BAYLOR GEOLOGICAL STUDIES

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Bulletin No. 49

Dinosaur Track-bearing Strata of the Lampasas Cut Plain and Edwards Plateau, Texas

J. MICHAEL HAWTHORNE

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

Frank Carney, Ph.D.
Professor of Geology
Baylor University
1929-1934

Objectives of Geological Training at Baylor

The training of a geologist in a university covers but a few years; his education continues throughout his active life. The purposes of training geologists at Baylor University are to provide a sound basis of understanding and to foster a truly geological point of view, both of which are essential for continued professional growth. The staff considers geology to be unique among sciences since it is primarily a field science. All geologic research including that done in laboratories must be firmly supported by field observations. The student is encouraged to develop an inquiring objective attitude and to examine critically all geological concepts and principles. The development of a mature and professional attitude toward geology and geological research is a principal concern of the department.

Cover: Davenport Ranch site.

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Dinosaur Track-bearing Strata of the Lampasas Cut Plain and Edwards Plateau, Texas

J. Michael Hawthorne

ABSTRACT

Abundant dinosaur tracks occur in the Trinity and Fredericksburg Groups of the Lower Cretaceous Comanchean Series in Texas. The Glen Rose Formation of the Trinity Group contains tracks in the lower Glen Rose, Thorp Springs, and upper Glen Rose members in the Lampasas Cut Plain and the lower and upper Glen Rose members in the Edwards Plateau physiographic province. In the Fredericksburg Group tracks occur in the Paluxy and Edwards Formations. The Paluxy Sand is confined to the Lampasas Cut Plain, and tracks have been encountered in sediments assigned to the Georges Creek and Eagle Mountain Members. The Edwards Formation tracks occur in the Fort Terrett Member on the Edwards Plateau.

Lower Glen Rose deposition took place on a carbonate ramp in shallow subtidal to supratidal environments, and dinosaur tracks were preserved in shallow subtidal to intertidal conditions. A carbonate shelf system developed during upper Glen Rose deposition. Complex facies patterns formed in the supratidal, shallow lagoonal to intertidal and subtidal environments in which tracks were preserved. The regression terminating Glen Rose deposition allowed progradation of the Paluxy Sand and preservation of dinosaur tracks in continental braided stream and marginal marine tidal flat deposits. During Edwards time tracks were preserved in tidal flat sediments of the Fort Terrett Member in the Edwards Plateau. In marginal marine settings, abundant, well-preserved dinosaur tracks with deeply impressed traces appear to be good indicators of intertidal to supratidal deposition.

INTRODUCTION*

PURPOSE

Dinosaur tracks occur in Lower Cretaceous strata throughout the Lampasas Cut Plain and Edwards Plateau physiographic provinces of Texas. While their presence has been recognized for more than 70 years, even now relatively few people are aware of their existence, and still fewer realize the great number of tracks. Even less information is known about the specific stratigraphy and depositional history of the beds in which the tracks occur, and these data are critical to understanding dinosaur ecology. No comprehensive regional study dealing with these impressive trace fossils or the conditions of their formation and preservation has been undertaken, though descriptions of isolated sites or localized regions have appeared from time to time. Therefore, this study describes the stratigraphy and interprets the depositional environments of the Texas track-bearing beds on a regional basis, both to help define conditions at the times of track formation, and to add to an understanding of dinosaur ecology.

The major objectives of this study are: 1) to list, locate, and map track sites in the Lampasas Cut Plain and Edwards Plateau physiographic province; 2) to determine the stratigraphic position of individual track beds and describe the lithologic sequence in which the track beds occur; 3) to correlate track-bearing strata locally and regionally; and 4) to interpret the depositional environments of the track-bearing strata and the environmental significance of the tracks.

*A thesis submitted in partial fulfillment of the requirements for the M.S. degree in Geology, Baylor University, 1987.

