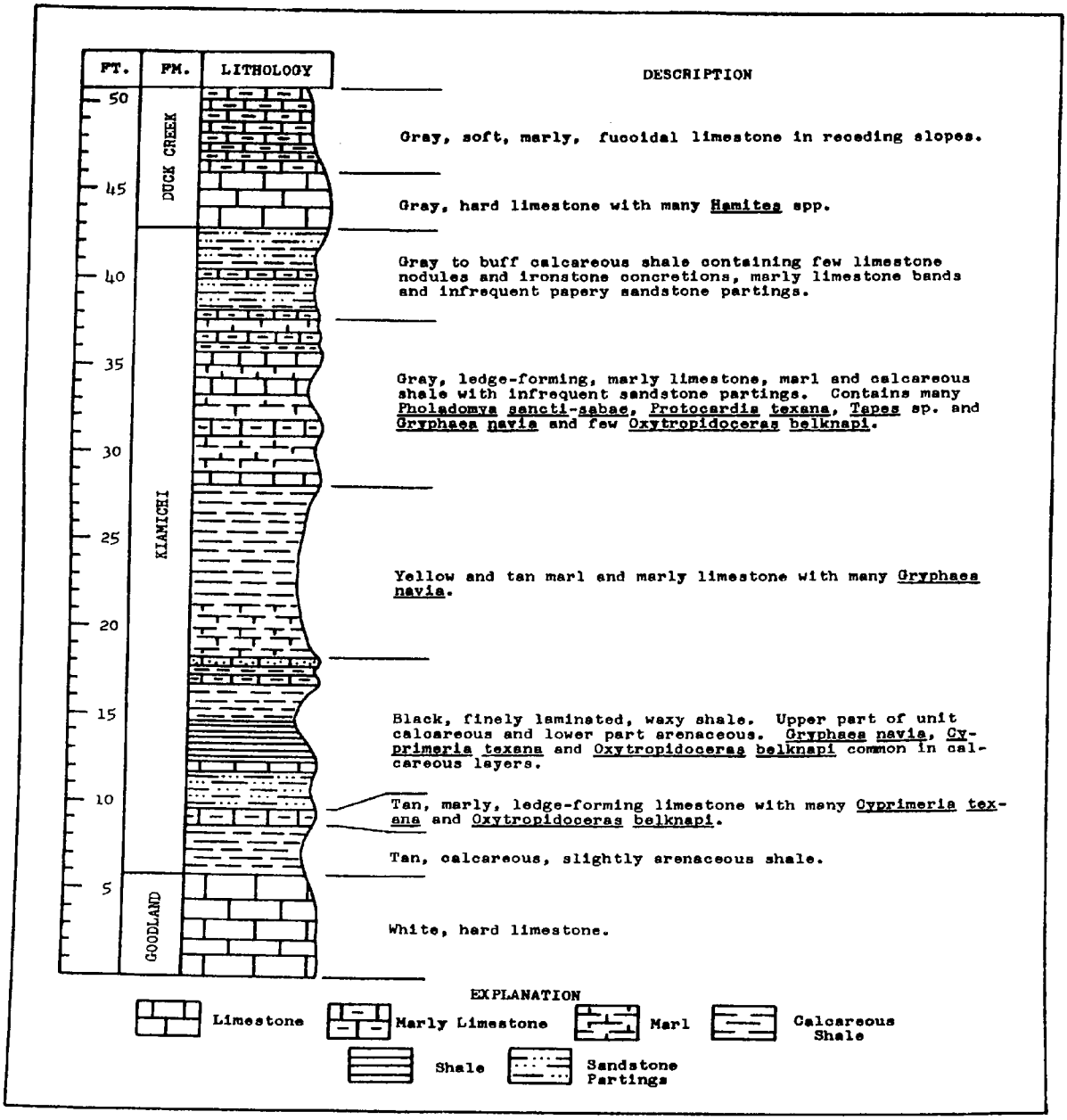


Figure 16. Graphic section of the Kiamichi formation in bluff southwest of Meacham Field, Tarrant County (Locality T-44).



Figure 17. View of the Kiamichi formation in a roadcut of Texas Highway 183 at its intersection with the Jacksboro Highway, Fort Worth (Locality T-73). Man's hand rests on the basal limestone of the Duck Creek formation.



Figure 18. Thin, fissile, ripple marked sandstone in the lower part of the Kiamichi formation southeast of Benbrook, Tarrant County.

Two notable exposures in which the complete thickness can be seen are a southwestward facing bluff at the southwest corner of Meacham Field (Loc. T-44) and a roadcut of Highway 183 just east of its intersection with the Jacksboro Highway (Loc. T-73; Fig. 17).

Structural relationships.- The basal blue marl of the Kiamichi rests with apparent conformity on the Goodland formation. This contact is quite pronounced throughout Tarrant and Parker counties and is easily discernable as the line at the top of the white limestone slope of the Goodland and the base of the grassy slope of the Kiamichi.

According to Adkins (1933, p. 349) the Kiamichi is possibly unconformable with the overlying Duck Creek formation. He cites as evidence: (1), the report of W. M. Winton and Gayle Scott that rounded pebbles and transported debris occur at this contact in the Fort Worth area; and (2), the absence of the formation south of McLennan County with an unconformable relationship between the Edwards (the central Texas equivalent of the upper part of the Goodland formation) and Duck Creek. Thompson (1935, p. 1521) also reports pebbles from the Kiamichi-Duck Creek contact in Tarrant County. During the present survey, careful examination of the contact at numerous localities in the area failed to reveal any conclusive evidence to support the existence of an unconformity between the Kiamichi and Duck Creek.

Faunal list.- The following fossils have been identified by the author from the Kiamichi formation in the Fort

Worth-Weatherford area. Those species which appear to be limited to the Kiamichi formation on the basis of the author's collections are marked with an asterisk.

Mollusca

Pelecypoda

Cucullaea recedens Cragin

Plicatula subgurgitis Böse

Pecten (*Neithea*) *occidentalis* (Conrad)

Inoceramus comancheanus Cragin

Ostrea subovata Shumard

**Gryphaea navia* Hall

Cyprimeria texana (Roemer)

Protocardia texana (Conrad)

Homomya sp.

Pholadomya sancti-sabae Roemer

Tapes gabbi Böse

Cephalopoda

Oxytropidoceras acutocarinatum (Shumard)

**O. belknapi* (Marcou)

Echinodermata

Echinoidea

Enallaster mexicanus Cotteau

Washita Group

Robert T. Hill (1887a, p. 298) originally defined the "Washita group" as the upper division of the Comanche series, consisting of limestones, sandstones, shales, and marls,

unconformably underlying the Timber Creek group [Woodbine sandstone] and overlying the Fredericksburg group. The group is named for old Fort Washita, Bryan County, Oklahoma.

Later (1887b, p. 303) Hill provisionally placed the boundary between the Washita and Fredericksburg groups at the base of the Kiamichi. Although this is the boundary accepted by the United States Geological Survey (Wilmarth, 1938, p. 2282), Adkins (1933), Scott (1933), Lozo (1944), the author, and others place the lower boundary at the top of the Kiamichi for reasons cited on page 19. In other respects the definition of the group is accepted as originally given by Hill.

Duck Creek Formation

Name and type section.- This formation was originally named the "Duck Creek chalk" by Robert T. Hill (1891, p. 504, 516). In the type area on the southern slope of Duck Creek north of Denison, Grayson County, Texas the formation is about 120 feet thick and consists of white chalky limestone and chalky marls. In the type area it is overlain by the Fort Worth limestone and underlain by the Kiamichi formation. In his report of 1901 Hill used the name "Duck Creek formation" for these beds.

Winton and Adkins (1920, p. 39-49) divided the Duck Creek formation in the Fort Worth area into four members and suggested restricting the name "Duck Creek" to the two lower members. Because the upper two members are paleontologically very similar to the Fort Worth limestone, they recommended

inclusion of these two members with this limestone.

In this report the name "Duck Creek" is used as originally defined by Hill, but because of the lithologic heterogeniety of the formation, the term "chalk" is replaced with "formation".

Lithology and thickness.- In Tarrant and Parker counties the Duck Creek formation consists of a lower thickly bedded fucoidal limestone and an upper marl with interbedded thin marly limestone (Figs. 19, 20).

The total thickness of the Duck Creek formation ranges from an estimated 60 feet in the northern part of Tarrant County to about 50 feet in the southern part. In north central Tarrant County (Loc. T-25) the lower thickly bedded limestone is about 45 feet thick, and the upper marl is estimated to be about 15 feet thick. In the southwestern part of the county (Loc. T-69) the lower limestone is 40 feet thick and the upper marl 13 feet thick.

The formation is characterized by an abundance of massive branching objects known as fucoids (Figs. 21, 22). They are so abundant in the lower limestone that they greatly obscure the bedding and impart a distinctive lumpiness to individual limestone beds. The fucoids do not weather out in most exposures. In the quarry of the Trinity Portland Cement Company in north Fort Worth, however, it is possible to examine fairly fresh cuts in which the fucoids are quite obvious. On many of the quarry faces and slumped blocks weathering has progressed sufficiently to cause the individual

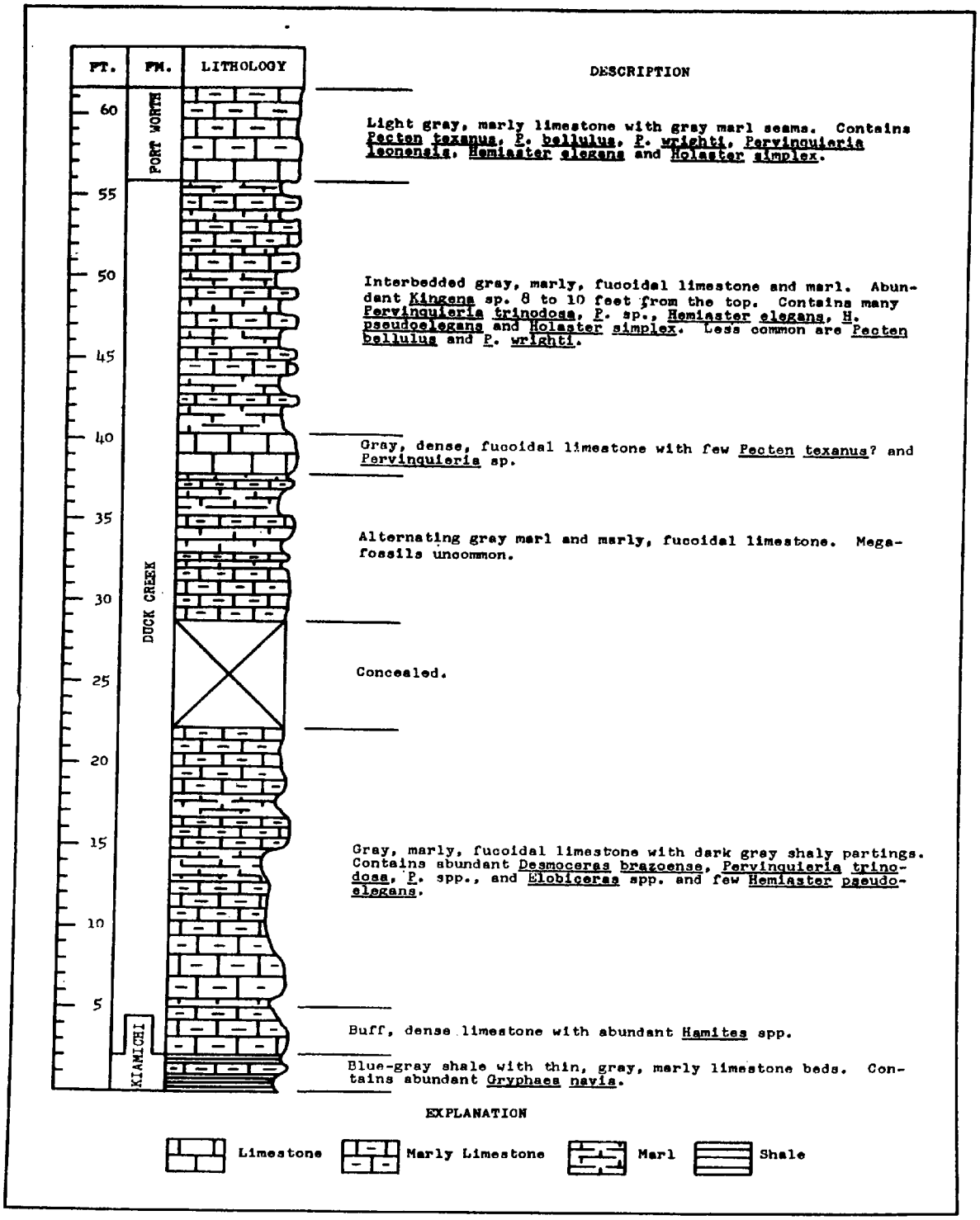


Figure 19. Graphic section of the Duck Creek formation in outs along the Sante Fe Railroad and in the Feltz Ranch quarry, southwestern Tarrant County (Localities T-69, T-68).

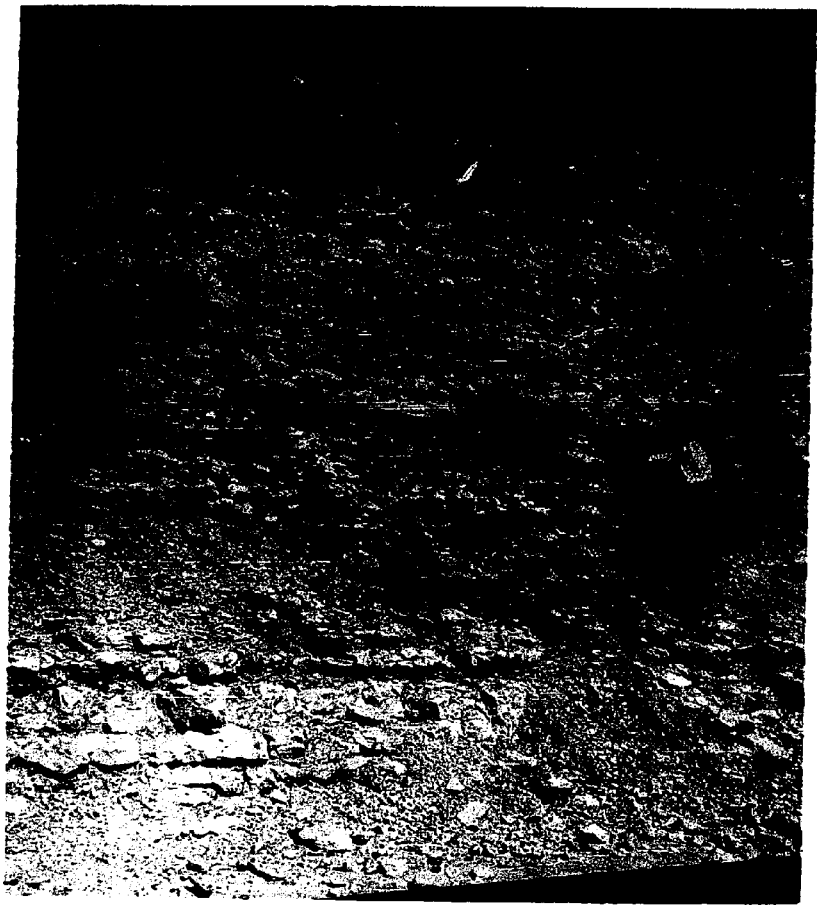


Figure 20. View of the middle part of the Duck Creek formation in a cut of the Santa Fe Railroad, southwestern Tarrant County (Locality T-69). See Figure 19 for graphic section.

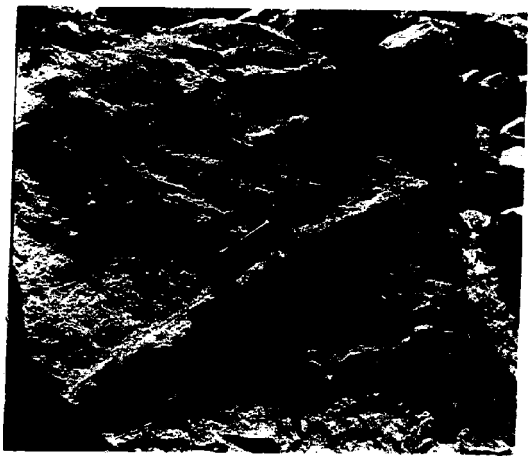


Figure 21. Slab of Duck Creek limestone showing several large fucoids, Trinity Portland Cement Company quarry, Fort Worth, Tarrant County (Locality T-25).

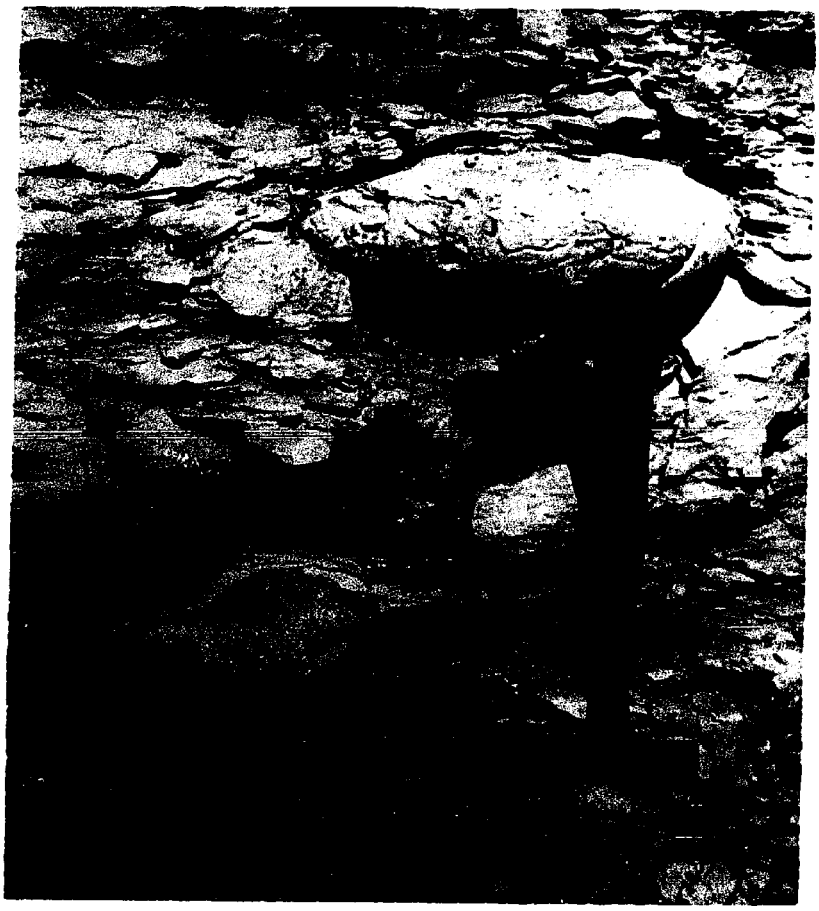


Figure 22. View of a large fucoid (left of pick) in transverse section and a large specimen of Desmoceras brazoense (Shumard) in place (above pick) in the middle Duck Creek formation (Locality T-69). See Figures 19, 20.

fucoids to stand in low relief. In the lower one to two feet of the formation the fucoids are separated by seams of blue shale having a maximum thickness of two inches. Higher in the formation the shale seams become progressively thinner and are absent five feet above the base; from this level to the upper marl the bulk of the limestones is fucoidal material. Thin sections of numerous fucoids have revealed no recognizable internal structure. Although some workers have suggested a plant origin for fucoids, their genesis is not yet established.

Much of the lower part of the formation consists of casts of the very large ammonite Desmoceras brazoense (Shumard) (Fig. 22).

The upper 13 to 15 feet of the formation consists of alternating thin gray marls and gray marly limestones. Fucoids are much less abundant here than in the lower part; small specimens one-half to one inch in diameter, however, are not uncommon.

Distribution.- In eastern Parker and western Tarrant counties the Duck Creek is topographically the highest formation (Pls. 1, 2). It occurs along the crests of the highest ridges and underlies the broad expanses of upland prairie in that area. Here, only the lower limestones of the formation occur and form small escarpments above the gentle slopes of the Kiamichi.

In central Tarrant County the formation crops out in a band from the city of Fort Worth southwestward along the

southeastern side of the Trinity River. In this region the formation is a slope-former with steep slopes developed on the lower limestones and gentle slopes on the upper marls leading up to the miniature escarpment of the Fort Worth limestone.

Structural relationships.- The Duck Creek formation is possibly unconformable with the subjacent Kiamichi formation, as described above, and is apparently conformable with the overlying Fort Worth limestone.

Faunal list.- The following fossils have been identified by the author from the Duck Creek formation in the Fort Worth-Weatherford area. Those species which appear to be limited to the Duck Creek formation on the basis of the author's collections are marked with an asterisk.

Brachiopoda

Kingena wacoensis (Roemer)

Mollusca

Pelecypoda

Plicatula subgurgitis Böse

Pecten (Neithea) bellulus Cragin

P. (Neithea) subalpinus (Böse)

P. (Neithea) texanus Roemer

Inoceramus comancheanus Cragin

Ostrea subovata Shumard

Lima (Mantellum) wacoensis Roemer

Cephalopoda

*Hamites comanchensis Adkins and Winton

*H. fremonti Marcou

*H. nokonis Adkins and Winton

*H. varians Scott

*Desmoceras brazoense (Shumard)

*Pervinquieria trinodosa (Bose)

Echinodermata

Echinoidea

*Goniophorus scotti (Lambert)

Hemiaster (Macraster) elegans subobesus (Adkins)

*H. (Macraster) elegans washitae (Lambert)

Fort Worth Limestone

Name and type section.- Hill applied the name "Fort Worth or Washita limestone" in 1889 (p. xiv, xxi, xxii) to the limestone resting on the upper Caprotina limestone (Fredericksburg) and underlying the Exogyra arietina clays. Hill later (1891, p. 516) restricted the name to the limestone overlying the Duck Creek chalk and underlying the Denison beds and indicated that typical exposures of the formation occur near the public square and in numerous quarries and railroad cuts in Fort Worth, Texas. This later definition of Hill is the one currently accepted by the United States Geological Survey (Wilmarth, 1938, p. 763) and is the one followed in this report.

Lithology and thickness.- In Tarrant County the Fort

Worth limestone is about 32 feet thick. It is especially well exposed at the intersection of Riverside and Lancaster drives where the formation consists of regularly alternating dense, gray limestone beds, six to twelve inches thick, and gray marls, two feet or less in thickness (Figs. 23, 24). The limestones making up the upper and lower ten feet of the formation are more marly (18 to 24 per cent acid-insoluble) than those in the middle ten feet which contains less than five per cent acid-insoluble material. The boundaries between the limestone and marl beds are somewhat gradational.

Masses of fucoids give some of the limestone beds a lumpy or indistinctly bedded appearance. Most of the fucoids in the Fort Worth limestone are smaller than those found in the Duck Creek formation. The largest specimen observed was about ten inches in diameter (Fig. 25); most specimens are about one to two inches in diameter.

Distribution.- The Fort Worth limestone underlies an upland prairie of variable width extending northeast-southwest through Tarrant County (Pl. 2). In the Fort Worth area this prairie ranges from one-half to two miles in width and extends southwestward from the city of Fort Worth along the northwest side of the Gulf, Colorado, and Santa Fe Railroad to Benbrook Lake. The western limit of this prairie is indistinctly marked by a small escarpment which is only a few feet high and below which the upper Duck Creek marls form a gentle slope. The eastern limit is even less distinct but vaguely recognizable at the base of the very gentle slope

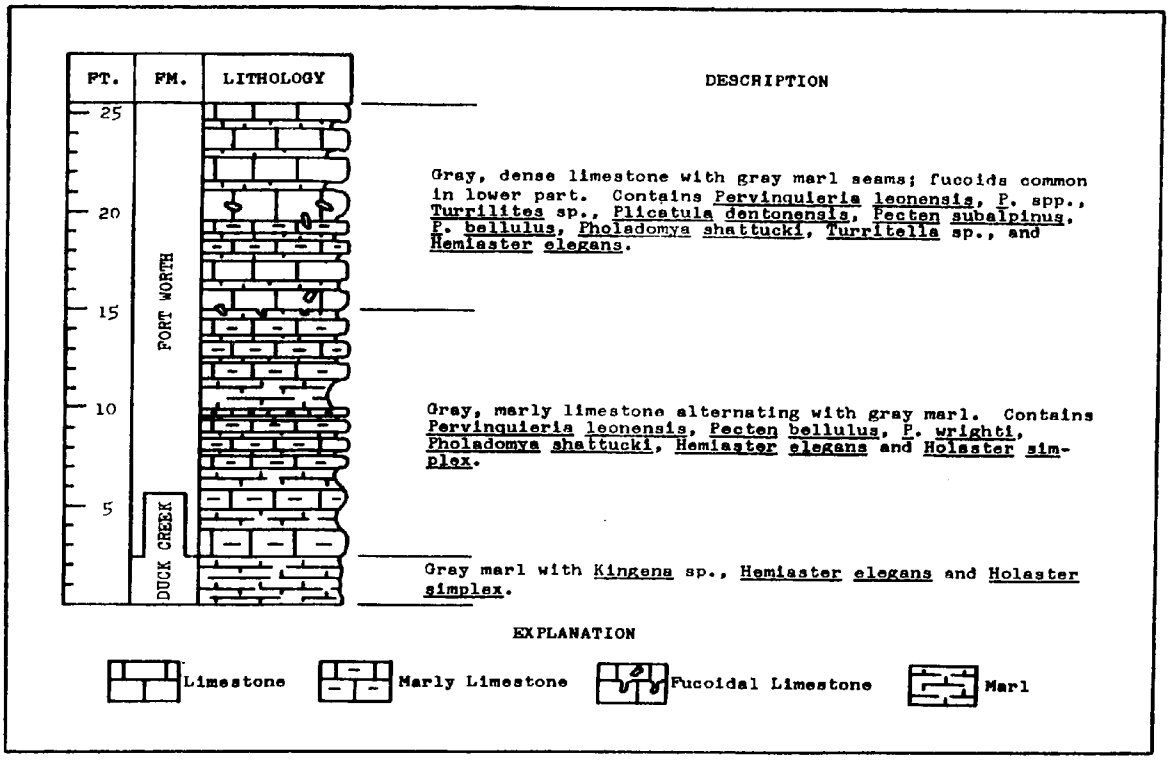


Figure 23. Graphic section of the Fort Worth limestone in bluffs on south side of the intersection of Lancaster and Riverside drives, Fort Worth, Tarrant County (Localities T-43, T-30).

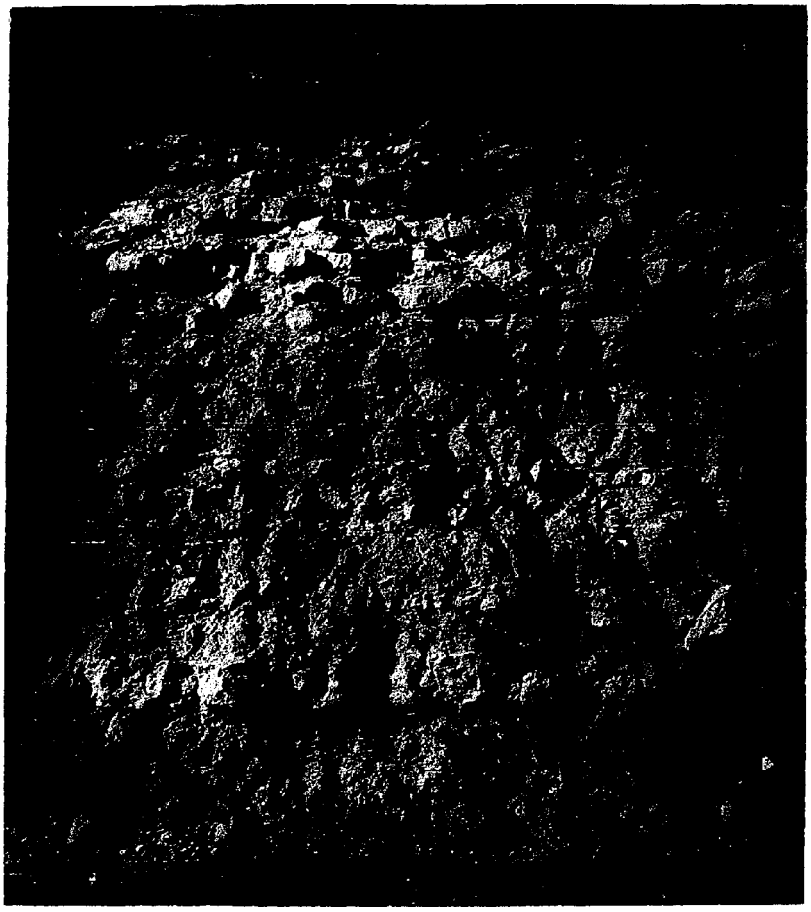


Figure 24. View of the Fort Worth limestone on the southwest corner at the intersection of Lancaster and Riverside drives, Fort Worth (Locality T-43). See Figure 23 for graphic section.

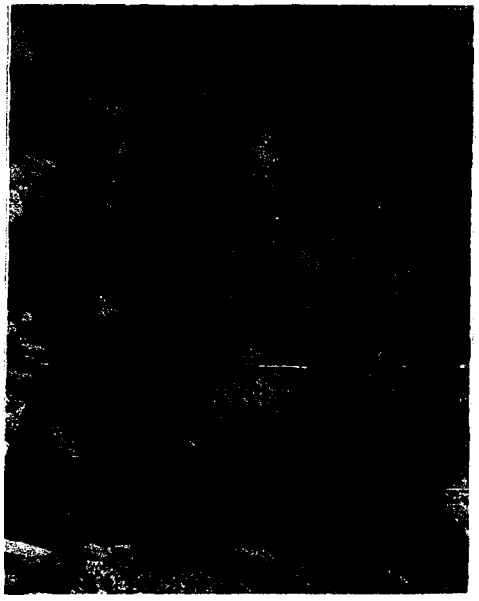


Figure 25. Large fucoid from the Fort Worth limestone in a cut of the Sante Fe Railroad, southwestern Tarrant County (Locality T-69).



Figure 26. View of the Fort Worth limestone showing typical appearance in a weathered exposure. West bank of Sycamore Creek in Cobb Park, Fort Worth (Locality T-5). Compare with view of fresh exposure in Figure 24.

developed on the Denton marls, which lead up to the more resistant limestones of the Weno. The northwest margin of the Fort Worth upland is deeply notched where the headwaters of small tributaries of the Trinity River cross the Fort Worth limestone-Duck Creek marl boundary.

In Cobb, Sycamore, and Glenwood parks in east central Fort Worth the Fort Worth limestone crops out in the bed and banks of Sycamore Creek and some of its tributaries. In bluffs along the streams, the limestone beds form resistent projecting shelves, and the marls are deeply incised (Fig. 26).

Structural relationships.- The Fort Worth limestone is apparently conformable with both the underlying Duck Creek formation and the overlying Denton marl member of the Denison formation.

Faunal list.- The following fossils have been identified by the author from the Fort Worth limestone in the Fort Worth-Weatherford area. Those species which appear to be limited to the Fort Worth limestone on the basis of the author's collections are marked with an asterisk.

Brachiopoda

Kingena sp.

Mollusca

Pelecypoda

Trigonia emoryi Conrad

Plicatula dentonensis Cragin

Pecten (*Neithea*) *bellulus* Cragin

Pecten (Neithea) subalpinus (Böse)

P. (Neithea) texanus Roemer

P. (Neithea) wrighti (Shumard)

Lopha (Arctostrea) colubrina (Lamarck)

Ostrea subovata Shumard

Gryphaea washitaensis Hill

Lima (Mantellum) wacoensis quadrangularis Stanton

Cyprimeria sp.

Protocardia multistriata Shumard

*Homomya kellumi Perkins, sp. nov.

Pholadomya shattucki Böse

Gastropoda

Pleurotomaria (Leptomaria) austinensis Shumard

*Turritella leonensis Conrad

Cephalopoda

Cymatoceras loeblichi Miller and Harris

C. hilli (Shattuck)

*Turrilites sp.

*Pervinquieria kiliani (Lasswitz)

*P. leonensis maxima (Lasswitz)

*P. sp. aff. P. aguilerae (Böse)

*Engonoceras sp. A

Echinodermata

Echinoidea

Hemiaster (Macraster) elegans Shumard

H. (Macraster) elegans subobesus (Adkins)

H. (Macraster) elegans washitae? (Lambert).

Enallaster mexicanus Cotteau

Holaster simplex Shumard

Denison Formation

Name and type section.- Hill (1889c, p. xxiv) first used the name "Denison beds" for the "alternations of clays and impure limestone containing an abundant littoral fauna" succeeding the "Washita limestone" north of Denison, Grayson County, Texas. In 1887 (1887b, p. 298, 299) he used "Upper Denison Fauna" for the thin limestones, sandstones, and shales at the top of the Washita division of the Comanche series. In 1889 (1889c, p. 290) he included "Denison beds" as the uppermost unit of the Washita division apparently applying the name to the same alternating sequence as before. Again, in 1891 (p. 517), Hill applied the name to the same strata and also gave for the first time a brief lithologic description. He stated that the Denison beds consist of three divisions: (1), the basal beds which are blue marly clays weathering brown, "with occasional layers of immense, rounded, fissile indurations, generally brown in color"; (2), the middle beds which are sandier and more ferruginous; and (3), the upper bed which is an impure yellow limestone and "which underlies Main Street in Denison".

In 1894 (p. 328-331) Hill redefined "Denison beds" naming four members as (in ascending order) the Marietta marls, the North Denison sands, the Paw Paw shales, and the Main Street limestone. He also stated that the beds overly the Fort Worth limestone and underly unconformably the Dakota

sandstone [Woodbine sandstone of present usage].

In 1901 Hill (p. 115, 266-288) again redefined the "Denison beds" formally naming the three division (in ascending order) the Denton Subgroup, the Weno Subgroup, and the Pottsboro Subgroup. The formations he assigned to each group are shown in Figure 3.

L. W. Stephenson (1918) restudied the type area for the Denison beds and proposed the following revisions. (1) The replacement of the name "Denison beds" by "Denison formation". (2) The abandonment of the three subgroup names. (3) The abandonment of the name "Marietta" which is preoccupied (Wilmarth, 1938, p. 1299). (4) The use of the following names for the members of the Denison formation (in ascending order): (a), Denton clay member (formerly Denton subgroup); (b), Weno clay member (formerly Weno formation of Weno subgroup); (c), Pawpaw sandy member (formerly Pawpaw beds of Weno subgroup); (d), Main Street limestone member (formerly of Pottsboro subgroup); and (e), Grayson marl member (formerly Grayson marls of Pottsboro subgroup).

Winton and Adkins (1920) in their study of Tarrant County did not use the name Denison formation in the area but raised the members as defined by Stephenson to formational rank.

In the Tarrant County area the units recognized by Hill, Stephenson and others in Grayson County are distinguishable though of somewhat different lethology and thickness. For this reason it seems practicable to refer these strata in Tarrant County to the Denison formation and the respective

members as defined by Stephenson.

Denton Marl Member

Name and type section.- The name "Denton marl" was used by J. A. Taff (1893, p. 272) to apply to a forty foot marl and shell bed sequence on Denton Creek, Denton County, Texas. A history of the usage of this name, which is presently used in the sense intended by Taff, is given by Wilmarth (1938, p. 598).

Lithology and thickness.- In Tarrant County the Denton marl member is about 35 feet thick consisting of gray marly limestone, gray marl, and weakly consolidated shell beds located near the top of the member (Figs. 27-31).

Distribution.- The Denton marl is best exposed in Tarrant County along Sycamore Creek from Cobb Park south to Seminary Drive (Pl. 1). It crops out in the creek banks, and at some points the harder marly limestone bands and the shell beds form the creek bottom. The member also occurs southwest of the Old Granbury Road. In this area exposures are poor, and the member is recognized only as a gentle slope-former leading from the uppermost Fort Worth limestone beds up to the fairly resistant basal Weno limestones.

Weno Marly Limestone Member

Name and type section.- Hill (1901, p. 121, 274) first used the name "Weno formation" in reference to "Impure clays with occasional thin strata of sandstone and limestone" overlying the Denton shell bed and underlying the Quarry

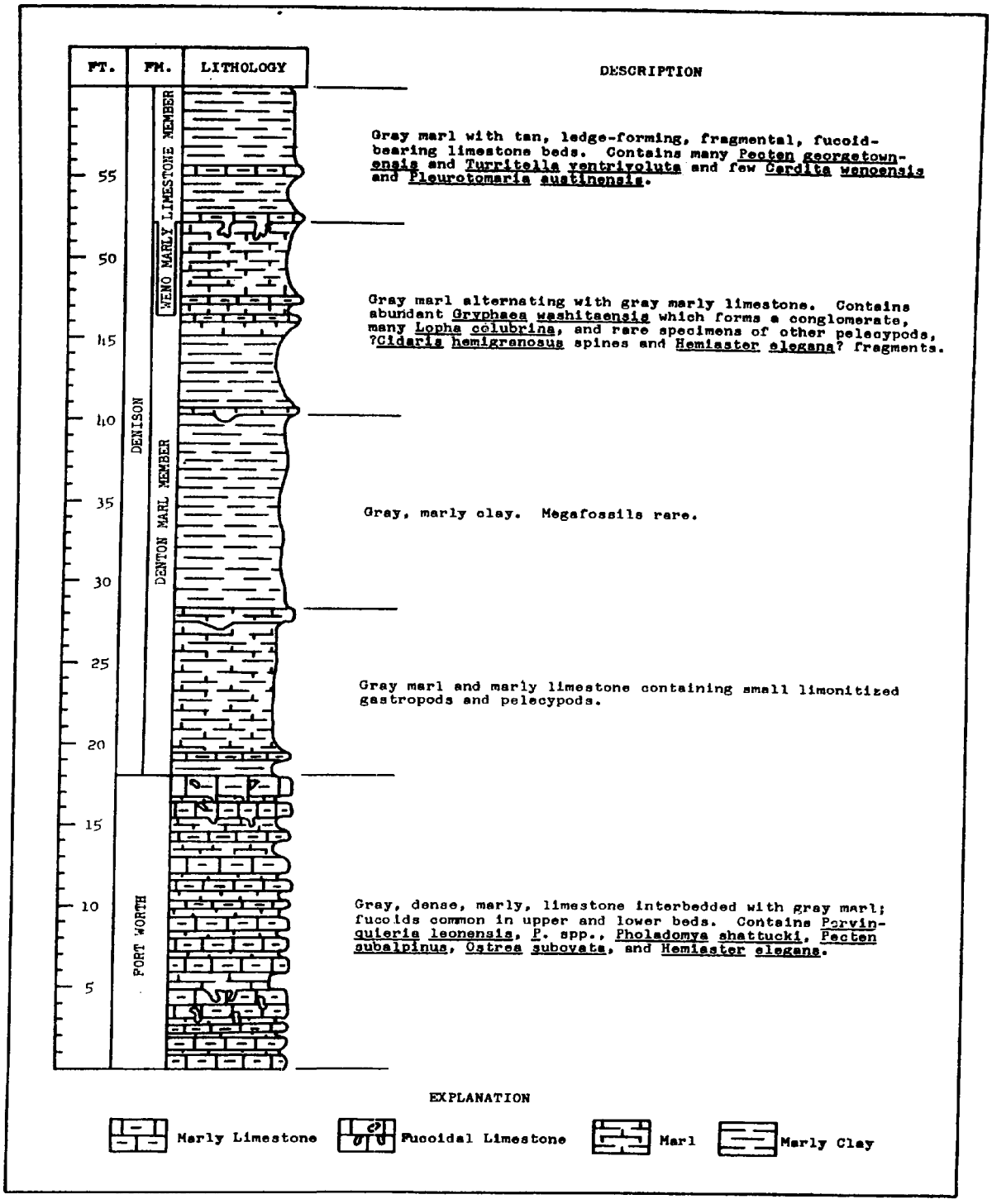


Figure 27. Graphic section of the Denton marl member of the Denison formation in east bank of Sycamore Creek, Cobb Park, Fort Worth (Locality T-3).



Figure 28. View of Denton marl member of Denison formation in east bank of Sycamore Creek, Cobb Park, Fort Worth (Locality T-3). Denton marl-Weno marly limestone contact indicated by arrow. See Figure 27 for graphic section.

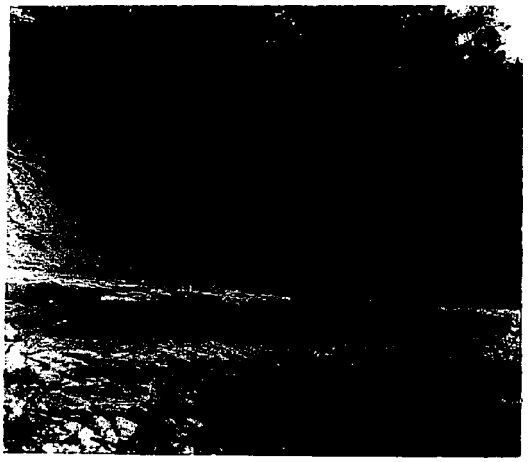


Figure 29. Fort Worth limestone-Denison formation (Denton marl member) contact at base of bluff shown in Figure 28 (Locality T-3). Pick rests on upper limestone of the Fort Worth.



Figure 30. Gryphaea washitaensis shell bed in the upper Denton marl member of the Denison formation on Sycamore Creek north of Seminary Drive bridge, Fort Worth (Locality T-37).

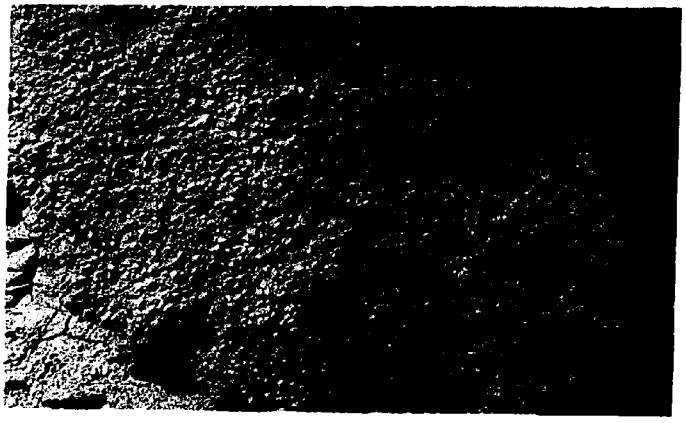


Figure 31. Limestone slab from the Gryphaea washitaensis shell bed of the Denton marl showing a layer comprised entirely of shells of young individuals (Locality T-37).

limestone near Weno, Grayson County, Texas. In the type area this member, which is the basal formation of Hill's Weno subgroup, is about 92 feet thick.

Lithology and thickness.- In the Fort Worth area the Weno largely consists of gray marl with several thick limestone beds in its uppermost and lowermost parts. In this area the member is about 50 feet thick (Figs. 32, 33).

The lower part of the member is more marly than the upper part, where the limestone beds are thick and numerous. The limestones throughout the member vary from very hard to soft marly limestones, are more fossiliferous than the marls, and at several levels are partly fucoidal.

Distribution.- The Weno marly limestone member is best exposed in the Fort Worth area along Sycamore Creek, especially south of Riverside Drive to U. S. Highway 81 (Pl. 2). From Seminary Drive southward the member is well exposed in the creek banks, and the harder limestones form the stream bed. The Weno also crops out between Sycamore Creek and the Old Granbury Road. In this area good exposures are few in number, and the Weno is distinguishable only topographically by the small slopes and benches developed on the alternating marls and harder limestones of the member.

Many small waterfalls are developed along the headwaters of the small tributaries to Sycamore Creek where these streams flow across the more resistant beds of the member.

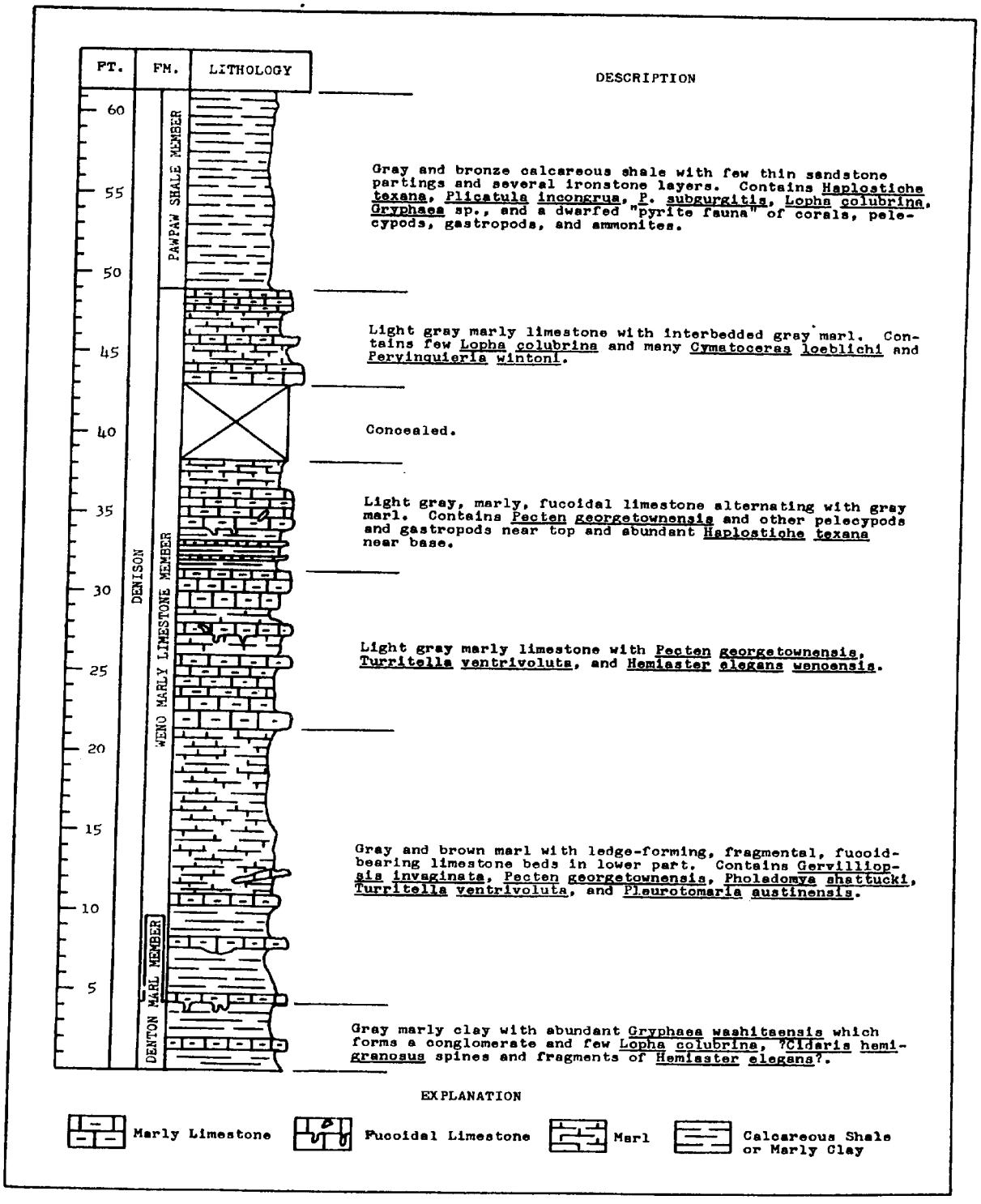


Figure 32. Graphic section of the upper Denton marl, Weno marly limestone and Pawpaw shale members of the Denison formation on Sycamore Creek at Seminary Drive (Localities T-37, T-18, T-61, T-19).

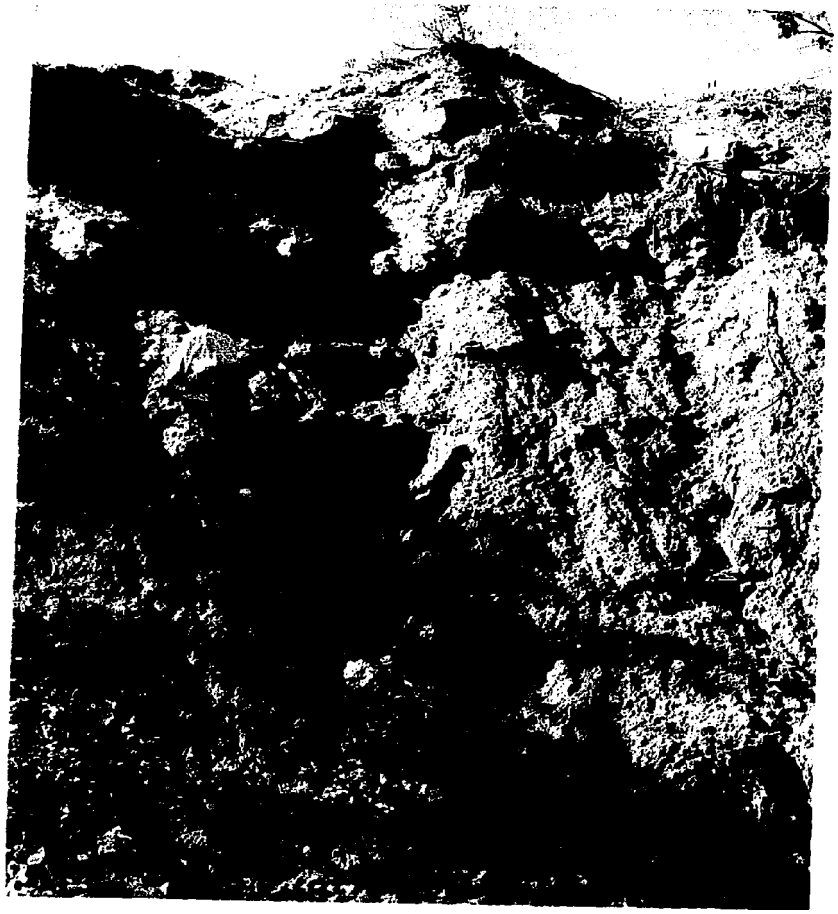


Figure 33. View of the middle part of the Weno marly limestone member of the Denison formation in bank of creek south of Seminary Drive, Amon Carter Parksite, Fort Worth (Locality T-61). See Figure 32 for graphic section.

Pawpaw Shale Member

Name and type section.- Hill (1894, p. 302, 303, 328-335) first used the name "Paw Paw clays" for the beds overlying the North Denison sands and underlying the Main Street limestone on Pawpaw Creek in Denison, Grayson County, Texas. In 1901 (p. 121, 276) he retained his first definition but placed the Pawpaw in the Weno subgroup. The member was redefined by Stephenson (1918, p. 142) to include, basally, the arenaceous Quarry limestone, which does not occur south of the Red River area.

In Tarrant County the name "Pawpaw" is applied to the shale sequence lying between the Weno marly limestone and the Main Street limestone.

Lithology and thickness.- The Pawpaw shale member thins rapidly from 30 feet at the northern border of Tarrant County to about 12 feet at the southern border (Winton and Adkins, 1920, p. 67). In south-central Tarrant County east of Sycamore Creek along Seminary Drive (Loc. T-19), where the entire thickness is exposed, the member is about 17 feet thick (Figs. 34, 35).

In the Fort Worth area the member is of relatively uniform lithology, consisting of gray and bronze-colored calcareous shale with scattered sandstone partings and ironstone lentils and concretions. The upper two feet of the member are much less calcareous than the lower part and contain numerous small fucoids and small ironstone lenses. In the upper two to four feet of the member shell beds of Lopha

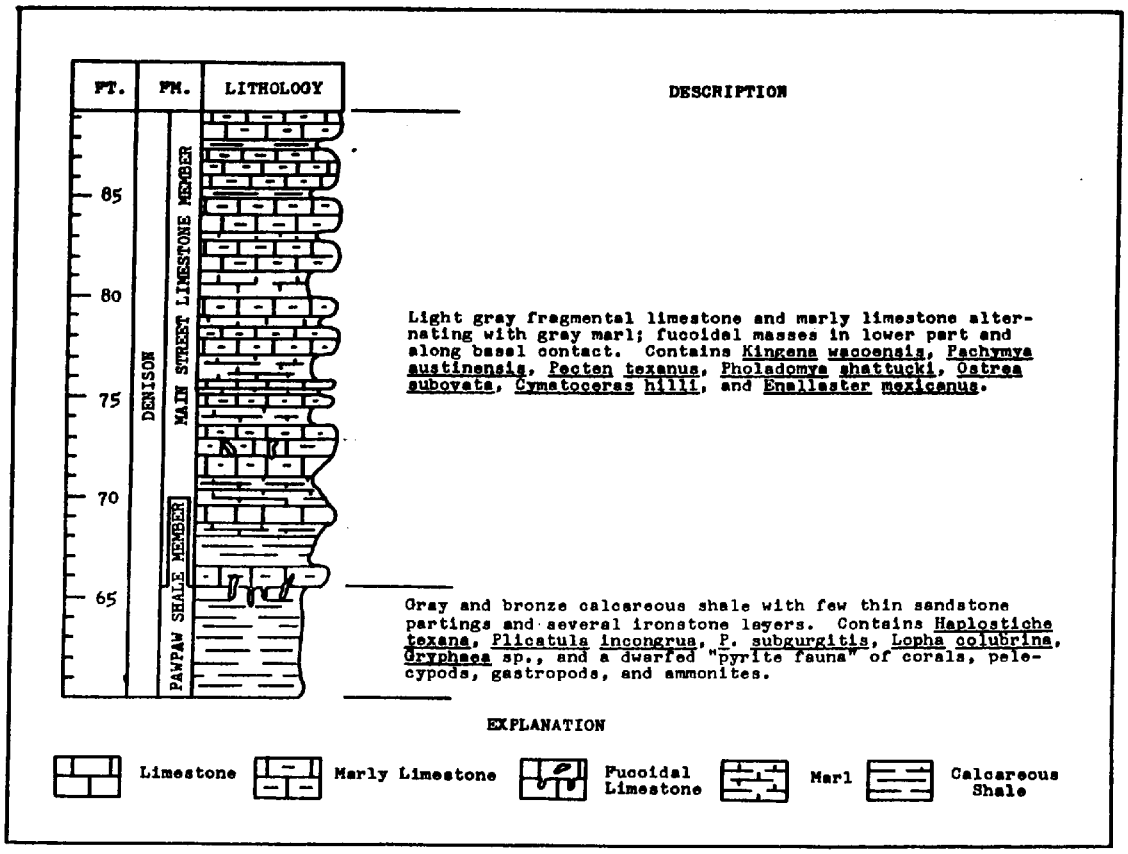


Figure 34. Graphic section of the upper Pawpaw shale and Main Street limestone members of the Denison formation on Seminary Drive east of Sycamore Creek, Tarrant County (Locality T-19).



Figure 35. View of Pawpaw shale and Main Street limestone members of the Denison formation on Seminary Drive east of Sycamore Creek, Tarrant County (Locality T-19).

colubrina (Lamarck) and tests of the large foraminifera Haplostiche texana (Conrad) occur in an ironstone matrix. The shell beds are discontinuous biohermal masses only two or three feet in maximum diameter and less than a half foot thick.

Distribution.- The Pawpaw is best exposed in the Fort Worth area in discontinuous outcrops along Sycamore Creek from Cobb Park south to the crossing of the Crowley Road (Pl. 2). It is especially well exposed on Seminary Drive east of Sycamore Creek (Loc. T-20) and on the Lester Weatherby Ranch east of the Crowley Road (Loc. T-59).

West of Sycamore Creek and southeast of the Old Granbury Road the Pawpaw underlies a narrow gentle slope leading from the uppermost Weno limestone bed to the basal Main Street limestone. A reddish brown soil formed by weathering of the member characterizes these gentle slopes.

Main Street Limestone Member

Name and type section.- Hill (1894, p. 302, 303, 317, 328-331) originally proposed the name "Main Street limestone" (after Main Street in Denison, Grayson County, Texas) for the uppermost member of the Denison beds and by his definition included the Main Street limestone and Grayson marl members as later defined. In the same year Cragin (1894, p. 41-48) divided Hill's Main Street limestone into two members giving the name "Grayson marl" to the upper, yellow, calcareous, arenaceous and fossiliferous marl member and "Choctaw limestone" to the lower, fossiliferous, quarry lime-

stone member. In 1901 Hill (p. 114, 115, 121-124, 245, 256-259, 266-271, 280-288) redefined "Main Street limestone" restricting the name to the lower limestone sequence, displacing the name "Choctaw", and retained the name "Grayson marl" for the upper member. This later definition has been followed consistently by subsequent workers (Wilmarth, 1938, p. 863; Stephenson, et al, 1942) and is the one used in the present report.

Lithology and thickness.- In Tarrant County the Main Street limestone thickens southward from about 20 feet at the northern border to more than 40 feet at the southern. East of Sycamore Creek at Seminary Drive (Loc. T-19) the member is about 32 feet thick (Figs. 34, 35). As exposed here the member is composed principally of alternating thickly bedded marly limestones and thin marl and marly clay beds. In the lower eight feet the marls and marly clays are more thickly bedded than higher in the member. The upper 12 feet of the member are not well exposed at this locality, but in an outcrop on Village Creek (Loc. T-62) the upper beds consist of the same alternations of thickly bedded marly limestones and thin marls as noted in the upper part of the section at locality T-19.

Throughout the member the beds of marly limestone are light gray to buff in color, are clastic in nature, and contain a limited number of large masses of pyrite (Fig. 35). They are indistinctly bedded, and at several localities this feature appears to be the result of the fact that the lime-

stones are composed of masses of the plant-like fossils, fucoids. Fucoids are expecially concentrated in the basal limestone bed and to a point about eight feet above the base. The marls are light gray to yellow in color and contain fucoids ranging in size from one-half to four inches in diameter.

Distribution.- The Main Street limestone member underlies a broad upland prairie along the eastern side of Sycamore Creek from Fort Worth southward (Pl. 2). The prairie gradually increases in width from north to south. The western border of the outcrop is marked by a prominent dendritic escarpment along Sycamore Creek. The Main Street prairie is continuous with that developed to the east on the Grayson marl. No topographic expression marks the contact between the two members.

Southeast of the Old Granbury Road the Main Street limestone forms the divide separating the drainage of Sycamore Creek from that of the Trinity River.

Grayson Marl Member

Name and type section.- This member was originally named by F. W. Cragin as noted on page 71. The member was described by Hill (1901, p. 114, 115, 121-124, 245, 246-249, 266-271, pls. 7, 18) as gray marls, lighter in color than the Main Street limestone, 15 to 60 feet thick, and as forming the uppermost member of the Denison formation. The type locality is generally considered to be a railroad cut in southeastern Denison, Grayson County (Hill, 1901, p. 237).

Lithology and thickness.- In the Fort Worth area the Grayson marl member is about 80 feet thick and is divisible into four easily recognizable subdivisions (Figs. 36-40). In ascending order the member consists of: (1), a lower yellowish-gray marl 18 feet thick with abundant Exogyra arietina Roemer, containing in the lower three to five feet a small number of lenticular bodies of hard, highly fossiliferous, clastic limestone about five to eight feet long and one foot in maximum thickness; (2), an unfossiliferous yellow to greenish-gray marly clay 24 feet thick; (3), a highly fossiliferous gray marl 21 feet thick with buff marly limestone and clay; and (4), a greenish-gray marly clay less fossiliferous than the underlying unit.

Distribution.- The Grayson marl member crops out on a broad open prairie along the western edge of the timbered belt of the Woodbine sandstone in eastern Tarrant County (pl. 2). Good exposures are rare, and to the author's knowledge a complete section is not exposed in the county. A very good exposure, however, is located at Grayson Bluff north-northeast of Roanoke in Denton County (Loc. T-26). The member is generally covered with debris washed from the Woodbine sandstone; because of this debris cover it is difficult to accurately locate and map the upper limit of the member.

The lower four or five feet of the member and its contact with the Main Street limestone member may be seen along Village Creek just south of Polly Webb Road (Loc. T-62).

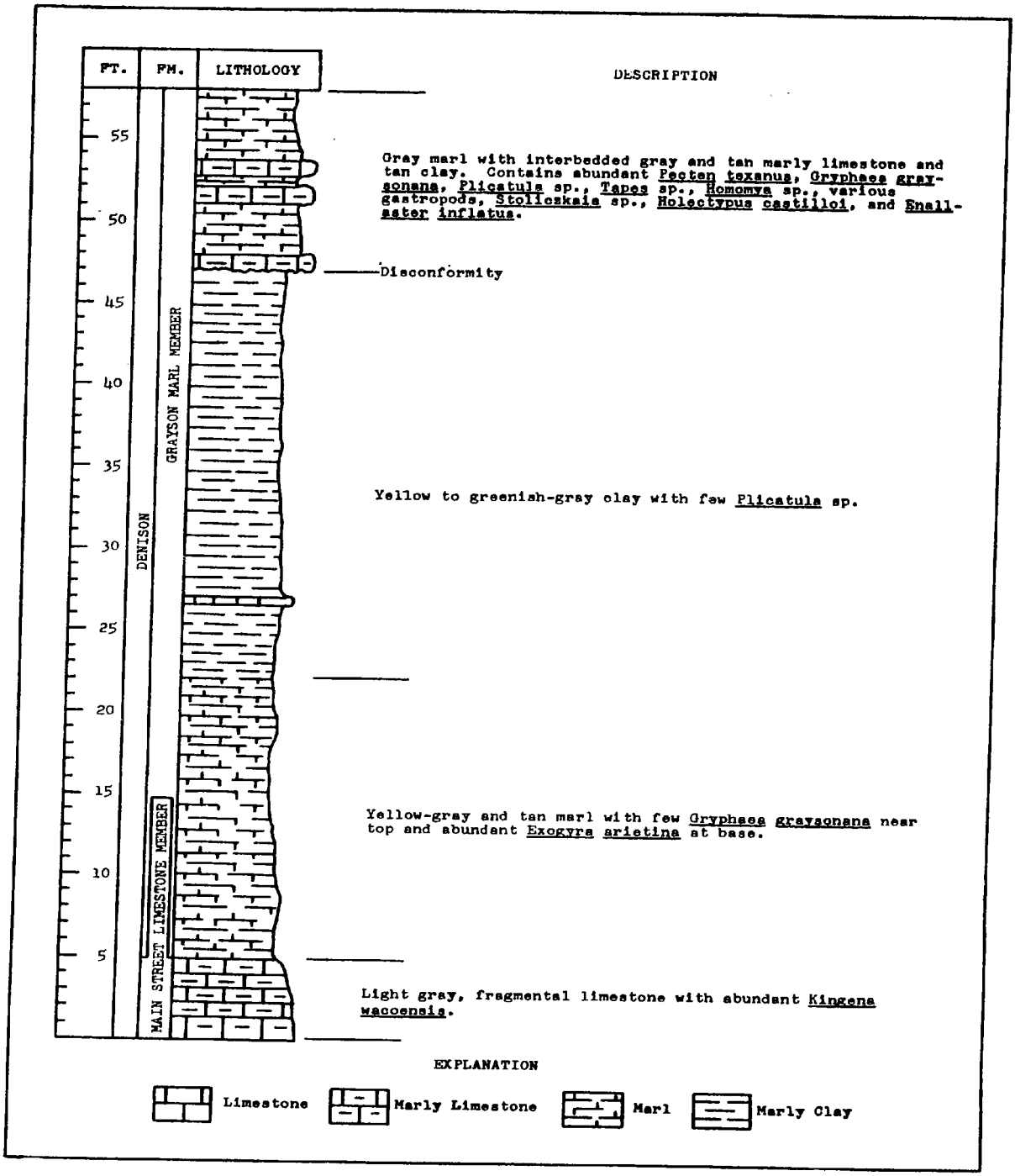


Figure 36. Graphic section of Grayson marl member (Denison formation) at Grayson Bluff northeast of Roanoke, Denton County (Locality T-26). See Figure 37 for upper part of section.

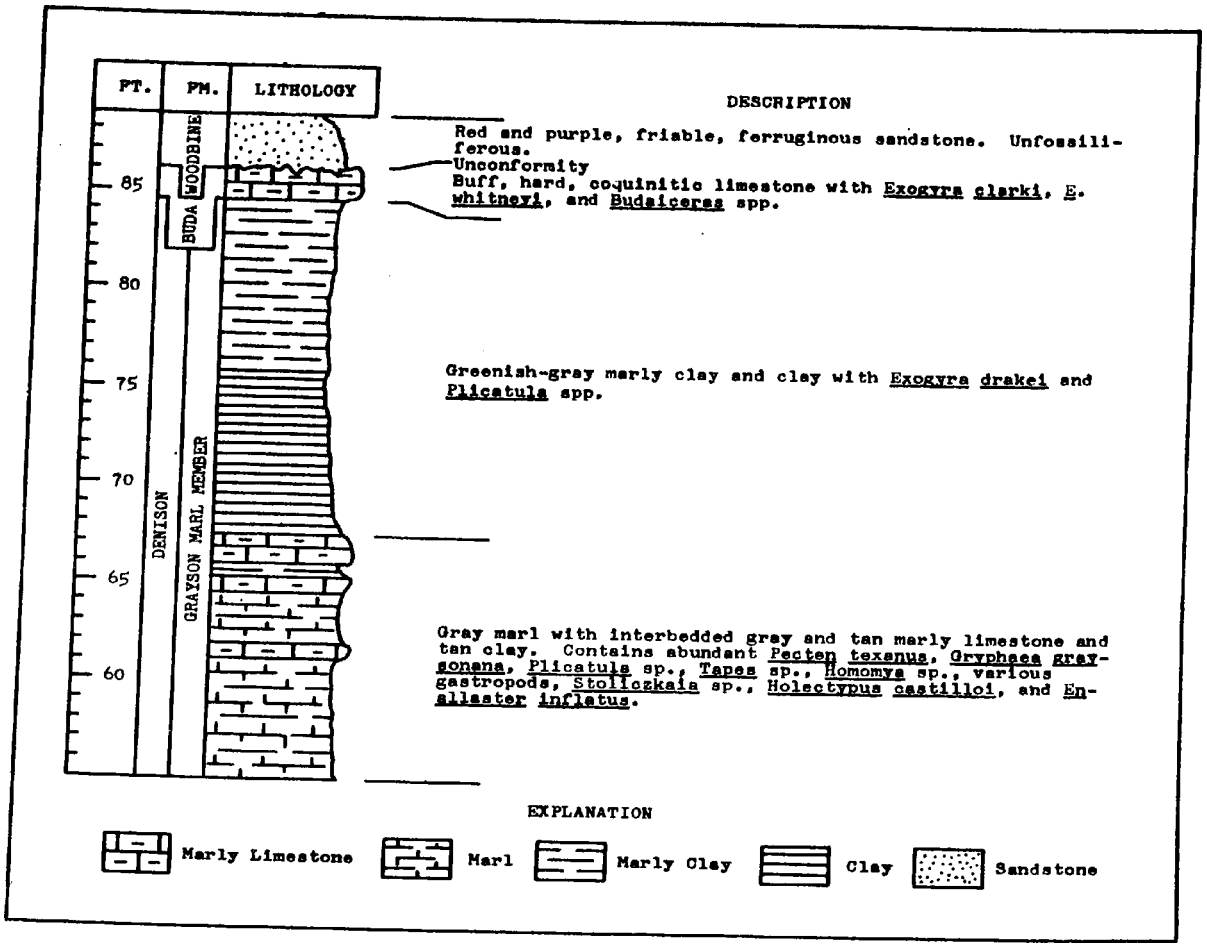


Figure 37. Graphic section of upper part of Grayson marl member of the Denison formation, Buda limestone, and basal Woodbine formation at Grayson Bluff northeast of Roanoke, Denton County (Locality T-26). See Figure 36 for lower part of section.

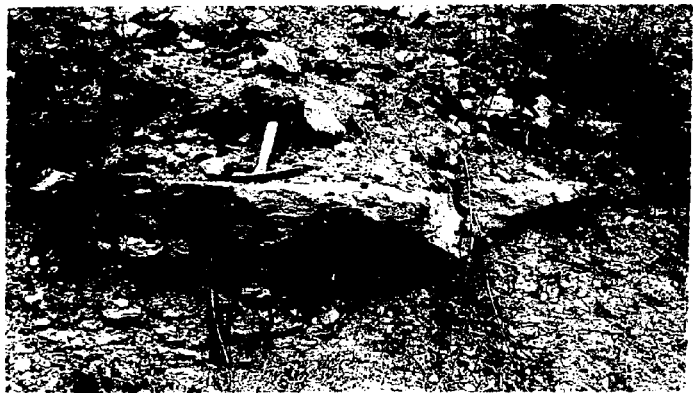


Figure 38. View of lense of clastic limestone in lower Grayson marl member of the Denison formation in roadcut west of Grayson Bluff, Denton County (Locality T-66).



Figure 39. View of middle part of the Grayson marl member of the Denison formation at Grayson Bluff northeast of Roanoke, Denton County (Locality T-26). See Figures 36, 37 for graphic section.



Figure 40. Main Street limestone-Grayson marl contact in roadcut east of Grayson Bluff, Denton County (Locality T-66). Pick rests on the upper limestone of the Main Street.

The lower marl and marly clay are well exposed along the south side of U. S. Highway 80 west of the Village Creek bridge. About ten feet of the upper marl and interbedded marly limestones can be seen along Precinct Road 1187 (Loos. T-46, T-47) in the southern part of the county. No exposures of the upper clay and marly clay, other than that at Grayson Bluff, were located in the area.

Structural relationships.- At Grayson Bluff (Loc. T-26) the Denison formation is overlain conformably by the Buda limestone. Elsewhere in the Tarrant County area the Buda (and part of the Grayson) was apparently removed during a period of post-Comanchean - pre-Woodbine erosion. Consequently, the Grayson marl, except at the Grayson Bluff locality, is overlain unconformably by the Woodbine sandstone. Although the relief of the upper Denison contact has not been accurately determined, the evidence suggests that no less than fifty feet of the Grayson has been removed by the post-Comanchean erosion in some areas (i.e. along the dip slope of the Denison formation northeast of Seminary Drive in the south-central part of the county).

Faunal list.- The following fossils have been identified by the author from the Denison formation in the Fort Worth area. Those species which are marked with an asterisk appear to be limited on the basis of the author's collections to the member of the Denison formation under which they are listed.

Denton Marl Member

Mollusca

Pelecypoda

*Nucula sp.

*Trigonia sp.

Plicatula dentonensis Cragin

Pecten (Neithea) subalpinus Böse

P. (Neithea) texanus Roemer

Lopha (Arctostrea) colubrina (Lamarck)

Ostrea quadriplicata Shumard

Gryphaea washitaensis Hill

Lima (Mantellum) wacoensis quadrangularis Stanton

Echinodermata

Echinoidea

?Cidaris hemigranosus Shumard

?Hemiaster (Macraster) elegans Shumard

Weno Marly Limestone Member

Protozoa

Foraminifera

Haplostiche texana (Conrad)

Mollusca

Pelecypoda

Nucula wenoensis Adkins

Trigonia clavigera Cragin

Plicatula subgurgitis Böse

*Gervilliopsis invaginata (White)

*Pecten (Neithea) georgetownensis Kniker

Pecten (Neithea) subalpinus Böse

P. (Neithea) texanus Roemer

Lopha (Arctostrea) colubrina (Lamarck)

Ostrea quadriplicata Shumard

Gryphaea washitaensis Hill

Lima (Mantellum) wacoensis quadrangularis Stanton

Cardita wenoensis (Adkins)

Protocardia multistriata Shumard

*P. prosogyrata Perkins, sp. nov.

Pholadomya shattucki Böse

*Tapes ehlersi Perkins, sp. nov.

Gastropoda

Pleurotomaria (Leptomaria) austinensis Shumard

*Turritella ventrivoluta Cragin

Cephalopoda

Cymatoceras loeblichi Miller and Harris

Paracymatoceras texanum (Shumard)

*Pervinquieria wintoni (Adkins)

*Engonoceras sp. C

Echinodermata

Echinoidea

Holectypus (Caenholectypus) castilloi Cotteau

*Hemiaster cranium Cooke

H. (Macraster) elegans Shumard

H. (Macraster) elegans subobesus (Adkins)

*H. (Macraster) elegans wenoensis (Adkins)

Enallaster (Washitaster) bravoensis Böse

Holaster simplex Shumard

*Holaster sp.

*Epiaster renfroae Cooke

Pawpaw Shale Member

Protozoa

Foraminifera

Haplostiche texana (Conrad)

Brachiopoda

Kingena sp.

Mollusca

Pelecypoda

Nucula wenoensis Adkins

Plicatula incongrua Conrad

P. subgurgitis Böse

Pecten (Neithea) subalpinus Böse

Lopha (Arctostrea) colubrina (Lamarck)

Ostrea quadriplicata Shumard

Gryphaea washitaensis Hill

Cardita wenoensis (Adkins)

Cephalopoda

Cymatoceras hilli (Shattuck)

Paracymatoceras texanum (Shumard)

*Turrilites worthensis Adkins and Winton

*Worthoceras worthense (Adkins)

Echinodermata

Echinoidea

*Cidaris sp.

*Salenia sp.

*Enallaster (Washitaster) longisulcus Adkins and Winton

*E. (Washitaster) riovistae wenoensis Adkins

Main Street Limestone Member

Brachiopoda

Kingena wacoensis (Roemer)

Mollusca

Pelecypoda

*Cucullaea sycamorensis Perkins, sp. nov.

Trigonia clavigera Cragin

T. emoryi Conrad

Plicatula incongrua Cragin

P. subgurgitis Böse

Pecten (Neithea) subalpinus Böse

P. (Neithea) texanus Roemer

Lopha (Arctostrea) colubrina (Lamarck)

Ostrea subovata Shumard

Exogyra arietina Roemer

E. drakei Cragin

Gryphaea washitaensis Hill

Lima (Mantellum) wacoensis quadrangularis Stanton

*Granocardium budaensis Shattuck

*Protocardia nutans Perkins, sp. nov.

*P. vaughani Shattuck

*Modiola exiguus Perkins, sp. nov.

*Pachymya austinensis Shumard

*Homomya washitae Cragin

Pholadomya shattucki Böse

*Meretrix fortworthensis Perkins, sp. nov.

Cephalopoda

Cymatoceras hilli (Shattuck)

Paracymatoceras texanum (Shumard)

*Turrilites brazoensis Roemer

*Engonoceras sp. B

Echinodermata

Echinoidea

Holectypus (Caenholectypus) castilloi Cotteau

Enallaster (Washitaster) bravoensis Böse

Grayson Marl Member

Coelenterata

*Parasmilia texana Vaughan

Brachiopoda

Kingena wacoensis (Roemer)

Mollusca

Pelecypoda

Trigonia clavigera Cragin

Plicatula subgurgitis Böse

Pecten (Neithea) subalpinus Böse

P. (Neithea) texanus Roemer

*Ostrea perversa Cragin

Exogyra arietina Roemer

E. drakei Cragin

*Gryphaea graysonana Stanton

*Cyprimeria gigantea Cragin

C. sp.

*Protocardia roanokensis Perkins, sp. nov.

*Homomya sp.

*Pholadomya sp.

Cephalopoda

Cymatoceras hilli (Shattuck)

*Turrilites bosquensis Adkins

T. brazoensis? Roemer

*Stoliczkaia sp.

Echinodermata

Echinodea

?Cidaris hemigranosus Shumard

Holectypus (Caenholectypus) castilloi Cotteau

*Hemiaster calvini Clark

*Enallaster (Washitaster) inflatus Cragin

*Pseudananchys completa (Cragin)

Holaster simplex Shumard

Buda Limestone

Name and type section.- This formation was first named "Shoal Creek or Vola limestone" by Robert T. Hill (1889d, e) for exposures on Shoal Creek at Austin, Texas. At this locality the formation is an impure, hard, yellowish limestone 50 to 75 feet thick and constitutes the uppermost formation of the Comanche series. Since the name "Shoal Creek" was preoccupied, T. W. Vaughan (1900, p. 18) gave the name "Buda limestone" (after Buda, Hays County, Texas) to the formation.

Lithology and thickness.- At Grayson Bluff in southern Denton County (Loc. T-26), the Buda consists of a clastic,

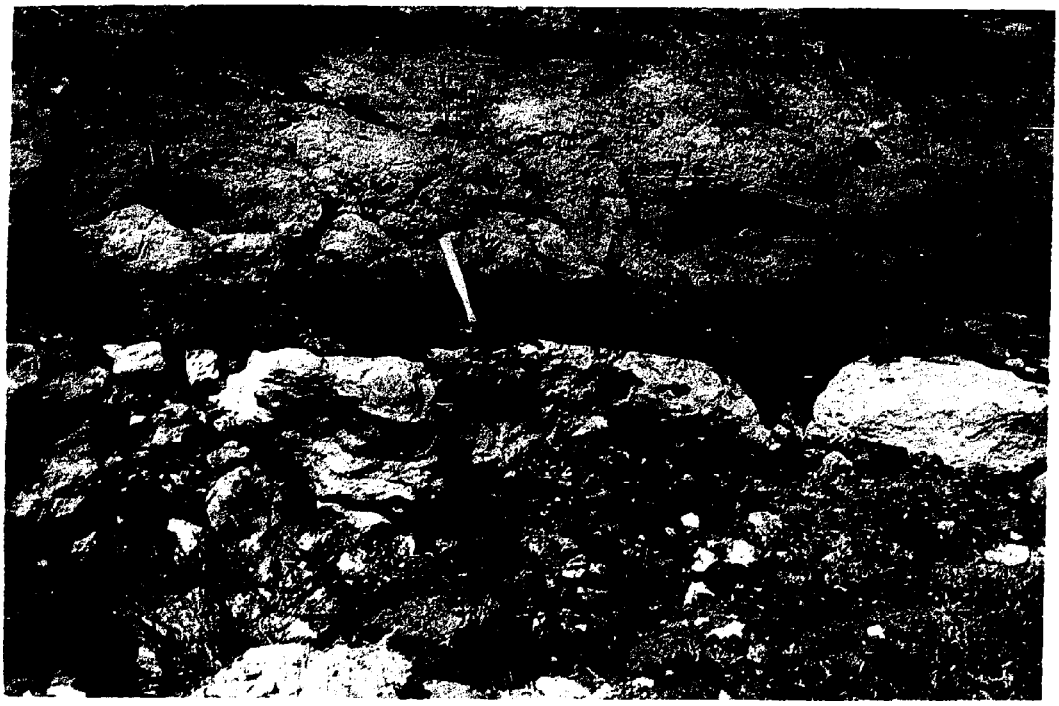


Figure 41. View of Buda limestone in roadcut immediately north of Grayson Bluff, Denton County (Locality T-26). Heavy line indicates Buda limestone-Woodbine sandstone contact.

coquinitic, buff to yellow limestone about 18 inches thick (Figs. 37, 41).

Distribution.- From the central Texas type area the formation thins northward; north of central Bell County it occurs in widely spaced inliers, as at Grayson Bluff. Here, the formation is exposed only in fresh road cuts or gulleys. On weathered slopes it becomes obscured by overwash from the overlying Woodbine sandstone. The Grayson Bluff inlier is the only known occurrence of the Buda in the Fort Worth area and is estimated to have a maximum areal extent of no more than five square miles. The occurrence of the Buda at this locality was first noted by Hill (1923, p. 72, 73). It has subsequently been described by Stephenson (1944, p. 1538-1541), who established the correlation of the limestone at this locality with the Buda of central Texas, and by Perkins and Albritton (1955, p. 14).

Structural relationships.- The Buda is conformable with the underlying Denison formation. The contact with the Woodbine above is along an irregular surface of erosion. The numerous cracks and depressions of the upper irregular surface of the Buda are filled with limonite concretions, apparently resulting from leaching and redeposition from the overlying Woodbine (Fig. 41).

Faunal list.- The following fossils have been identified from the Buda limestone at Grayson Bluff. Those species which appear to be limited to the Buda limestone on the basis

of the author's collections are marked with one asterisk. Those species that have not been found by the author but are reported by Stephenson (1944, p. 1540) are marked with two asterisks.

Mollusca

Pelecypoda

**Trigonia emoryi? Conrad

Pecten (Neithea) subalpinus Böse

*Inoceramus sp.

*Exogyra clarki Shattuck

*E. whitneyi Böse

**Homomya austinensis Shattuck

Pholadomya shattucki Böse

Gastropoda

**Tylostoma sp.

Cephalopoda

**Turrilites cf. T. brazoensis Roemer

*Budaiceras spp.

STRATIGRAPHIC FAUNAL SUMMARY

A list of the species of invertebrate fossils collected by the author in the Fort Worth-Weatherford area with their localities of occurrence and geologic ranges is given on Plate 3. Of these 157 species several were found to have sufficiently limited vertical ranges and to be sufficiently widespread within the area to serve as useful zonal guide fossils. Most of these species have been previously recognized by Adkins and Winton (1920), and the ranges assigned to these species by the author agree closely with the ranges given for them by Adkins and Winton. A list of the useful zonal guide fossils for the Worth-Weatherford area and their geologic ranges in the area is given below.

Zonal Guide Fossil	Geologic Range in the Fort Worth-Weatherford Area
Gryphaea mucronata Gabb	Walnut marl and Goodland formation
Gryphaea navia Hall	Kiamichi formation
Hamites comanchensis Adkins and Winton	Lower 4 feet of Duck Creek formation
Desmoceras brazoense (Shumard)	Lower 15 feet of Duck Creek formation
Pervinquieria trinodosa (Böse)	Upper 10 to 20 feet of Duck Creek formation
Pecten (Neithea) bellulus Cragin	Upper 10 feet of Duck Creek formation and lower 10 feet of Fort Worth limestone
Hemiaster (Macraster) elegans Shumard and *Pervinquieria leonensis maxima* (Lasswitz)	Fort Worth limestone

Gervilliopsis invaginata (White)	Lower six feet of Weno marly limestone member of Denison formation
Pecten (Neithea) georgetownensis Kniker and Turritella ventrivoluta Cragin	Lower 35 feet of Weno marly limestone member of Denison formation
Pervinquieria wintoni (Adkins)	Upper ten feet of Weno marly limestone member of Denison formation
Haplostiche texana (Conrad)	Upper fifteen feet of Weno marly limestone member and Pawpaw shale member of Denison formation
Pachymya austinensis Shumard	Lower fifteen feet of Main Street limestone member of Denison formation
Turrilites brazoensis Roemer	Main Street limestone member of Denison formation
Exogyra arietina Roemer	Upper five feet of Main Street limestone member and lower twenty feet of Grayson marl member of Denison formation
Pseudananchys completa (Cragin)	Lower ten feet of Grayson marl member of Denison formation
Gryphaea graysonana Stanton	Upper 75 feet of Grayson marl member of Denison formation

FOSSIL LOCALITIES

The following fossil localities are shown on the index maps of portions of Parker, Tarrant, and Denton counties (Figs. 42-44).

T-1. East bank of Marys Creek immediately north of U. S. Highway 80-180 bridge, Tarrant County. Goodland formation (Marys Creek marl member).

T-2. Bluff on south bank of Marys Creek on Rawl ranch, 0.8 miles south of U. S. Highway 80-180 and 0.5 miles east of Chaplin School Road, Tarrant County. Goodland formation (complete section).

T-3. East bank of Sycamore Creek, 50 yards south of the northernmost dry weather crossing in Cobb Park, Fort Worth, Tarrant County. Fort Worth limestone and Denison formation (Denton marl and basal Weno marly limestone members).

T-4. Bluff and slopes at north end of Pebble Creek Road in Westover Hills area, Fort Worth, Tarrant County. Goodland formation (Benbrook limestone member), Kiamichi formation, and Duck Creek formation (basal beds).

T-5. West bank of Sycamore Creek in Cobb Park, 100 yards south of Maddox Avenue, Fort Worth, Tarrant County. Fort Worth limestone (upper 20 feet).

T-6. West bank of Sycamore Creek about 100 yards south of Texas and New Orleans Railroad bridge, Fort Worth, Tarrant County. Denison formation (Weno marly limestone member).

T-7. Bed of Sycamore Creek about 60 yards southwest of Old Mansfield Road bridge, Fort Worth, Tarrant County. Fort Worth limestone (uppermost bed).

T-8. Along unnamed creek in Glenwood Park, Fort Worth, Tarrant County. Fort Worth limestone (complete section).

T-9. Southeast bank and slopes above Sycamore Creek in Amon Carter Parksite, about 0.2 miles northeast of the International Great Northern Railroad bridge, Fort Worth, Tarrant County. Denison formation (Weno marly limestone, Pawpaw shale, and lower Main Street limestone members).

T-10. Hillside 150 yards north of Stove Foundary Road and 200 yards west of Snyder Road, Fort Worth, Tarrant County. Goodland formation (Benbrook limestone member).

T-11. Hills (Cragin Knobs) along north side of Stove Foundry Road, 2 miles northeast of intersection with Benbrook Road, Fort Worth, Tarrant County. Goodland formation (Benbrook limestone member).

T-12. Roadcut 4.5 miles east of Weatherford Courthouse on U. S. Highway 80-180, Parker County. Walnut marl (complete section).

T-13. Along east side of private road into Fowler farm and about 50 yards north of the intersection of that road with U. S. Highway 80-180 which point is about 25 yards east of Marys Creek bridge, Tarrant County. Goodland formation (Marys Creek marl member).

T-14. West bank of Sycamore Creek in Sycamore Park under Rosedale Avenue bridge, Fort Worth, Tarrant County. Fort Worth limestone (about middle 20 feet).

T-15. Hillside on north side of Glen Garden Drive, about 0.5 miles east of intersection with Old Mansfield Road, Fort Worth, Tarrant County. Denison formation (upper Weno marly limestone and Pawpaw shale members).

T-16. Roadcut and exposures along railroad at west end of the Texas and Pacific Railroad, Lancaster yards, Fort Worth, Tarrant County. Goodland formation (upper Benbrook limestone member), Kiamichi formation, and Duck Creek formation (basal bed).

T-17. Hill about 0.7 miles north of U. S. Highway 80-180 immediately east of the main house at Clear Fork ranch which is reached by private road intersecting U. S. Highway 80-180 about 1.2 miles east of the intersection of U. S. Highway 80-180 and Texas Farm Road 1545. Walnut marl (lower 15 feet).

T-18. Bed and east bank of Sycamore Creek about 50 yards north of Seminary Drive, Fort Worth, Tarrant County. Denison formation (upper Denton marl and basal Weno marly limestone members).

T-19. Roadside gully and roadcut on Seminary Drive about 200 yards east of Sycamore Creek, Fort Worth, Tarrant County. Denison formation (upper Weno marly limestone, Pawpaw shale, and Main Street limestone members).

T-20. Low brownish knobs in Amon Carter Parksite and about 50 yards south of Seminary Drive and about 200 yards east of Sycamore Creek, Fort Worth, Tarrant County. Denison formation (Pawpaw shale member).

T-21. Bed of Sycamore Creek about 75 yards south of Seminary

Drive bridge, Fort Worth, Tarrant County. Denison formation (lower Weno marly limestone member).

T-22. Roadcut on old Fort Worth-Weatherford highway, one mile east of its intersection with U. S. Highway 80-180, Parker County. Walnut marl (lower 10 feet).

T-23. East side of Texas Farm Road 5, about 0.2 miles south of junction with old Fort Worth-Weatherford highway and directly across road from Harrisdale Farms, Parker County. Goodland formation (Benbrook limestone member).

T-24. North wall of shale pit of the Fort Worth quarry of the Trinity Portland Cement Company, west of Meacham Field, Tarrant County. Kiamichi formation (upper 6 feet) and Duck Creek formation (lower 3 feet).

T-25. North wall of quarry of the Trinity Portland Cement Company, west of Meacham Field, Tarrant County. Duck Creek formation (lower 40 feet).

T-26. Grayson Bluff along north side of Denton Creek, about 4 miles northeast of the intersection of Texas Highway 114 and U. S. Highway 377 in Roanoke, Denton County. Denison formation (upper Main Street limestone and complete section of Grayson marl members) and Buda limestone.

T-27. Bed of Denton Creek at abandoned crossing of U. S. Highway 377 and in roadcut 100 yards north of creek, Denton County. Denison formation (upper Weno marly limestone, Pawpaw shale and basal Main Street limestone members).

T-28. Along Sycamore Creek and east of Texas Farm Road 731, about 3 miles north of railroad station in Crowley, Tarrant County. Denison formation (lower 15 feet of Main Street limestone member).