LOCATION

The area of study is confined to the Edwards Plateau and Lampasas Cut Plain physiographic provinces of Texas. It includes Bandera, Blanco, Bosque, Burnet, Comal, Coryell, Erath, Gillespie, Hamilton, Hays, Hood, Kendall, Kerr, Kimble, Lampasas, Medina, Somervell, Travis, and Williamson Counties. The two physiographic provinces in the study area are separated by the Llano Uplift (Fig. 1). All of the tracks occur on the Central Texas Platform structural province (Rose,

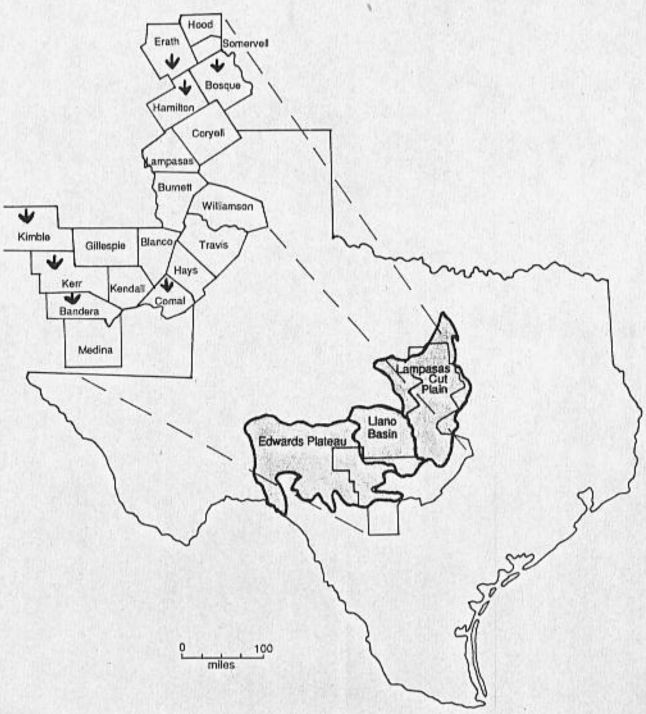


Fig. 1. Physiographic and index map of the study area. The Lampasas Cut Plain is actually the northern extension of the Edwards Plateau; however, north-south facies changes in the relevant geologic units create differing physiographies in the two regions. Note the presence of the Llano area between the Lampasas Cut Plain and the Edwards Plateau. The entire study area is shown in the expanded area, and those counties that contain tracks are indicated by a small tridactyl track.

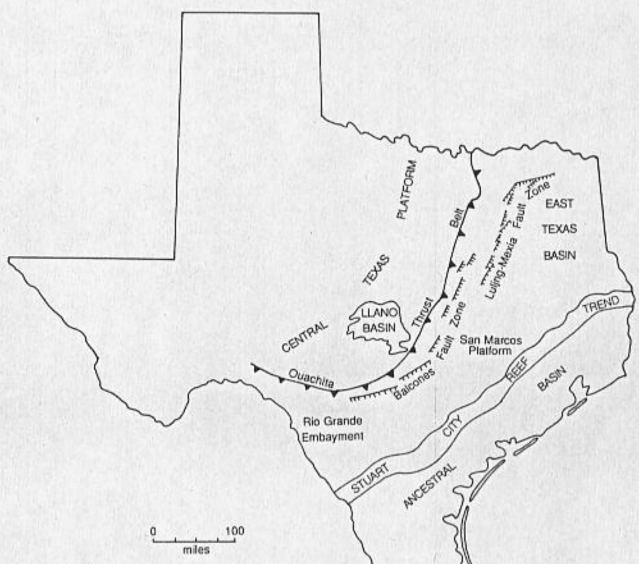


Fig. 2. Structural elements that affected Lower Cretaceous deposition in Texas (after Corwin, 1982).