T-30. Bluff on southeast corner of intersection of Lancaster and Riverside drives, Fort Worth, Tarrant County. Fort Worth limestone (complete section).

T-31. Slopes behind houses on east side of north half of 4500 block of Inwood Drive, West Cliff area, Fort Worth, Tarrant County. Duck Creek formation (upper 15 feet) and Fort Worth limestone (lower 10 feet).

T-32. Bluff north of main house of Ward Ranch, 1.25 miles east of Parker-Tarrant County line on U. S. Highway 80-180, Tarrant County. Goodland formation (upper 100 feet).

T-33. Cuts along International and Great Northern Railroad at west end of Atkins Street and about 0.1 miles south of Texas and New Orleans Railroad crossing, Fort Worth, Tarrant County. Denison formation (upper Denton marl and lower 40 feet of Weno marly limestone members).

T-34. Slopes along south side of Oak Grove Road and 0.1 to 0.2 miles southeast of Sycamore Creek, Fort Worth, Tarrant County. Denison formation (Pawpaw shale and lower Main Street limestone members).

T-35. Slopes around tank, about 25 yards north of Oak Grove Road and about 0.2 miles east of Sycamore Creek, Fort Worth, Tarrant County. Denison formation (Pawpaw shale member).

T-36. Slopes around tank of Cowtown Posse stables, 0.1 miles south of Oak Grove Road and 0.1 miles east of Sycamore Creek, Tarrant County. Denison formation (about upper 30 feet of Weno marly limestone member).

T-37. Bed of Sycamore Creek 150 yards north of Seminary Drive, Fort Worth, Tarrant County. Denison formation (upper 10 feet of Denton marl member).

T-39. North bank of Sycamore Creek, about 150 yards north of Oak Grove Road, Fort Worth, Tarrant County. Denison formation (Weno marly limestone member).

T-40. Banks of stream immediately south of Clyde Street and about 100 yards northwest of intersection of Clyde and Russell streets, west of Consolidated Aircraft Corporation Plant, White Settlement area, Tarrant County. Goodland formation (Marys creek marl member).

T-41. Slopes east of intersection of Dirks Road and Old Granbury Road, east of Benbrook Dam, Tarrant County. Denison formation (Pawpaw shale member).

T-43. Bluff on southwest corner of intersection of Lancaster and Riverside drives, Fort Worth, Tarrant County. Fort Worth limestone (complete section).

T-44. Creek bed and bluffs immediately southwest of Meacham Field and immediately southeast of the Trinity Portland Cement Company property, Tarrant County. Goodland formation (upper Benbrook limestone member), Kiamichi formation, and Duck Creek formation (lower 15 feet).

T-45. Along south side of U. S. Highway 80-180, 10.1 miles east of Weatherford Courthouse, Parker county. Walnut marl (upper 15 feet).

T-46. In roadside gullies on Texas Farm Road 1187, about 0.2 miles west of International Great Northern Railroad crossing, Tarrant County. Denison formation (upper part of Grayson marl member).

T-47. In roadside gullies on Texas Farm Road 1187, about 0.4 miles west of International Great Northern Railroad crossing, Tarrant County. Denison formation (upper part of Grayson marl member).

T-48. South bank of Village Creek, immediately east of Texas Farm Road 731 and about 0.7 miles northeast of railroad station at Crowley, Tarrant County. Denison formation (upper 20 feet of Main Street limestone member).

T-49. Bed of Sycamore Creek on Blacklock farm, between the Gulf Colorado and Santa Fe Railroad and Texas Farm Road 731, about 2.9 miles north-northeast of railroad station at Crowley, Tarrant County. Denison formation (lower 10 feet of Main Street limestone member).

T-50. Stream bed and slopes east of tributary to Marys Creek, 0.2 miles south of U. S. Highway 80-180 and 0.1 miles east of Alemeda Street east of Westland, Tarrant County. Goodland formation (Benbrook limestone member).

T-51. Slopes between Kermit and Garza streets, immediately east of Grafa-Marys Creek Road (Williams Road), Fort Worth, Tarrant County. Goodland formation (Benbrook limestone member).

T-52. Roadcut north of U. S. Highway 80-180, about 0.4 miles east of its intersection with Alemeda Street, east of Westland, Tarrant County. Goodland formation (Benbrook limestone member).

T-53. Deep roadcut on U. S. Highway 80-180, about 0.45 miles east of its intersection with Texas Farm Road 5, Parker County. Kiamichi formation and Duck Creek formation (basal 5 feet).

T-54. Slopes along north side of U. S. Highway 80-180, about 1.3 miles west of its intersection with Texas Farm Road 1545, Parker County. Goodland formation (Benbrook limestone member).

T-55. Roadcut of U. S. Highway 80-180 about 1.75 miles west of its intersection with Texas Farm Road 1545, Parker County. Goodland formation (Marys Creek marl member).

T-57. Bed of unnamed creek, about 50 yards east of bridge over Marys Creek on U. S. Highway 80-180, Tarrant County. Goodland formation (Marys Creek marl member).

T-58. Bluffs east of main house of Ward Ranch, 1.25 miles east of Parker-Tarrant county line on U. S. Highway 80-180, Tarrant County. Goodland formation (Benbrook limestone member).

T-59. On Sycamore Creek, 150 to 200 yards downstream from Texas Farm Road 731 bridge, Tarrant County. Denison formation (upper 3 feet of Pawpaw shale and lower 12 feet of Main Street limestone members).

T-60. Slopes south of Village Creek and about 0.15 miles west of Texas Farm Road 731, immediately east of Crowley Feed Mills, and about 0.6 miles east of railroad station at Crowley, Tarrant County. Denison formation (upper Main Street limestone member).

T-61. Bluff along south bank of first tributary to Sycamore Creek, about 300 yards south of Seminary Drive and about 100 yards upstream from the confluence of the tributary and Sycamore Creek, in Amon Carter Parksite, Fort Worth, Tarrant County. Denison formation (upper 25 feet of Weno marly limestone member).

T-62. On Village Creek at Polly Webb Road bridge, south of Handley, Tarrant County. Denison formation (upper 8 feet of Main Street limestone and lower 6 feet of Grayson marl members).

T-63. Roadcut on Mitchell Blvd., 25 yards south of its intersection with Glen Garden Road, Fort Worth, Tarrant County. Denison formation (Main Street limestone member).

T-64. Slopes along east side of Riverside Drive, about 0.2 miles south of bridge over Sycamore Creek, Fort Worth, Tarrant County. Denison formation (upper 25 feet of Weno marly limestone member).

T-65. West side of unnamed stream west of Consolidated Aircraft Corporation Plant, and about 200 yards downstream from locality T-40, White Settlement area, Tarrant County. Goodland formation (Marys Creek marl member).

T-66. Cut on south side of road from Grayson Bluff to U. S. Highway 377 and approximately 3.5 miles northeast of the intersection of Texas Highway 114 and U. S. Highway 377 in Roanoke, Denton County. Denison formation (upper 6 feet of Main Street limestone and lower 15 feet of Grayson marl members).

T-67. Roadside gully along Crowley-Plover Road, from bridge over Rock Creek west to top of hill, Tarrant County. Duck Creek formation (nearly complete section).

T-68. Abandoned quarry on west side of Gulf Colorado and Santa Fe Railroad about 200 yards south of Rock Creek on Feltz Ranch, Tarrant County. Kiamichi formation (upper 3 feet) and Duck Creek formation (lower 30 feet).

T-69. In cuts of Gulf Colorado and Santa Fe Railroad immediately north of bridge over Mustang Creek and about 1.4 miles south of the intersection of that railroad with Crowley-Plover Road, Tarrant County. Duck Creek formation (nearly complete section) and Fort Worth limestone (lower 10 feet).

T-73. Roadcut on Texas Highway 183 immediately east of its intersection with Texas Highway 199, Fort Worth, Tarrant County. Goodland formation (upper Benbrook limestone member), Kiamichi formation, and Duck Creek formation (lower 5 feet).

T-74. Slopes along creeks, north of 3200 block of Bomar Street, Sycamore Heights area, Fort Worth, Tarrant County. Denison formation (nearly complete sections of Weno marly limestone and Pawpaw shale members).

T-75. Bed of Rock Creek, immediately east of Gulf Colorado and Santa Fe Railroad bridge on Feltz Ranch, Tarrant County. Kiamichi formation (lower 10 feet).

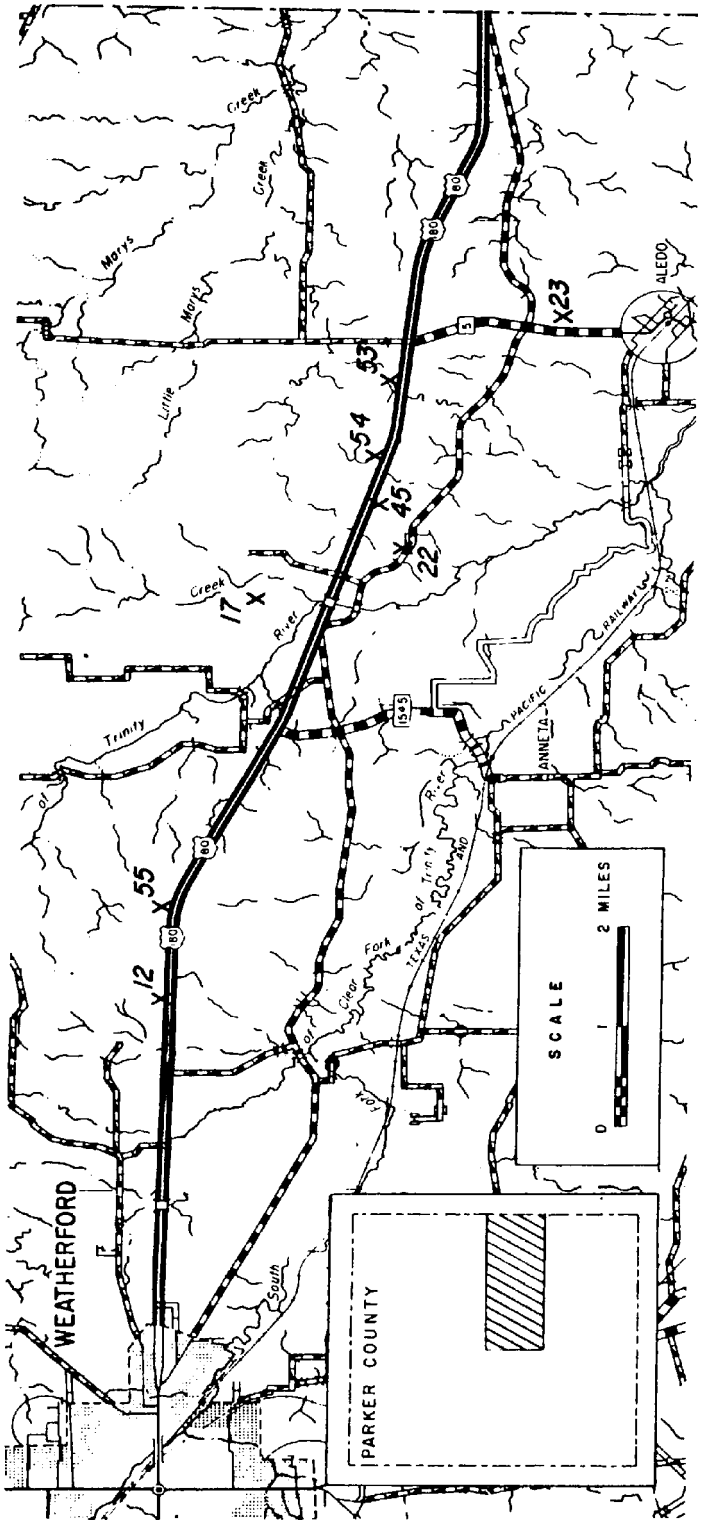


Figure 42. Sketch map of a portion of Parker County showing fossil localities. (Based on Texas State Highway Department Parker County Highway Map, 1954.)

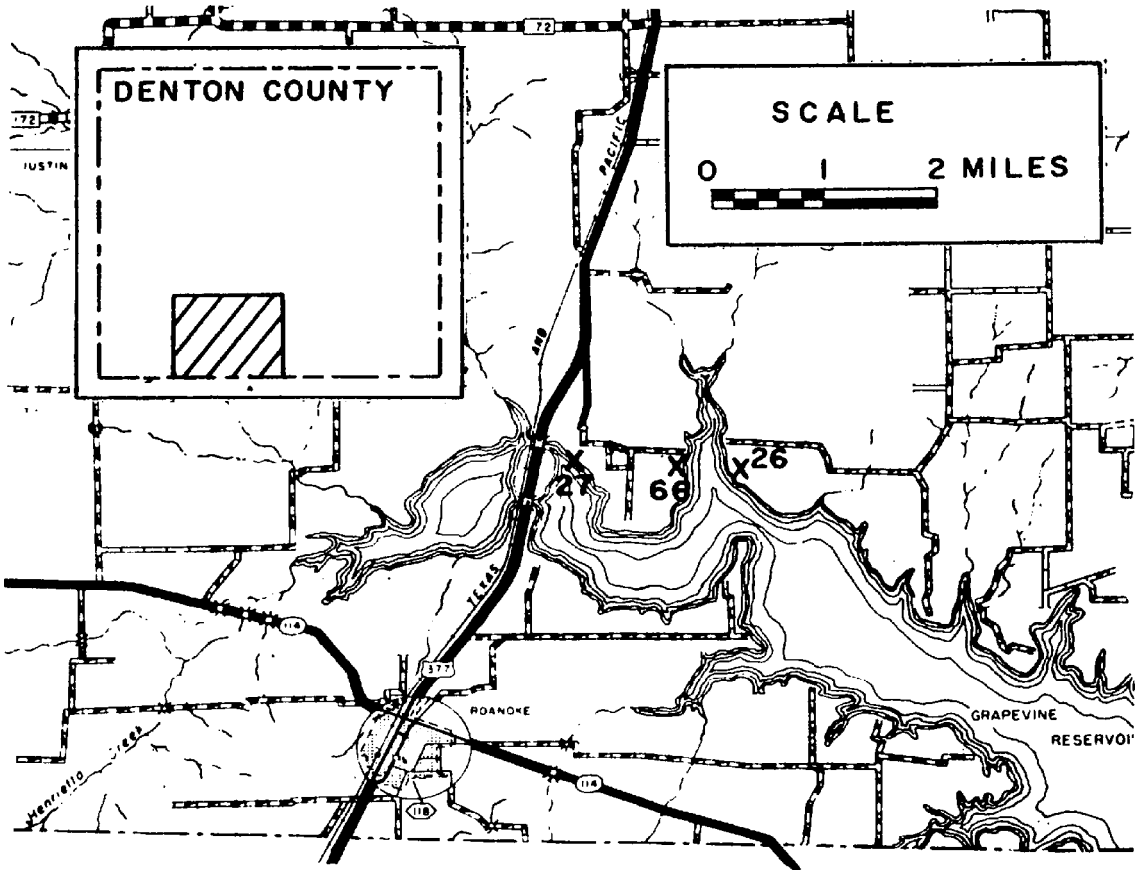


Figure 43. Sketch map of a portion of Denton County showing fossil localities. (Based on Texas State Highway Department Denton County Highway Map, 1954.)

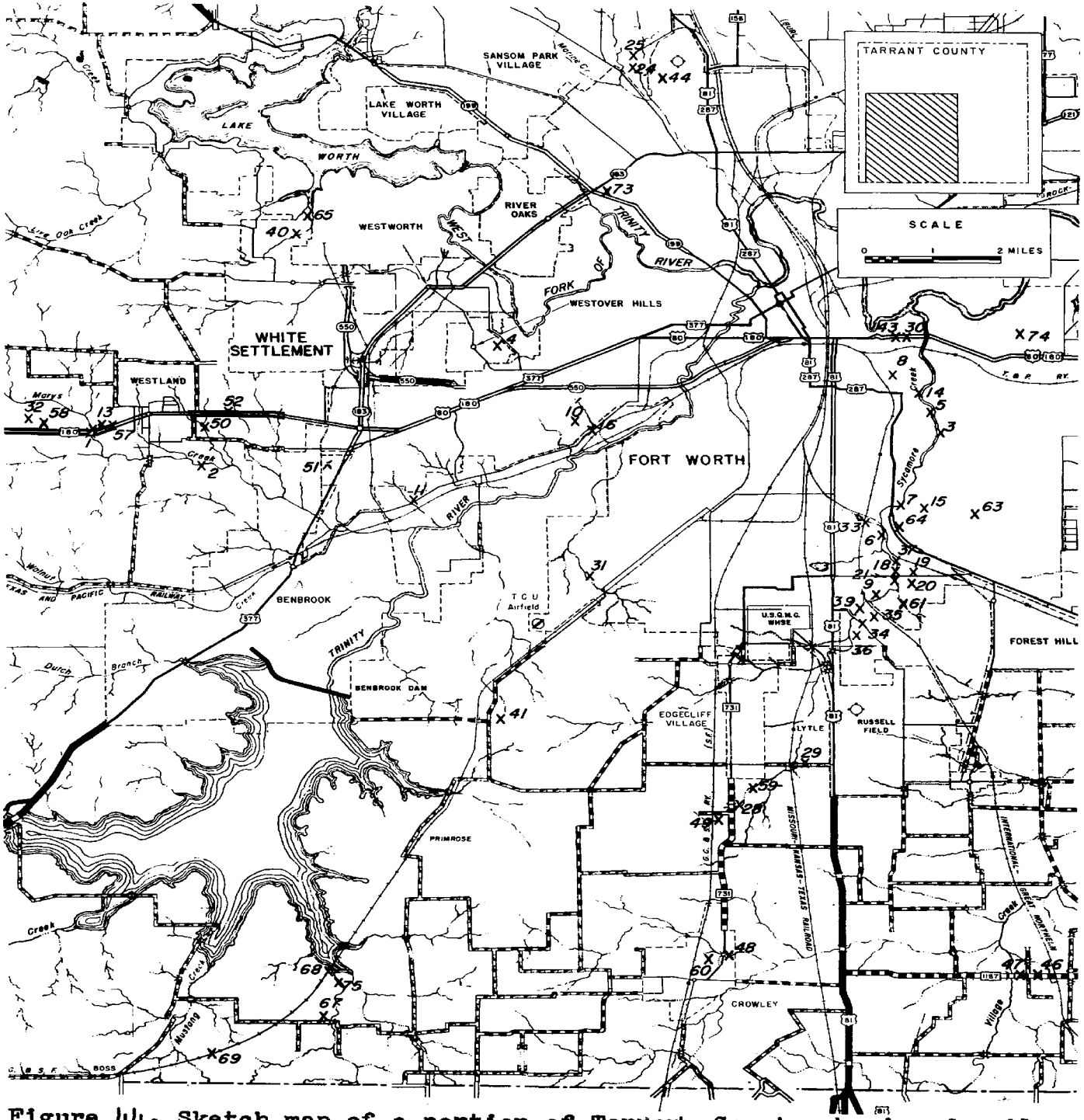


Figure 44. Sketch map of a portion of Tarrant County showing fossil localities. (Based on Texas State Highway Department Tarrant County Highway Map, 1954.)

SYSTEMATIC PALEONTOLOGY

Phylum MOLLUSCA

Class Pelecypoda

Genus Cucullaea Lamarck, 1801

Cucullaea sycamorensis Perkins, sp. nov.

Pl. 6, figs. 1, 2, 4

Holotype.- U.M.M.P. 33004, steinkern with small amount of shell material adhering along ventral and posterior margins of right valve. Collected by Bob F. Perkins and party, spring of 1954.

Horizon and type locality.- Comanchean, Washita group, Denison formation, Main Street limestone member. Locality T-9, slope above southeast bank of Sycamore Creek in Amon Carter Parksite, about 0.2 miles northeast of the International-Great Northern Railroad bridge, Fort Worth, Texas.

Diagnosis.- Cucullaea sycamorensis is similar to C. terminalis Conrad from the Trinity group and C. recedens Cragin from the Fredericksburg group. It differs from C. terminalis in having a more strongly convex antero-ventral border, a somewhat more elongate form, and strongly prosogyrate beaks, and in being smaller. C. sycamorensis differs from C. recedens in having more terminal and prosogyrate beaks and a greater height, and in lacking radial ribs.

Description.- Shell medium size, equivalved, inequilateral, antero-posteriorly elongate, outline subtriangular;

hinge short, about one-half total length of shell; beaks prominent, elevated, prosogyrate, subterminal in position. Dorsal border convex and sloping downward from beaks to join the short and sharply rounded posterior border; ventral border almost straight, rounded at extremities; anterior border broadly rounded, strongly convex. Anterior adductor muscle scars very pronounced and located inside anterior margin about half way between beaks and ventral margin. Rounded shoulder extends from the beaks downward and backward to posterior border. Sculpture consisting of fine concentric ribs. Hinge structure not preserved.

Measurements.- (in mm.)

U.M.M.P. No.	Length	Height	Thickness
33004 (Holotype)	56.5	42.2	36.0

Remarks.- In addition to the holotype a fragment of a smaller specimen (U.M.M.P. 33005) collected at the type locality has been referred to the species.

Genus Leptosolen Conrad, 1865

Leptosolen striatula Perkins, sp. nov.

Pl. 6, figs. 3, 5

Types.- Holotype: U.M.M.P. 33006, a cast showing exterior of both valves. Paratype: U.M.M.P. 33007, a cast of a smaller individual, also showing exterior of both valves. Collected by Bob F. Perkins and party, spring of 1954.

Horizon and type locality.- Comanchean, Fredericksburg group, Goodland formation, Marys Creek marl member. Locality T-1, east bank of Marys Creek immediately north of U. S. Highway 80-180 bridge, Tarrant County, Texas.

Diagnosis.- Leptosolen striatula can be distinguished from L. conradi Meek and L. otterensis Cragin, both from the Kiowa formation of Kansas, by the presence of fine radial striae in the posterior part of the shell and by the rounded instead of truncated posterior margin.

Description.- Shell medium size, equivalved, inequilateral, elongate antero-posteriorly, subquadrangular in outline, length about two and one-half times height. Valves slightly convergent anterior to beaks; posterior border broadly rounded; anterior margin more sharply but evenly rounded; beaks low, inconspicuous and slightly prosogyrate.

Two pronounced sulci separated by a very low broad swelling radiate from beak region; shorter of two sulci extends from point just antero-ventral to beaks to antero-central border, bottom shallow, broadly rounded, gradually widens from beaks outward; longer of two sulci begins at a point postero-ventrally to beaks and extends backward and downward to ventral margin intersecting the margin at about the midline, shallow bottom, broadly rounded, gradually widens from beaks backward. Third less conspicuous long sulcus located posterior to pronounced ones extends backward from dorsal margin, posterior to beaks, and curves slightly

downward to postero-ventral margin; narrower than other two sulci, almost disappearing before reaching postero-ventral border; separated from other long sulcus by a very low broad swelling.

Numerous fine radial striae arise at beak and extend to postero-ventral and posterior borders on the swelling that separates the two long sulci and posterior to the less conspicuous long sulcus. Shell ornamented by rounded, low, concentric ribs which parallel the shell outline and are slightly convex beakward in sulci.

Measurements.- (in mm.)

U.M.M.P. No.	Length	Height	Thickness
33006 (Holotype)	43.0	19.0	10.5
33007 (Paratype)	19.8	8.8	4.7

Genus Protocardia Beyrich, 1845

Protocardia prosogyrata Perkins, sp. nov.

Pl. 6, figs. 6, 9

1918 [?] Protocardia sp. aff. multistriata (Shumard). Adkins, Texas Univ. Bull. 1856, p. 126, pl. 10, figs. 21-26, 32.

1928 [?] Protocardia multistriata [partim] Shumard. Adkins, Texas Univ. Bull. 2838, p. 160.

Types.- Holotype: U.M.M.P. 33008, a cast showing exterior of right valve and broken postero-ventral margin. Paratype: U.M.M.P. 33009, a cast showing exterior of left valve. Collected by Bob F. and Patricia W. Perkins, fall of 1954.

Horizon and type locality.- Comanchean, Washita group, Denison formation, upper part of Weno marly limestone member. Locality T-61, bluff along south bank of first tributary to Sycamore Creek, about 300 yards south of Seminary Drive and about 100 yards upstream from the confluence of the tributary and Sycamore Creek, in Amon Carter Parksite, Fort Worth Texas.

Diagnosis.- Protocardia prosogyrata may be distinguished from other previously described Comanchean Protocardias by its strongly prosogyrate beaks and its rather strongly compressed form.

Description.- Shell medium size, equivalved, inequilateral, compressed, outline subtriangular, length and height about equal. Beaks acutely rounded, strongly prosogyrate, anterior to center of shell. Anterior border concave centrally, intersects ventral border in sharp angle; ventral border semi-circular, intersection with posterior border broken; posterior border sharply truncated; hinge line short, straight.

Sculpture consists of concentric ribs uniformly increasing in size from older to younger portion of shell, low and flat topped in older part, broadly rounded and low in mature portion; interspaces narrow and flat bottomed; about 15 angular, straight radial ribs posteriorly.

Measurements.- (in mm.)

U.M.M.P. No.	Length	Height	Depth of one valve
33008 (Holotype)	42.0 (estimated)	39.0	11.0
33009 (Paratype)	38.0 (estimated)	36.0 (estimated)	11.0

Discussion.- This species is probably the one referred to by Adkins (1918) as Protocardia sp. aff. multistriata. His illustrations show an ornamentation similar to that of P. prosogyrata and one figure (pl. 10, fig. 32) shows a specimen with a distinctly prosogyrate beak.

This species differs from P. multistriata (Shumard) (1854, p. 194). Shumard's species has prominent but not anteriorly directed beaks and fine radial and concentric striae. In P. prosogyrata the beaks are distinctly prosogyrate, and the concentric and radial ribs are fairly large and prominent.

Protocardia roanokensis Perkins, sp. nov.

Pl. 6, figs. 7, 8

Holotype.- U.M.M.P. 33010, a cast showing the exterior of both valves but with beaks broken off. Collected by Bob F. Perkins, summer of 1954.

Horizon and type locality.- Comanchean, Washita group, Denison formation, upper part of Grayson marl member. Locality T-26, Grayson Bluff on north side of Denton Creek, about four miles northeast of the intersection of Texas Highway 114

and U. S. Highway 377 in Roanoke, Denton County, Texas.

Diagnosis.- A small Protocardia distinguished by its relatively high slender form and the large number (25) of fine radial posterior striae.

Description.- Shell small, equivalved, slightly inequilateral, subtriangular, slender; beaks high, narrow, pointed. Hinge line short, straight; posterior border slightly truncated, curved dorsally and ventrally; ventral and anterior border gently curved; posterior, ventral and anterior borders forming a nearly smooth arc. Sculpture consists of about 25 very fine radial striae on posterior one-fifth of shell and very faint (possibly worn) concentric striae on remainder of shell.

Measurements.- (in mm.)

U.M.M.P. No.	Length	Height	Thickness
33010 (Holotype)	21.8	25.3	13.2

Protocardia nutans Perkins, sp. nov.

Pl. 6, figs. 10, 11

Holotype.- U.M.M.P. 33011, a cast showing complete exterior of right valve but only postero-dorsal area of left valve. Collected by Bob F. Perkins and party, spring of 1955.

Horizon and type locality.- Comanchean, Washita group, Denison formation, lower part of Main Street limestone member. Locality T-19, roadcut on north side of Seminary Drive, about

200 yards east of Sycamore Creek, Fort Worth, Texas.

Diagnosis.- A Protocardia distinguished by having a pronounced subangular shoulder extending from the beaks to postero-ventral border and 36-40 fine radial striae postero-dorsal to the shoulder.

Description.- Shell medium size, equivalved, inequilateral, ventro-posteriorly extended, outline subtriangular; beaks subterminal, elevated, narrow, pointed, prosogyrate. Hinge line long, straight(?); posterior border broadly curved, long, intersecting ventral border in subangular curve; ventral border long, slightly curved at mid-length, more strongly curved anteriorly; anterior border short, strongly curved. Shell inflated; subangular shoulder extends from beaks to postero-ventral border, gradually becoming more rounded about two-thirds the distance from the beaks to the border; a shorter, very angular shoulder, located on the anterior side of the beaks extends along the anterior slope of the umbones about five mm. and then flattens out and is no farther distinguishable. Sculpture consists of about 36-40 fine radial ribs on the posterior slope between the subangular shoulder and the dorsal border and concentric ribs over the remainder of the shell; the concentric ribs are fine, low and rounded in the earlier part of the test and become coarser in the mature portions.

Measurements.- (in mm.)

U.M.M.P. No.	Length	Height	Depth of one valve
33011 (Holotype)	31.0	38.2	19.0

Genus Homomya Agassiz, 1843

Homomya cymbiformis Perkins, sp. nov.

Pl. 7, figs. 1, 2, 6

Types.- Holotype: U.M.M.P. 33012, a nearly perfect cast of exterior of both valves. Paratype: U.M.M.P. 33013, a worn cast with anterior margin broken. Collected by Bob F. Perkins and party, spring 1954.

Horizon and type locality.- Comanchean, Fredericksburg group, Goodland formation, lower part of Marys Creek marl member. Locality T-1, east bank of Marys Creek immediately north of U. S. Highway 80-180 bridge, Tarrant County, Texas.

Diagnosis.- A Homomya distinguished by the strong central concavity of the dorsal border and its cymbiform profile.

Description.- Shell medium size, equivalved, very inequilateral, antero-posteriorly elongate, compressed posteriorly, widened anteriorly, valves gaping postero-dorsally. Beaks narrow, pointed, prosogyrate, slightly elevated, subterminal in position (about 0.17 the length of the shell from the anterior end). Valve sculpture consists of low, broad, rounded, concentric ribs, interspaces shallow and

narrow.

Hinge line short. Anterior border a semi-circle extending from hinge line to ventral border which is gently curved; postero-ventral margin curved rather sharply upward to postero-dorsal border which is convex upward; dorsal border concave centrally.

Measurements.- (in mm.)

U.M.M.P. No.	Length	Height	Thickness
33012 (Holotype)	71.2	43.7	32.8
33013 (Paratype)	60.0 (estimated)	37.3	27.8

Homomya tarrantensis Perkins, sp. nov.

Pl. 7, figs. 3-5, 7, 9

Types.- Holotype: U.M.M.P. 33014, a nearly perfect cast showing exterior of both valves but postero-dorsal border slightly broken. Paratypes: U.M.M.P. 33015, a nearly perfect cast showing exterior of a smaller individual than the holotype; U.M.M.P. 33016-33019, imperfect casts showing exterior of both valves but posterior border broken in all specimens. Collected by Bob F. and Patricia W. Perkins, spring of 1955.

Horizon and type locality.- Holotype U.M.M.P. 33014 and paratypes U.M.M.P. 33016, 33017: Comanchean, Fredericksburg group, Goodland formation, lower part of Benbrook limestone member. Locality T-2, bluff on south bank of Marys Creek on Rawl ranch, 0.8 miles south of U. S. Highway 80-180

and 0.5 miles east of Chaplin School Road, Tarrant County, Texas.

Paratype U.M.M.P. 33018: Goodland formation, Benbrook limestone member. Locality T-50, slopes east of tributary to Marys Creek, 0.2 miles south of U. S. Highway 80-180 and 0.1 miles east of Alemeda Street east of Westland, Tarrant County, Texas.

Paratype U.M.M.P. 33019: Goodland formation, Marys Creek marl member. Locality T-57, bed of unnamed creek, about 50 yards east of bridge over Marys Creek on U. S. Highway 80-180, Tarrant County, Texas.

Paratype U.M.M.P. 33015: Goodland formation, Marys Creek marl member. Locality T-1, east bank of Marys Creek immediately north of U. S. Highway 80-180 bridge, Tarrant County, Texas.

Diagnosis.- Homomya tarrantensis may be distinguished from H. cymbiformis Perkins, sp. nov., with which it is associated, by having a much less concave dorsal border, less anteriorly placed beaks, a more laterally compressed form, and a smaller size.

Description.- Shell small to medium size, equivalved, very inequilateral, antero-posteriorly elongate, compressed posteriorly. Valves gaping postero-dorsally. Beaks narrow, pointed, incurved, orthogyrate, elevated slightly, located about one-third the length of the shell from the anterior end. Valves ornamented by coarse, rounded concentric ribs

separated by narrower shallow depressions.

Hinge line short, apparently straight, a continuation of the anterior and posterior margins. Antero-dorsal border slopes in straight line from hinge to intersect anterior border which is semi-circular; ventral border gently curved; posterior border strongly curved bending upward and forward to postero-dorsal border which is convex upward.

Measurements.- (in mm.)

U.M.M.P. No.	Length	Height	Thickness
33014 (Holotype)	54.0	35.5	25.0
33015 (Paratype)	40.3	23.2	17.7
33016 (Paratype)	62.0 (estimated)	41.0	30.2
33017 (Paratype)	42.3 (estimated)	28.0	21.2
33018 (Paratype)	48.0 (estimated)	32.3	26.0
33019 (Paratype)	47.0 (estimated)	32.1	23.1

Remarks.- This species appears to be one of the most widespread and abundant Homomyas in the Fredericksburg group of north Texas. In addition to the holotype and five paratypes the author has collected from the Goodland formation in Tarrant County about twenty fragmentary casts which are probably referable to this species.

Genus Tapes Megerle, 1811

Tapes ehlersi Perkins, sp. nov.

Pl. 7, figs. 8, 10-12

Types.- Holotype: U.M.M.P. 33020, a nearly perfect cast

showing exterior of both valves. Paratypes: U.M.M.P. 33021, a nearly perfect cast showing exterior of both valves; U.M.M.P. 33022, a worn cast showing exterior of both valves. Collected by Bob F. and Patricia W. Perkins, summer of 1954.

Horizon and type locality.- Holotype U.M.M.P. 33021: Comanchean, Washita group, Denison formation, middle part of Weno marly limestone member. Locality T-9, southeast bank of Sycamore Creek in Amon Carter Parksite, about 0.2 miles northeast of International-Great Northern Railroad bridge, Fort Worth, Texas.

Paratypes U.M.M.P. 33021, 33022: Denison formation, middle part of Weno marly limestone member. Locality T-33, railroad cut along International-Great Northern Railroad at west end of Atkins Street and about 0.1 miles south of Texas and New Orleans Railroad crossing, Fort Worth, Texas.

Diagnosis.- A Tapes closely resembling T. aldamensis Böse but differing from that species in being more elongate, more rounded and produced anteriorly, somewhat more inflated, and in having a more obscure notch anterior to the beaks. T. ehlersi differs from T. austinensis Whitney in having more rounded and more anteriorly located beaks.

Description.- Shell small, equivalved, inequilateral, moderately gibbous; beaks slightly elevated, incurved, prosogyrate, about one-third total length of shell from anterior extremity. Hinge line short, straight; dorsal margin weakly notched anterior to beaks, sloping gently downward and back-

ward posterior to beaks; posterior margin short, sharply rounded; ventral margin long and gently rounded; anterior margin short, sharply rounded. Lunule small and elliptical; escutcheon narrow, elongate. Very narrow, faint sulcus in each valve extends from posterior slopes of beaks along dorsal slope of umbones to postero-dorsal angle. Growth lines fine, concentric and rounded.

Measurements.- (in mm.)

U.M.M.P. No.	Length	Height	Thickness
33020 (Holotype)	28.0	21.0	11.9
33021 (Paratype)	29.8	20.9	10.8
33022 (Paratype)	26.4	18.3	10.5

Remarks.- This species is named in honor of George M. Ehlers who has always encouraged students in the study of invertebrate paleontology.

Genus Meretrix Lamarck, 1799

Meretrix? fortworthensis Perkins, sp. nov.

Pl. 7, figs. 13, 14; Pl. 8, figs. 1, 2

Types.- Holotype: U.M.M.P. 33023, a well preserved steinkern. Paratype: U.M.M.P. 33024, a steinkern with the posterior border broken. Collected by Bob F. Perkins and party, spring of 1954.

Horizon and type locality.- Comanchean, Washita group, Denison formation, Main Street limestone member. Locality

T-9, crest of hill immediately southeast of Sycamore Creek in Amon Carter Parksite, about 0.2 miles northeast of International-Great Northern Railroad bridge, Fort Worth, Texas.

Diagnosis.- A species resembling Meretrix leonensis Conrad, which Whitney (1911) reports from the Buda limestone, but differing in having the dorsal margin less convex posterior to the beaks and more concave anterior to them; the beaks are more anterior in Meretrix? fortworthensis than in M. leonensis. Since the dentition is not observable in these steinkerns, this form is provisionally referred to the genus Meretrix.

Description.- Shell small, equivalved, inequilateral, oval in outline. Beaks anterior to midline of shell, elevated, pointed, prosogyrate. Dorsal margin long, gently convex posterior to beaks, strongly concave anterior to beaks; posterior margin short, sharply rounded; ventral margin gently curved, long; anterior margin short, sharply curved. Shell thick along dorsal margin and in central part, compressed along the posterior, ventral and anterior margins. Anterior muscle scars pronounced, ridge-like, extending downward from the dorsal margin.

Measurements.- (in mm.)

U.M.M.P. No.	Height	Length	Thickness
33023 (Holotype)	27.0	34.0	15.5
33024 (Paratype)	31.2	36.3	18.0

Genus Trapezium Megerle, 1811

Trapezium microsolen Perkins, sp. nov.

Pl. 8, figs. 3-5

Holotype.- U.M.M.P. 33025, a well preserved cast showing exterior of both valves. Collected by Patricia W. Perkins, fall of 1954.

Horizon and type locality.- Comanchean, Fredericksburg group, Goodland formation, Benbrook limestone member. Locality T-2, bluff on south bank of Marys Creek on Rawl Ranch, 0.8 miles south of U. S. Highway 80-180 and 0.5 miles east of Chaplin School Road, Tarrant County, Texas.

Diagnosis.- A Trapezium resembling Cypricardia [Trapezium] texana Roemer in size and general outline but differing from it in having the beaks less elevated and more strongly prosogyrate, in being more inflated, in having a more rounded posterior margin, and in possessing fine (microscopic) radial striae.

Description.- Shell small, equivalved, inequilateral, antero-posteriorly elongate, outline trapezoidal; beaks narrow, pointed, incurved, prosogyrate, not elevated, near anterior. Hinge line long, straight or slightly convex; ventral and dorsal borders subparallel; ventral border longer; posterior border short, gently curved backward and downward to join ventral border; ventral border straight or only slightly convex; anterior border short and protruding

forward to form a keel-like process. Subangular carina extends from beaks to postero-ventral margin, becoming wider and more rounded posteriorward. Growth lines fine, subequal, concentric; microscopic, closely spaced radial striae extend from beaks to posterior and ventral margins.

Measurements.- (in mm.)

U.M.M.P. No.	Length	Height	Depth of one valve
33025 (Holotype)	24.0	13.7	8.0

Remarks.- This species is known only from the holotype. However, many fragments of a pelecypod showing a carina and fine radial striae similar to those on the holotype have been collected by the author from the Goodland formation and may be referable to this species.

Genus Modiolus Lamarck, 1799

Modiolus exiguus Perkins, sp. nov.

Pl. 8, figs. 6, 9, 10

Holotype.- U.M.M.P. 33026, specimen in which most of shell material of both valves is preserved. Collected by Bob F. Perkins, fall of 1954.

Horizon and type locality.- Comanchean, Washita group, Denison formation, lower part of Main Street limestone member. Locality T-59, east bank of Sycamore Creek about 150 yards downstream from Texas Farm Road 731 bridge, Tarrant County, Texas.

Diagnosis.- A Modiolus readily distinguished by its very small size. It resembles M. concentrice-costellata Roemer from the Fredericksburg group in outline, but M. exiguus is apparently more compressed, and the dorsal and ventral margins do not diverge so greatly in the posterior part of the shell.

Description.- Shell small, equivalved, inequilateral, elongate. Anterior margin rounded, ventral and dorsal margins subparallel and straight, posterior margin broadly rounded; shell slightly higher posteriorly. Beaks small, low, prosogyrate, subterminal in position. Pronounced ridge extends and gradually widens from a point posterior to the beak to the postero-ventral margin. Anterior to ridge is a broad shallow depression gradually increasing in width as it extends from umbone to ventral margin; shell slightly widened anterior to depression. Shell surface ornamented by fine concentric striae.

Measurements.- (in mm.)

U.M.M.P. No.	Length	Height	Thickness
33026 (Holotype)	23.0	10.8	8.0

Genus Barbatia Gray, 1842

Barbatia subquadrata Perkins, sp. nov.

Pl. 8, figs. 1-5, 7-9

Types.- Holotype: U.M.M.P. 32810, a well preserved cast showing the exterior of both valves. Paratypes: 33027-33031,

well preserved casts showing exterior of both valves. Collected by Bob F. and Patricia W. Perkins, winter of 1955.

Horizon and type locality.- Comanchean, Fredericksburg group, Goodland formation, lower part of Marys Creek marl member. Locality T-40, west bank of stream immediately south of Clyde Street and about 100 yards northwest of intersection of Clyde and Russell streets, west of Consolidated Aircraft Corporation Plant, White Settlement area, Tarrant County, Texas.

Diagnosis.- A small Barbatia characterized by its subquadrate outline and fine radial striae extending from the beaks to the ventral and posterior margins.

Description.- Shell small, equivalved, inequilateral, subquadrate in outline. Beaks about one-fifth total length of shell from anterior, prominent but not greatly elevated, incurved, prosogyrate. Hinge line long, convex posteriorly. Posterior border straight, sloping backward from dorsal border to intersect ventral border, curved sharply at intersection; ventral border straight, subparallel to dorsal border; anterior border broadly rounded. Central part of shell strongly gibbous; greatest width about one-half distance from beaks to posterior border; anterior part of shell, ventral and posterior to inflation, depressed. Posterior margin of inflated area marked by broadly rounded and gradually widening shoulder which extends from beaks to postero-ventral border. Surface marked by low, flat topped,

irregular growth lines and very faint radial striae.

Measurements.- (in mm.)

U.M.M.P. No.	Length	Height	Thickness
32810 (Holotype)	18.3	11.3	9.0
33027 (Paratype)	23.3	13.7	9.2
33028 (Paratype)	16.6	9.5	7.0
33029 (Paratype)	17.0	10.0	6.4
33030 (Paratype)	19.0	10.8	8.4
33031 (Paratype)	13.2	7.2	4.4

Remarks.- This species is common in the Marys Creek marl member of the Goodland formation in Tarrant County. In addition to the holotype and five paratypes the author has collected numerous fragmentary and worn casts which are probably referable to this species.

PART II. BIOSTRATIGRAPHY OF THE AURORA FORMATION IN THE OJO DE AGUA AREA, SIERRA DE TLAHUALILO, COAHUILA, MEXICO

INTRODUCTION

Location and Accessibility

The Sierra de Tlahualilo is a small mountain range, adjacent to the western boundary of Coahuila, on the Plateau Central of northern Mexico (Figs. 45, 46). The range is between latitudes 26° and 27° north and longitudes 103° and 103° 30' west. The Sierra is one of several ranges in central Coahuila trending north-south to northwest-southeast and lying along the northern border of the Parras Basin, a broad east-west valley. The range is bounded on the east by the Valle de Acatita, on the north by the narrow Puerto Astilleros separating it from the Sierra del Rey, and on the west by the Laguna de Tlahualilo (now dry).

The Sierra de Tlahualilo lies about 35 miles northeast of the city of Torreon, and its south end is about ten miles east of the town of Tlahualilo.

Tlahualilo is connected with Torreon by a roadbed of crushed rock constructed as a base for a highway. A branch line of the Ferrocarril Nacional de Mexico also connects Tlahualilo with Torreon. Unimproved roads extend along the valleys on each side of the Sierra de Tlahualilo. The mountains and valleys are crossed by numerous horse and foot trails.

The area mapped and from which most of the fossils described were collected is in the vicinity of the Ojo de

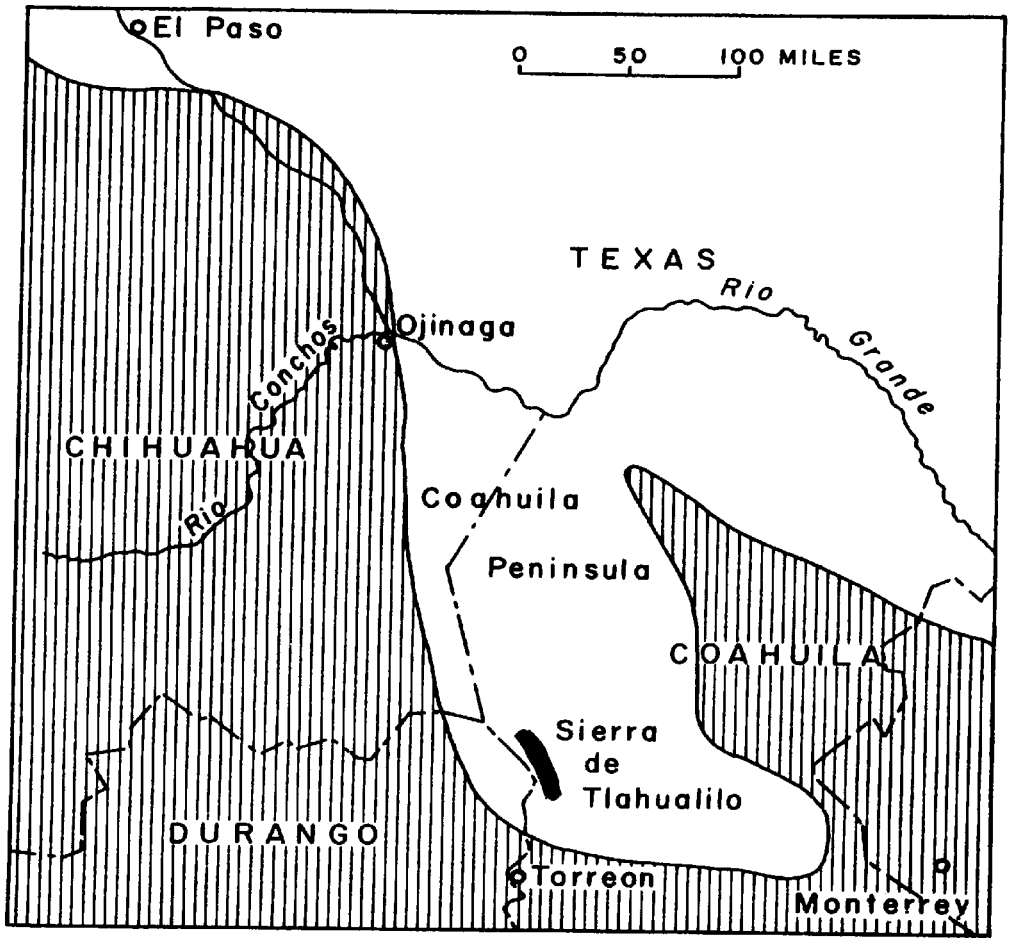


Figure 45. Index map of northern Mexico showing location of the Sierra de Tlahualilo and outline of the pre-Aptian Coahuila Peninsula (after Kellum et al, 1936). Shaded areas represent seaways and unshaded represent landmass.

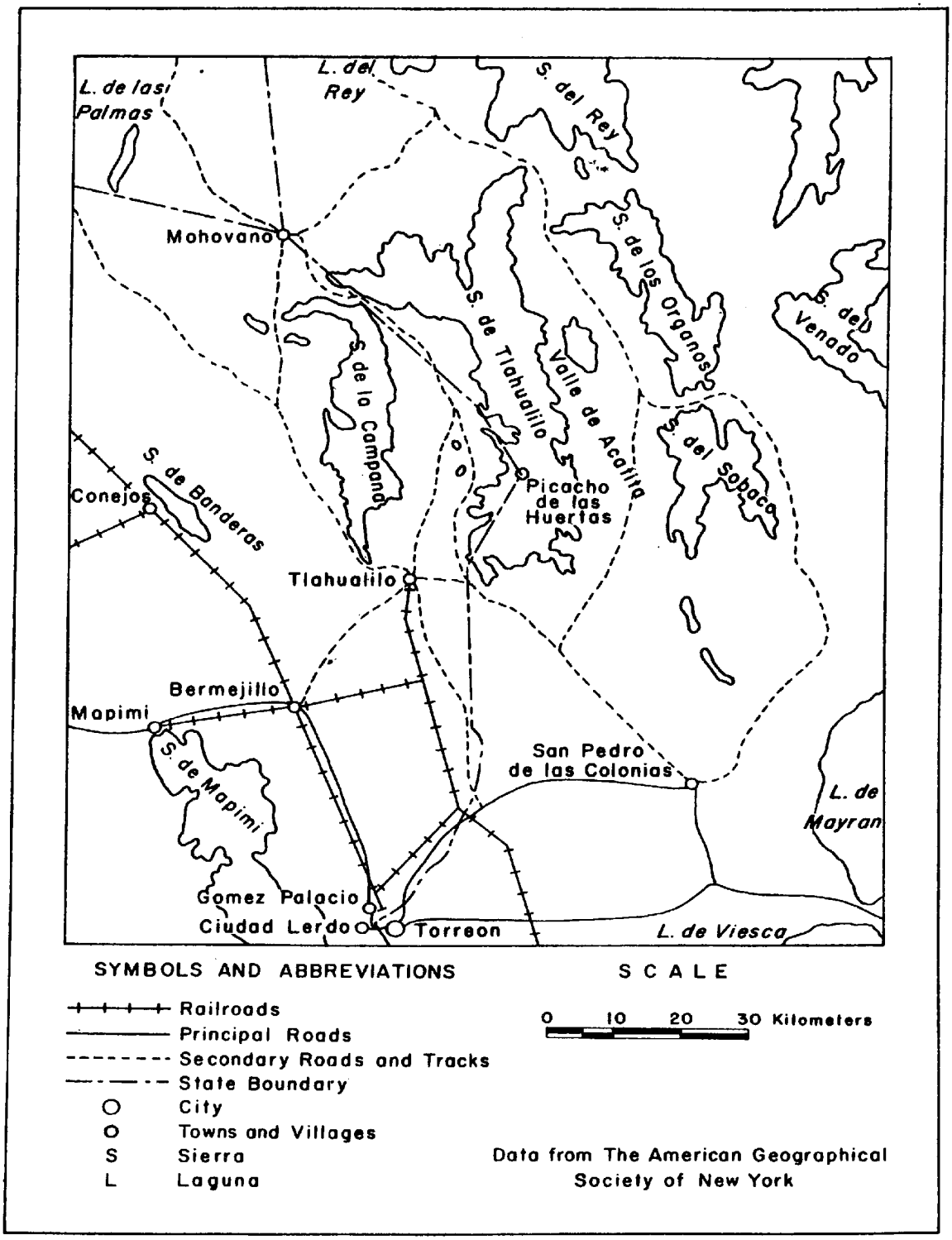


Figure 46. Sketch map of the Sierra de Tlahualilo area showing prinoipal topographic and cultural features.

Agua, a campsite in the west-central part of the range. The Ojo de Agua area is about 17 square miles in extent and is located on the western flank of the range.

Previous Investigations

The Sierra de Tlahualilo was briefly referred to by Kellum, Imlay, and Kane (1936, p. 973, 976, 990, 994) in their discussion of the Coahuila Peninsula. Basing their statements on the unpublished manuscript of W. I. Robinson entitled "The Geology of the Sierra de Tlahualilo, Durango", they described the general stratigraphy and structure of the range.

In a paper given at the meeting of the Geological Society of America in 1941 Robinson and Kellum (1941, p. 1930) briefly described their observations made in the area during 1934, 1935, and 1941. In 1954, Kellum described the geology of one of the major features, the Villareal Uplift, of the Sierra de Tlahualilo.

Method of Investigation

A map showing the principal topographic features and the geologic contacts in the area was constructed by use of plane table and alidade on a scale of one inch to 1000 feet. Additional geological mapping was done by pace and compass traverses from points located on the plane table base. The stratigraphic sections were measured and described by L. B. Kellum. Measurements were made by tape and calculations based on detailed pace and compass surveys.

Geography

Topography.- The Sierra de Tlahualilo, trending slightly west of north, is about 40 miles long and 15 miles wide. At its northern end is a cross ridge which projects east and west beyond the margin farther south.

The western front of the range is indented by numerous canyons. The largest is Cañon Rancherias in the south half of the range just south of Picacho de las Huertas, the highest peak. The elevation rises from about 1100 meters at the western margin to 2826 on Picacho de las Huertas.

Climate and culture.- The climate of the area is arid and supports a scant vegetation typical of the type known as Chihuahuan Desert Shrub (Shreve, 1942, p. 235-243; Müller, 1947, p. 38). The most common plant species occurring in the area are: Larrea (greasewood), Parthenium argentatum (guayule), Agave lechugilla, Agave (century plant), Euphorbia antisyphilitica (candelilla), Opuntia and Mamillaria (cacti), Fouquieria splendens (ocotillo), and Prosopis (mesquite).

There are no permanent settlements in the Sierra de Tlahualilo, although temporary camps are infrequently established in some of the peripheral canyons by people engaged in gathering candelilla for wax and guayule for rubber.

Several ranches which were established in the 19th century by a Spanish agricultural company and subsequently operated by an English company are situated near the range in the bolson north of Tlahualilo. These companies developed

an elaborate system of irrigation canals and extensively cultivated the area of the Laguna de Tlahualilo. Since the reparto of 1936, when foreign holdings in Mexico were terminated and the land parceled out to the local inhabitants, the canal system has been allowed to deteriorate, but it is still in use. Present agricultural activities consist of raising small quantities of cotton, corn, and melons.

Regional Geologic Setting

The Sierra de Tlahualilo is located near the southwest margin of the Coahuila Peninsula, which is at the south end of the North American mid-Mesozoic landmass (Fig. 45; Böse, 1923; Kellum et al, 1936). The existence of the peninsula in the Sierra de Tlahualilo area during earliest Cretaceous time is evidenced by the Aptian rocks resting unconformably on highly folded slates, shales, and quartzites of Paleozoic age (Kellum et al, 1936, p. 976). The Cretaceous sediments in the range include the gypsiferous Cuchillo formation, the Aurora limestone, and the Indidura formation, all of which were laid down in the sea that submerged the Coahuila Peninsula.

The folding and uplift responsible for the formation of the Sierra apparently began in the late Cretaceous, continued into the Tertiary, and were followed by periods of erosion and volcanism in mid-Tertiary time (Kellum, 1954, p. 69).

The Aurora limestone makes up the main mountain mass. It is underlain by the gypsiferous Cuchillo formation, which

is exposed in several of the deeper canyons along the western side of the range and in the area of the Villareal Uplift (Kellum, 1954, p. 69). At several places along the margins (Pl. 4) and over the top of the range at the northern extremity (Robinson and Kellum, 1941, p. 1930) fossiliferous marls and platy limestones of the overlying Indidura formation remain as erosional remnants. The basement Paleozoic rocks are well exposed in Cañon Rancherias.

Structurally, the Sierra de Tlahualilo is an anticlinal ridge trending slightly west of north. Two prominent cross folds are developed perpendicular to the major axis and are located at the north end of the range and about 15 miles farther south. According to Kellum et al (1936, p. 994), these cross folds probably represent "topographic features or zones of displacement, in the underlying basement rocks".

STRATIGRAPHIC GEOLOGY

General Stratigraphy

The rocks exposed in the Sierra de Tlahualilo are as follows:

Quaternary

Recent alluvium

Tertiary

Volcanic tuffs and breccias

Upper and Lower Cretaceous

Indidura formation

Lower Cretaceous

Aurora limestone

Cuchillo formation

Paleozoic (system not determined)

Folded slates, shales and quartzites

The Aurora limestone is estimated to be over 900 feet thick, but the thicknesses of the other formations have not been determined nor estimated.

Aurora Limestone

Name and type section.- R. H. Burrows (1909, p. 324; 1910, p. 96-98) named the limestone forming the crest of the Cuchillo Parado range the "Aurora formation" after the exposures near the Mina Aurora in the range. Here the formation is a thickly-bedded, massive, rudistid-bearing limestone, locally containing nodules of flint and iron ore. In the

type area the formation is about 5000 feet thick (King and Adkins, 1946, p. 286). At Cuchillo Parado the formation is considered to be of middle and upper Albian age and is correlated with the Fredericksburg group and the Georgetown limestone of Texas. Elsewhere in Mexico the formation is reported to be of middle and early Albian age and is correlated with the upper Trinity and Fredericksburg groups of Texas (Fig. 49; Imlay, 1942). In and near the type area the formation is an important mineral-bearer containing deposits of lead, silver, zinc, and copper.

Lithology and thickness.- In the Ojo de Agua area the Aurora consists of marly, nodular, and massive limestones, dolomites, and gypsum (Fig. 47). Lithologically, it is divisible into three members of which only the upper two have been measured and described.

MIDDLE MEMBER: This unit is composed of alternating thickly-bedded limestone, dolomite, and gypsum. The member is over 500 feet thick and is especially well exposed along the eastern side of the Cañon Ojo de Agua (Pl. 4). Fossils are rare in this member.

UPPER MEMBER: This member is comprised of beds of thick, granular limestone alternating with beds of nodular, marly limestone and infrequent shaly partings. The upper contact with the nodular Indidura formation is sharp. This member, which is exposed in the Cañon Ojo de Agua and in the Guayule Embayment (Pl. 4), is 365 feet thick and relatively fossiliferous.

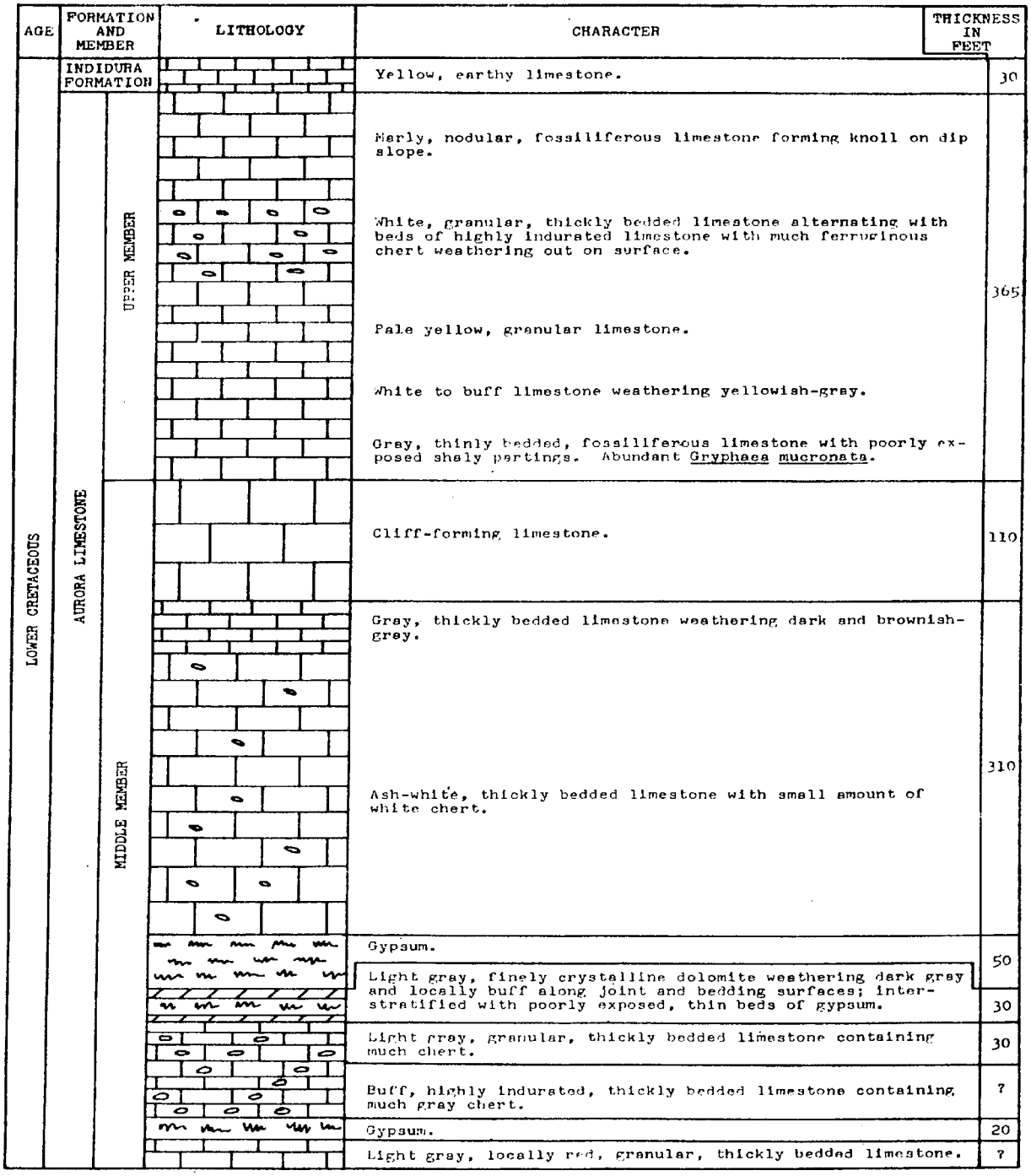


Figure 47. Generalized graphic section of the Aurora limestone in the Ojo de Agua area, Sierra de Tlahualilo, Coahuila. Section measured 7750 feet S. 58° 30' E. from the Ojo de Agua.

Paleontology.- Most of the fossils collected from the Aurora are steinkerns and casts with shell material present only on the oysters, pectens, echinoids, and a few gastropods. The imperfect preservation of the fossils prevents positive identification in some cases. The fauna is dominated by bivalves (27 species); echinoids (5 species) are less common; and cephalopods (2 species) are rare. Apparently, over the entire area of the formation's outcrop Aurora fossils are poorly preserved and are difficult to obtain from the hard limestones (Burrows, 1910, p. 97; Kelly, 1936, p. 1028; Jones, 1938, p. 80).

The fossils occur in two principal zones of abundance. The lower zone is about 50 feet above the base of the upper member. This zone is thin and is dominated by Gryphaea mucronata Gabb. The upper zone occurs through the upper 125 feet of the formation and is characterized by Homomya kellumi Perkins sp. nov. and other species of Homomya.

A list of the fossils collected from the Aurora limestone of the Sierra de Tlahualilo with indication of their occurrences is given in Plate 5. Those described here are deposited in the University of Michigan Museum of Paleontology (U.M.M.P.).

Stratigraphic faunal analysis.- The fauna described includes 45 species of which: (1), twenty-seven are identified and (2), five are compared with species known from the Texas Comanchean; (3), two are identified with species previously known from the Mexican Cretaceous; (4), six are

described as new species (one of these is also reported from Texas for the first time); and (5), six are given generic assignments only.

AURORA SPECIES IDENTIFIED WITH TEXAS SPECIES: The 27 Aurora species identified with Texas species may be subdivided into five categories on the basis of their ranges in the Texas section:

a. Trinity and Fredericksburg - one species. Pecten occidentalis (Conrad) is represented by three fragmentary individuals showing the distinctive ornamentation of this species.

b. Fredericksburg - five species. Exogyra texana Roemer is represented by a single diminutive valve the identification of which may be open to question on the basis of size even though the specimen was compared with small individuals of E. texana from Texas and found to be similar.

Gryphaea mucronata Gabb is very abundant but consists almost entirely of lower valves, which may indicate that they represent a reworked shell conglomerate from an older bed rather than a biocoenosic assemblage. It should be noted, however, that there is a widespread uniformity of lithology immediately subjacent to the shell conglomerate (L. B. Kellum, personal communication).

Cyprimeria texana (Roemer) is represented by two poorly preserved casts.

Tapes aldamensis Böse is represented by several fragmentary casts.

The identification of Tylostoma chihuahuaensis Böse is based on a weathered and broken cast. Species of Tylostoma are differentiated chiefly on the basis of size and proportions.

c. Fredericksburg and Washita - five species. Pecten (Neithea) texanus Roemer is common in the Aurora limestone, and in Texas it questionably occurs below the Washita group.

Lopha (Arctostrea) colubrina (Lamarck) rarely occurs below the Washita group in Texas.

Protocardia texana (Conrad) is well represented in the Aurora limestone, and in Texas the species appears to be more common in the Fredericksburg than in the Washita group.

Pecten (Neithea) subalpinus (Böse) is represented only by fragments and is distinguished from P. texanus on the basis of proportions.

Aporrhais? subfusiformis (Shumard) is known from the Aurora only by fragments, but they are sufficiently well preserved so as to leave no doubt regarding their identification.

d. Washita - 14 species. Ten species in this category are represented in sufficient numbers and by well enough preserved individuals to permit identification as follows:

Protocardia multistriata Shumard

P. denisonensis (Cragin)

Homomya budaensis Whitney

Pholadomya shattucki Böse

Pleurotomaria (Leptomaria) austinensis Shumard

Ampullina? collina (Conrad)

Cymatoceras hilli (Shattuck)

Turrilites brazoensis Roemer

Holectypus (Caenholectypus) castilloi Cotteau

Hemiaster calvini Clark

Homomya kellumi Perkins, sp. nov. is abundant in the Aurora limestone but is known from Texas only by two incomplete individuals from the Fort Worth limestone at Fort Worth.

All specimens of the two echinoids Enallaster (Washitaster) bravoensis Böse and Pseudananchys completa (Cragin) are worn and their plate systems are not well shown.

The identification of Turritella leononsis Conrad is based entirely on the ornamentation preserved on several fragments.

e. Trinity, Fredericksburg, and Washita - two species. Kingena wacoensis (Roemer) is rarely found below the Washita group in Texas.

Lima (Mantellum) wacoensis Roemer is rarely found below the Fredericksburg group in Texas. The specimens referred to this species are not well

enough preserved to determine whether or not they belong to the variety L. (Mantellum) wacoensis quadrangularis Stanton. Professor Kellum has collected several well preserved specimens from the Aurora of this area and has referred his specimens to this variety, which in Texas is limited to the Washita group.

Of the 27 Aurora species identified with Texas species one-half are limited to the Washita group, one-fifth occur in both the Fredericksburg and Washita groups, and one-fifth can be identified with species limited to the Fredericksburg. Of this latter group only one species, Gryphaea mucronata, can be unquestionably recognized.

AURORA SPECIES COMPARED WITH TEXAS SPECIES: The five Aurora species that are compared with Texas species are not considered of value in the correlation since none of the specimens is sufficiently well preserved to permit other than a very general comparison with the Texan forms.

AURORA SPECIES IDENTIFIED WITH PREVIOUSLY KNOWN MEXICAN FORMS: The two species, Veniella coahuilaensis Jones and Pholadomya toribioensis Jones, which have been identified with previously known Mexican forms have been reported heretofore only from the middle and upper members of the Indidura formation of upper Albian through lower Turonian age (upper Washita and lower Gulfian).

NEW SPECIES: Of the six new species from the Aurora limestone four appear to be identical with or closely allied

to forms known from Texas or Mexico. The ranges of the identical or allied forms are shown in Table 2.

Table 2. New species from the Aurora limestone with stratigraphic ranges of identical or allied forms from Texas or Mexico.

New Species	Identical or Allied Species	Stratigraphic Range
Pteria bösei	P. bösei	Fredericksburg equivalent (Cerro de Muleros)
Eoradiolites albrittoni	?	---
Homomya auroraensis	H. vulgaris	Buda limestone
H. kellumi	H. kellumi	Fort Worth limestone
H. tlahualiloensis	H. kellumi	Fort Worth limestone
Natica parvum	?	---

Of the four new species which appear to be the same as or allied to forms from Texas or Mexico, three are most closely related to middle and upper Washita species, and only one is related to a Fredericksburg species.

AURORA SPECIES GIVEN GENERIC ASSIGNMENTS ONLY: The author considers specimens to which only generic assignments can be given not sufficiently reliable for use in such a detailed correlation as is attempted in this report.

Age and correlation.- On the basis of the ranges of the Texan and Mexican species with which the Aurora forms are identified (Fig. 48) and the ranges of the Texan and Mexican species allied to the new species from the Aurora, it is concluded that the upper member of the Aurora limestone of

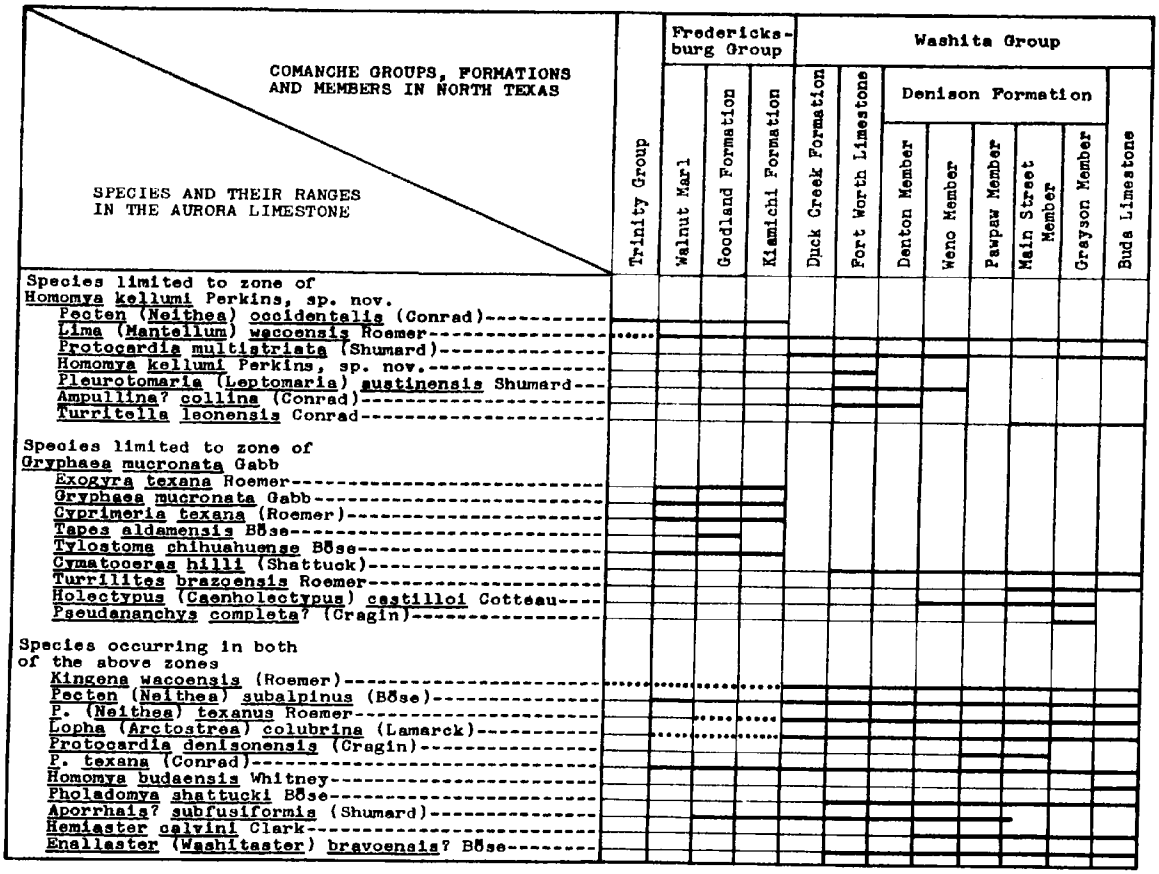


Figure 48. Range of some Aurora fossils showing basis for correlation with the Washita group of north Texas.

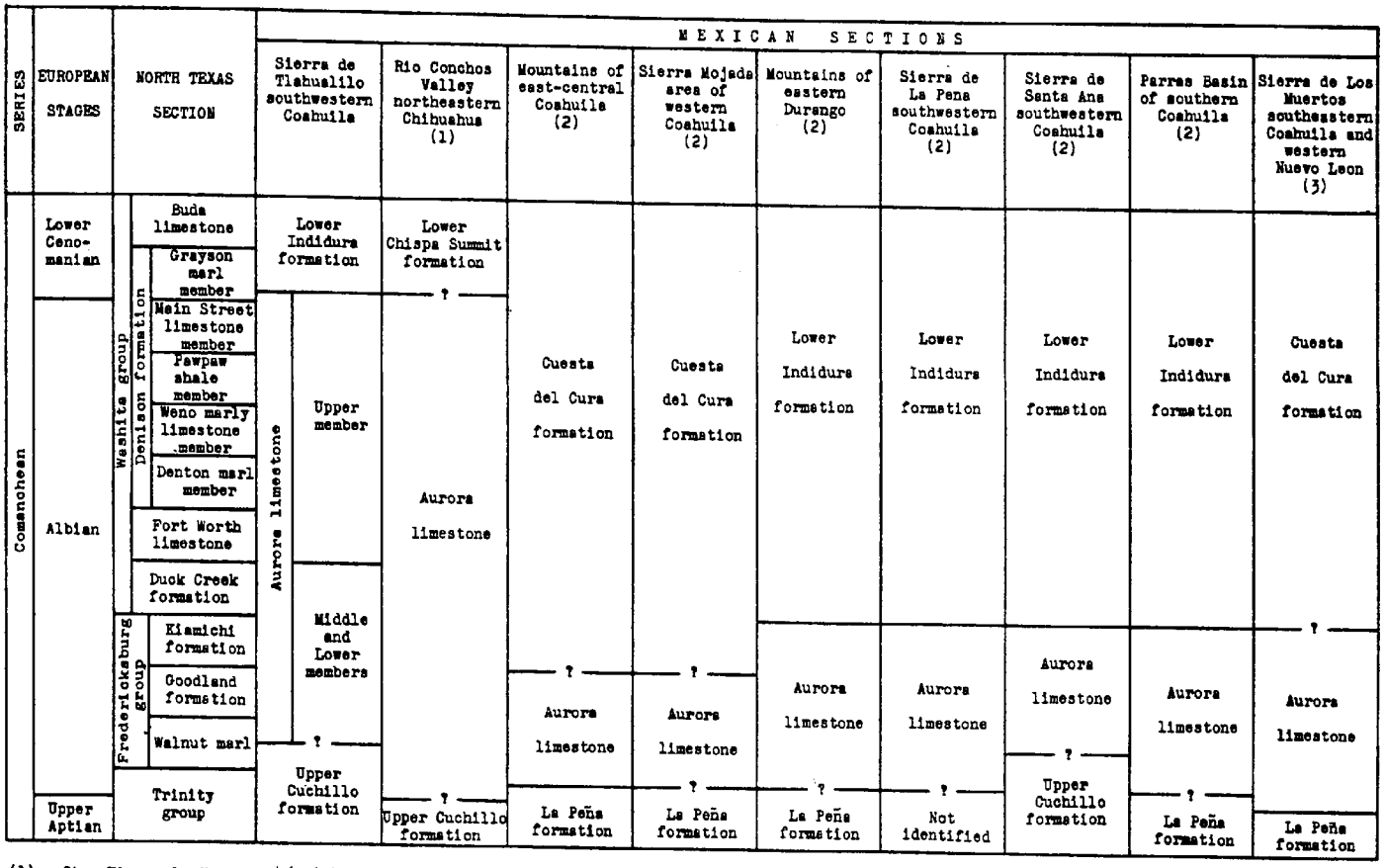
the Sierra de Tlahualilo should be correlated with the Washita group of Texas.

The lower part of the upper member is correlated with the Fort Worth limestone, because of the 14 species of the Aurora fauna limited to the Washita group in Texas, 13 range no lower than the Fort Worth limestone. Also, Professor Kellum reports that (personal communication):

> About 50 feet below the G. mucronata zone [at the base of the upper member]... is a cliff-forming unit about 60 feet thick made up of thick beds of limestone. This is a persistant and conspicuous unit comparable in appearance to the Edwards limestone. It is underlain by white miliolid-bearing limestone which is definitely Fredericksburg in age. ...I did not recognize these units in the Cañon Ojo de Agua, but it seems probable that ... locality 4 ... is at or near the top of the cliff-forming unit 50 feet below the G. mucronata zone.

Therefore, it is possible that the 110 foot section overlying the miliolid limestone is the age-equivalent of the upper Fredericksburg and lower Washita of Texas, although there is no conclusive faunal evidence for this correlation.

The uppermost part of the formation is correlated with the upper Washita, because of the 14 Aurora species limited to the Washita group seven range as high as the Buda limestone and three others range as high as the Grayson marl member of the Denison formation.



(1), after King and Adkins, 1946; (2), after Imlay, 1944; (3), after Humphrey, 1949.

Figure 49. Correlation chart of Albian formations in northern Mexico and north Texas.

Professor Kellum (personal communication) has found in the overlying Indidura formation at a locality southeast of the Ojo de Agua three faunal zones as follows in descending order:

(1) Inoceramus labiatus Schlotheim

(2) Hemiaster calvini Clark

(3) Exogyra arietina Roemer

In Texas Exogyra arietina ranges from the Main Street limestone member of the Denison formation to the basal Buda limestone and Hemiaster calvini extends through the Buda. If the Indidura faunal zones three and two can be correlated with the upper part of the Grayson and the Buda, respectively, it seems probable that the uppermost part of the Aurora can be correlated with strata no higher than the lowermost part of the Grayson marl.

This correlation indicates an upper Albian to possibly a lower Cenomanian age (Stephenson et al, 1942) for the upper member of the Aurora limestone in the Sierra de Tlahualilo.

As shown in Figure 49, the age of the formation has been determined as ranging from lower to middle Albian in most area in northern Mexico. Outside of the Sierra de Tlahualilo area, only at Cuchillo Parado in eastern Chihuahua has the upper part of the Aurora limestone been considered as young as uppermost Albian or possibly Cenomanian.

FOSSIL LOCALITIES

Fossil collections from localities 1-3 were made by W. I. Robinson in 1934; collections from 4-9 in 1935. The collection from locality 10 was made by L. B. Kellum in 1941; collections from 48-56 were made by him in 1953. Collections from localities 11-47 were made by the members of the Museum of Paleontology 1952 Mexican Expedition comprised of L. B. Kellum, C. C. Kersting, and the author. The directions "right" and "left" sides of the arroyos are used with reference to the observer facing downstream.

1. Small outlying hill north of Puerto Cañon Rancheria.
2. In hills east of the Ojo de Agua.
3. North side of Los Maranos.
4. Indidura outliers seven miles S. 63° E. from Camp and 15 miles easterly from La Noria.
5. From Camp X 860 paces east and about one niles north of the Ojo de Agua ash beds.
6. Robinson's 1935 Locality 13.
7. One mile S. 30° E. from Camp X, Sierra de Tlahualilo.
8. Canyon 1.5 miles north of Rancheria.
9. Float from steeply dipping Aurora beds in two arroyos east of the Ojo de Agua.
10. Right side of valley which drains N. 55° W. into a reentrant on west side of Sierra de Tlahualilo, about five or six miles from the north end of the range.
11. Right side of Cañon Ojo de Agua about 9000 feet N. 72° E. of the Ojo de Agua.
12. Beneath overhanging cliff on right side of Cañon Ojo de Agua, about 10,750 feet N. 87° 15' E. of the Ojo de Agua.
13. Benches of rubbly limestone along left side of valley on

trail from the Ojo de Agua northward to Guayule camp.

14. On trail that leads northeast from the Ojo de Agua across rim into Cañon Ojo de Agua, about 7000 feet N. 71° 45' E. of the Ojo de Agua.

15. About 9560 feet N. 34° E. of the Ojo de Agua.

16. Left side of mouth of canyon tributary to Cañon Ojo de Agua, about 10,120 feet N. 40° 15' E. of the Ojo de Agua.

17. Scuth end of outlying limestone ridge, about 9135 feet N. 36° 45' E. of the Ojo de Agua.

18. Top of rim overlooking the Cañon Ojo de Agua on trail leading northeast from the Ojo de Agua, about 8150 feet N. 72° 15' E. of the Ojo de Agua.

19. Left side of Cañon Ojo de Agua, about 8250 feet N. 70° 30' E. of the Ojo de Agua.

20. Left side of Cañon Ojo de Agua, about 9705 feet N. 84° 20' E. of the Ojo de Agua.

21. Left side of Cañon Ojo de Agua, about 9860 feet N. 84° 40' E. of the Ojo de Agua.

22. Right side of Cañon Ojo de Agua, about 10,980 feet N. 84° E. of the Ojo de Agua.

23. Left side of Cañon Ojo de Agua, about 10,666 feet N. 84° 40' E. of the Ojo de Agua.

24. On tributary which drains east into left side of Cañon Ojo de Agua, about 10,985 feet S. 78° E. of the Ojo de Agua.

25. About 8045 feet S. 70° 20' E. of the Ojo de Agua.

26. About 10,365 feet S. 76° E. of the Ojo de Agua.

27. About 9795 feet S. 26° 50' E. of the Ojo de Agua.

28. Cañon Ojo de Agua about 11,385 feet S. 80° E. of the Ojo de Agua.

29. About 8500 feet S. 72° 42' E. of the Ojo de Agua.

30. Left side of Cañon Ojo de Agua, about 9960 feet N. 45° 20' E. of the Ojo de Agua.

31. About six miles northeast of the Ojo de Agua.

32. Cañon Ojo de Agua.

33. Cañon Ojo de Agua, about 9230 feet N. 66° 40' E. of the Ojo de Agua.

34. Left side of Cañon Ojo de Agua, about 9265 feet N. 63° E. of the Ojo de Agua.

35. Right side of Cañon Ojo de Agua, about 10,220 feet N. 43° 40' E. of the Ojo de Agua.

36. About six miles northeast of the Ojo de Agua.

37. Right side of north branch of Cañon Ojo de Agua.

38. Top of knob N. 30° E. of the conspicuous ash cone hill near the Ojo de Agua.

39. Left side of north tributary to Cañon Ojo de Agua.

40. Right side of Cañon Guayule.

41. Left side of Cañon Guayule.

42. In first tributary of Cañon Guayule north of the Guayule Camp.

43. In third large canyon tributary to Cañon Guayule north of the Guayule Camp.

44. On the nose of the ridge S. 67° E. of the north end of the igneous hills area.

45. North side of Guayule reentrant S. 64° E. of the north end of the volcanic hills.

46. Right side of the large canyon that drains the Villareal uplift. N. 25° E. of the north end of the volcanic hills.

47. Right side of Cañon Ojo de Agua, about 9000 feet N. 23° E. of the Ojo de Agua.

48. On top of the ridge on the right side of tributary of Arroyo Guayule, upstream from and about 2100 feet northeast of Camp 531.

49. Near top of the ridge on the left side of tributary of Arroyo Guayule, about 1400 feet northeast of Camp 531.

50. On side of small outlying knob between tributaries of Arroyo Guayule, about 5100 feet northeast of Camp 531.

51. On crest of hill on left side of canyon of Arroyo Guayule, about 900 feet east of Camp 531.

52. Outcrop forms bench extending along left side of bed of Arroyo Gonzalez, about 400 feet upstream from Locality

23 and about 2350 feet southeast of Camp 532.

53. In the northern part of the Gonzalez Basin, on hillside at left of draw which drains about S. 45° W., about 5100 feet northeast of Camp 532.

54. In saddle on top of ridge, on opposite side of draw from Locality 53, about 4700 feet northeast of Camp 532.

55. Right side of tributary of Arroyo Gonzalez, about 600 feet upstream from Locality 28.

56. Same location as Locality 53, but fossils collected from float at somewhat lower stratigraphic position.

SYSTEMATIC PALEONTOLOGY

Phylum BRACHIOPODA

Genus Kingena Davidson, 1852

Kingena wacoensis (Roemer)

Pl. 9, figs. 1-8

1852 Terebratula wacoensis Roemer, Kreidebildungen von Texas, p. 81, 82, pl. 6, figs. 2a-c, Bonn.

1857 Terebratula wacoensis Roemer. Conrad, U. S. and Mex. Boundary Survey, v. 1, pt. 2, p. 147, pl. 3, figs. 1a-d.

1902 Kingena wacoensis (Roemer). Hill, U.S.G.S. 21st Annual Report, pt. 7, pl. 37, figs. 5, 5a.

1928 Kingena wacoensis (Roemer). Adkins, Texas Univ. Bull. 2838, p. 80.

Material.- About 180 specimens, U.M.M.P. 17416, 17560, 17492, 17282, 29498, 32880-32898.

Occurrence.- Upper Aurora limestone, Sierra de Tlahualilo, Coahuila. Zone of Gryphaea mucronata, localities 11, 12, 21-24, 28, 30, 32-34, 36-45; zone of Homomya kellumi, locality 29.

Abundant in Washita group; rare in Fredericksburg and Trinity groups (fide Adkins, 1928) of Texas.

Description.- Shell small to large, subpentagonal in outline, length-width ratio 1:1 to 1:0.86, biconvex, rectimarginate to uniplicate. Pedicle valve generally more inflated than brachial; beak suberect to erect. Foramen medium size. Surface marked by fine to coarse growth lines.

Measurements.- (in mm.)

U.M.M.P. No.	Length	Width	Thickness
32824	28.4	26.6	16.5
32825	14.6	13.5	8.9

Discussion.- This species is very abundant in the Texas Comanchean where it has considerable variation in size, biconvexity, and outline. The Aurora limestone specimens fall within the limits of these variations and are therefore referred to this species.

Phylum MOLLUSCA

Class Pelecypoda

Genus Pterotrigonia Hoepen, 1929

Pterotrigonia cf. P. guadalupae (Böse)

Pl. 9, figs. 9, 10

Material.- One specimen, U.M.M.P. 32826.

Occurrence.- Upper Aurora limestone, Sierra de Tlahualilo, Coahuila. Zone of Gryphaea mucronata, locality 38.

Occurrence of P. guadalupae.- Denison formation (Weno marly limestone member), north Texas; Fredericksburg group, La Encantada, Chihuahua.

Description.- Shell small to medium size, equivalved, very inequilateral; beaks prominent with tips broken; dorsal border concave; ventral border very convex; anterior border long and gently rounded; posterior border very short and

angular; area anterior to beaks short; area posterior to beaks long and tapering; several posteriorly convex ribs extending from dorsal to ventral margins faintly evident.

Measurements.- (in mm.)

U.M.M.P. No.	Length	Height	Thickness
32826	40.0	31.0	22.0

Comparison.- The specimen has the general form and size of Pterotrigonia guadalupae (Böse) (1910, p. 124-125, pl. 23, figs. 11-16); however, its poor preservation does not permit determination of specific identity.

Genus Pteria Scapoli, 1777

Pteria bösei Perkins, sp. nov.

Pl. 9, figs. 11-13; Pl. 10, figs. 1, 2, 10, 15

1910 Avicula pedernalis Böse [non Roemer, 1849]. Böse, Inst. Geol. Mexico, Bol. 25, p. 84, pl. 12, figs. 4-9.

1928 Pteria pedernalis (Roemer) [partim]. Adkins, Texas Univ. Bull. 2838, p. 97.

1938 Pteria pedernalis (Böse) non (Roemer). Jones, Geol. Soc. Am., Bull., v. 49, p. 104, pl. 2, fig. 20, pl. 3, figs. 8, 10, 13, 17.

Types.- Holotype: U.M.M.P. 16694, a well preserved steinkern with fragments of original shell along dorsal margin. Paratype: U.M.M.P. 16693, steinkern of smaller individual with shell showing surface markings of left valve.

Horizon and type locality.- Holotype U.M.M.P. 16694:

Lower Cretaceous, Indidura formation, members two and three. Locality north of Tanque Toribio, Sierra de Santa Ana, Coahuila (locality J-69, Jones, 1938, p. 104).

Paratype U.M.M.P. 16693: Lower Cretaceous, Indidura formation, members two and three. Hill just southeast of the mouth of Indidura Canyon, Sierra de Santa Ana, Coahuila (locality J-57, Jones, 1938, p. 104).

Diagnosis.- A Pteria differing from P. pedernalis (Roemer) in being higher in proportion to the length, in being somewhat thicker, and in having coarser and more regular concentric lamellae. P. bösei is similar in outline to P. aguilerae (Böse), but differs from that species in having a greater convexity, prominent muscle scars below the beak, and broad concentric lamellae, and in lacking a sulcus separating the posterior wing from the remainder of the shell.

Description.- Shell medium to large, subequivalved, inequilateral, obliquely elongate, semi-oval in outline; beaks of moderate size, very slightly elevated, inturned, about one-third total length of hinge line from anterior end; greatest thickness slightly anterior to center of shell with left valve slightly more inflated than right; small triangular wing anterior to beaks not separated from rest of shell by sulcus; a similar but larger, rounded, triangular wing without sulcus posterior to beaks; small prominent muscle scars anterior to beaks. Surface of valves marked by broad concentric subequal lamellae.