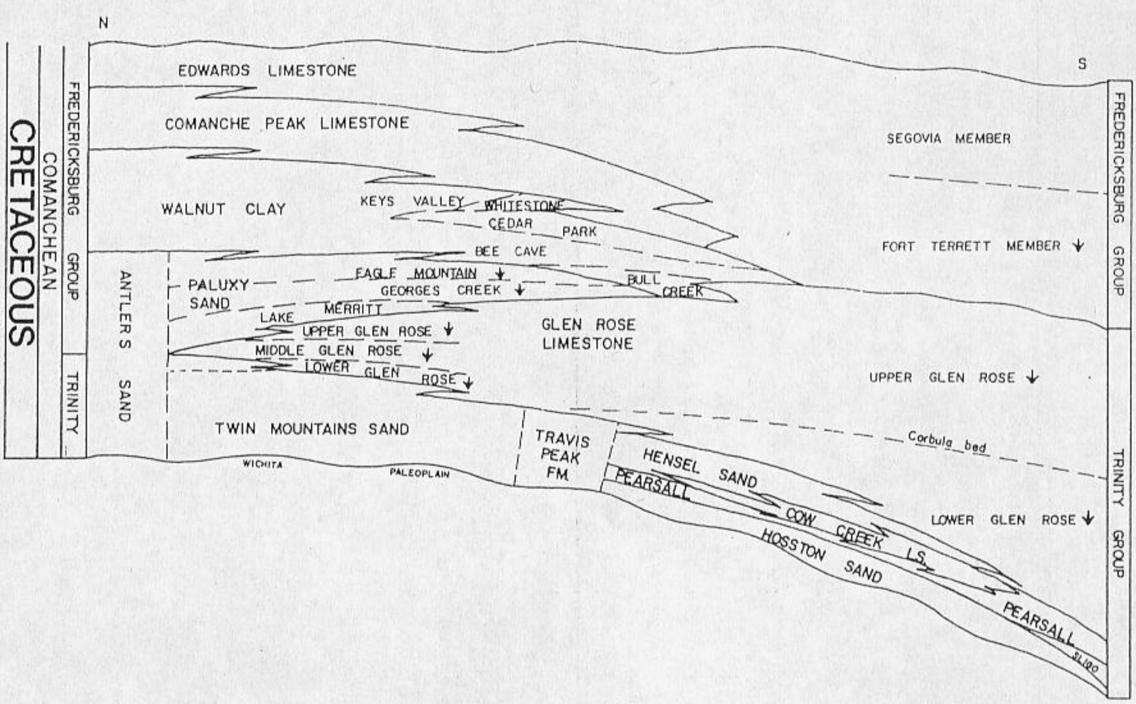


Fig. 3. North-south diagrammatic cross section showing stratigraphic relationships. This illustrates the regional relationships of Lower Cretaceous deposits in the study area. Note complex stratigraphic variations, which were products of facies changes resulting from local depositional

1971), which is bounded on the east and south by the Balcones Fault Zone (Fig. 2).

The stratigraphic units that contain tracks include the Glen Rose Limestone of the Trinity Group, and the Paluxy Sand and Edwards Limestone of the Fredericksburg Group. Important differences in the stratigraphy of the two provinces are the result of facies changes from north to south in the Comanchean (Lower Cretaceous) strata of Texas (Fig. 3).

METHODS

A comprehensive review of previous literature dealing with the Trinity and Fredericksburg Groups, dinosaurs and their tracks, Lower Cretaceous paleontology, and marginal marine depositional systems was undertaken to provide a broad background of supportive material for this study and is included as Appendix I. Following initial library research, field investigations of track sites consisted of mapping each site and measuring the stratigraphic section in detail. Additionally, due to the continuity of outcrops in the Paluxy River basin of Somervell County, track-bearing beds were continuously correlated along the stream valley.

Laboratory work consisted of determination of lithology, faunal content, carbonate composition, and calcite/dolomite ratios.

Regional and local cross sections based on field and laboratory work were constructed to illustrate stratigraphic relationships of track sites. Finally, analysis of measured sections, cross sections, and dinosaur paleoecology provided information on the depositional environments of the track-bearing beds.