Referred material.- In addition to the types, two specimens, U.M.M.P. 32711, 32827, are referred to this species. These specimens have the form and proportions of the types but are much less well preserved steinkerns devoid of shell material.

Occurrence of referred material.- Upper Aurora limestone, Sierra de Tlahualilo, Coahuila. Zone of Gryphaea mucronata, locality 50; zone of Homomya kellumi, locality 14.

Measurements.- (in mm.)

U.M.M.P. No.	Length	Height	Thickness
16694 (Holotype)	68.5	69.5	42.0
16693 (Paratype)	42.2	48.5	28.0
32827	64.0(estimate)	72.0	45.0
32711	72.0(estimate)	81.0(estimate)	40.0(estimate)

Discussion.- Although Jones (1938, p. 104) did not describe this form as a new species, he recognized its similarity with the specimens referred to by Böse (1910, p. 84) as Avicula pedernalis Roemer and its distinction from Roemer's material. Because of the differences cited by Jones and those given in the above diagnosis, it seems desirable to distinguish the material of Jones and Böse from Roemer's species by defining a new species as is done here.

Genus Pecten Müller, 1776

Pecten (Neithea) occidentalis (Conrad)

Pl. 10, figs. 3, 4

1855 Neithea occidentalis Conrad, Acad. Nat. Sci. Philadelphia, Proc. 1854-55, p. 269.

1857 Neithea occidentalis Conrad, U. S. and Mexican Boundary Survey, v. 1, pt. 2, p. 150, pl. 5, figs. 1a, b.

1947 Pecten (Neithea) occidentalis (Conrad). Stanton, U.S.G.S. Prof. Paper 211, p. 43, pl. 27, figs. 1-4.

For a more complete synonomy of this species see Stanton (1947).

Material.- Three specimens, U.M.M.P. 22828, 32898, 32899.

Occurrence.- Upper Aurora limestone, Sierra de Tlahualilo, Coahuila. Zone of Homomya kellumi, localities 16, 17, 26.

Fredericksburg group, central and north Texas; Quitman formation (Trinity), Quitman Mountains, trans-Pecos Texas; Glen Rose limestone (Trinity), Austin, Texas; Purgatoire formation, Mesa Tucumcari, New Mexico; Kiowa shale, Belvidere, Kansas.

Measurements.- (in mm.)

U.M.M.P. No.	Length	Height	Convexity
22828	18.2	20.3	8.0

Discussion.- This species is particularly characterized by the sculpture of the right valve. The sculpture consists

of six principal ribs with two smaller secondary ribs in each interspace; both sets of ribs are elevated and subangular. The principal ribs have on one or both sides a much smaller tertiary rib; the two external principal ribs have this smaller rib only on the inside. The Aurora specimens, which consist of right valves only, demonstrate this typical ornamemtation and agree closely with other characters described and figured by Conrad and Stanton.

Pecten (Neithea) subalpinus (Böse)

Pl. 10, figs. 5, 6

1910 Vola subalpinus Böse, Inst. Geol. Mexico Bol. 25, p. 96, pl. 15, figs. 5, 7-9.

1947 Pecten (Neithea) subalpinus (Böse). Stanton, U.S.G.S. Prof. Paper 211, p. 42, pl. 44, figs. 7, 8.

See Stanton (1947) for a complete synonomy of this species.

Material.- Seventeen specimens, U.M.M.P. 17370, 17383, 17469, 17493, 32900-32906.

Occurrence.- Upper Aurora limestone, Sierra de Tlahualilo, Coahuila. Zone of Gryphaea mucronata, localities 21, 22, 39, 41; zone of Homomya kellumi, localities 16, 25; zone unknown, localities 5, 7-9.

Fredericksburg and Washita groups in Texas and their equivalents in Mexico.

Measurements.- (in mm.)

U.M.M.P. No.	Length	Height	Thickness
17469	18.0	21.0	7.0

Comparison.- A study of a large Texas collection of Pecten texanus Roemer and P. subalpinus indicates that the two species intergrade (as suggested by Stanton, 1947, p. 46). Typically, however, P. subalpinus is more slender and has narrower, more highly elevated ribs than P. texanus. The Aurora specimens referred to P. subalpinus have the typical slender form, but the ribs are so worn as to prevent comparison with P. texanus.

Pecten (Neithea) texanus Roemer

Pl. 10, figs. 7-9, 11

1852 Pecten texanus Roemer, Kreidebildungen von Texas, p. 65, pl. 8, figs. 3a, b, Bonn.

1947 Pecten (Neithea) texanus Roemer. Stanton, U.S.G.S. Prof. Paper 211, p. 45, pl. 38, figs. 2, 4, 5; pl. 39, figs. 3-5, 7.

See Stanton (1947) for a complete synonomy of this species.

Material.- Twenty-nine specimens, U.M.M.P. 17417, 32829-32830, 32907-32911.

Occurrence.- Upper Aurora limestone, Sierra de Tlahualilo, Coahuila. Zone of Gryphaea mucronata, localities 11, 28, 33; zone of Homomya kellumi, locality 13; zone unknown, localities 4, 10.

Washita group throughout Texas; questionably from the Fredericksburg (Stanton, 1947, p. 46).

Measurements.- (in mm.)

U.M.M.P. No.	Length	Height	Convexity
32829 (right valve)	19.2	21.5	7.0
32830 (left valve)	21.0	22.0	---

Discussion.- The Aurora specimens referred to this species include several poorly preserved right valves and some fragmentary left valves. Although the specimens are incomplete, the observable characters agree closely with those described and illustrated by Roemer and Stanton.

Pecten (Neithea?) sp.

Pl. 11, fig. 1

Material.- One specimen, U.M.M.P. No. 17280.

Occurrence.- Upper Aurora limestone, Sierra de Tlahualilo, Coahuila. Zone unknown, locality 3.

Description.- Shell large; ornamented with broad, low, rounded, radial ribs separated by narrower shallow flat bottomed depressions; posterior? auricle large and ornamented with radial ribs about one-fourth the width of the principal ribs, interspaces and ribs about equal in width. The principal ribs increase in size from the posterior? margin to the center of the shell and some of them appear to bear fine radial striae.

Measurements.- (in mm.)

U.M.M.P. No.	Height	Length
17280	50.0	54.5

Comparisons.- The possession of subequal ribs that gradually increase in size from the posterior? margin to the center of the shell distinguishes this species from Pecten roemeri Hill. The ribs of this form tend to be broadly rounded to flat topped, whereas the ribs of Hill's species are subangular to broadly rounded, flat topped ribs being rare in P. roemeri.

This species resembles Ctenostreon cumminsi Stanton in size and in the structure of the ribs, but it differs from Stanton's species in having ribs with somewhat narrower interspaces on the auricle.

Genus Lopha Bolten, 1798

Lopha (Arctostrea) colubrina (Lamarck)

Pl. 10, fig. 12

1819 Ostrea colubrina Lamarck, Animaus sans Vertebres, v. 6, pt. 1, p. 216.

1910 Ostrea colubrina Lamarck. Pervinquiere, Paleontologia Universalis, no. 198.

1912 Ostrea diluviana Woods [non Linné], Cretaceous Lamellibranchia of England, v. 2, p. 342, text-figs. 98-138.

1924 Lopha rectangularis Newton, Malacological Soc. London, Proc. v. 16, p. 143, pl. 7, figs. 1-3.

1947 Ostrea (Arctostrea) carinata Stanton [non Schröter, 1802], U.S.G.S. Prof. Paper 211, p. 18, pl. 7, figs. 8-13.

1954 Lopha (Arctostrea) colubrina (Lamarck). Cox, Jour. Paleontology, v. 28, no. 5, p. 630, pl. 64, figs. 2, 3.

See Stanton (1947) for a more complete synonomy of this species. Cox gives a thorough discussion of the proper usage of the name Lopha colubrina (Lamarck) and the misapplication of Ostrea carinata.

Material.- Four specimens, U.M.M.P. 32831, 32912-32914.

Occurrence.- Upper Aurora limestone, Sierra de Tlahualilo, Coahuila. Zone of Gryphaea mucronata, localities 21, 38; zone of Homomya kellumi, localities 15, 31.

Common in Washita group, Texas; rare in Fredericksburg group, Texas; Cenomanian, Germany, France, England; Barremian or Aptian, Pointe-A-Pierre, Trinidad (Cox, 1954).

Measurements.- (in mm.)

U.M.M.P. No.	Length
32831	26.0 (estimate)

Discussion.- Several fragmentary specimens showing the characteristic strong plications on the upper surface of the shell and one showing the zig-zag line of commissure are referred to this species.

Genus Exogyra Say, 1820

Exogyra texana Roemer

Pl. 10, figs. 13, 14

1852 Exogyra texana Roemer, Kreidebildungen von Texas, p. 69, pl. 10, figs. 1a-e, Bonn.

1947 Exogyra texana Roemer. Stanton, U.S.G.S. Prof. Paper 211, p. 36, pl. 28, figs. 1-5; pl. 29, figs. 1-6; pl. 30, figs. 1, 2.

See Stanton (1947) for a complete synonomy of this species.

Material.- One specimen, U.M.M.P. No. 32832.

Occurrence.- Upper Aurora limestone, Sierra de Tlahualilo, Coahuila. Zone of Gryphaea mucronata, locality 49.

Fredericksburg group, Texas and its equivalent, northern Mexico; Kiowa shale, Blevidere, Kansas.

Measurements.- (in mm.)

U.M.M.P. No.	Length	Width	Thickness
32832	9.0	7.0	3.8

Discussion.- This species is represented by a single diminutive lower valve in which the strongly curved beak, the strong convexity, the radiating rugose ribs, and the margin thickened by concentric lamellae, structures typical of the species, are preserved.

This specimen has been compared with several examples of E. texana of comparable size from the Walnut marl of north Texas and appears to be conspecific.

Genus Gryphaea Lamarck, 1801

Gryphaea mucronata Gabb

Pl. 11, figs. 2-11

1869 Gryphaea mucronata Gabb [partim], California Geol. Survey, Paleontology, v. 2, p. 274.

1947 Gryphaea mucronata Gabb. Stanton, U.S.G.S. Prof. Paper Paper 211, p. 28, pl. 18, figs. 1-26.

See Stanton (1947) for a complete synonomy of this species.

Material.- About 525 specimens, U.M.M.P. 32395, 32749, 32810, 32833-32835, 32915-32937.

Occurrence.- Upper Aurora limestone, Sierra de Tlahualilo, Coahuila. Zone of Gryphaea mucronata, localities 11, 12, 21-24, 28, 30, 32-46, 52, 59.

Fredericksburg group, Texas and its equivalent, northern Mexico.

Measurements.- (in mm.)

U.M.M.P. No.	Height	Width	Convexity
32395	35.5	21.7	21.3
32749	27.5 (estimate)	16.0 (estimate)	19.3
32810	39.0 (estimate)	27.4	29.0 (estimate)
32833	40.7	31.4	26.0
32834	26.4	20.3	11.3
32835	30.5	20.9	17.3

Discussion.- According to previous descriptions and figures, this species is somewhat variable. The Aurora examples, however, are relatively constant in form, are more or less oval in outline, and most specimens are less elongate than many of the specimens illustrated by Stanton (1947).

Genus Lima Bruguiere, 1797

Lima (Mantellum) wacoensis Roemer

Pl. 11, figs. 12, 13

1852 Lima wacoensis Roemer, Kreidebildungen von Texas, p. 63, pl. 8, figs. 7a, b, Bonn.

1947 Lima wacoensis Roemer. Stanton, U.S.G.S. Prof. Paper 211, p. 50, pl. 41, figs. 4-8, 10.

See Stanton (1947) for a complete synonomy of this species.

Material.- Forty-one specimens, U.M.M.P. 17333, 32836, 32938-32941.

Occurrence.- Upper Aurora Limestone, Sierra de Tlahualilo, Coahuila. Zone of Homomya kellumi, localities 13, 16, 19, 31; zone unknown, locality 8.

Uncommon in Trinity group, Texas; abundant in Fredericksburg group, Texas; less common in Washita group, Texas.

Measurements.- (in mm.)

U.M.M.P. No.	Length	Height	Thickness
17333	34.0	23.0	----
32836	30.4	19.0 (estimated)	13.0

Discussion.- Most of the specimens referred to this species appear to be of the general size and proportions and to have ribs of the same shape and number as specimens described by previous writers. Several of the specimens are slightly elongate and appear to ahve the general proportions of the variety L. wacoensis quadrangularis Stanton,

but they are too poorly preserved to show the presence or absence of the "posterior" truncation typical of this variety. Furthermore, the Aurora specimens possess only 18 to 20 radial ribs rather than the 22 to 30 typical of Stanton's variety.

Genus Veniella Stoliczka, 1870

Veniella coahuilaensis Jones

Pl. 12, figs. 1, 2, 3

1938 Veniella coahuilaensis Jones, Geol. Soc. America Bull. v. 49, p. 113, pl. 4, figs. 10, 20; pl. 5, fig. 8.

Material.- Two specimens, U.M.M.P. 32696, 32837.

Occurrence.- Upper Aurora limestone, Sierra de Tlahualilo, Coahuila. Zone of Gryphaea mucronata, locality 48.

Indidura formation, Sierra de Santa Ana and Sierra de la Peña, Coahuila.

Measurements.- (in mm.)

U.M.M.P. No.	Length	Height	Thickness
32696	40.0 (estimate)	38.0 (estimate)	28.0
32837	43.9	40.9	32.5

Discussion.- The Aurora specimens agree in all respects with those described by Jones.

Genus Astarte Sowerby, 1816

Astarte? sp.

Pl. 11, figs. 14, 15

Material.- Two specimens, U.M.M.P. 32839, 32942.

Occurrence.- Upper Aurora limestone, Sierra de Tlahualilo, Coahuila. Zone of Gryphaea mucronata, locality 48.

Description.- Shell small, equivalved, slightly inequilateral, subcircular in outline; beaks pointed, elevated, prosogyrate; dorsal border concave anterior to beaks, straight or very slightly convex posterior to beaks; posterior, ventral and anterior borders form arcs of a circle; lunule small and apparently elongate; escutcheon narrow, elongate; no ornamentation preserved.

Measurements.- (in mm.)

U.M.M.P. No.	Length	Height	Thickness
32839	28.6	27.8	15.3

Comparison.- This species resembles Astarte texana Conrad but differs from that species in being taller and in lacking an angular anterior border.

Genus Cyprimeria Conrad, 1864

Cyprimeria texana (Roemer)

Pl. 12, figs. 4, 5

1849 Lucina sp. ind. Roemer, Texas, p. 407, Bonn.

1852 Acropagia texana Roemer, Kreidebildungen von Texas, p. 46, pl. 6, figs. 8a, b, Bonn.

1893 Cyprimeria texana (Roemer). Cragin, Geol. Sur. Texas, 4th Ann. Rept., p. 177.

1928 Cyprimeria texana (Roemer). Adkins, Texas Univ. Bull. 2838, p. 162, pl. 18, fig. 3.

Material.- Two specimens, U.M.M.P. 32840, 32943.

Occurrence.- Upper Aurora limestone, Sierra de Tlahualilo, Coahuila. Zone of Gryphaea mucronata, localities 39, 54.

Fredericksburg group, Texas.

Description.- Shell medium size, subequivalved, subequilateral, subcircular in outline, thin; beaks rounded, notched anteriorly; dorsal border anterior to beaks straight, sloping to intersect anterior border; dorsal border posterior to beaks straight, sloping to intersect posterior border; anterior, ventral and posterior borders forming arcs of a circle; on the left valve posterior to the beaks a shallow depression extends along the dorsal and posterior margins.

Measurements.- (in mm.)

U.M.M.P. No.	Length	Height	Thickness
32840	39.0	37.2	13.0

Discussion.- The Aurora specimens agree in all of the essentials with the descriptions of Roemer and Cragin.

Genus Protocardia Beyrich, 1845

Protocardia denisonensis (Cragin)

Pl. 13, figs. 4, 7; Pl. 14, figs. 1, 2

1894 Roudairia denisonensis Cragin, Colorado College Studies, Ann. Pub. 5, p. 57.

1928 Roudairia denisonensis Cragin. Adkins, Texas Univ. Bull. 2838, p. 151.

Material.- Six specimens, U.M.M.P. 32846, 32944-32946.

Occurrence.- Upper Aurora limestone, Sierra de Tlahualilo, Coahuila. Zone of Gryphaea mucronata, localities 11, 38; zone of Homomya kellumi, localities 16, 17.

Denison formation (Grayson marl and Main Street limestone members), north Texas.

Description.- Cragin described this species as follows:

> Shell among the larger representatives of its genus, elevated-triangular, the lateral profile of its cast approaching an isosceles triangle with convex base, but the supero-posterior part of that profile presenting, as in R. quadrans, a low shoulder (the angulated summit-line of the feeble keel made by the apposed edges of the valves) a short distance from the beaks; valves of quite moderate convexity; beaks placed a little in advance of the middle, narrow, their tangent apices curved inward and downward, but inclined forward in only a very slight degree; anterior and posterior slopes more

or less flattened, the posterior separated from the distal slope, in a cast, by a faint angulation; distal and anterior slopes ornamented with unequal concentric lines, and the posterior slope with 35 or more radial raised lines, which are relatively much finer than those of R. quadrans.

Measurements.- (in mm.)

Number	Length	Height	Thickness
U.M.M.P. 32846	56.0	64.0	42.0
S.M.U.M.P. 1035	67.0	71.0	46.0

Discussion.- Cragin originally referred this species to the Upper Cretaceous genus Roudairia, but the presence of posterior radial ribs suggests that it should be assigned to the genus Protocardia. The Aurora specimens have the same form and proportions as Cragins's specimens but are slightly smaller.

Remarks.- A plaster cast of Cragin's type specimen for this previously unillustrated species is given on Plate 3, Figures 7, 8. This cast was prepared at the U.S.N.M. and given to the Author by Dr. John B. Reeside, Jr.

Protocardia multistriata (Shumard)

Pl. 12, fig. 6

1854 Cardium multistriatum Shumard, in R. B. Marcy, 32d Cong., 2nd Sess., S. Doc. 54, p. 194.

1857 Cardium (Protocardia) multistriatum Shumard. Conrad, U. S. and Mex. Boundary Survey, v. 1, pt. 2, p. 149, pl. 6, figs. 4a, b, c.

1928 Protocardia multistriata Shumard [partim] Adkins, Texas Univ. Bull. 2838.

Material.- Three specimens, U.M.M.P. 32841, 32947, 32948.

Occurrence.- Upper Aurora limestone, Sierra de Tlahualilo. Zone of Homomya kellumi, localities 16, 17, 31. Washita group, Texas.

Description.- Shell equivalved, inequilateral, moderately biconvex, rounded triangular in outline; beaks rounded, elevated, orthogyrate, central in position; sculpture consists of fine subequal concentric ribs with narrow interspaces over the anterior four-fifths of shell, about 12 to 15 fine radial ribs in posterior one-fifth of shell; concentric ribs round topped in mature portion of shell and flat in earlier stages.

Measurements.- (in mm.)

U.M.M.P. No.	Length	Height	Convexity of one valve
32841	31.4	30.6	8.0

Protocardia cf. P. securiformis (Cragin)

Pl. 12, figs. 7-9, 11

Material.- Eleven specimens, U.M.M.P. 32842, 32949-32955.

Occurrence.- Upper Aurora limestone, Sierra de Tlahualilo, Coahuila. Zone of Gryphaea mucronata, localities 23, 28, 30, 33, 38, 39; zone of Homomya kellumi, locality 13.

Occurrence of P. securiformis.- Goodland limestone and Comanche Peak limestone, north and central Texas; Kiowa shale, Belvidere, Kansas.

Description.- Shell small, equivalved, inequilateral, obliquely elongate, subtriangular in outline; beaks pointed, elevated, incurved, slightly prosogyrate; valves highly inflated; antero-dorsal slope slightly convex, merging with very short broadly rounded anterior border; ventral border broadly rounded; postero-ventral angle broadly rounded; posterior slope straight or slightly convex, longer than antero-dorsal slope; ornamentation not observed.

Measurements.- (in mm.)

Number	Length	Height	Thickness
U.M.M.P. 32842	22.8	29.7	23.5
S.M.U.M.P. 1031	17.8	22.4	17.5

Discussion.- Although the Aurora specimens do not show posterior radial ribs which are typical of the genus Protocardia, the outline of these specimens suggests the species P. securiformis. Figures of an example of P. securiformis from the Goodland formation of north Texas are given for comparison (Pl. 4, figs. 3, 6).

Protocardia texana (Conrad)

Pl. 12, figs. 10, 12-14; pl. 13, figs. 1-3, 5

1852 Cardium Hillanum Sowerby. Roemer, Kreidebildungen von Texas, p. 49, pl. 6, fig. 12, Bonn.

1857 Cardium (Protocardia) texana Conrad, U. S. and Mexican Boundary Survey, v. 1, pt. 2, p. 150, pl. 6, figs. 6a-c.

1871 Cardium (Protocardia) salinaensis Meek, Hayden's 2nd Ann. Rept., Geol. Survey of Territories, p. 174, pl. 2, figs. 13a-c.

1890 Cardium Hillanum? Sowerby. Cragin, Bull. Washburn Coll. Lab. Nat. Hist., v. 2, no. 11, p. 81.

1889 Protocardia (Cardium) Hillanum Sowerby. Hill, Geol. Survey Texas Bull. 4, p. 14, 35, 48.

1895 Protocardia texana (Conrad). Cragin, Am. Geologist, v. 16, p. 164.

1895 Cardium (Protocardia) texanum Conrad. Stanton, in Hill, Am. Jour. Sci., v. 50, p. 218.

1900 Protocardia texana (Conrad). Stanton, in Gould, Am. Geologist, v. 25, p. 36.

1910 Cardium (Protocardia) Hillanum Sowerby. Böse, Inst. Geol. de Mex. Bol. 25, p. 129, pl. 27, figs. 4, 5; pl. 28, figs. 1, 3.

1924 Protocardia texana Conrad. Twenhofel, State Geol. Survey Kans. Bull. 9, p. 80, pl. 20, figs. 1-6.

1928 Protocardia texana (Conrad). Bullard, Oklahoma Geol. Survey Bull. 47, p. 96, pl. 5, figs. 1, 2.

1928 Protocardia hillana (Sowerby). Adkins, Texas Univ. Bull. 2838, p. 159.

1928 Protocardia texana (Conrad). Adkins, Texas Univ. Bull. 2838, p. 159, pl. 2, fig. 5; pl. 16, fig. 2.

Material.- Sixteen specimens U.M.M.P. 32843-32845 32956-60.

Occurrence.- Upper Aurora limestone, Sierra de Tlahualilo, Coahuila. Zone of Gryphaea mucronata, localities 22, 23, 38, 39, 57, 58; zone of Homomya kellumi, locality 17.

Fredericksburg group, central, north-central, and trans-Pecos Texas; Washita?, central Texas; Kiowa shale, Belvidere, Kansas.

Measurements.- (in mm.)

Number	Length	Height	Thickness
U.M.M.P. 32843	34.0 (estimated)	31.5	24.0 (estimated)
U.M.M.P. 32844	40.8	41.4	28.0
U.M.M.P. 32845	39.0	39.1	26.5
S.M.U.M.P. 1032	79.0	68.9	53.2
S.M.U.M.P. 1033	56.0	55.4	33.2
S.M.U.M.P. 1034	58.0	58.4	37.2

Discussion.- A study of several collections of Protocardia texana from the Texas Fredericksburg group indicates that this species is highly variable. Specimens range in length from two to eight mm.; the outline varies from nearly circular to oval; width of shell ranges from moderately biconvex to globose.

The Aurora specimens referred to this species are of moderate size and vary in outline from circular to very slightly oval. In general, the Aurora specimens are slightly thicker than Texan specimens of comparable size. Although most of the Aurora specimens are devoid of ornamentation, three individuals show the rather large rounded regular concentric ribs and several of the smaller rounded radiating posterior costae that are typical of the species. Several other specimens show very large adductor muscle scars like those on many Texan specimens.

Genus Eoradiolites Douville, 1900

Eoradiolites? albrittoni Perkins, sp. nov.

Pl. 13, fig. 6; pl. 14, figs. 3-6

Types.- Holotype: U.M.M.P. 32847, a fragment of a well preserved individual in which much of the original shell material is preserved. Paratypes: U.M.M.P. 32848-32850, internal casts of various portions of the living cavity of three individuals; U.M.M.P. 32851, a fragment of a moderately well preserved smaller individual than the holotype in which the character of the shell wall is well shown. Collected by L. B. Kellum and party, summer of 1952.

Horizon and type locality.- Holotype U.M.M.P. 32847 and paratypes U.M.M.P. 32848, 32850-32851: Lower Cretaceous, upper Aurora limestone, zone of Homomya kellumi. Locality 29, about 8500 feet S. 72° 42' E. of the Ojo de Agua, Sierra de Tlahualilo, Coahuila.

Paratype U.M.M.P. 32849: Lower Cretaceous, upper Aurora limestone, zone of Homomya kellumi. Locality 18, top of the rim overlooking the Canon Ojo de Agua on trail leading northeast from the Ojo de Agua, about 8150 feet N. 72° 15' E. of the Ojo de Agua, Sierra de Tlahualilo, Coahuila.

Diagnosis.- A rudistid distinguished by its oval outline in transverse section, the outline of the three parts of the living cavity, and its distinctive shell structure.

Description.- Lower valve elongate, slightly curved,

oval in cross section; surface marked with thin longitudinal ridges separated by wide interspaces. Shell composed of two layers of cellules; cellules of both layers elongate with the long axis of the shell and internally partitioned by transverse tabulae-like platforms. Cellules of outer layer, in transverse section, range in outline from rectangular to elliptical with long axes normal to surface of test, and connected to exterior by small canals. Cellules of inner layer occur only in thick parts of shell and, in transverse section, vary in outline from elliptical with the long axis parallel to surface of test to rounded-triangular; cellules of this layer not connected to exterior.

Living cavity large, ovate, and divided into three parts by thin septa. In transverse cross section (Pl. 14, fig. 3) these parts appear as: (1), a large semi-circle with two truncated edges, the truncations intersecting; truncated edges in contact with septa and semi-circular border in contact with shell wall; constitutes about one-half the cross-sectional area of the living cavity; (2), a smaller part having the general outline of the first described part but being more oval; truncate along the septum separating it from the larger part but gently curved along the septum separating it from the third part and along the contact with the shell wall; and (3), a sub-lunate part truncated along the contact of the septum separating it from the first part but curved along the septum separating it from the second part and gently curved along the contact with the shell wall.

Measurements.- (in mm.)

U.M.M.P. No.	Transverse Cross Section	
	Long Axis	Short Axis
32847 (Holotype)	76.3	40.7

	Internal Cast of Living Cavities	
U.M.M.P. No.	Longitudinal Dimension	Maximum Cross-sectional Dimension
32848 (Paratype)	38.0	30.5
32849 (Paratype)	50.4	21.5
32850 (Paratype)	65.8	36.0

	Nearly Complete Individual Showing Exterior of Shell Wall	
U.M.M.P. No.	Longitudinal Dimension	Maximum Cross-sectional Dimension
32851 (Paratype)	56.9	29.1

Referred material.- In addition to the types about 110 internal casts of various parts of the living cavity are referred to the species. U.M.M.P. 32961-32970.

Occurrence of referred material.- Upper Aurora limestone, Sierra de Tlahualilo, Coahuila. Zone of Homomya kellumi, localities 14-19, 25-27, 29.

Genus Modiolus Lamarck, 1799

Modiolus sp.

Pl. 15, figs. 1, 2

Material.- One specimen, U.M.M.P. 32852.

Occurrence.- Upper Aurora limestone, Sierra de Tlahualilo, Coahuila. Zone of Homomya kellumi, locality 27.

Description.- Shell large, elongate, subrectangular, equivalved, very inequilateral; beaks small, slightly inflated, prosogyrate?, subterminal in position; dorsal and ventral borders nearly straight and subparallel, slightly divergent posteriorly, ventral border longer; postero-dorsal border sharply truncated; posterior border short, sharply rounded; anterior border broken; umbonal ridge strong, rounded gradually widens in curving backward and downward from beaks to postero-ventral angle.

Measurements.- (in mm.)

U.M.M.P. No.	Length	Height	Thickness
32852	70.0	30.0	28.0

Comparison.- The general shape of this specimen is strongly suggestive of M. concentrice-costellata Roemer from the Fredericksburg group of Texas.

Genus Homomya Agassiz, 1843

Homomya auroraensis Perkins, sp. nov.

Pl. 15, figs. 3-5

Holotype.- U.M.M.P. 32853, a moderately well preserved cast showing surface sculpture on a portion of the left valve. Collected by L. B. Kellum and party, summer of 1952.

Horizon and type locality.- Lower Cretaceous, upper Aurora limestone, zone of Homomya kellumi. Locality 18, top of the rim overlooking the Canon Ojo de Agua on trail leading northeast from the Ojo de Agua, about 8150 feet N. 72° 15' E. of the Ojo de Agua, Sierra de Tlahualilo, Coahuila.

Diagnosis.- A Homomya resembling Homomya vulgaris Shattuck but differing from that form in having a more concave dorsal border, a more rounded posterior extremity, beaks less terminal and less prosogyrate, and in being taller in proportion to the thickness. Also, from Shattuck's figures it appears that the greatest width of the valves in H. vulgaris is more posterior than in H. auroraensis. This species differs from H. budaensis Whitney in having a more concave dorsal border, a greater height in relation to the thickness of the shell and in not having the broad posterior, vertical expansion. The growth lines in H. auroraensis seem to be less coarse than those of H. vulgaris or H. budaensis.

Description.- Shell large, equivalved, inequilateral, antero-posteriorly inflated; beaks subterminal in position, rounded, low, incurved, slightly prosogyrate; ventral and dorsal borders subparallel; dorsal border concave; posterior border broadly rounded; ventral border long, gently rounded; anterior border short, gently rounded; lunule small, elliptical; escutcheon wide, long; surface ornamented by coarse, irregular, concentric growth lines.

Measurements.- (in mm.)

U.M.M.P. No.	Length	Height	Thickness
32853	85.0	52.5	43.7

Homomya budaensis Whitney

Pl. 15, fig. 6; pl. 16, figs. 1, 3

1911 Homomya budaensis Whitney, Texas Univ. Bull. 184, p. 15, pl. 3, figs. 1, 2; pl. 4, figs. 1, 2.

1928 Homomya budaensis Whitney. Adkins, Texas Univ. Bull. 2838, p. 141.

Material.- Fourteen specimens, U.M.M.P. 32854, 32971-32977.

Occurrence.- Upper Aurora limestone, Sierra de Tlahualilo, Coahuila. Zone of Gryphaea mucronata, localities 22, 28, 33, 39; zone of Homomya kellumi, localities 18, 26, 29.

Description.- Shell large, equivalved, inequilateral, antero-posteriorly elongate, strongly gibbous, valves gaping posteriorly; beaks low, large, subterminal in position, rounded, incurved, and slightly prosogyrate; ventral and dorsal borders subparallel; dorsal border concave, arching upward posteriorly; posterior border broadly curved, much higher than anterior border; ventral border convex, broadly curved; anterior border short, gently curved; surface ornamented with irregular, coarse, concentric growth lines.

Measurements.- (in mm.)

U.M.M.P. No.	Length	Height	Thickness
32854	88.7	55.0	50.1

Discussion.- Several specimens of this large Homomya characterized by the flaring posterior were collected from the Aurora limestone. Although the Aurora specimens are slightly smaller than Whitney's, they agree in other respects with those described by him.

Homomya kellumi Perkins, sp. nov.

Pl. 16, figs. 2, 4-6; pl. 17, figs. 1, 2

Types.- Holotype: U.M.M.P. 32855, a well preserved cast showing exterior of both valves. Paratypes: U.M.M.P. 32856, a weathered cast showing a portion of the exterior of the left valve; U.M.M.P. 32857, fragment of the anterior portion of an individual showing exterior of left valve. Holotype and paratype U.M.M.P. 32857 collected by L. B. Kellum and party, summer of 1952; paratype U.M.M.P. 32856 collected by L. B. Kellum and party, summer of 1953.

Horizon and type locality.- Holotype U.M.M.P. 32855: Lower Cretaceous, upper Aurora limestone, zone of Homomya kellumi. Locality 19, left side of Canon Ojo de Agua, about 3250 feet N. 70° 30' E. of the Ojo de Agua, Sierra de Tlahualilo, Coahuila.

Paratype U.M.M.P. 32856: Lower Cretaceous, upper Aurora limestone, zone of Homomya kellumi. Locality 51, on crest

of hill on left side of canyon of Arroyo Guayule, about 900 feet east of Camp 531, Sierra de Tlahualilo, Coahuila.

Paratype U.M.M.P. 32857: Lower Cretaceous, upper Aurora limestone, zone of Homomya kellumi. Locality 15, about 9560 feet N. 34° E. of the Ojo de Agua, Sierra de Tlahualilo, Coahuila.

Diagnosis.- Homomya kellumi may be recognized by its high beaks and pronounced shoulder anterior to the beaks. It is distinguished from H. bravoensis Böse by its greater height in proportion to its thickness and from H. sp. aff. H. ligeriensis d'Orbigny (Böse, 1910) in having coarser concentric ribs and in being more elongate.

Description.- Shell medium size, equivalved, very inequilateral, elongate, somewhat compressed posteriorly. Valves gaping posteriorly. Beaks narrow, pointed, incurved, slightly prosogyrate, elevated, located about 0.2 the length of the shell from the anterior end. Anterior rounded shoulder extending downward from the beaks to the anteroventral margin producing a truncation of the anterior end of each valve. Valves ornamented by coarse, rounded, concentric ribs, separated by shallow depressions narrower than the ribs. Hinge line short and straight, a continuation of the anterior and posterior borders. Anterior border semicircular; ventral border gently curved; posterior border strongly curved bending sharply upward and forward to join hinge line.

Measurements.- (in mm.)

U.M.M.P. No.	Length	Height	Thickness
32955 (Holotype)	69.0	51.5	37.3
32856 (Paratype)	71.0	56.8	33.0
32857 (Paratype)	60.0 (estimate)	45.8	43.4

Referred material.- In addition to the types six fragmentary casts of a pelecypod resembling the types are referred to this species. U.M.M.P. 32978-32981.

Occurrence of referred material.- Upper Aurora limestone, Sierra de Tlahualilo, Coahuila. Zone of Homomya kellumi, localities 13, 14, 18, 31.

Homomya tlahualiloensis Perkins, sp. nov.

Pl. 16, figs. 1-10; pl. 17, figs. 3-7

Types.- Holotype: U.M.M.P. 32858, a well preserved cast showing exterior of left valve. Paratype: U.M.M.P. 32859, a well preserved cast showing exterior of both valves but broken along posterior and postero-dorsal borders. Collected by L. B. Kellum and party, summer of 1952.

Horizon and type locality.- Lower Cretaceous, upper Aurora limestone, zone of Homomya kellumi. Locality 26, about 10,365 feet S. 76° E. of the Ojo de Agua, Sierra de Tlahualilo, Coahuila.

Diagnosis.- This species is distinguished from H.

kellumi in having the beaks less pointed and less terminal in position, in possessing a slightly thicker form, and in not having a pronounced shoulder anterior to the beaks. It is distinguished from H. bravoensis Böse in having a greater height in proportion to the thickness, the beaks less terminal, and the dorsal border more concave.

Description.- Shell medium size, equivalved, inequilateral, antero-posteriorly elongate, inflated, valves slightly gaping posteriorly; beaks about one-third length of shell from anterior end, elevated, rounded, incurved, very slightly prosogyrate; dorsal border slightly concave; posterior, ventral, and anterior borders forming arcs of a circle; ventral border less curved centrally; lunule small, elliptical; escutcheon small, wide; surface ornamented by fine to medium, concentric growth undulations.

Measurements.- (in mm.)

U.M.M.P. No.	Length	Height	Thickness
32858 (Holotype)	59.4	43.6	32.0
32859 (Paratype)	57.0 (estimate)	40.0	29.5

Referred material.- Eleven poorly preserved fragmentary or worn casts which appear to have the same characters as the types are referred to this species. U.M.M.P. 32982-32985.

Occurrence of referred material.- Upper Aurora limestone, Sierra de Tlahualilo, Coahuila. Zone of Homomya

kellumi, localities 14, 18, 26, 29.

Genus Pholadomya Sowerby, 1823

Pholadomya shattucki Böse

Pl. 18, figs. 1-6

1903 Pholadomya roemeri Shattuck [non Whitfield, 1885], U. S. Geol. Survey Bull. 205, p. 28, pl. 15, figs. 3-6.

1910 Pholadomya shattucki Böse, Inst. Geol. de Mex. Bol. 25, p. 137, pl. 29, figs. 7-9.

Material.- Twenty-three specimens, U.M.M.P. 32860-32862, 32986-32996.

Occurrence.- Upper Aurora limestone, Sierra de Tlahualilo, Coahuila. Zone of Gryphaea mucronata localities 21, 22, 28, 39, 43; zone of Homomya kellumi, localities 14, 16, 18, 19, 29, 31.

Buda limestone, Austin, Texas; Fort Worth limestone and Denison formation (Weno clay and Main Street limestone members), north Texas; Subdividion 5 (Fort Worth-Denton), Cerro de Muleros, Chihuahua.

Description.- Shell medium to large, equivalved, inequilateral, ventricose, wider anteriorly than posteriorly, compressed ventrally and posteriorly; beaks prominent, elevated, prosogyrate; hinge line straight, about two-thirds length of shell. Ornamentation consisting of radial and concentric ribs; 17 to 20 radial ribs extending from beaks to ventral margin, present from anterior margin of shell to

posterior slope of umbones and absent in postero-dorsal compressed area of shell; concentric ribs fine, low, rounded, and most conspicuous in postero-dorsal compressed area; intersections of concentric and radial ribs over umbones marked by tubercules.

Measurements.- (in mm.)

U.M.M.P. No.	Length	Height	Thickness
32860	86.7	72.3	61.7
32861	45.0 (estimate)	42.0 (estimate)	22.0 (1 valve)
32862	52.0	49.0	24.0 (1 valve)

Discussion.- The Aurora specimens agree in all respects with those described and figured by Shattuck and Böse.

According to Adkins (1928, p. 139) this species has 25 or more radial ribs. Although Shattuck does not state the number of ribs on his specimens, his figures show about 20. Böse indicates that about 17 occur on his specimens. An examination of numerous individuals from the Fort Worth limestone and the Denison formation of north Texas shows that the average number of radial ribs is 18.

Pholadomya toribioensis Jones

Pl. 19, figs. 1-4

1938 Pholadomya toribioensis Jones, Geol. Soc. America Bull. 49, p. 112, pl. 4, figs. 11-13.

Material.- Twelve specimens, U.M.M.P. 17266, 32863,

32864, 32997-33000.

Occurrence.- Upper Aurora limestone, Sierra de Tlahualilo, Coahuila. Zone of Homomya kellumi, localities 14, 18, 29, 31; zone unknown, locality 2.

Indidura formation, Sierra de Santa Ana and Sierra de la Pena, Coahuila.

Description.- Shell medium size, equivalved, inequilateral, antero-posteriorly elongate, valves slightly gaping posteriorly; beaks prominent, elevated, orthogyrate to slightly prosogyrate, located about one-fourth the length of the shell from the anterior end; hinge line long, about four-fifth total length of shell. Anterior border broadly rounded, merging with ventral border without a sharp angle; ventral border gently curved passing into sharply but evenly rounded posterior border. Shell highest anterior to beaks, tapering rapidly to posterior. Surface covered with concentric and radial ribs; concentric ribs broad, low, and subequal; radial ribs, faint, rounded, and about 10 to 12 in number, extending from beak to ventral margin.

Measurements.- (in mm.)

U.M.M.P. No.	Length	Height	Thickness
32863	59.0 (estimate)	39.4	32.3
32864	59.0 (estimate)	39.0	33.3

Discussion.- The specimens from the Aurora limestone are generally larger and have coarser concentric ribs than

Jones' specimens but otherwise agree in structure with his specimens.

Worn specimens of P. toribioensis may be difficult to distinguish from Homomya tlahualiloensis; however, P. toribioensis is more elongate, does not have so strong a concavity of the dorsal border posterior to the beaks, and has more rounded and regular concentric ribs.

Genus Tapes Megerle, 1811

Tapes aldamensis Böse

Pl. 19, figs. 5, 6

1910 Tapes aldamensis Böse, Inst. Geol. de Mex. Bol. 25, p. 134, pl. 28, figs. 23, 24.

1923 Tapes aldamensis Böse. Adkins, Texas Univ. Bull. 2838, p. 165.

Material.- Eight specimens, U.M.M.P. 32865, 33001.

Occurrence.- Upper Aurora limestone, Sierra de Tlahualilo. Zone of Gryphaea mucronata, locality 32.

Fredericksburg equivalent, La Encantada, Chihuahua; Goodland limestone, north Texas.

Description.- The Aurora specimens agree in essential detail with those described by Böse. A translation of his description follows.

> Shell small, oval-oblique, transversely elongate; anterior and posterior ends are rounded; poster-dorsal border is slightly curved, antero-dorsal is somewhat concave, the ventral border is long and

curved. The umbones are small and moderately separated, are a distance of one-third the total length of the shell from the anterior border. A small lunule is moderately well defined. The hinge is unknown. The surface is covered with fine concentric striations.

Measurements.- (in mm.)

U.M.M.P. No.	Length	Height	Thickness
32865	26.0 (estimate)	18.5	10.3

Discussion.- Most of the Aurora specimens are incomplete. Reconstruction from numerous fragments, however, indicates a form identical with T. aldamensis.

Class Gastropoda

Genus Pleurotomaria Sowerby, 1821

Pleurotomaria austinensis Shumard

Pl. 19, figs. 7-9; pl. 20, figs. 1, 7

1849 Pleurotomaria sp. ind. Roemer, Texas, p. 414, Bonn.

1852 Pleurotomaria sp. ind. Roemer, Kreidebildungen von Texas, p. 39, Bonn.

1861 Pleurotomaria austinensis Shumard, Boston Soc. Nat. Hist. Proc. 8, p. 193.

1893 Pleurotomaria robusta Cragin, Texas Geol. Survey 4th Ann. Rept., p. 228.

1920 Pleurotomaria austinensis Shumard. Adkins and Winton, Texas Univ. Bull. 1945, p. 76, pl. 13, figs. 2, 3.

1928 Pleurotomaria austinensis Shumard. Adkins, Texas. Univ. Bull. 2838, p. 172.

1947 Pleurotomaria austinensis Shumard. Stanton, U.S.G.S. Prof. Paper 211, p. 52, pl. 48, figs. 1, 7-10.

Material.- Eleven specimens, U.M.M.P. 32647, 32866, 32793-32794, 32797-32798.

Occurrence.- Upper Aurora limestone, Sierra de Tlahualilo, Coahuila. Zone of Homomya kellumi, localities 14, 18, 26, 29, 51; zone unknown, localities 1, 2.

Duck Creek formation, Fort Worth limestone, Denison formation(Weno clay member), north Texas; Georgetown limestone, central Texas.

Measurements.- (in mm.)

U.M.M.P. No.	Height	Greatest Breadth	Apical Angle
32647	38.7	76.0	96°
32866	37.2	44.0	--

Discussion.- The Aurora specimens consist of several fragmentary internal molds only one of which retains traces of the characteristic revolving striae on the ventral surface. Most of the individuals consist of three or fewer apical whorls.

Genus Ampullina Bosdich, 1822

Ampullina? collina (Conrad)

Pl. 20, figs. 2, 3, 5

1857 Natica collina Conrad, U. S. and Mexican boundary survey, v. 1, pt. 2, p. 157, pl. 13, figs. 2a, b.

1910 Natica aff. collina Conrad. Bose, Inst. Geol. de Mexico Bol. 25, p. 143, pl. 30, figs. 7, 8.

1928 Ampullina? collina (Conrad). Adkins, Texas Univ. Bull. 2838, p. 177.

Material.- Thirteen specimens, U.M.M.P. 17274, 32800, 32802, 32811, 32867, 33002-33003.