ACKNOWLEDGMENTS

Numerous individuals contributed much toward the completion of this work. Thanks are due to R. M. Bonem, who provided guidance and assistance throughout all phases of the work and critically reviewed the manuscript. R. C. Grayson, Jr. assisted with the laboratory analysis of samples and kindly reviewed the manuscript. J. O. Farlow contributed a large amount of data and advice, and provided a critical review of the manuscript from the viewpoint of a vertebrate paleontologist. Ken Wilkins's and Viola Shivers's reviews of the final manuscript were greatly appreciated. O. T. Hayward contributed guidelines and advice during fieldwork and reviewed the manuscript. I extend appreciation to the following landowners who allowed access to track sites on their land and provided generous assistance: the Texas Parks and Wildlife Department, Emmet McFall, the Lancaster family, H. D. Head, W. J. Schmidt, David Akers and family, C. L. Hall, the Charlie Isings, Claybourne Davenport, C. E. Nichols, Ken Thayer, LaVerne Moore and Elaine Hurt (and Doris Tischler who helped contact them), Edith Hicks, and Mr. Dow (and Phillip Murray for help in contacting him). Other people who provided assistance include Joe Hawthorne and James H. Holland, Jr.

Thanks are extend to my wife Kay for her help with field work and most other facets of this research.

TEXAS DINOSAURS AND TRACK TYPES

The dinosaurs were one of the most successful groups of vertebrates ever to have evolved, dominating the terrestrial landscape for nearly 150 million years, from the Triassic to the Cretaceous Periods of the Mesozoic Era. The focus of this study is on those dinosaurs living in middle North America along the shoreline of an Early Cretaceous epeiric sea. Our knowledge of these creatures comes not only from fossilized bones and teeth, which have been found in Kansas, Oklahoma, and Texas (Gould, 1929; Langston, 1974; Thurmond, 1974; Gallup, 1975; Perkins and Langston, 1979), but also from footprints of several of these dinosaurs, which have been preserved in Mesozoic strata (Farlow, 1987; Farlow, Pittman, and Hawthorne, 1989). The dinosaur tracks relevant to this study can be divided into two groups on the basis of their appearance—tridactyl prints and sauropod prints. The tridactyl prints can be further subdivided into herbivore and carnivore tracks.

Farlow (1987) describes the tridactyl dinosaur tracks from Texas as forming a continuous spectrum, with herbivore tracks at one end and carnivore tracks at the other (Fig. 4). Herbivore tridactyl tracks are characterized by three wide toes with short claws and a well-defined heel. The toes tend to point straight or turn inward, and the heel is deep, wide and well rounded. All of these tracks are deeply impressed to a uniform depth throughout the track, suggesting a relatively slow, herbivorous, track-maker (Langston, 1974; Perkins and Langston, 1979; Farlow, 1987).

Carnivore tridactyl tracks, on the other end of the spectrum, are characterized by long, slender toes that tend to splay outwards and bear long claws. The heel is slender and tends to be impressed less deeply than the toes, indicating that this creature placed most of its weight on its toes. This suggests a relatively fast-moving, actively hunting carnivore (Langston, 1974; Perkins and Langston, 1979; Farlow, 1987).

The tracks of tridactyl dinosaurs (herbivores and carnivores) usually exhibit a morphology consistent with the above-described spectrum. However, two unusual track types, probably of tridactyl dinosaurs, have been described in Texas. The first is referred to as a collapsed mud track (Fig. 4). These tracks are small, generally lack a distinct heel, often possess thin furrows at the heel and toes, and usually exhibit an overhang as if the creature had stepped into an extremely soft substrate, and, as the foot was withdrawn, the substrate collapsed in on the track (Perkins and Langston, 1979). The second type of track is a single digit track which consists of an oblong depression, often with a claw mark at one end (Fig. 4). Kuban (1989a) interprets these to be tridactyl dinosaur tracks in which the majority of the creature's weight was borne on the middle toe.

Sauropod tracks include forefoot (manus) and hindfoot (pes) prints (Fig. 5). Forefoot prints exhibit two types of expression: U-shaped and crescent-shaped. U-shaped tracks represent unaltered prints. More commonly, forefoot prints occur as crescent-shaped tracks. This shape may be the result of deformation of the typically U-shaped forefoot print by the hindfoot, which was placed directly behind the forefoot in the dinosaur's stride sequence. Hindfoot tracks are subcircular and may be up to several feet long. They often show stubby claw marks.