Occurrence.- Upper Aurora limestone, Sierra de Tlahualilo, Coahuila. Zone of Homomya kellumi, localities 16, 17, 19, 26, 29; zone unknown, localities 2, 6.

Subdivision 5 (Fort Worth-Denton), Cerro de Muleros, Chihuahua.

Description.- Shell small, inflated, low spired; three to four strongly convex whorls; apical angle about 70 degrees; spire depressed, about one-fifth total height of the shell; sutures impressed; anomphalous; aperture auriform, broad and rounded below, slightly narrower and sharply rounded above; varices and other sculpture apparently absent.

Measurements.- (in mm.)

U.M.M.P. No.	Height	Greatest Breadth
32367	20.0	18.7

Discussion.- The above description is based on Conrad's type (deposited in the U. S. National Museum) which he figured but did not describe. The Aurora limestone specimens agree in all structures with the holotype.

Genus Turritella Lamarck, 1799

Turritella leonensis Conrad

Pl. 20, fig. 9

1857 Turritella leonensis Conrad. U. S. and Mex. boundary Survey Rept., v. 1, pt. 2, pl. 21, figs. 7a, b.

1894 Turritella denisonensis Cragin, Colorado College Studies, Ann. Pub. 5, p. 65.

1903 Turritella budaensis Shattuck, U.S.G.S. bull. 205, p. 31, pl. 19, figs. 4-6.

1918 Turritella budaensis Shattuck. Ellisor, Texas Univ. Bull. 1840, p. 10, pl. 2, figs. 4-6.

1928 [non] Turritella leonensis Conrad. Adkins, Texas Univ. Bull. 2838, p. 182.

1947 Turritella leonensis Conrad. Stanton, U.S.G.S. Prof. Paper 211, p. 73, pl. 55, figs. 1-3, 10, 11.

Material.- Twenty-one specimens, U.M.M.P. 17273, 32803-32806, 32809, 32868.

Occurrence.- Upper Aurora limestone, Sierra de Tlahualilo, Coahuila. Zone of Homomya kellumi, localities 15, 16, 18, 29, 31; zone unknown, locality 2.

Denison formation (Main Street limestone member) of north Texas, Buda limestone of central Texas; upper Washita group of trans-Pecos, Texas.

Description.- Shell medium size; whorls subangular; four large granular revolving ribs on each whorl with fine filiform lines between; sutures deeply impressed.

Measurements.- (in mm.)

U.M.M.P. No.	Height	Greatest Breadth
32868	17.3	16.5

Discussion.- The Aurora specimens referred to this species are greatly worn and fragmentary and consist of only two to four whorls. Several of the specimens show the four large revolving ribs characteristic of T. leonensis, but the finer filiform lines are obscure.

Turritella sp.

Material.- About 80 specimens, U.M.M.P. 32812, 32814, 32816-32823.

Discussion.- Numerous internal molds of Turritella were collected from the Aurora limestone. Most of them are devoid of sculpture and consist of not more than three whorls. It is probable that these fragments represent several species of Turritella.

Genus Aporrhais Da Costa, 1778

Aporrhais? subfusiformis (Shumard)

Pl. 20, figs. 3, 10

1853 Eulima subfusiformis Shumard, in R. B. Marcy, 32d Cong., 2d Sess., S. Doc. 54, p. 208, pl. 4, fig. 3.

1923 Rostellaria? subfusiformis (Shumard). Adkins, Texas Univ. Bull. 2333, p. 192.

1947 Aporrhais? subfusiformis (Shumard). Stanton, U.S.G.S. Prof. Paper 211, p. 106, pl. 65, figs. 20, 21.

Material.- Five specimens, U.M.M.P. 32790-32792, 32869-32870.

Occurrence.- Upper Aurora limestone, Sierra de Tlahualilo, Coahuila. Zone of Gryphaea mucronata, localities 22, 38; zone of Homomya kellumi, localities 13, 15, 16, 31.

Washita group, trans-Pecos, Texas; Goodland limestone, Tarrant County, Texas; Comanche Peak limestone, Erath County, Texas.

Measurements.- (in mm.)

U.M.M.P. No.	Height	Greatest Breadth
32869	64.0 (estimate)	29.1
32870	65.0 (estimate)	32.4

Discussion.- The specimens from the Aurora limestone consist of only the last one and one-half to two whorls but agree in all of the structures with previously described specimens.

Genus Natica Scopoli, 1777

Natica? parvum Perkins, sp. nov.

Pl. 20, figs. 4, 6

Holotype.- U.M.M.P. 32871, a well preserved silicified shell slightly crushed immediately behind the aperture. Collected by L. B. Kellum and party, summer of 1952.

Horizon and type locality.- Lower Cretaceous, lower Aurora limestone. Locality 47, right side of Canon Ojo de

Agua, about 9000 feet N. 23° E. of the Ojo de Agua, Sierra de Tlahualilo, Coahuila.

Diagnosis.- This species has the general form of Tylostoma elevatum (Shumard) but may be distinguished from it by being smaller, in having a proportionately shorter spire and a narrower aperture, and in lacking varices.

Description.- Shell small, inflated, five whorls; outer surface of whorls conves; apical angle about 50 degrees; suture impressed; spire elevated and about one-fifth total height of shell; surface smooth; aperture oblique, auriform, narrow above, groader and rounded below; cryptomphalous; inner lip with thin callus; outer lip thickened(?).

Measurements.- (in mm.)

U.M.M.P. No.	Height	Greatest Breadth	Greatest Width of Aperture
32871 (Holotype)	10.4	7.4	1.1

Genus Tylostoma Sharpe, 1849

Tylostoma chihuahuense Böse

Pl. 20, figs. 11, 12

1910 Tylostoma Chihuahuense Böse, Inst. Geol. Mex. Bol. 25, p. 144, pl. 30, fig. 13, pl. 31, figs. 1, 2.

1928 Tylostoma chihuahuense Böse. Adkins, Texas Univ. Bull. 2838, p. 178.

Material.- Two specimens, U.M.M.P. 32799, 32872.

Occurrence.- Upper Aurora limestone, Sierra de Tlahua-

lilo, Coahuila. Zone of Gryphaea mucronata, localities 11, 23.

Fredericksburg equivalent, Cerro de Muleros, Chihuahua; Goodland limestone, Tarrant County, Texas.

Description.- The Aurora specimens appear to conform in structure with the specimens described by Böse. A translation of his description follows:

> Shell large with high spire consisting of slightly convex whorls; the last whorl is shorter than the spire but is moderately extended. The surface shows no ornamentation other than fine striations of growth and varices in the middle of each whorl. The aperture is oval, posteriorly sharply-pointed, anteriorly rounded, lip somewhat thickened so that a curved furrow is formed on its boundary; the upper lip is elevated at its extremity above the posterior suture. On the molds are generally noted on the last whorl the impressions of accidental holes, but in well preserved specimens they are noted also on the whorls of the spire. The height of this last changes somewhat in relation to that of the last whorl.

Measurements.- (in mm.)

U.M.M.P. No.	Height	Greatest Breadth	Height of Aperture
32872	65.0	45.5	43.0 (estimate)

Discussion.- The Aurora specimens, although apparently identical with Böse's specimens in most respects, do not show the character of the aperture.

Tylostoma sp. cf. T. elevatum (Shumard)

Pl. 21, fig. 5

Material.- Three specimens, U.M.M.P. 32795, 32796, 32873.

Occurrence.- Upper Aurora limestone, Sierra de Tlahualilo, Coahuila. Zone of Gryphaea mucronata, localities 21, 38; zone of Homomya kellumi, locality 17.

Occurrence of T. elevatum.- Goodland limestone, north-central Texas; Comanche Peak limestone, central Texas; Washita and Fredericksburg groups, trans-Pecos, Texas.

Description.- Shell small to medium size; outer surface of whorls convex, number unknown; suture impressed; aperture auriform; structure of outer lip unknown; no indication of varices.

Measurements.- (in mm.)

U.M.M.P. No.	Height	Greatest Breadth
32873	33.3 (estimate)	26.7

Tylostoma sp. cf. T. regina (Cragin)

Pl. 21, figs. 1, 2

Material.- One specimen, U.M.M.P. 32874.

Occurrence.- Upper Aurora limestone, Sierra de Tlahualilo, Coahuila. Zone of Homomya kellumi, locality 16.

Occurrence of Tylostoma regina.- Glen Rose limestone, central Texas; Glen Rose equivalent, trans-Pecos, Texas.

Description.- Shell large, elongate, consisting of about six whorls; apical angle about 50 degrees; spire elevated, slightly less than one-half total height of shell; sutures apparently deeply impressed; outer surface of whorls apparently convex; cryptomphalous(?); aperture elongate, narrow and rounded above, broader and rounded below.

Measurements.- (in mm.)

U.M.M.P.	Height	Greatest Breadth	Height of Aperture	Greatest Breadth of Aperture
32374	100	80 (estimate)	52	30 (estimate)

Discussion.- The Aurora specimen is compared to Cragin's species on the basis of the general form and size of the shell.

Tylostoma sp.

Pl. 21, figs. 3, 4

Material.- One specimen, U.M.M.P. 17270.

Occurrence.- Upper Aurora limestone, Sierra de Tlahualilo, Coahuila. Zone unknown, locality 2.

Description.- Shell large, robust, consisting of four

to five whorls; apical angle about 45 degrees; spire elevated, about equal to last whorl in height; suture conspicuous; convexity of whorls indeterminate; nature of umbilicus unknown; aperture wide, oval, broad throughout, narrowly rounded above, broadly rounded below.

Measurements.- (in mm.)

U.M.M.P.	Height	Greatest Breadth	Height of Aperture	Greatest Breadth of Aperture
17270	74.7	53.0	42 (estimate)	20 (estimate)

Discussion.- This species is of the size of T. regina (Cragin) but has a much less elevated spire.

Class Cephalopoda

Genus Cymatoceras Hyatt, 1884

Cymatoceras hilli (Shattuck)

Pl. 22, figs. 1-4, pl. 23, pl. 24, figs. 1, 2, pls. 25, 26

1903 Nautilus hilli Shattuck, U.S.G.S. Bull. 205, pl 35, pl. 23, fig. 3; pl. 24, figs. 3, 4.

1924 Cymatoceras hilli (Shattuck). Miller and Harris, Jour. Paleontology, v. 19, p. 5, pl. 1, figs. 1, 2; pl. 4, figs. 4, 5; pl. 5, fig. 4; text. fig. 2.

See Millar and Harris (1945) for a complete synonomy of this species.

Material.- Ten specimens, U.M.M.P. 30717-30720, 32389, 32391.

Occurrence.- Upper Aurora limestone, Sierra de Tlahualilo, Coahuila. Zone of Gryphaea mucronata, localities 20,

22, 28, 39, 55.

Fort Worth limestone and Denison formation, north Texas; Buda limestone, central Texas.

Measurements.- (in mm.)

U.M.M.P. No.	Height	Width	Thickness
30717	58.0 (estimate)	40.3	20.3
30718	66.4	52.7	21.4
32389	135.7	110.3	44.7
32391	131.5	104.5	36.7

Discussion.- Although the Aurora limestone specimens are poorly preserved, the general form of the sutures and ornamentation are sufficiently well preserved to demonstrate an agreement with previously described specimens.

Genus Turrilites Lamarck, 1801

Turrilites brazoensis Roemer

Pl. 27, figs. 2, 3, pl. 28

1849 Turrilites brazoensis Roemer, Texas, p. 415, Bonn.

1852 Turrilites brazoensis Roemer, Kreidebildungen von Texas, pl 37, pl. 3, fig. 2, Bonn.

1901 Turrilites brazoensis Roemer. Hill, U.S.G.S. 21st Ann. Rept., p. 7, pl. 37, fig. 3a [non fig. 3].

1904 Turrilites brazoënsis Roemer. Lasswitz, Geol. und Falcon. Adhandlungen, neu folge band 6, heft. 4, p. 223, pl. 14, fig. 2.

1913 Turrilites brazoensis Roemer. Whitney, Texas Acad. Sci. Proc., p. 24, pl. 12, fig. 1.

1920 Turrilites brazoensis Roemer. Adkins and Winton, Texas Univ. Bull. 1945, p. 45, pl. 7, figs. 14, 15.

1928 Turrilites brazoensis Roemer. Böse, Texas Univ. Bull. 2748, p. 199, pl. 1, fig. 1.

1928 Turrilites brazoensis Roemer. Adkins, Texas Univ. Bull. 2838, p. 214, pl. 21, fig. 10.

Material.- One specimen, U.M.M.P. 32396.

Occurrence.- Upper Aurora limestone, Sierra de Tlahualilo, Coahuila. Zone of Gryphaea mucronata, locality 55.

Denison formation (Main Street limestone and Grayson marl members), north Texas; Buda and Georgetwon limestone, central Texas; upper Georgetown beds near Villa Acuña, Coahuila; Del Rio clay, Jimenez region, Coahuila.

Measurements.- (in mm.)

U.M.M.P. No.	Height	Greatest Width	Narrowest Width
32396	184.0	115.8	34.0

Discussion.- The Aurora limestone specimen referred to this species is compressed and consists of two whorls. The large size and tuberculate ornamentation of these whorls, however, are typical of T. brazoensis.

Turrilites sp.

Pl. 27, fig. 1

Material.- One specimen, U.M.M.P. 32375.

Occurrence.- Upper Aurora limestone, Sierra de Tlahualilo, Coahuila. Zone of Homomya Hellumi, locality 31.

Measurements.- (in mm.)

U.M.M.P. No.	Height	Greatest Breadth
32875	37.0	35.2

Discussion.- A fragment consisting of a single whorl of a turreted cephalopod was obrained from the Aurora limestone. The visible ornamentation consists of two rows of small tubercules on the lower shoulder of the whorl and a few transverse ribs on the underside of the smaller end of the whorl. The size and ornamentation seem to resemble those of T. worthensis.

Phylum ECHINODERMATA

Genus Cottaldia Desor, 1856

Cottaldia sp. cf. C. routula Clark

Pl. 29, figs. 1, 2

Material.- One specimen, U.M.M.P. 32876.

Occurrence.- Upper Aurora limestone, Sierra de Tlahualilo, Coahuila. Zone of Homomya kellumi, locality 18.

Occurrence of Cottaldia routula.- Buda limestone, central Texas.

Description.- Test small, slightly depressed, circular in outline; oral surface womowhat flattened(?); aboral surface only very slightly flattened; lateral walls convox; apical system apparently large, plates not preserved; ambulacral areas gradually widen away from apical system, not

observed at ambitus or on lower surface; pore pairs uniserial in very straight lines; individual pores round; interambulacral plates relatively low and slightly bent; nature of tubercules unknown; peristome unknown.

Measurements.- (in mm.)

U.M.M.P. No.	Diameter	Height
32876	11.5	8.6

Discussion.- The specimen is greatly eroded. The only plates remaining in tact are those of the upper parts of two and one-half ambulacral and two and one-half interambulacral areas. The proportions and size of the test seem to resemble those of C. routula. Furthermore, the pore pairs are uniserial and in very straight lines, and the interambulacral plates are low and apparently bent as is the case with C. routula.

Genus Holectypus Agassiz, 1342

Holectypus (Caenholectypus) castilloi Cotteau

Pl. 29, figs. 3-5

1890 Holectypus castilloi Cotteau, Soc. Geol. France Bull., ser. 3, v. 18, p. 295, pl. 1, figs. 1-8.

1893 Holectypus charltoni Cragin, Texas Geol. Survey Ann. Rept. 4, pt. 2, p. 158, pl. 24, figs. 8, 9.

1915 Holectypus planatus Roemer [partim]. Clark, U.S.G.S. Mon. 54, p. 65, pl. 26, figs. 1a-e. [non pl. 25, figs. 2-4, fide Cooke, 1955].

1920 Holectypus limitis Böse. Adkins and Winton, Texas Univ. Bull. 1945, p. 51, pl. 9, figs. 1, 3.

1925 Holectypus limitis Böse. Winton, Texas Univ. Bull. 2544, pl. 60, pl. 13, fig. 7.

1928 Holectypus castilloi Cotteau. Adkins, Texas Univ. Bull. 2838, p. 282.

1928 Holectypus charltoni Cragin. Adkins, Texas Univ. Bull. 2838, p. 282, pl. 8, fig. 8.

1928 Holectypus limitis Böse. Adkins, Texas Univ. Bull. 2838, p. 282, pl. 8, fig. 7, pl. 14, fig. 7.

1933 [?] Holectypus castilloi Cotteau. Smiser, Jour. Paleontology, v. 7, no. 2, p. 148, pl. 20, fig. 5.

1938 [?] Holectypus sp. aff. H. castilloi Cotteau. Jones, Geol. Soc. America Bull. 132, pl. 12, figs. 8, 9, pl. 13, fig. 7.

1946 Holectypus (Caenholectypus) castilloi Cotteau. Cooke. Jour. Paleontology, v. 20, no. 3, p. 218, pl. 32, fig. 15.

1955 Holectypus (Caenholectypus) castilloi Cotteau. Cooke, U.S.G.S. Prof. Paper 264-E, p. 95, pl. 21, figs. 7-10.

Material.- Seven specimens, U.M.M.P. 29494, 32785-32789.

Occurrence.- Upper Aurora limestone, Sierra de Tlahualilo, Coahuila. Zone of Gryphaea mucronata, localities 21, 22, 28, 38, 39, 41.

Late Albian, Jalpa, Jalisco, Mexico (type locality); Dept. Magdalena, Colombia; ?Aurora limestone, Sierra de la Peña, Coahuila; Denison formation (Weno clay, Main Street limestone, and Grayson marl members), north Texas.

Description.- Test subpentagonal, upper surface convex, subconical; lower surface flat and slightly depressed around peristome; ambitus rounded. Ambulacra straight,

increasing in width from apex and peristome to ambitus; pores uniserial, small and circular or only slightly elliptical; interambulacra more than three times as wide as ambulacra at ambitus. Apical system small, individual plates not discernable. Peristome small, about one-tenth maximum diameter of test; periproct located in outer half of radius, outline not preserved.

Measurements.- (in mm.)

U.M.M.P. No.	Greatest Diameter	Width of Ambulacra at Ambitus	Width of Interambulacra at Ambitus	Diameter of Peristome	Height
29494	67.0	10.0	32.8	7.7	29.4

Discussion.- With the exception of being slightly larger, the Aurora specimens agree in all respects with specimens previously described.

Genus Hemiaster Desor, 1847

Hemiaster calvini Clark

Pl. 29, figs. 6-8

1893 Hemiaster calvini Clark, Johns Hopkins Univ. Circ., v. 12, p. 52, Nomen nudum.

1893 Hemiaster calvini Clark, U.S.G.S. Bull. 97, p. 90, pl. 49, figs. 2a-i.

1938 Hemiaster calvini Clark. Jones, Geol. Soc. America Bull. 49, p. 135, pl. 13, figs. 1-20.

1946 Hemiaster calvini Clark. Cooke, Jour. Paleontology, v. 20, p. 225, pl. 32, fig. 5.

See Cooke (1946) for a more complete synonomy of this species.

Material.- Seven specimens, U.M.M.P. 29493, 32499, 32784.

Occurrence.- Upper Aurora limestone, Sierra de Tlahualilo, Coahuila. Zone of Gryphaea mucronata, localities 23, 52; zone of Homomya kellumi, locality 14.

Indidura formation, Sierra de Santa Ana and Sierra de la Peña, Coahuila; Washita group, Buda limestone, Denison formation (Grayson marl and ?Weno limestone members), and Georgetown limestone, central and north central Texas.

Measurements.- (in mm.)

U.M.M.P. No.	Length	Width	Height
32499	31.8	29.0	21.4

Discussion.- The specimens from the Aurora limestone referred to this species differ from previously described specimens in: (1), being somewhat less elevated and (2), being more tapering posteriorly with the greatest width more anterior. The Aurora specimens are very similar to the examples of Hemiaster calvini reported by Jones (1938) from the Indidura formation of Coahuila. Cooke (1946) considers Jones' specimens representative of a different species on the bases that in the Indidura specimens: (1), the petals are broader and longer and (2), they probably have a more conspicuous fasciole. In a species as abundant and widespread as H. calvini these seem to be reasonable intraspecific variations, and in the absence of better specimens showing

more conclusive evidence to the contrary it seems preferable to refer both the Aurora and Indidura fossils to the species H. calvini.

Genus Enallaster d'Orbigny, 1855

Enallaster (Washitaster) bravoensis? Böse

Pl. 29, figs. 9-11; pl. 30, figs. 1, 2

1910 Enallaster bravoensis Böse, Inst. Geol. Mex. Bol. 25, p. 168, pl. 41, figs. 5-10; pl. 42, figs. 2-12; pl. 43, figs. 1, 2, 6, 7.

1955 Enallaster (Washitaster) bravoensis Böse. Cooke, U.S.G.S. Prof. Paper 264-E, p. 106, pl. 27, figs. 5-12.

See Cooke (1955) for a more complete synonomy of this species.

Material.- Seventeen specimens, U.M.M.P. 32776-32782, 32877-32878.

Occurrence.- Upper Aurora limestone, Sierra de Tlahualilo, Coahuila. Zone of Gryphaea mucronata, localities 34, 39; zone of Homomya kellumi, localities 15, 17, 19, 29, 31.

Washita group, Georgetown limestone and equivalents of late Albian age, Mexico, trans-Pecos Texas, and Colombia.

Measurements.- (in mm.)

U.M.M.P. No.	Length	Width	Height
32877	25.2	22.4	14.7
32878	35.0	31.5	26.8

Discussion.- Enallaster bravoensis is similar to E.

mexicanus from the Fredericksburg group but differs from it in having narrow, branching fascioles typical of Washitaster and, also, in being less elevated than E. mexicanus.

The Aurora limestone specimens provisionally referred to E. bravoensis show the arrangement of pore (i.e., pairs of round or oval pores alternating with pairs of elongate pores) in the anterior ambulacrum diagnostic of Enallaster. The specimens are all too greatly worn, however, to reveal the character or the presence of the fascioles. Consequently, the identification is based entirely upon a similarity of profile and outline between the Aurora specimens and specimens of E. bravoensis figured by Böse (1910) and Cooke (1955).

Genus Pseudananchys Pomel, 1883

Pseudananchys completa? (Cragin)

Pl. 30, figs. 3, 4

1893 Holaster completus Cragin, Texas Geol. Survey Ann. Rept. 4, pt. 9, p. 155, pl. 24, fig. 10; pl. 25, fig. 14; pl. 27, figs. 6-8.

1893 Holaster supernus Cragin, Texas Geol. Survey Ann. Rept. 4, pt. 9, p. 157.

1946 Pseudananchys completa (Cragin). Cooke, Jour. Paleontology, v. 20, p. 233, pl. 34, figs. 7, 8.

1951 Pseudananchys supernus (Cragin). Adkins and Lozo, Fondren Science Ser. no. 4 p. 154.

Material.- Six specimens, U.M.N.P. 32773-32775, 32783, 32879.

Occurrence.- Upper Aurora limestone, Sierra de

Tlahualilo, Coahuila. Zone of Gryphaea mucronata, localities 11, 23, 28, 35, 39.

Denison formation (basal Grayson marl member), north Texas.

Description.- Following is Cragin's description of this species:

> Test rather small, subsylindrical upon a rotund-ovate to broadly oval base, lateral walls high and subvertical but slightly convex, summit-region flattish-convex; outline, as seen from above, not anteriorly emarginate, unpaired ambulacrum about as conspicuous as the others, presenting two rows of pores in each belt, not occupying a furrow on the superior and anterior wall, the anteoral depression being feeble and confined to the inferior surface of the test; pores of the inner row in each pore-belt, dot-like, or but little elongate, those of the outer row more elongate and mainly cuneato-slit-like, these rows converging slowly as they extend down the lateral wall, and meeting on the lower part of it, a single row of remote dot-like pores continuing thence, on each semiarea of the anterior paired (? and unpaired) ambulacra, across the inferior surface of the test to the peristome; apical disc oblong, shorter and broader than that of H. simplex, Shum., bilaterally symmetrical or nearly so, the madreporic function, instead of

being confined to a single, much larger genital plate, being shared by the four genitals and two intermediate oculars; peristome transversely subreniform, the posterior lip protruding, periproct longitudinally ovate, pointed above; tubercles small, surrounded by simple, or sometimes partly double rings of granules; pores on circumoral parts of ambulacra subtended by compressed tubercles, which form an imperfect star-like pattern.

Measurements.- (in mm.)

U.M.M.P. No.	Length	Width	Height
32879	66.4	56.7 (estimate)	46.0

Discussion.- Originally Cragin applied the name Holaster completus to the small individuals having the characters given in the above description and placed the larger individuals in another species, H. supernus Cragin. In the description of the latter species Cragin observes that is is "closely related to H. completus, and it is possible that future collections may show that it is synonomous with it". Without explanation Cooke (1946) considers H. supernus synonomous with H. completus assigning the latter name to the species (on the basis of page priority). This disposition of Cragins's two species appears to be proper since collections made by the author from the Grayson marl member of southern Denton County, Texas indicate that Cragin's H. supernus is the adult form of Pseudananchys completa.

The Aurora specimens are not preserved well enough to show any of the plates or their arrangement, and the questionable assignment is based entirely upon the general form and especially upon the profile of the specimens. In figures given by Cragin (1893, pl. 27, figs. 6-8) and Cooke (1946, pl. 34, figs. 7, 8) and in the present paper (pl. 14, figs. 3-5) the high lateral walls, slightly convex upper surface, the steep anterior face, the overhanging posterior face, and the post-peristomal ridge can be seen to characterize the profile and dorsal views of the species. The Aurora specimens show this typical profile and dorsal outline.

CONCLUSIONS

As a result of this study it is established that the Aurora limestone of the Sierra de Tlahualilo is of Albian age and is approximately equivalent to the Fredericksburg and Washita groups of Texas. In the Sierra de Tlahualilo the formation is divisible into three members of which only the upper is fossiliferous and was measured. The top of the upper member is correlated with the lowermost part of the Grayson marl member (lowest Cenomanian) of the Denison formation, and the base of the member is correlated with the base of the Fort Worth limestone of north Texas. In the absence of more conclusive faunal data the base of the formation is tentatively correlated with the Walnut marl of north Texas.

The environment responsible for the origin of the Aurora limestone did not appear everywhere in northern Mexico at the same time nor did it persist for an equally long period at every place in the region. In the Rio Conchos valley, the type area, of northeastern Chihuahua and the Sierra de los Muertos area of southeastern Coahuila and western Nuevo Leon the beginning of Aurora sedimentation was coincident with the beginning of the Albian stage. Elsewhere in northern Mexico Aurora deposition apparently began slightly earlier in the Early Aptian. The cessation of Aurora deposition over most of northern Mexico came about at approximately the end of Early Albian time. Only in the Sierra de Tlahualilo area and in the type area did conditions

favorable for the deposition of the Aurora persist until the close of the Albian (Fig. 49).

The Aurora limestone is interpreted as a biohermal unit of epineritic origin deposited far from a source of clastics as indicated by the fauna consisting of miliolid foraminifers, rudistids, mud-burrowing clams, gastropods, and echinoids and by the lack of a varied cephalopod suite and by the almost complete absence of terriginous material within the formation. This is in contrast with the Fredericksburg and Washita groups in north Texas where the formations are principally shelf deposits of epi- to infraneritic origin as shown by the fauna including many species of pelecypods, gastropods, nautiloids, ammonoids, and echinoids and the abundance of fine-grained clastics throughout the section.

This study represents the first detailed field comparison and correlation of a selected Comanchean section in northern Mexico with the type Comanchean section of north Texas. Only general conclusions regarding Cretaceous paleogeographic features and depositional environment of Texas and northern Mexico may be drawn from this study. Additional studies, however, such as the author's current investigation of Cretaceous biostratigraphy of the southern trans-Pecos area may provide data for a more detailed interpretation of Cretaceous history and paleogeography of the region.

BIBLIOGRAPHY

Adkins, W. S., 1918, The Weno and Pawpaw formations of the Texas Comanchean: Univ. Texas Bull. 1856, 172 p., 11 pls., 13 figs.

——— 1928, Handbook of Texas Cretaceous fossils: Univ. Texas Bull. 2838, 358 p., 27 pls.

——— 1930, New rudistids from the Texas and Mexican Cretaceous: Univ. Texas Bull. 3001, p. 77-100, 6 pls., 1 fig.

——— 1930a, Texas Comanchean echinoids of the genus Macraster: Univ. Texas Bull. 3001, p. 101-120, 2 pls.

——— 1933, The geology of Texas, Part 2, The Mesozoic systems in Texas: Univ. Texas Bull. 3232, p. 239-518, 15 figs.

——— and Winton, W. M., 1920, Paleontological correlation of the Fredericksburg and Washita formations in north Texas: Univ. Texas Bull. 1945, 128 p., 22 pls., 6 figs.

Albritton, C. C., Jr., Schell, W. W., Hill, C. S., and Puryear, J. R., 1954, Foraminiferal populations in the Grayson marl: Geol. Soc. America Bull., v. 65, p. 327-336, 3 figs.

Böhm, J., 1898, Uber Ammonites pedernalis von Buch: Zeitschr. Deutsch. Geol. Gesell., v. 50, p. 183-201.

Böse, E., 1910, Monografia geologica y paleontologica del Cerro de Muleros cerca de Ciudad, Juarez, Estado de Chihuahua y descripcion de la fauna Cretacea de la Encantada, Placer de Guadalupe, Estado de Chihuahua: Inst. Geol. de Mex. Bol. 25, 193 p., 48 pls.

——— 1919, On a new Exogyra from the Del Rio clay and some observations on the evolution of Exogyra in the Texas Cretaceous: Univ. Texas Bull. 1902, 22 p., 5 pls., 1 fig.

——— 1923, Algunas faunas Cretacicas de Zacatecas, Durango y Guerrero: Inst. Geol. de Mex. Bol. 42, 219 p., 19 pls.

——— 1927, Cretaceous ammonites from Texas and northern Mexico: Univ. Texas Bull. 2748, p. 143-312, 18 pls.

——— and Cavins, O. A., 1927, The Cretaceous and Tertiary of southern Texas and northern Mexico: Univ. Texas Bull. 2748, p. 7-142, 1 pl.

Bullard, F. M., 1928, Lower Cretaceous of western Oklahoma; a study of the outlying areas of Lower Cretaceous in Oklahoma and adjacent states: Oklahoma Geol. Survey Bull. 47, 116 p., 11 pls., 7 figs.

Burrows, R. H., 1909, Geology in northern Mexico: Mining and Scientific Press, v. 99, p. 290-294, 324-327.

——— 1910, Prospecting in Chihuahua: Mining and Scientific Press, v. 100, p. 392-393.

Clark, W. B., 1893, The Mesozoic echinodermata of the United States: U. S. Geol. Survey Bull. 97, 207 p.

——— and Twitchell, M. W., 1915, The Mesozoic and Cenozoic echinodermata of the United States: U. S. Geol. Survey Mon. 54, 341 p.

Conrad, T. A., 1855, Descriptions of eighteen new Cretaceous and Tertiary fossils...: Philadelphia Acad. Nat. Sci. Proc. 7, p. 265-268.

——— 1855a, Description of one Tertiary and eight new Cretaceous fossils from Texas: Philadelphia Acad. Nat. Sci. Proc. 7, p. 268-269.

——— 1857, Descriptions of Cretaceous and Tertiary fossils, in: W. H. Emory, Report of the United States and Mexican boundary survey, v. 1, pt. 2, p. 141-174, 21 pls.

Cooke, C. W., 1946, Comanche echinoids: Jour. Paleontology, v. 7, no. 3, p. 193-237, 34 pls.

——— 1955, Some Cretaceous echinoids from the Americas: U. S. Geol. Survey Prof. Paper 264-E, p. 87-112, 12 pls., 1 fig.

Coquand, H., 1869, Monographie du genre Ostrea; terrain cretace: Marseille, 215 p., 75 pls.

Cotteau, G. H., 1890, Note sur quelques echinides du terrain cretace du Mexique: Soc. Geol. France Bull., ser. 3, v. 18, p. 292-299.

Cox, L. R., 1954, Lower Cretaceous Mollusca from Pointe-A-Pierre, Trinidad: Jour. Paleontology, v. 28, no. 5, p. 622-636, pls. 64-67.

Cragin, F. W., 1890, On the Cheyenne sandstone and the Neocomian shales of Kansas: Washburn College Lab. Nat. Hist. Bull., v. 2, p. 69-80.

Cragin, F. W., 1893, A contribution to the invertebrate paleontology of the Texas Cretaceous: Texas Geol. Survey 4th Ann. Rept., p. 141-246, pl. 24-46.

——— 1894, New and little known invertebrata from the Neocomian of Kansas: Am. Geologist, v. 14, p. 1-12, 1 pl.

——— 1894a, The Choctaw and Grayson terranes of the Arietina: Colorado College Studies, Ann. Pub. 5, p. 40-48.

——— 1894b, Descriptions of invertebrate fossils from the Comanche series in Texas, Kansas, and Indian Territory: Colorado College Studies, Ann. Pub. 5, p. 49-68.

——— 1895, A study of the Belvidere beds: Am. Geologist, v. 16, p. 357-385.

——— 1897, Notes on some fossils of the Comanche series; Stratigraphic names for Caprina and Caprotina (or Requienia) -bearing beds of northern Texas: Science, n. ser. 6, p. 134-136.

Credner, G. R., 1875, Ceratites fastigatus und Salenia texana: Zeitschr. gesammten naturwiss., n. ser. 12, p. 105-116.

Douville, H., 1890, Etudes sur les rudistes: Revision des principales especes d'Hippurites: Soc. Geol. France Mem. 66.

——— 1898, Sur les conches a rudistes de Texas: Soc. Geol. France Bull., 3rd ser., v. 26, p. 387-388.

——— 1900, Sur quelques rudistes americains; Texas: Soc. Geol. France Bull., 3rd ser., v. 28, p. 218.

——— 1910, Etudes sur les rudistes: Soc. Geol. France Mem. 41.

Eardley, A. J., 1942, Aerial Photographs; their use and interpretation: N. Y., Harper and Bros.

——— 1951, Structural geology of North America: N. Y., Harper and Bros.

Ellisor, A. C., 1918, Species of Turritella from the Buda and Georgetown limestones of Texas: Univ. Texas Bull. 1840, 26 p., 4 pls.

Emory, W. H., 1857, Report on the United States and Mexican boundary survey...: U. S., 34th Cong. 1st Sess., Senate Executive Doc. 108 and House Executive Doc. 135, 174 p., 21 pls.

Gabb, W. M., 1869, Cretaceous and Tertiary fossils: California Geol. Survey, Paleontology, v. 2, 299 p.

Gardner, J. S., 1875, On the Gault Aporrhaidae: Geol. Mag., Dec. 2, v. 2, p. 49-56, 124-230, 198-203, 291-298, pls. 3-7.

Hawley, J. B., and Smith, J. P., 1933, Geological notes on the Lower Cretaceous of Eagle Mountain and vacinity, Tarrant County, Texas: Univ. Texas Bull. 3201, p. 93-104, 1 pl.

Hill, R. T., 1887, The present condition of knowledge of the geology of Texas: U. S. Geol. Survey Bull. 45, 95 p.

——— 1887a, The topography and geology of the Cross Timbers and surrounding regions in northern Texas: Am. Jour. Sci., 3rd ser., v. 33, p. 291-303.

——— 1887b, The Texas section of the American Cretaceous: Am. Jour. Sci., 3rd ser., v. 34, p. 287-309.

——— 1889, A preliminary annotated check list of the Cretaceous invertebrate fossils of Texas accompanied by a short description of the lithology and stratigraphy of the system: Texas Geol. Survey Bull. 4, 57 p.

——— 1889a, Check list of the invertebrate fossils from the Cretaceous formations of Texas...: Austin, Texas, 16 p.

——— 1889b, Paleontology of the Cretaceous formation of Texas, Part 1: Univ. Texas School of Geology, Austin, 7 p.

——— 1889c, Events in North American Cretaceous history illustrated in the Arkansas-Texas division of the southwestern region of the United States: Am. Jour. Sci., 3rd ser., v. 37, p. 282-290.

——— 1889d, The foraminiferal origin of certain Cretaceous limestones and the sequence of sediments in North American Cretaceous: Am. Geologist, v. 4, p. 174-177.

——— 1890, The Texas Cretaceous: Am. Geologist, v. 6, p. 253-254.

——— 1891, The Comanche series of the Texas-Arkansas region (with discussion by C. A. White et al): Geol. Soc. America Bull. 2, p. 503-528.

——— 1893, The paleontology of the Cretaceous formations of Texas; The invertebrate paleontology of the Trinity division: Washington Biol. Soc. Proc., v. 8, p. 9-40.

——— 1893a, The paleontology of the Cretaceous formations of Texas; The invertebrate fossils of the Caprina limestone beds: Washington Biol. Soc. Proc., v. 8, p. 97-108, pls. 12, 13.

Hill, R. T., 1894, Geology of parts of Texas, Indian Territory and Arkansas adjacent to Red River region: Geol. Soc. America Bull. 5, p. 297-338.

——— 1895, On outlying areas of the Comanche series in Kansas, Oklahoma, and New Mexico: Am. Jour. Sci., 3rd ser., v. 50, p. 205-234.

——— 1901, Geography and geology of the Black and Grand Prairies, Texas: U. S. Geol. Survey 21st Ann. Rept., pt. 7, 666 p.

——— 1923, Further contributions to the knowledge of the Cretaceous of Texas and northern Mexico (abst.): Geol. Soc. America Bull. 34, no. 1, p. 72-73.

——— and Penrose, R. A. F., Jr., 1889, Relation of the uppermost Cretaceous beds of the eastern and southern United States; and the Tertiary-Cretaceous parting of Arkansas and Texas: Am. Jour. Sci., 3rd ser., v. 38, p. 468-473.

——— and Vaughan, T. W., 1898, The Lower Cretaceous Gryphaeas of the Texas region: U. S. Geol. Survey Bull. 151, 139 p.

Hyatt, A., 1903, Pseudoceratites of the Cretaceous, edited by T. W. Stanton: U. S. Geol. Survey Mon. 44, 351 p.

Ikens, W. C., and Clabaugh, S. E., 1940, Some fossils from the Edwards formation of Texas: Bull. Am. Paleontology, v. 26, no. 96, 22 p. 2 pls.

Imlay, R. W., 1944, Correlation of the Cretaceous formations of the Greater Antilles, Central America, and Mexico: Geol. Soc. America Bull. 55, p. 1005-1046, 3 pls., 1 fig.

Jones, T. S., 1938, Geology of the Sierra de la Peña and paleontology of the Indidura formation, Coahuila, Mexico: Geol. Soc. America Bull. 49, p. 69-150, 13 pls., 4 figs.

Kellum, L. B., 1944, Geologic history of northern Mexico and its bearing on petroleum exploration: Am. Assoc. Petroleum Geologists Bull., v. 28, no. 3, p. 301-325.

——— 1954, Geology of the Villareal uplift, Sierra de Tlahualilo, Coahuila, Mexico (abst.): Geol. Soc. America Bull. 65, p. 1273.

——— Imlay, R. W., and Kane, W. G., 1936, Evolution of the Coahuila Peninsula, Mexico; Part 1, Relation of structure, stratigraphy, and igneous activity to an early continental margin: Geol. Soc. America Bull. 47, p. 969-1008.

Kelly, W. A., 1936, Evolution of the Coahuila Peninsula, Mexico; Part 2, Geology of the mountains bordering the valleys of Acatita and las Delicias: Geol. Soc. America Bull. 47, p. 1009-1038.

King, R. E., 1939, Geological reconnaissance in northern Sierra Madre Occidental of Mexico: Geol. Soc. America Bull. 50, p. 1625-1722.

____ and Adkins, W. S., 1946, Geology of a part of the lower Conchos Valley, Chihuahua, Mexico: Geol. Soc. America Bull. 57, p. 275-294, 4 pls., 2 figs.

Kniker, H. T., 1918, Comanchean and Cretaceous Pectinidae of Texas: Univ. Texas Bull. 1817, 56 p.

Lamarck, J. B. P. A., 1819, Animaus sans vertebres, v. 6, pt. 1.

Lambert, J., 1920, Etude sur quelques formes primitives de Spatangides: Soc. des Sci. Hist, et Nat. de l'Yonne Bull., Annee 1919, p. 107-147.

____ 1927, Considerations sur les echinides de la Comanche serie du Texas: Soc. Geol. France Bull., v. 26, p. 263-278, 2 figs.

____ and Thiery, F., 1909-1925, Essae de nomenclature raisonnee des echinides: Chaumont, 605 p., 15 pls.

Lasswitz, R., 1904, Die Kreide-Ammoniten von Texas: Geologische und Paleontologische Abhandlungen, v. 10 (n. ser. 6), no. 4, p. 223-259, 8 pls., 8 figs.

Lozo, F. E., Jr., 1944, Biostratigraphic relations of some north Texas Trinity and Fredericksburg (Comanchean) foraminifers: Am. Midland Naturalist, v. 31, no. 3, p. 512-582, 5 pls., 23 figs.

____ 1951, The Woodbine and adjacent strata of the Waco area of central Texas; A symposium: Southern Methodist Univ. Fondren Sci. Ser. 4, 197 p.

Marcou, J., 1861, Notes on the Cretaceous and Carboniferous rocks of Texas: Boston Soc. Nat. Hist. Proc. 8, p. 86-97.

Meek, F. B., 1871, Preliminary paleontological report, consisting of lists of fossils, with descriptions of some new types..., in: F. V. Hayden, Preliminary report [fourth annual] of the United States Geological Survey of Wyoming and portions of contiguous Territories (being a second annual report of progress), p. 287-318.

Meek, F. B., 1876, A report on the invertebrate Cretaceous and Tertiary fossils of the upper Missouri country, in: F. V. Hayden, Report of the United States Geological Survey of the Territories, v. 9, 629 p.

Miller, A. K., and Harris, R. A., 1945, North American Cymatoceratidae (Mesozoic Nautiloidea): Jour. Paleontology, v. 19, no. 1, p. 1-12, 5 pls., 4 figs.

Müller, C. H., 1947, Vegetation and climate of Coahuila, Mexico: Madrono, v. 9, no. 2, p. 33-57, 7 pls.

Nicol, D., 1939, A brief study of some Pelecypod genera of the Goodland formation: Texas Christian Univ. thesis, Fort Worth, Texas, 167 p., 1 pl.

D'Orbigny, A., 1840-1847, Paleontologie francaise, terrain cretace; 1840-42, t. 1; 1842-43, t. 2; 1844-47, t. 3.

Perkins, B. F., and Albritton, C. C., Jr., 1955, The Washita group in the valley of the Trinity River, Texas; a field guide: Southern Methodist Univ. Fondren Sci. Ser. 5, 27 p., 5 pls., 7 figs.

Pettijohn, F. J., 1949, Sedimentary Rocks: N. Y., Harper and Bros.

Robinson, W. I., and Kellum, L. B., 1941, Geology of Sierra de Tlahualilo, Durango (abst.): Geol. Soc. America Bull. 52, p. 1930-31.

Roemer, F., 1849, Texas...: Bonn, 464 p.

——— 1852, Die Kreidebildungen von Texas und ihre organischen Einschlüsse: Bonn, 100 p., 11 pls.

——— 1889, Macraster, eine neue Spantangoiden-Gattung aus der Kreide von Texas: Neues Jahrb., 1888, v. 1, 191-195, pl. 6.

Scott, G., 1924, Some gerontic ammonites of the Duck Creek formation: Texas Christian Univ. Quart., v. 1, no. 1, p. 5-31.

——— 1926, Etudes stratigraphiques et paleontologiques sur les terrains cretaces du Texas: Univ. de Grenoble Annales, n. ser., sec. sci., v. 3, p. 93-210.

——— 1928, Ammonites of the genus Dipoloceras, and a new Hamites from the Texas Cretaceous: Jour. Paleontology, v. 2, no. 2, p. 108-118, 2 pls., 1 fig.

——— 1933, The Cretaceous of Texas, in: W. E. Wrather et al, Oklahoma and Texas: 16th Internat. Geol. Cong., U. S. 1933, Guidebook 6, Excursion A-6, p. 46-61.