Dinosaur remains that have been found in Texas Lower Cretaceous deposits include "a big allosaurid (Acrocanthosaurus), the sauropod Pleurocoelus, hypsilophodonts (including Tenontosaurus), and probably an iguanodontid" (Farlow, 1987). It seems reasonable that the carnivore tridactyl tracks were made by Acrocanthosaurus, the herbivore tridactyl tracks were made by either Iguanodon or Tenontosaurus, and the sauropod prints represent Pleurocoelus (Langston, 1974; Perkins and Langston, 1979; Farlow, 1987). Illustrations of these dinosaurs or similar creatures are shown in Figure 6.

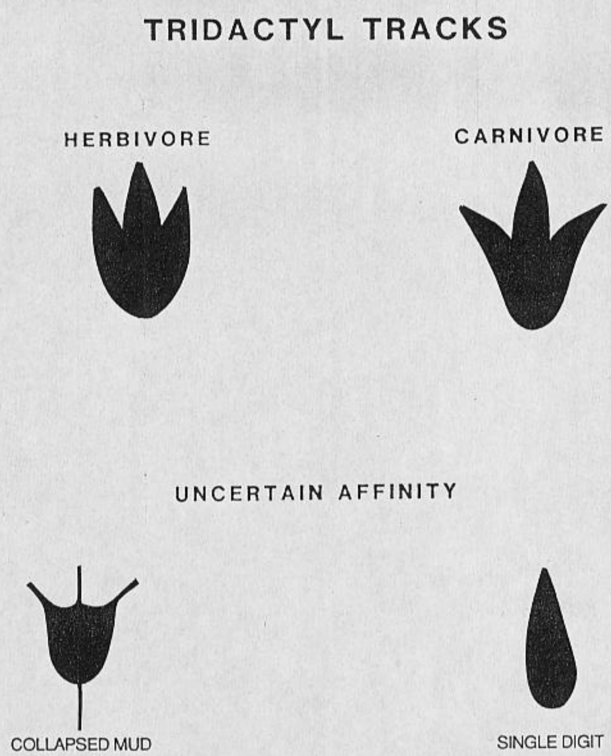


Fig. 4. Tridactyl tracks. The ends of the normal tridactyl track spectrum—herbivore and carnivore—are shown at the top of this diagram. Unusual tracks currently attributed to tridactyl dinosaurs are shown at the bottom.

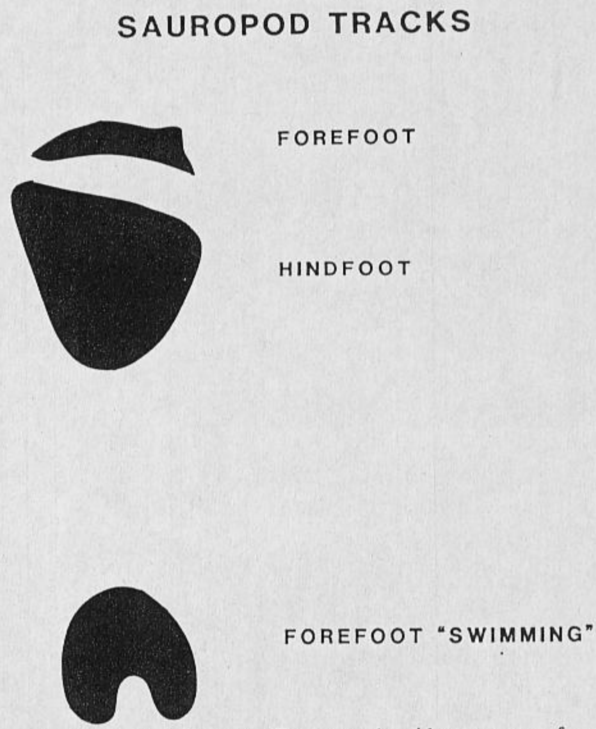


Fig. 5. Sauropod tracks. The normal stride sequence of sauropod tracks (top) results in large hindfoot prints immediately behind deformed, crescent-shaped forefoot prints. Undeformed forefoot prints (bottom) occurring without hindfoot prints have been interpreted as those of a "swimming" sauropod (Bird, 1944).