Scott, G., 1940, Paleoecological factors controlling the distribution and mode of life of Cretaceous ammonoids in the Texas area: Jour. Paleontology, v. 14, no. 4, p. 299-323, 9 figs.

Sharpe, D., 1849, On Tylostoma, a proposed genus of gastropodous mollusks: Geol. Soc. London Quart. Jour. 5, p. 376-380, pl. 9.

Shattuck, G. B., 1903, The mollusca of the Buda limestone: U. S. Geol. Survey Bull. 205, 94 p., 27 pls.

Shreve, F., 1942, The desert vegetation of North America: Botanical Review, v. 8, 195-246.

Shumard, B. F., 1860, Observation upon the Cretaceous strata of Texas: St. Louis Acad. Sci. Trans. 1, p. 582-590.

____ 1860a, Descriptions of new Cretaceous fossils from Texas: St. Louis Acad. Sci. Trans. 1, p. 590-610.

____ 1861, Descriptions of new Cretaceous fossils from Texas: Boston Soc. Nat. Hist. Proc. 8, p. 188-205.

____ 1853 and 1854, Paleontology; description of the species of Carboniferous and Cretaceous fossils collected, in: R. B. Marcy, Exploration of the Red River of Louisiana in the year 1852: U. S., 32d Cong. 2d Sess, Senate Executive Doc. 54, p. 197-211 (1853): U. S., 33d Cong. 1st Sess., House Executive Doc., p. 173-185 (1854).

Shumard, G. G., 1853 and 1854, Remarks upon the general geolong of the country passed over by the exploring expedition to the sources of the Red River..., in: R. B. Marcy, Exploration of the Red River of Louisiana in the year 1852: U. S., 32d Cong. 2d Sess, Senate Executive Doc. 54, p. 179-195 (1853): U. S., 33d Cong. 1st Sess., House Executive Doc., p. 156-172 (1854).

Smiser, J. S., 1933, A study of the echinoid fragments in the Cretaceous rocks of Texas: Jour. Paleontology, v. 7, no. 2, p. 123-163, 6 pls.

Stainbrook, M. A., 1940, Gastropoda of the Kiamichi shale of the Texas Panhandle: Univ. Texas Bull. 3945, p. 705-716, pl. 33.

Stanton, T. W., 1928, The Lower Cretaceous or Comanche series: Am. Jour. Sci., 5th ser., v. 16, p. 399-409, 1 fig.

____ 1947, Studies of some Comanche pelecypods and gastropods: U. S. Geol. Survey Prof. Paper 211, 256 p., 6 pls., 1 fig.

Stephenson, L. W., 1918, A contribution to the geology of northeastern Texas and southern Oklahoma: U. S. Geol. Survey Prof. Paper 120-H, p. 129-163, 30 pls.

____ 1944, Fossils from limestone of Buda age in Denton County, Texas: Am. Assoc. Petroleum Geologists Bull., v. 28, no. 10, p. 1538-1541.

____ King, P. B., Watson, H. M., and Imlay, R. W., 1942, Correlation of the outcropping Cretaceous formations of the Atlantic and Gulf Coastal Plain and trans-Pecos Texas [Chart no. 9]: Geol. Soc. America Bull. 53, p. 435-448.

Taff, J. A., 1892, Chalk of southwestern Arkansas: U. S. Geol. Survey 22d Ann. Rept., pt. 3, p. 687-742.

____ 1893, Report on the Cretaceous area north of the Colorado River: Texas Geol. Survey Ann. Rept. 4, pt. 1, p. 241-354.

Thompson, S. A., 1935, Fredericksburg group of Lower Cretaceous with special reference to north-central Texas: Am. Assoc. Petroleum Geologists Bull., v. 19, no. 10, p. 1508-1537.

Twenhofel, W. H., 1924, The geology and invertebrate paleontology of the Comanchean and "Dakota" formations of Kansas: State Geol. Survey Kans. Bull. 9, 135 p., 23 pls. Review by T. W. Stanton, Am. Jour. Sci., 5th ser., v. 9, p. 340-342.

Vaughan, T. W., 1900, Reconnaissance in the Rio Grande coal fields of Texas: U. S. Geol. Survey Bull. 164, p. 1-88.

____ 1903, The corals of the Buda limestone: U. S. Geol. Survey Bull. 205, p. 37-40.

White, C. A., 1884, A review of the fossil Ostreidae of North America: U. S. Geol. Survey 4th Ann. Rept., p. 279-430, pls. 34-82.

Whitney, F. L., 1911, Fauna of the Buda limestone: Texas Univ. Bull. 184, 55 p., 13 pls.

____ 1916, The echinoidea of the Buda limestone: Bull. Am. Paleontology, no. 26, 36 p.

Wilmarth, M. G., 1938, Lexicon of geologic names of the United States (including Alaska): U. S. Geol. Survey Bull. 896, pt. 1, A-L, p. 1-1244, pt. 2, M-Z, p. 1245-2396.

Winton, W. M., 1925, The geology of Denton County: Univ. Texas Bull. 2544, 86 p., 2 pls., 8 figs.

Winton W. M., and Adkins, W. S., 1920, The geology of Tarrant County: Univ. Texas Bull. 2229, 68 p.

Woods, H., 1889-1913, A monograph of the Cretaceous Lamellibranchia of England: Paleontographical Soc. London Mon., v. 1, 196 p., 41 pls. (1889-1903), and v. 2, 473 p., 62 pls. (1904-1913).

PLATES 6-30

EXPLANATION OF PLATE 6

(All figures X 1 unless otherwise indicated)

Page

Cucullaea sycamorensis Perkins, sp. nov. 100
Holotype U.M.M.P. 33004 from the Denison formation (Main Street limestone member), locality T-9.
Fig. 1. View of right valve.
Fig. 2. Dorsal view.
Fig. 4. Anterior view.

Leptosolen striatula Perkins, sp. nov. 101
Holotype U.M.M.P. 33006 from the Goodland formation (Marys Creek marl member), locality T-1.
Fig. 3. Dorsal view.
Fig. 5. View of right valve.

Protocardia prosogyrata Perkins, sp. nov. 103
Holotype U.M.M.P. 33008 from the Denison formation (Weno marly limestone member), locality T-61.
Fig. 6. Postero-dorsal view.
Fig. 9. View of right valve.

Protocardia roanokensis Perkins, sp. nov. 105
Holotype U.M.M.P. 33010 from the Denison formation (Grayson marl member), locality T-26. All views X 1½.
Fig. 7. View of left valve.
Fig. 8. Posterior view.

Protocardia nutans Perkins, sp. nov. 106
Holotype U.M.M.P. 33011 from the Denison formation (Main Street limestone member), locality T-19.
Fig. 10. View of right valve.
Fig. 11. Postero-dorsal view.

PLATE 6



EXPLANATION OF PLATE 7

(All figures X 1)

Page

Homomya cymbiformis Perkins, sp. nov. 108
Holotype U.M.M.P. 33012 from the Goodland formation (Marys Creek marl member), locality T-1.
Fig. 1. View of left valve.
Fig. 2. Anterior view.
Fig. 6. Dorsal view.

Homomya tarrantensis Perkins, sp. nov. 109
Holotype U.M.M.P. 33014 from the Goodland formation (Benbrook limestone member), locality T-2.
Fig. 3. View of left valve.
Fig. 4. Anterior view.
Fig. 5. Dorsal view.

Paratype U.M.M.P. 33015 from the Goodland formation (Marys Creek marl member), locality T-1.
Fig. 7. Dorsal view.
Fig. 9. View of left valve.

Tapes ehlersi Perkins, sp. nov. 111
Holotype U.M.M.P. 33020 from the Denison formation (Weno marly limestone member), locality T-9.
Fig. 8. View of right valve.
Fig. 10. Dorsal view.

Paratype U.M.M.P. 33021 from the Denison formation (Weno marly limestone member), locality T-33.
Fig. 11. View of right valve.
Fig. 12. Dorsal view.

Meretrix? fortworthensis Perkins, sp. nov. 113
Holotype U.M.M.P. 33023 from the Denison formation (Main Street limestone member), locality T-9.
Fig. 13. Anterior view.
Fig. 14. View of right valve.

PLATE 7



EXPLANATION OF PLATE 8

(All figures X 1 unless otherwise indicated)

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Meretrix? fortworthensis Perkins, sp. nov. 113
Paratype U.M.M.P. 33024 from the Denison formation (Main Street limestone member), locality T-9.
Fig. 1. View of left valve.
Fig. 2. Dorsal view.

Trapezium microsolen Perkins, sp. nov. 115
Holotype U.M.M.P. 33025 from the Goodland formation (Benbrook limestone member), locality T-2.
Fig. 3. Dorsal view.
Fig. 4. View of left valve.
Fig. 5. Anterior view.

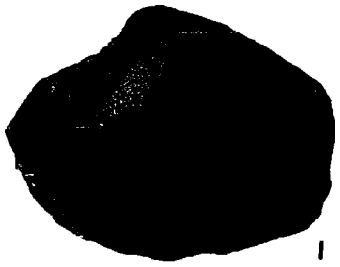
Modiolus exiguus Perkins, sp. nov. 116
Holotype U.M.M.P. 33026 from the Denison formation (Main Street limestone member), locality T-59.
All views X 1½.
Fig. 6. View of left valve.
Fig. 9. Anterior view.
Fig. 10. Dorsal view.

Barbatia subquadrata Perkins, sp. nov. 117
Holotype U.M.M.P. 32810 from the Goodland formation (Marys Creek marl member), locality T-40. All figures X 1½.
Fig. 7. View of left valve.
Fig. 8. Anterior view.
Fig. 12. Dorsal view.

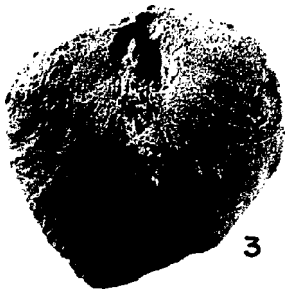
Paratype U.M.M.P. 33027 from the Goodland formation (Marys Creek marl member), locality T-40. View X 1½.
Fig. 11. View of right valve.

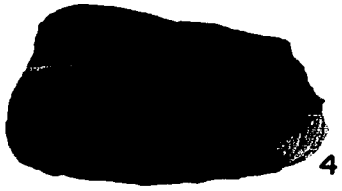
Paratype U.M.M.P. 33028 from the Goodland formation (Marys Creek marl member), locality T-40. Both views X 1½.
Fig. 13. Dorsal view.
Fig. 14. View of left valve.

PLATE 8


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EXPLANATION OF PLATE 9

(All figures X 1)

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Kingena wacoensis (Roemer) 144

U.M.M.P. 32825 from the Aurora limestone, locality 11.

Fig. 1. Pedicle valve.
Fig. 2. Brachial valve.
Fig. 3. Posterior view.
Fig. 4. Anterior view.

U.M.M.P. 32824 from the Aurora limestone, locality 33.

Fig. 5. Brachial valve.
Fig. 6. Pedicle valve.
Fig. 7. Anterior view.
Fig. 8. Posterior view.

Pterotrigonia sp. cf. P. guadalupae (Böse) 145

U.M.M.P. 32826 from the Aurora limestone, locality 38.

Fig. 9. View of left valve.
Fig. 10. Dorsal view.

Pteria bösei Perkins, sp. nov. 146

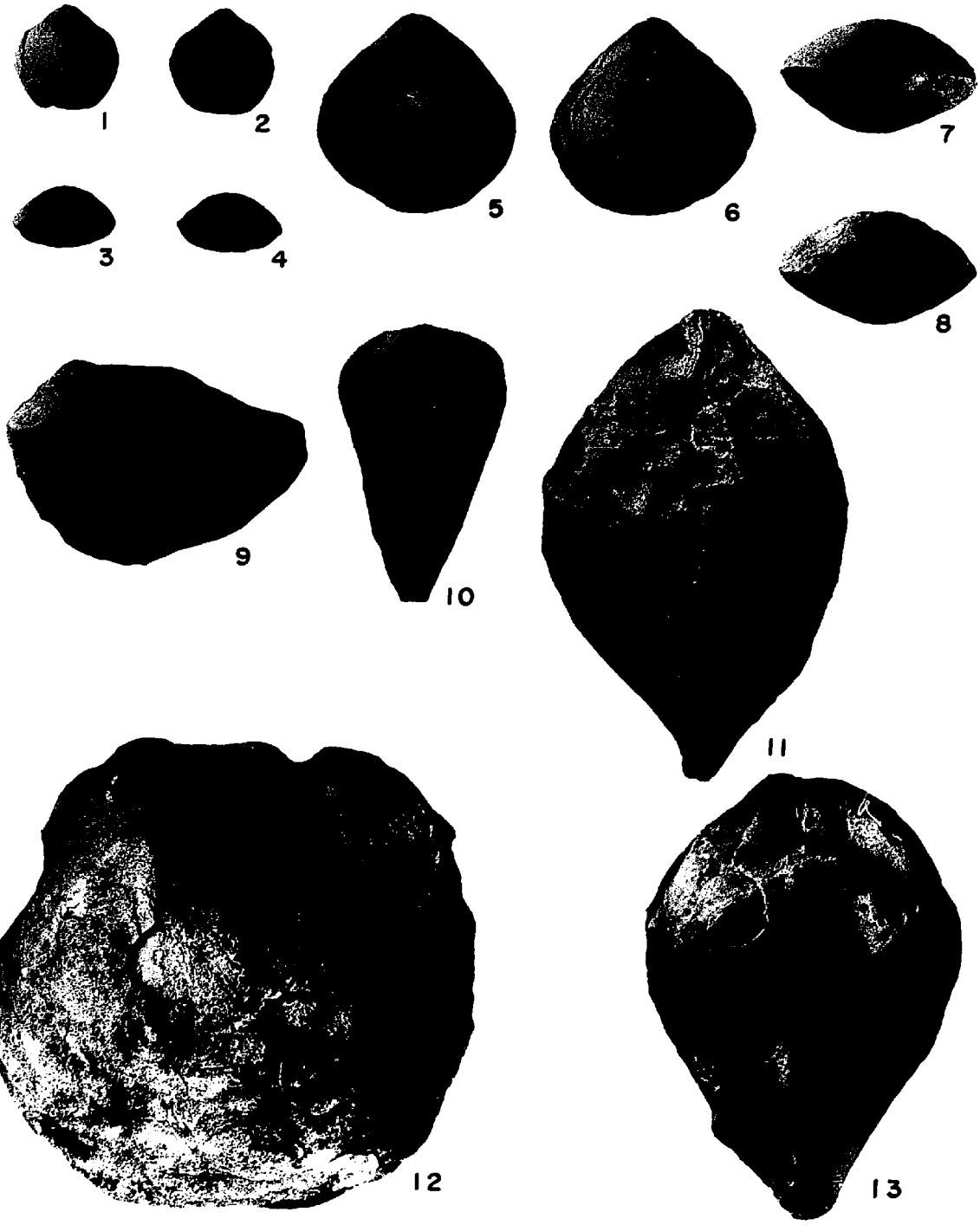
Holotype U.M.M.P. 16694 from the Indidura formation of the Sierra de Santa Ana, Coahuila, T. S. Jones locality J-69 (1938, p. 104).

Fig. 11. Dorsal view.
Fig. 12. View of left valve.

U.M.M.P. 32827 from the Aurora limestone, locality 14.

Fig. 13. Dorsal view.

PLATE 9



EXPLANATION OF PLATE 10

(All figures X 1 unless otherwise indicated)

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Pteria bösei Perkins, sp. nov. 146
Paratype U.M.M.P. 16693 from the Indidura formation of the Sierra de Santa Ana, Coahuila, T. S. Jones locality J-57 (1938, p. 104).
Fig. 1. View of left valve showing broad concentric lamellae.
Fig. 2. Dorsal view.

U.M.M.P. 32827 from the Aurora limestone, locality 14.
Fig. 10. View of right valve.

U.M.M.P. 32711 from the Aurora limestone, locality 50.
Fig. 15. View of left valve.

Pecten (Neithea) occidentalis (Conrad) 149
U.M.M.P. 22828 from the Aurora limestone, locality 26.
Fig. 3. Exterior view of right valve.
Fig. 4. Side view.

Pecten (Neithea) subalpinus (Böse) 150
U.M.M.P. 17469 from the Aurora limestone, locality 7.
Fig. 5. Side view.
Fig. 6. Exterior view of right valve.

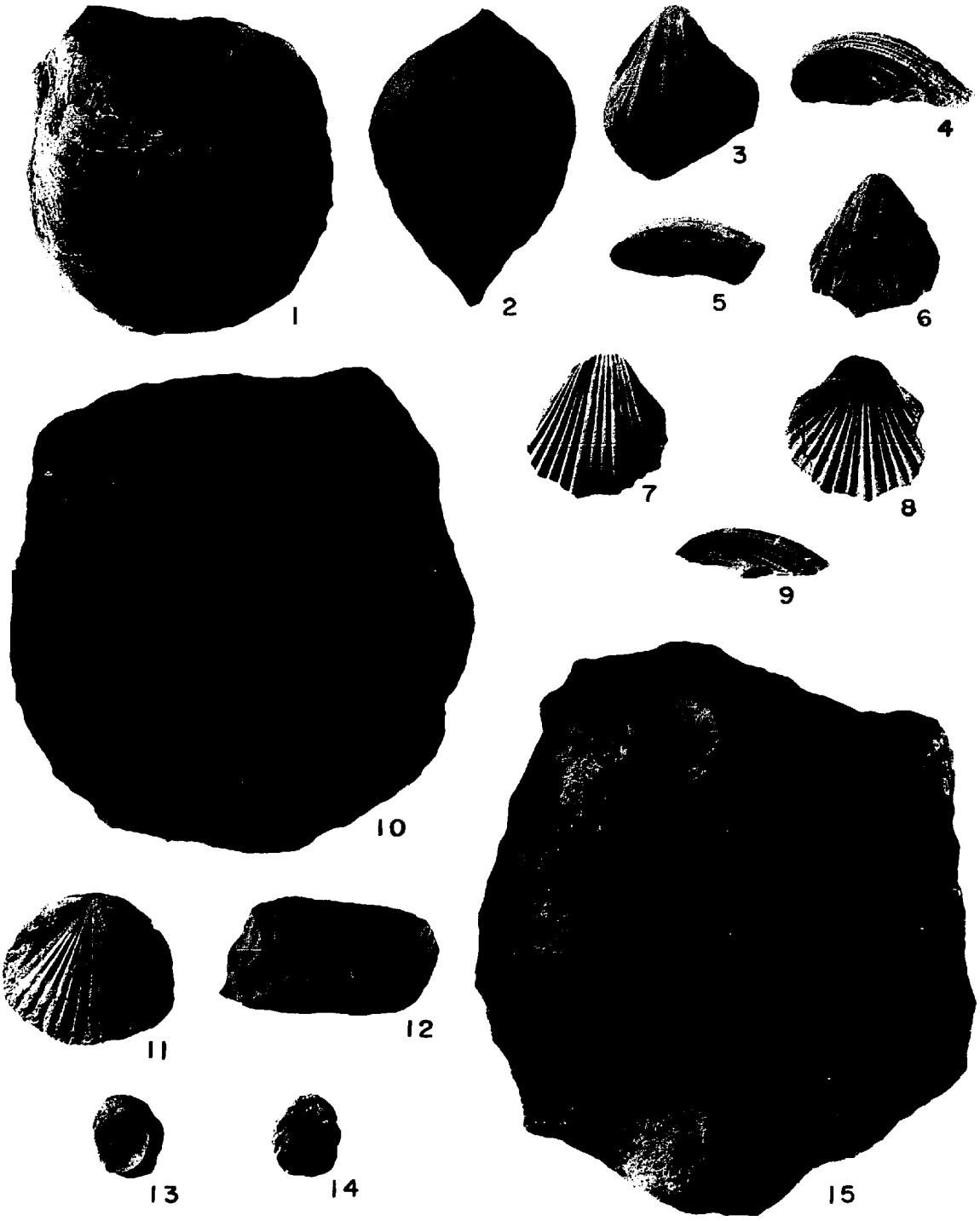
Pecten (Neithea) texanus Roemer 151
U.M.M.P. 32829 from the Aurora limestone, locality 10.
Fig. 7. Exterior view of right valve.
Fig. 8. Exterior view of left valve.
Fig. 9. Side view.

U.M.M.P. 32830 from the Aurora limestone, locality 10.
Fig. 11. Interior view of left valve.

Lopha (Arctostrea) colubrina (Lamarck) 153
U.M.M.P. 32831 from the Aurora limestone, locality 21.
Fig. 12. Exterior view of left? valve.

Exogyra texana Roemer 154
U.M.M.P. 32832 from the Aurora limestone, locality 49. All views X 1½.
Fig. 13. Interior of left valve.
Fig. 14. Exterior of left valve.

PLATE 10



EXPLANATION OF PLATE 11

(All figures X 1)

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Pecten (Neithea?) sp. 152
U.M.M.P. 17296 from the Aurora limestone, locality 3.
Fig. 1. View of artificial cast of right valve exterior.

Gryphaea mucronata Gabb 155
U.M.M.P. 32395 from the Aurora limestone, locality 52.
Fig. 2. Exterior view of left valve.
Fig. 3. Side view.

U.M.M.P. 32749 from the Aurora limestone, locality 52.
Fig. 4. Exterior view of left valve.
Fig. 5. Side view.

U.M.M.P. 32833 from the Aurora limestone, locality 32.
Fig. 6. Exterior view of left valve.
Fig. 7. Side view.

U.M.M.P. 32834 from the Aurora limestone, locality 52.
Fig. 8. Exterior view of right valve.

U.M.M.P. 32835 from the Aurora limestone, locality 52.
Fig. 9. Interior view of left valve.
Fig. 10. Exterior view of left valve.

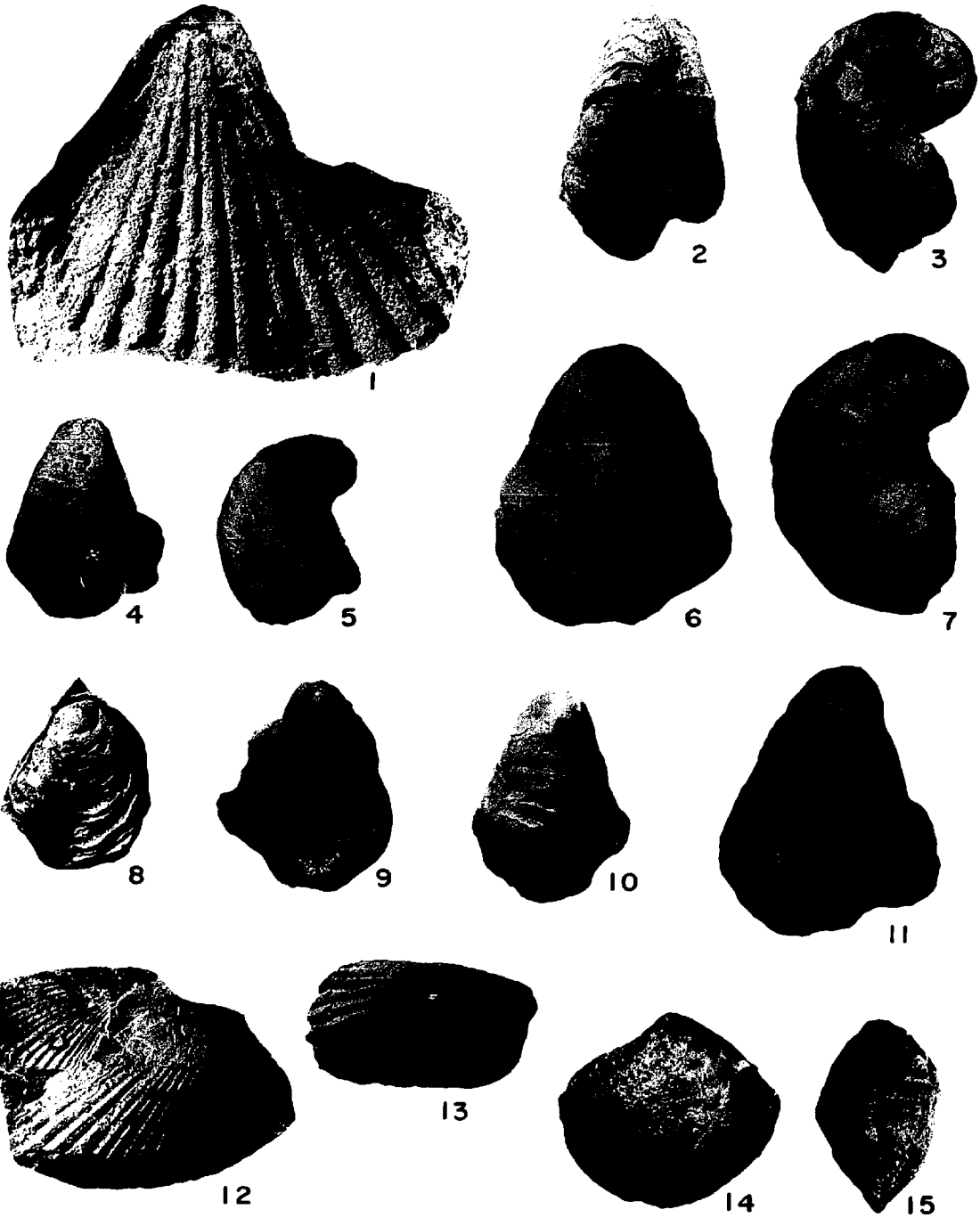
U.M.M.P. 32810 from the Aurora limestone, locality 52.
Fig. 11. Exterior view of left valve.

Lima (Mantellum) waccensis Roemer 157
U.M.M.P. 17333 from the Aurora limestone, locality 9.
Fig. 12. Exterior view of left valve.

U.M.M.P. 32836 from the Aurora limestone, locality 13.
Fig. 13. Exterior view of left valve.

Asterte? sp. 159
U.M.M.P. 32839 from the Aurora limestone, locality 48.
Fig. 14. View of left valve.
Fig. 15. Dorsal view.

PLATE II



EXPLANATION OF PLATE 12

(All figures X 1)

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Veniella coahuilaensis Jones 158
U.M.M.P. 32837 from the Indidura formation, Sierra de Tlahualilo.
Fig. 1. Exterior view of right valve.
Fig. 2. Dorsal view.

U.M.M.P. 32696 from the Aurora limestone, locality 48.
Fig. 3. Exterior view of right valve.

Cyprimeria texana (Roemer) 159
U.M.M.P. 32840 from the Aurora limestone, locality 32.
Fig. 4. Exterior view of left valve.
Fig. 5. Dorsal view.

Protocardia multistriata (Shumard) 162
U.M.M.P. 32841 from the Aurora limestone, locality 17.
Fig. 6. Exterior view of left valve.

Protocardia securiformis (Cragin) 163
S.M.U.M.P. 1031 from the Goodland formation (Marys Creek marl member), locality T-40.
Fig. 7. Exterior view of left valve.
Fig. 11. Posterior view.

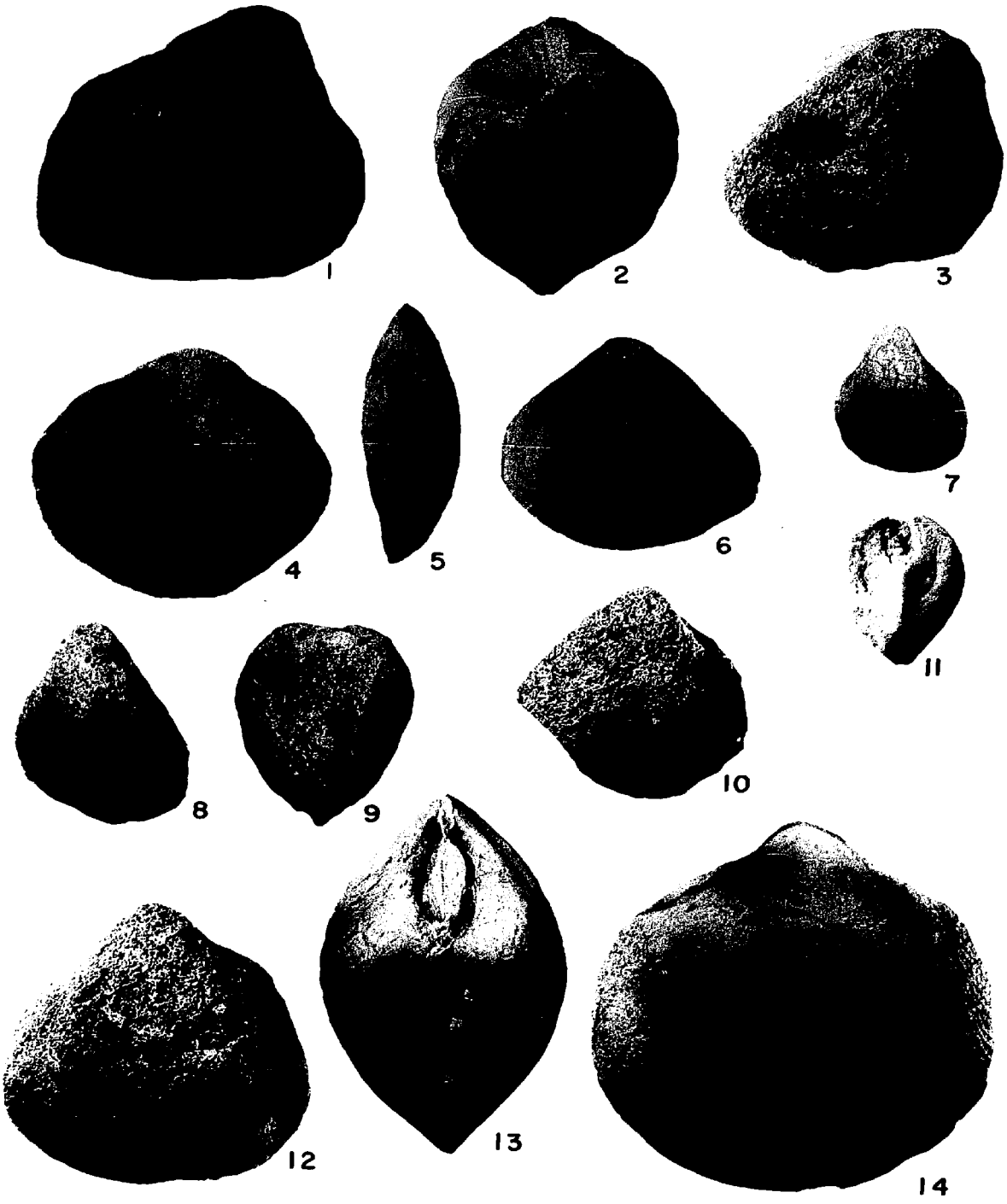
Protocardia sp. cf. *P. securiformis* (Cragin) 163
U.M.M.P. 32842 from the Aurora limestone, locality 38.
Fig. 8. Exterior view of left valve.
Fig. 9. Posterior view.

Protocardia texana (Conrad) 164
U.M.M.P. 32843 from the Aurora limestone, locality 57.
Fig. 10. Exterior view of left valve showing poorly preserved posterior radial ribs and concentric ribs.

U.M.M.P. 32844 from the Aurora limestone, locality 38.
Fig. 12. Exterior view of left valve.

S.M.U.M.P. 1033 from the Goodland formation, (Marys Creek marl member), locality T-40.
Fig. 13. Dorsal view.
Fig. 14. View of left valve.

PLATE 12



EXPLANATION OF PLATE 13

(All figures X 1)

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<u>Protocardia texana</u> (Conrad) 164

S.M.U.M.P. 1032 from the Goodland formation (Marys Creek marl member), locality T-40.

Fig. 1. Exterior view of left valve.

Fig. 2. Postero-dorsal view.

S.M.U.M.P. 1034 from the Goodland formation (Marys Creek marl member), locality T-40.

Fig. 3. View of left side of steinkern showing prominent muscle scars.

U.M.M.P. 32845 from the Aurora limestone, locality 57.

Fig. 5. View of left side of steinkern showing anterior muscle scar.

<u>Protocardia denisonensis</u> (Cragin) 161

S.M.U.M.P. 1035 from the Denison formation, Grayson County, Texas (Cragin, 1894b, p. 57). See also Plate 14, figure 1.

Fig. 4. Posterior view of a plaster cast of Cragin's holotype in the United States National Museum.

U.M.M.P. 32846 from the Aurora limestone, locality 17. See also Plate 14, figure 2.

Fig. 7. Posterior view.

<u>Eoradiolites? albrittoni</u> Perkins, sp. nov. 167

Paratype U.M.M.P. 32849 from the Aurora limestone, locality 18.

Fig. 6. Side view of internal cast of a part of the living cavity.

PLATE 13



EXPLANATION OF PLATE 14

(All figures X 1)

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<u>Protocardia denisonensis</u> (Cragin) 161

S.M.U.M.P. 1035 from the Denison formation, Grayson County, Texas (Cragin, 1894b, p. 57).

Fig. 1. View of left valve of a plaster cast of Cragin's holotype in the United States National Museum. See also Plate 13, figure 4.

U.M.M.P. 32846 from the Aurora limestone, locality 17.

Fig. 2. View of left valve. See also Plate 13, figure 7.

<u>Eoradiolites</u>? <u>albrittoni</u> Perkins, sp. nov. 167

Paratype U.M.M.P. 32848 from the Aurora limestone, locality 29.

Fig. 3. Side view of internal cast of a part of a living cavity.

Paratype U.M.M.P. 32850 from the Aurora limestone, locality 29.

Fig. 4. Side view of internal cast of a part of a living cavity.

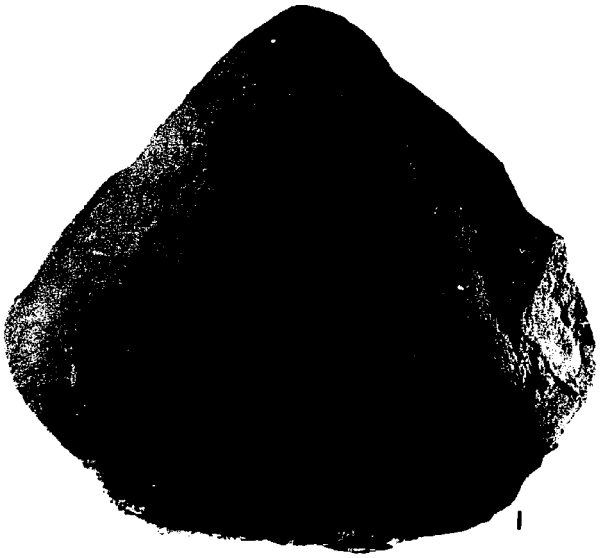
Paratype U.M.M.P. 32851 from the Aurora limestone, locality 29.

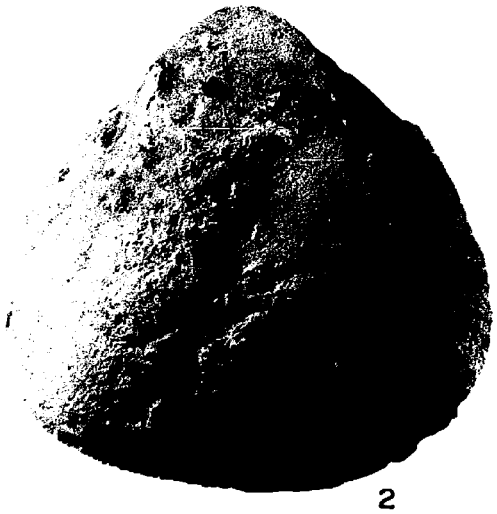
Fig. 5. Sketch of exterior showing vertical partitions and transverse tabulae.

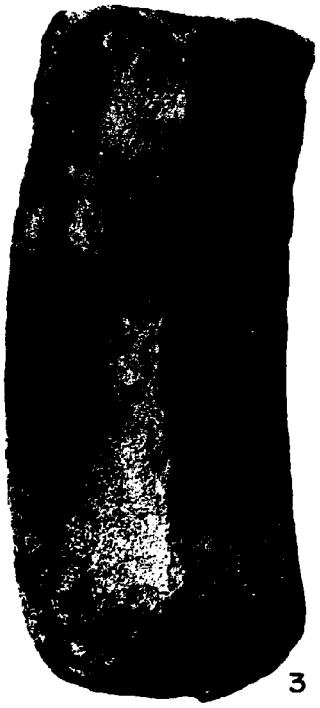
Holotype U.M.M.P. 32847 from the Aurora limestone, locality 29.

Fig. 6. Sketch of transverse section showing living cavities (numbered) and shell structure.

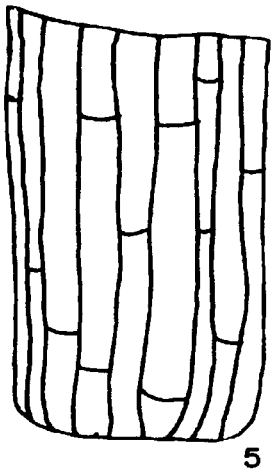
PLATE 14

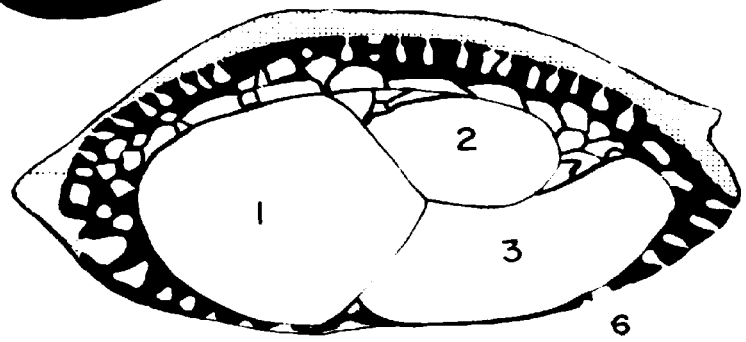

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EXPLANATION OF PLATE 15

(All figures X 1)

Page

Modiolus sp. 169
U.M.M.P. 32852 from the Aurora limestone, locality 27.
Fig. 1. Dorsal view.
Fig. 2. View of right side.

Homomya auroraensis Perkins, sp. nov. 170
Holotype U.M.M.P. 32853 from the Aurora limestone, locality 18.
Fig. 3. View of left valve.
Fig. 4. Dorsal view.
Fig. 5. Anterior view showing convexity of valves.

Homomya budaensis Whitney 172
U.M.M.P. 32854 from the Aurora limestone, locality 29.
Fig. 6. Anterior view showing convexity of valves. See also Plate 16, figures 1, 3.

PLATE 15



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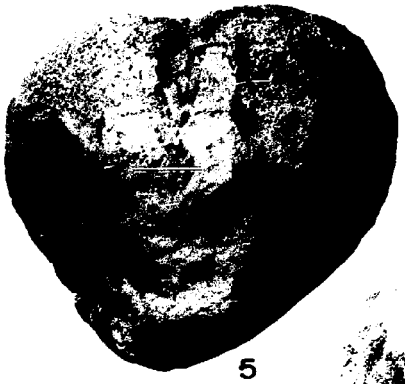
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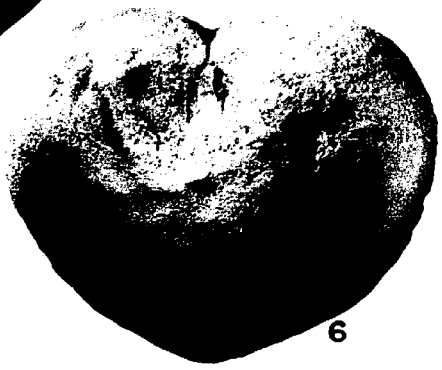
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EXPLANATION OF PLATE 16

(All figures X 1)

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Homomya budaensis Whitney 172
U.M.M.P. 32854 from the Aurora limestone, locality 29.
Fig. 1. Dorsal view.
Fig. 3. View of left valve. See also Plate 15, figure 6.

Homomya kellumi Perkins, sp. nov. 173
Holotype U.M.M.P. 32855 from the Aurora limestone, locality 19.
Fig. 2. View of left valve.
Fig. 4. Dorsal view.
Fig. 5. Anterior view.

Paratype U.M.M.P. 32857 from the Aurora limestone, locality 15.
Fig. 6. View of left valve of specimen with prominent anterior shoulder. See also Plate 17, figures 1, 2.

PLATE 16



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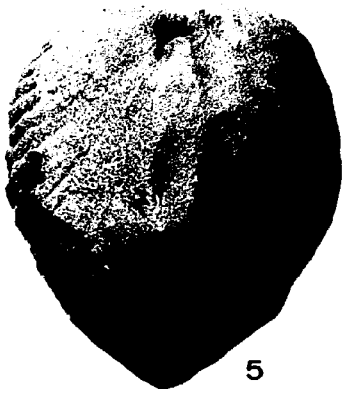
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EXPLANATION OF PLATE 17

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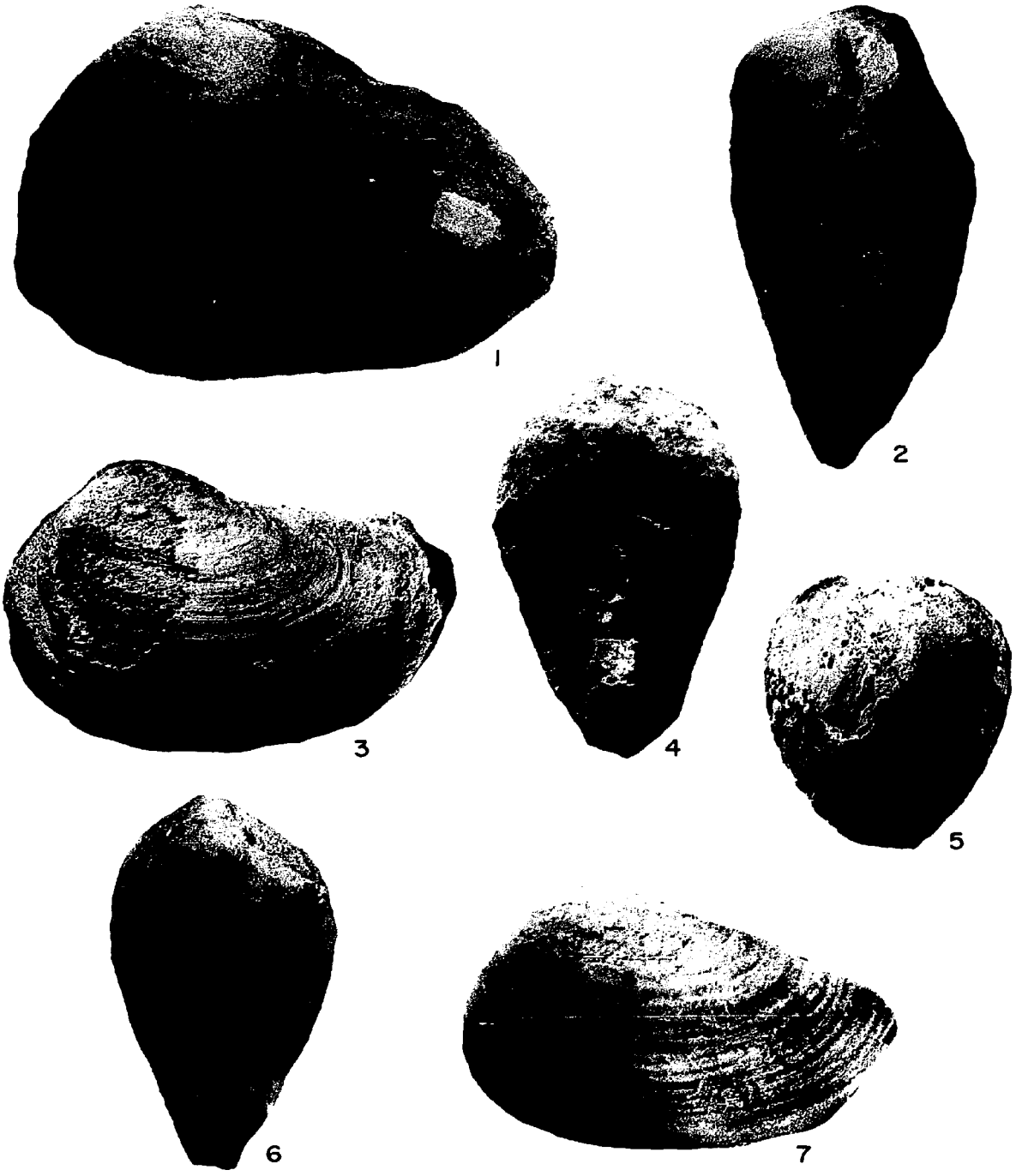
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Homomya kellumi Perkins, sp. nov. 173
Paratype U.M.M.P. 32856 from the Aurora limestone, locality 51.
Fig. 1. View of left valve.
Fig. 2. Dorsal view. See also Plate 16, figures 2, 4-6.

Homomya tlahualiloensis Perkins, sp. nov. 175
Holotype U.M.M.P. 32858 from the Aurora limestone, locality 26.
Fig. 3. View of left valve.
Fig. 4. Dorsal view.
Fig. 5. Anterior view.

Paratype U.M.M.P. 32859 from the Aurora limestone, locality 26.
Fig. 6. Dorsal view.
Fig. 7. View of left valve.

PLATE 17



EXPLANATION OF PLATE 18

(All figures X 1)

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Pholadomya shattucki Böse 177

U.M.M.P. 32860 from the Aurora limestone, locality 29.

Fig. 1. View of right valve of large specimen.

Fig. 5. Dorsal view.

U.M.M.P. 32861 from the Aurora limestone, locality 18.

Fig. 2. Dorsal view.

Fig. 3. View of right valve.

U.M.M.P. 32862 from the Aurora limestone, locality 16.

Fig. 4. Dorsal view.

Fig. 6. View of left valve.

PLATE 18



EXPLANATION OF PLATE 19

(All figures X 1)

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<u>Pholadomya toribioensis</u> Jones 178

U.M.M.P. 32863 from the Aurora limestone, locality 29.

Fig. 1. View of right valve.
Fig. 2. Dorsal view.
Fig. 3. Anterior view.

U.M.M.P. 32864 from the Aurora limestone, locality 18.

Fig. 4. View of right valve of incomplete specimen showing strong radial ribs.

<u>Tapes aldamensis</u> Böse 180

U.M.M.P. 32865 from the Aurora limestone, locality 32.

Fig. 5. Dorsal view.
Fig. 6. View of left valve.

<u>Pleurotomaria austinensis</u> Shumard 131

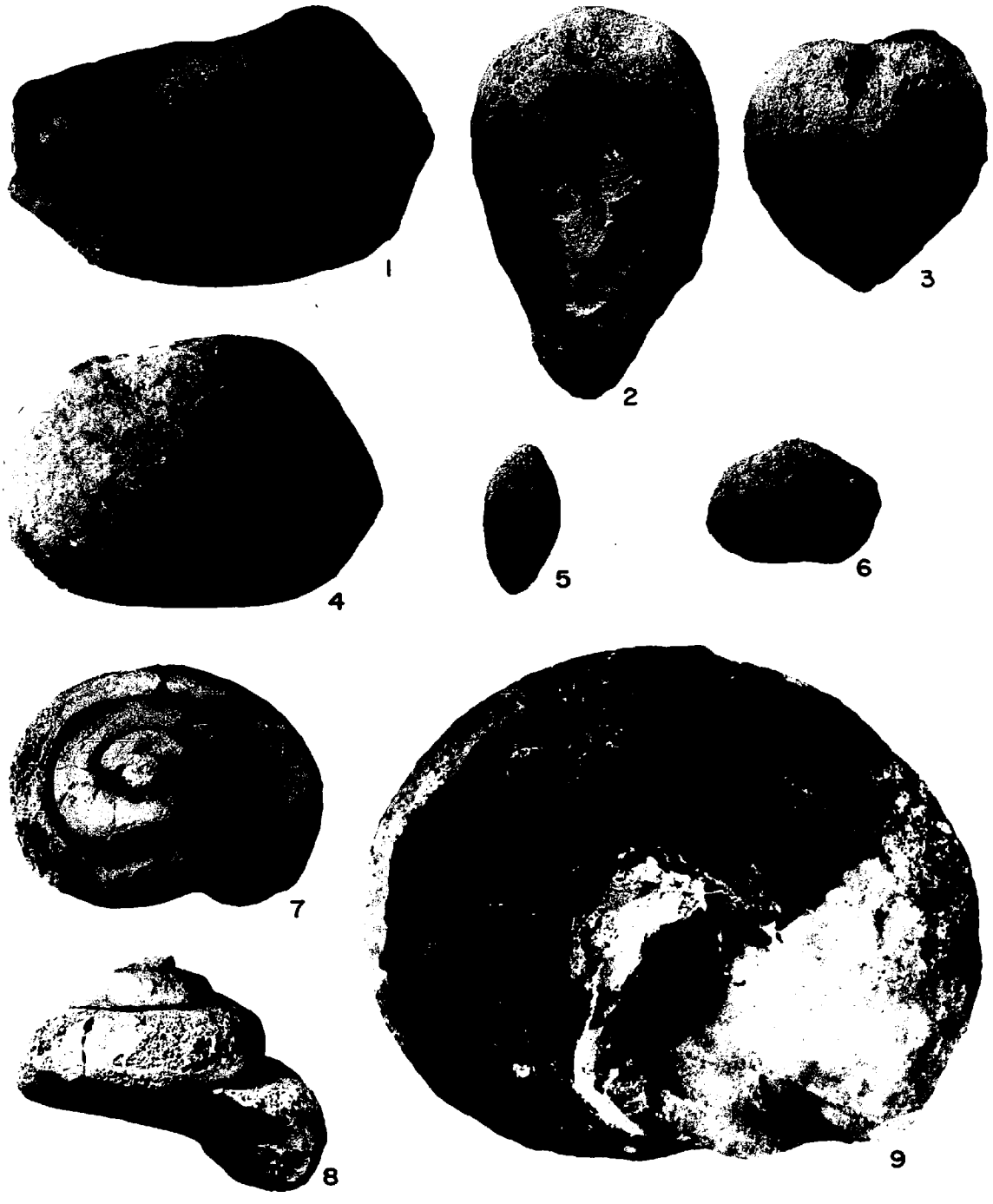
U.M.M.P. 32866 from the Aurora limestone, locality 26.

Fig. 7. Apical view of a steinkern.
Fig. 8. Side view.

U.M.M.P. 32647 from the Aurora limestone, locality 51.

Fig. 9. Bottom view of a large specimen showing characteristic revolving striae. See also Plate 20, figures 1, 7.

PLATE 19



EXPLANATION OF PLATE 20

(All figures X 1 unless otherwise indicated)

Page

Pleurotomaria austinensis Shumard 181
U.M.M.P. 32647 from the Aurora limestone, locality 51.
Fig. 1. Apical view of a large specimen.
Fig. 7. Side view. See also Plate 19, fig. 9.

Ampullina? collina (Conrad) 182
U.M.M.P. 32867 from the Aurora limestone, locality 17.
Fig. 2. Apertural view.
Fig. 3. Dorsal view.
Fig. 5. Apical view.

Aporrhais? subfusiformis (Shumard) 185
U.M.M.P. 32869 from the Aurora limestone, locality 32.
Fig. 8. Apertural view.

U.M.M.P. 32870 from the Aurora limestone, locality 16.
Fig. 10. Apertural view of an incomplete specimen showing revolving carinae.

Turritella leonensis Conrad 184
U.M.M.P. 32868 from the Aurora limestone, locality 31.
Fig. 9. Side view of incomplete specimen showing surface ornamentation.

Natica? parvum Perkins, sp. nov. 186
Holotype U.M.M.P. 32871 from the Aurora limestone, locality 47. Both views X 1½.
Fig. 4. Apertural view.
Fig. 6. Dorsal view.

Tylostoma chihuahuense Böse 187
U.M.M.P. 32872 from the Aurora limestone, locality 11.
Fig. 11. Apical view.
Fig. 12. Apertural view.

PLATE 20



EXPLANATION OF PLATE 21

(All figures X 1)

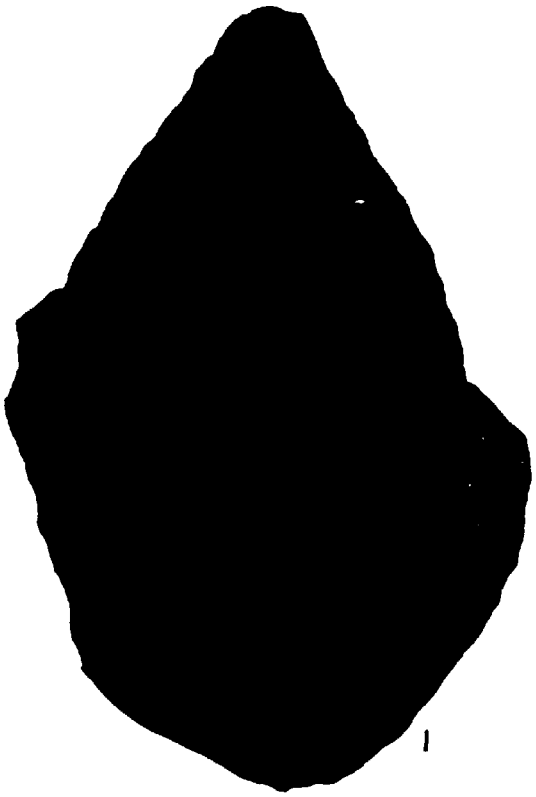
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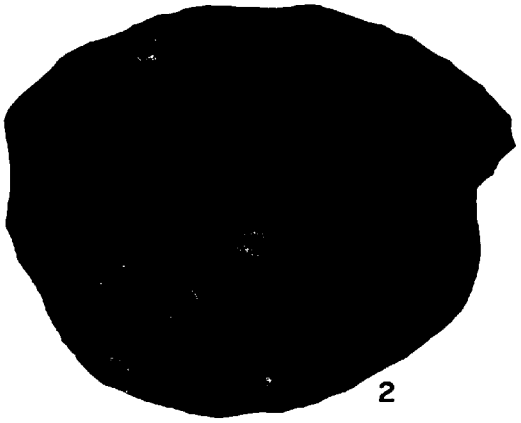
Tylostoma sp. cf. *T. regina* (Conrad) 189
U.M.M.P. 32874 from the Aurora limestone, locality 16.
Fig. 1. Apertural view.
Fig. 2. Apical view.

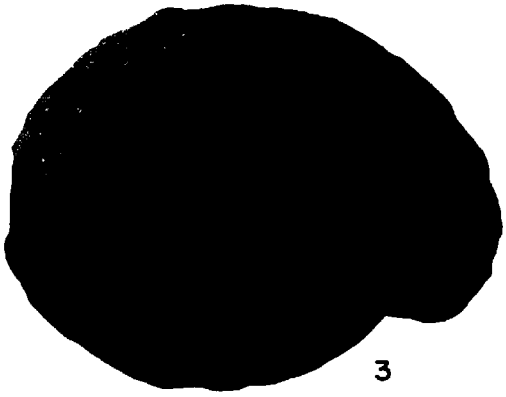
Tylostoma sp. 190
U.M.M.P. 17270 from the Aurora limestone, locality 2.
Fig. 3. Apical view.
Fig. 4. Apertural view.

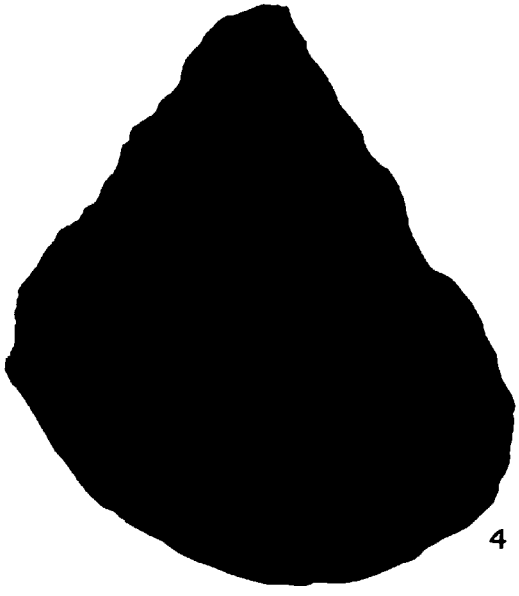
Tylostoma sp. cf. *T. elevatum* (Shumard) 189
U.M.M.P. 32873 from the Aurora limestone, locality 38.
Fig. 5. Apertural view.

PLATE 21


1


2


3


4


5

EXPLANATION OF PLATE 22

(All figures X 1)

Page

Cymatoceras hilli (Shattuck) 191

U.M.M.P. 30718 from the Aurora limestone, locality 39.

Fig. 1. Lateral view of internal whorls of a medium sized specimen showing sutures.

Fig. 2. Apertural view.

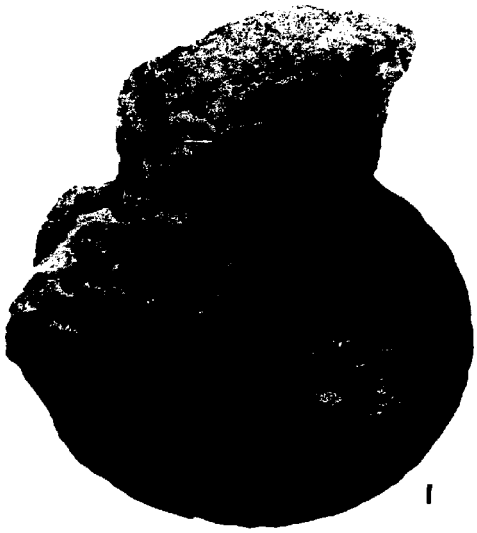
U.M.M.P. 32389 from the Aurora limestone, locality 55.

Fig. 3. Ventral view showing faint traces of surface sculpture on left side. See also Plate 23.

U.M.M.P. 30717 from the Aurora limestone, locality 22.

Fig. 4. Lateral view of a small specimen showing sutures.

PLATE 22



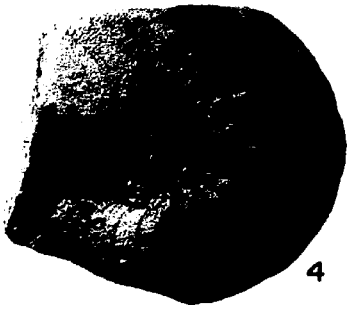
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3



2



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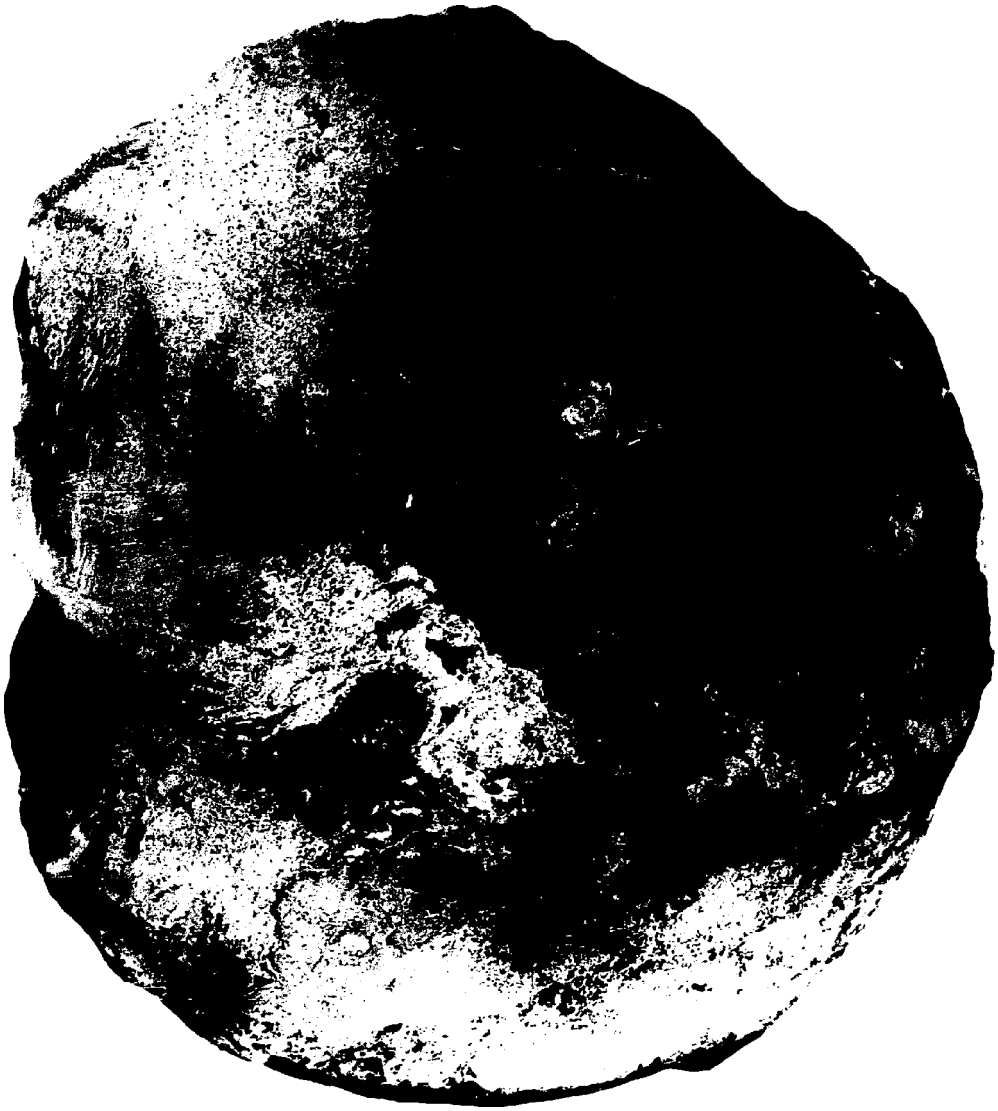
EXPLANATION OF PLATE 23

(Figure X 1)

Page

Cymatoceras hilli (Shattuck) 191
U.M.M.P. 32389 from the Aurora limestone, locality 55.
Lateral view showing surface surface sculpture on right. See also Plate 22, figure 3.

PLATE 23



EXPLANATION OF PLATE 24

(All figures X 1)

Page

Cymatoceras hilli (Shattuck) 191

U.M.M.P. 32391 from the Aurora limestone, locality 55.

Fig. 1. Ventral view.

Fig. 2. Apertural view. See also Plates 25, 26.

PLATE 24



1



2

EXPLANATION OF PLATE 25

(Figure X 1)

Page

Cymatoceras hilli (Shattuck) 191
U.M.M.P. 32391 from the Aurora limestone, locality 55.
Lateral view. See also Plates 24, 26.

PLATE 25



EXPLANATION OF PLATE 26

(Figure X 1)

Page

Cymatoceras hilli (Shattuck) 191
U.M.M.P. 32391 from the Aurora limestone, locality 55.
Lateral view showing sutures. See also Plates 24, 25.

PLATE 26



EXPLANATION OF PLATE 27

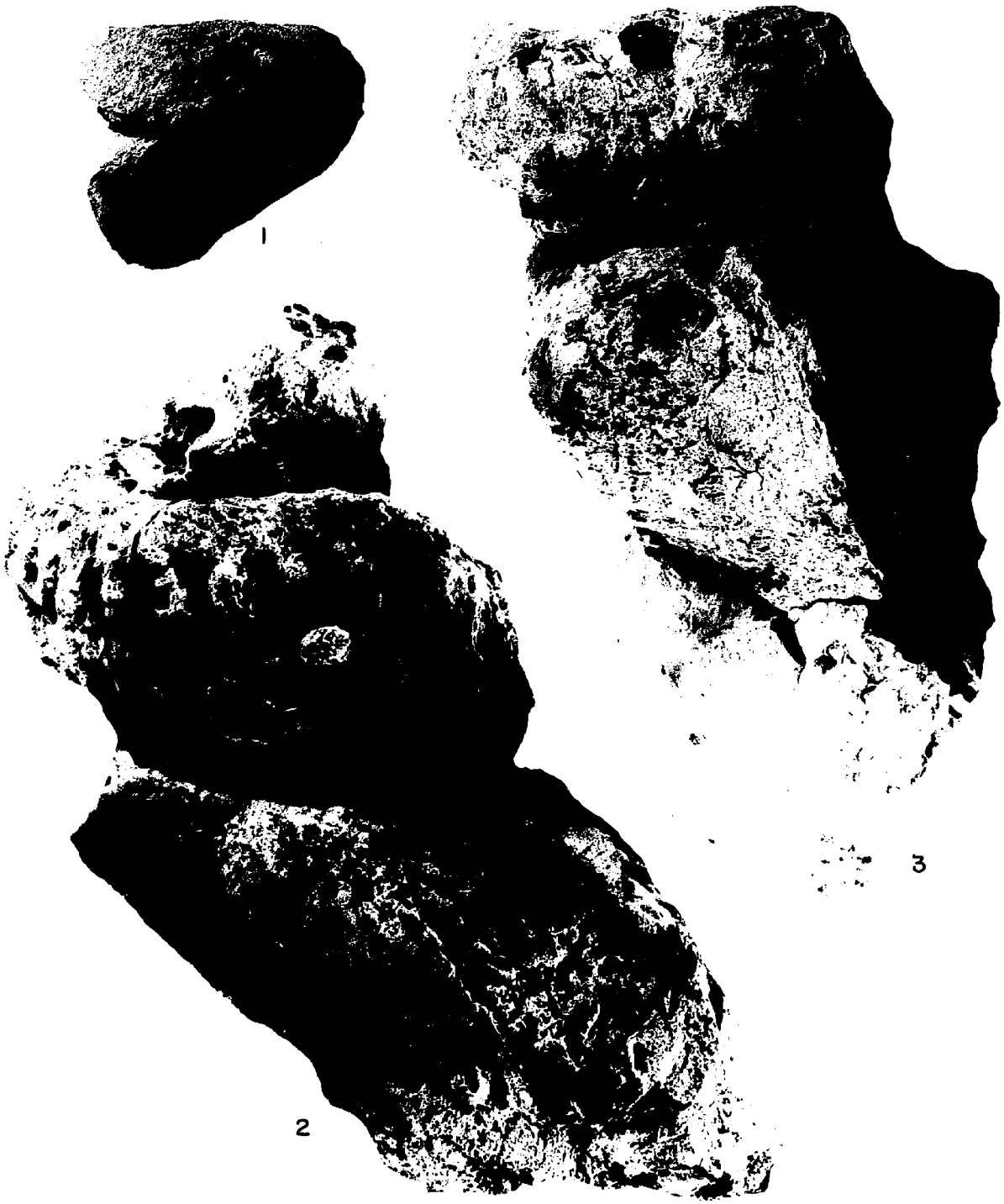
(All figures X 1 unless otherwise indicated)

Page

<u>Turrilites</u> sp. 193
U.M.M.P. 32875 from the Aurora limestone, locality 31.
Fig. 1. Lateral view.

<u>Turrilites brazoensis</u> Roemer 192
U.M.M.P. 32396 from the Aurora limestone, locality 55. Both figures X 3/4.
Fig. 2. Lateral view.
Fig. 3. Lateral view. See also Plate 28.

PLATE 27



EXPLANATION OF PLATE 28

(Figure X 3/4)

Page

Turrilites brazoensis Roemer 192
U.M.M.P. 32396 from the Aurora limestone, locality 55.
Lateral view of a large specimen.
See also Plate 27, figures 2, 3.

PLATE 28



EXPLANATION OF PLATE 29

(All figures X 1 unless otherwise indicated)

Page

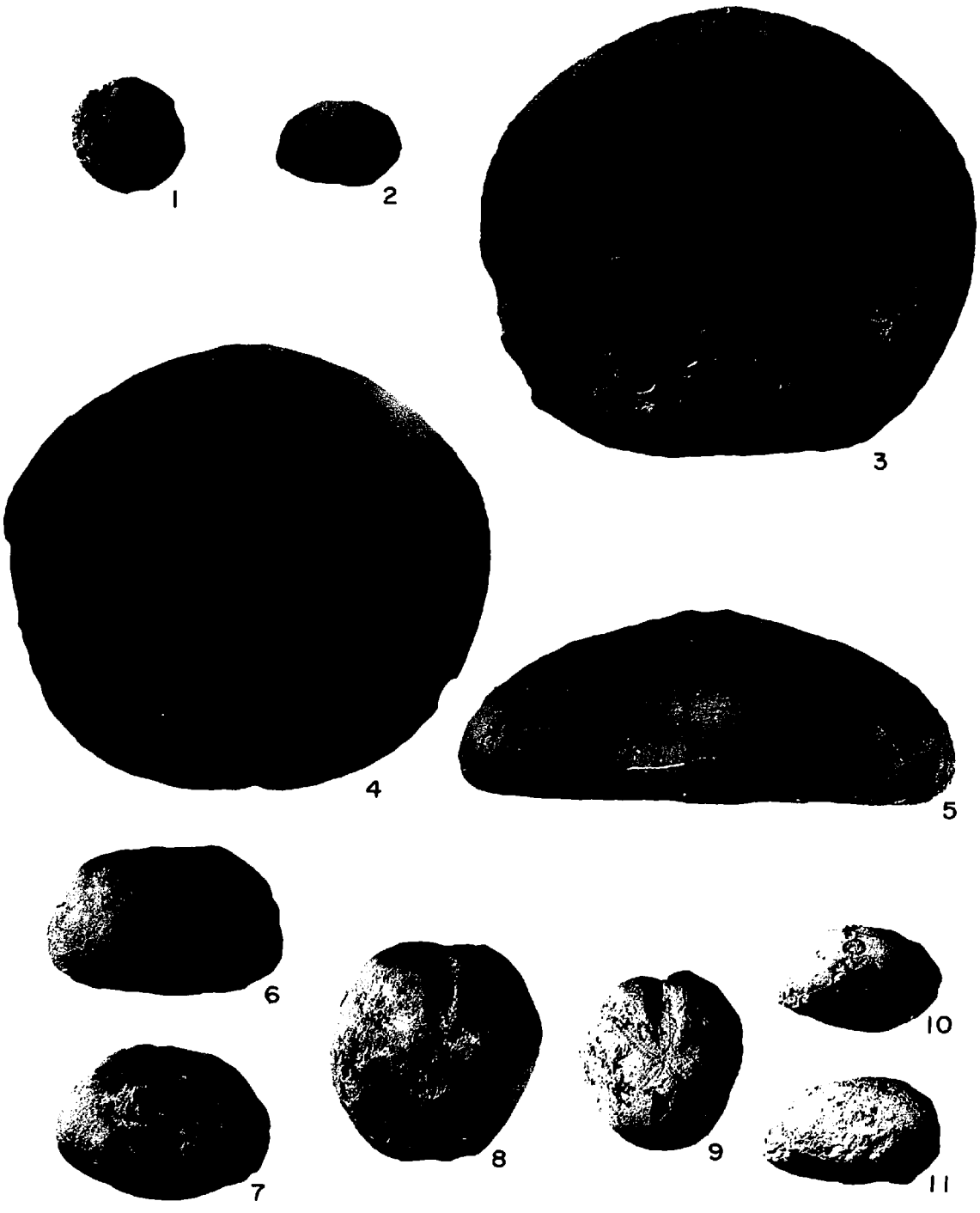
Cottaldia sp. cf. C. routula Clark 194
U.M.M.P. 32876 from the Aurora limestone, locality 18. Both views X 1½.
Fig. 1. Apical view.
Fig. 2. Lateral view.

Holectypus (Caenholectypus) castilloi Cotteau 195
U.M.M.P. 29494 from the Aurora limestone, locality 21.
Fig. 3. Ventral view with position of periproct outlined.
Fig. 4. Apical view.
Fig. 5. Anterior view.

Hemiaster calvini Clark 197
U.M.M.P 32499 from the Aurora limestone, locality 52.
Fig. 6. Lateral view.
Fig. 7. Posterior view.
Fig. 8. Apical view.

Enallaster (Washitaster) bravoensis? Böse 199
U.M.M.P. 32877 from the Aurora limestone, locality 34.
Fig. 9. Apical view.
Fig. 10. Posterior view.
Fig. 11. Lateral view.

PLATE 29



EXPLANATION OF PLATE 30

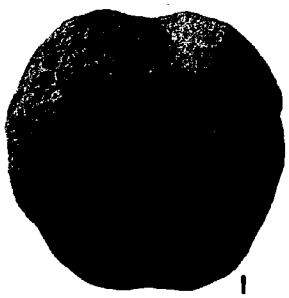
(All figures X 1)

Page

Enallaster (*Washitaster*) *bravoensis*? Böse 199
U.M.M.P. 32878 from the Aurora limestone, locality 29.
Fig. 1. Apical view.
Fig. 2. Lateral view.

Pseudananchys completa (Cragin) 200
U.M.M.P. 32879 from the Aurora limestone, locality 28.
Fig. 3. Apical view.
Fig. 4. Lateral view.

PLATE 30



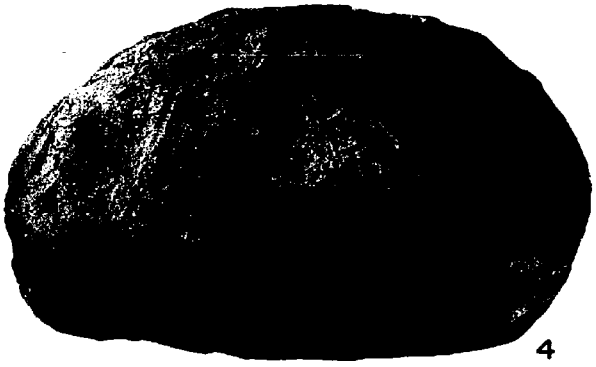
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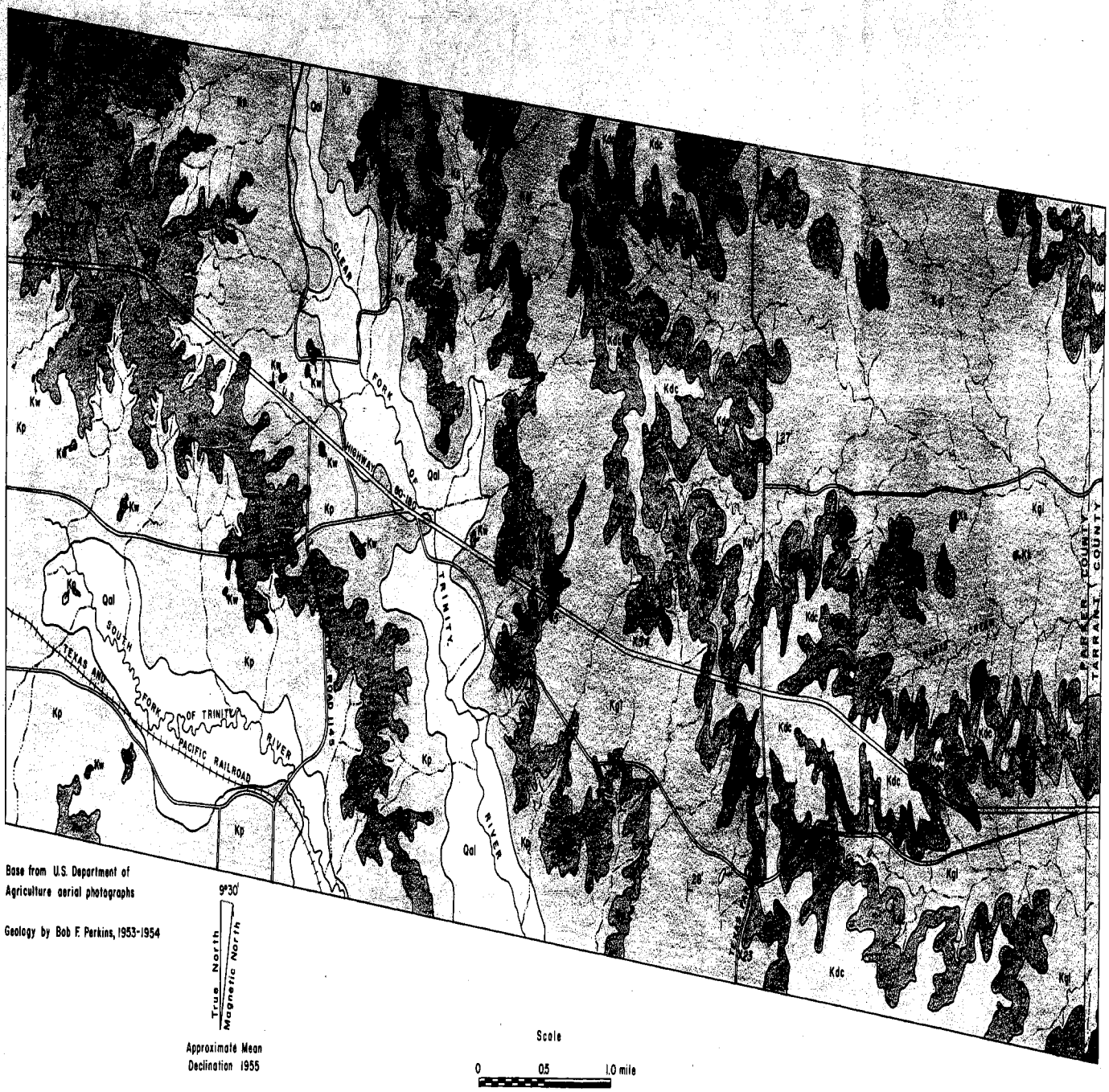
2



3



4



Base from U.S. Department of Agriculture aerial photographs

Geology by Bob F. Perkins, 1953-1954

9°30'

True North
Magnetic North

Approximate Mean Declination 1955

Scale

0 0.5 1.0 mile

EXPLANATION

SEDIMENTARY ROCKS

QUATERNARY

- Qal — Alluvium

CRETACEOUS

Washita group
- Kdc — Duck Creek formation

Fredericksburg group
- Kgl — Goodland formation
- Kw — Walnut marl

UNCONFORMITY

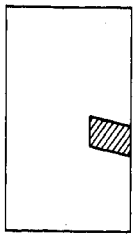
Trinity group
- Kp — Paluxy sandstone

SYMBOLS

Formation contact

27' — Strike and dip of beds (Dip expressed in minutes)

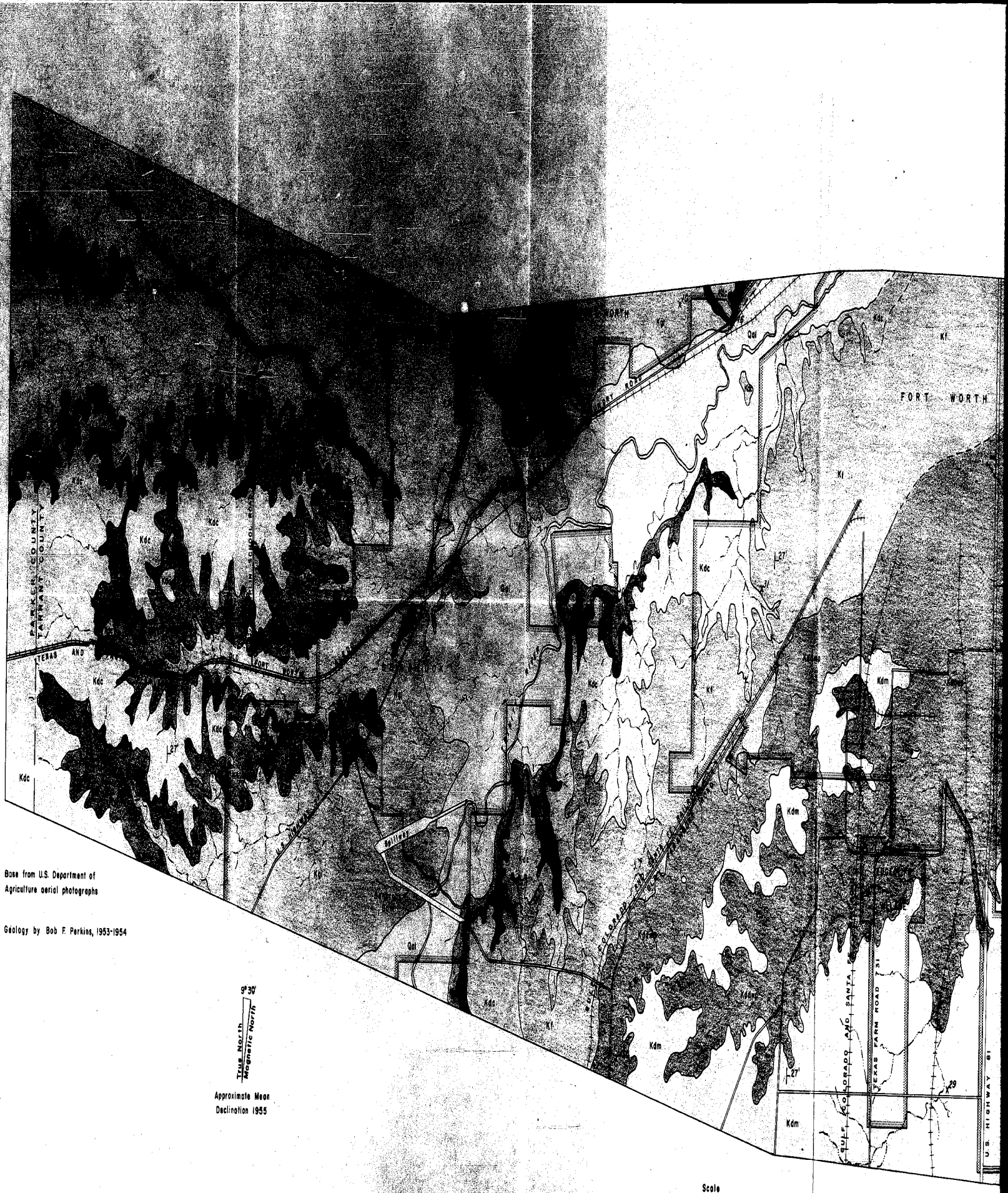
X55 — Fossil locality



Index map of Parker County showing area mapped.

GEOLOGIC MAP OF MIDDLE EASTERN PARKER COUNTY, TEXAS

ALONG U.S. HIGHWAY 80-180



Base from U.S. Department of Agriculture aerial photographs

Geology by Bob F. Perkins, 1953-1954

Approximate Mean Declination 1955

GEOLOGIC MAP OF A PORTION OF SOUTHWESTERN TARRANT COUNTY, TEXAS



EXPLANATION

SEDIMENTARY ROCKS

- Qal — Alluvium
- Woodbine formation — Gulf series — QUATERNARY

UNCONFORMITY

- Grayson marl member — Washita group — Denison formation — Comanche series — CRETACEOUS
- Kdm — Main Street limestone member — Washita group — Denison formation — Comanche series — CRETACEOUS
- Denton marl, Weno marly limestone and Pawpaw shale members — Washita group — Denison formation — Comanche series — CRETACEOUS
- Fort Worth limestone — Washita group — Comanche series — CRETACEOUS
- Kdc — Duck Creek formation — Washita group — Comanche series — CRETACEOUS
- Kiamichi formation — Fredericksburg group — Comanche series — CRETACEOUS
- Kgl — Goodland formation — Fredericksburg group — Comanche series — CRETACEOUS
- Walnut marl — Fredericksburg group — Comanche series — CRETACEOUS

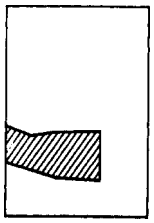
SYMBOLS

Formation contact (Dashed where approximately located)

X27' — Strike and dip of beds (Dip expressed in minutes)

X23 — Fossil locality

City and town limits

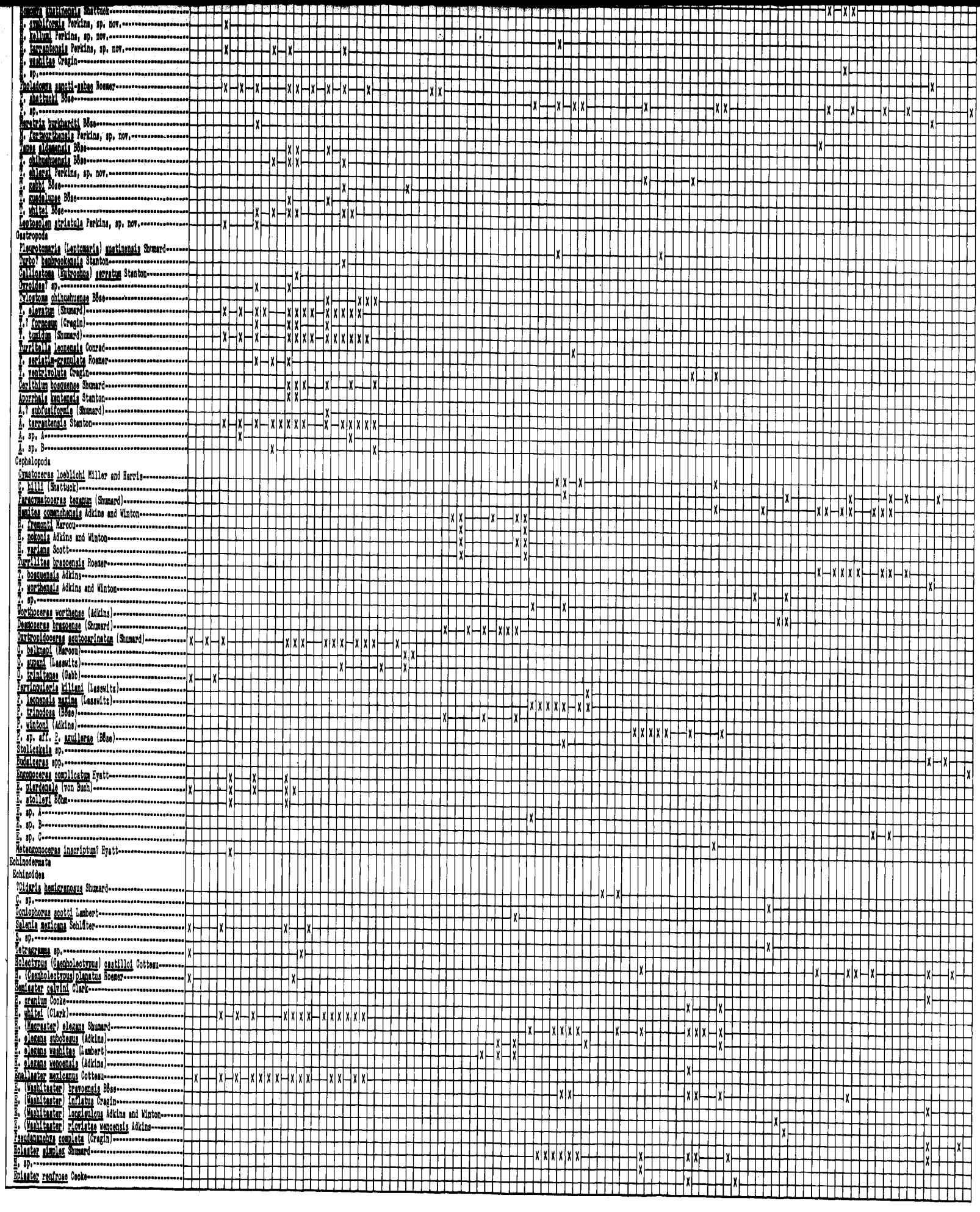


Index map of Tarrant County showing area mapped.

RRANT COUNTY, TEXAS

Distribution and Range of Invertebrate Fossils in the Comanche (Cretaceous) Fredericksburg and Washita Groups of the Fort Worth-Weatherford Area, Texas

| SPECIES \ LOCALITY (ft.) | Fredericksburg Group | | |





EXPLANATION

SEDIMENTARY ROCKS

- Qal — Alluvium (QUATERNARY)
- Indidura formation (CRETACEOUS)
- Aurora limestone
  - Kau — Upper member
  - Middle member

IGNEOUS ROCKS

- Tv — Volcanics (TERTIARY)

SYMBOLS

- Formation contact
- Fault
- Anticline (Showing trace of axial plane. Approximately located)
- Track or trail
- x33 — Fossil locality

Geology by Lewis B. Kellum, 1952 and 1953

Assisstants: Cecil C. Kersting, Robert M. Linsley and Bob F. Perkins

Scale

0 — 1 — 2 mile

GEOLOGIC MAP OF THE OJO DE AGUA AREA, SIERRA DE TLAHUALILO, COAHUILA, MEXICO

Distribution and Range of Invertebrate Fossils in the Aurora Limestone, Sierra de Tlahualilo, Coahuila, Mexico

| SPECIES \ FAUNAL ZONE → / LOCALITY ↘ | Zone of Gryphaea mucronata Gabb | | |