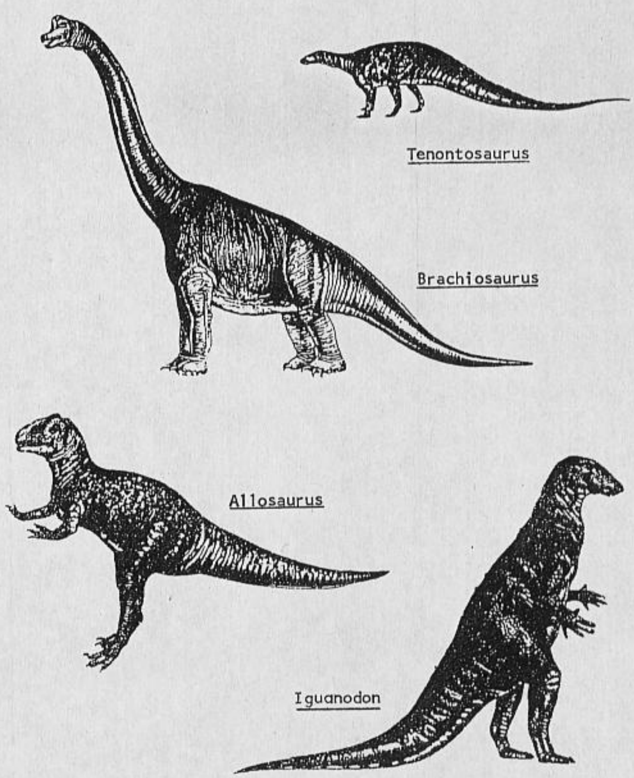


Fig. 6. Central Texas dinosaurs. The dinosaur that probably made the sauropod tracks in Texas—Pleurocoelus—was similar to, though smaller than, the Brachiosaurus shown above. Probable tridactyl trackmakers include Tenontosaurus, Iguanodont, and the carnivore Acrocanthosaurus, which was similar to the Allosaurus shown above (Halstead and Halstead, 1981).

TEXAS DINOSAUR TRACK SITES

The following site information includes locations, descriptions, and maps, where possible. Detailed measured sections are provided in Appendix II. Several of the descriptions were taken from previous literature and are noted as such. However, most of the descriptions reflect data collected in the field.

GLEN ROSE LIMESTONE

Lampasas Cut Plain

Paluxy River Basin

Dinosaur tracks from the lower Glen Rose Limestone are found in the Paluxy River bed immediately west of the town of Glen Rose, Somervell County, Texas. This area includes the well-known track exposures in Dinosaur Valley State Park, as well as numerous sites outside the park boundaries (Fig. 7). The following section describes the track sites in this area.

The River Crossing site, Locality (Loc.) 1, occurs just downstream from the point at which the surface of State Road 205 is formed by an outcropping, extremely resistant, limestone ledge. Tracks are found on both sides of the river where the resistant limestone bed has been removed, exposing abundant, shallow, poorly preserved tridactyl tracks. Because of their overall poor preservation these tracks were not mapped.

The McFall site (Loc. 2) is located a few hundred yards downstream from the River Crossing site. Most of the tracks occur in the same layer as locality 1, but one trackway is in the upper, resistant limestone bed (Fig. 8). In general, the tridactyl tracks in the lower layer are relatively shallow and poorly preserved, while the upper layer contains well-preserved, relatively deep tridactyl tracks.

The Taylor site (Loc. 3) occurs several hundred yards downstream from the McFall site and exhibits both single digit and tridactyl tracks (Fig. 9). These tracks are generally water and silt covered, but they are fairly well preserved, and some morphologic features can be discerned. In particular, claw marks are clearly visible on the single digit tracks.

The B.S. 6 site (Loc. 4) occurs within the boundaries of Dinosaur Valley State Park, in the Paluxy river where a limestone bed has broken away creating a small "ledge." The tracks are near the edge of this limestone ledge and they consist of a few tridactyl tracks and one possible sauropod track (Fig. 10). A partial track at the edge of the ledge suggests more tracks were once present but have been destroyed by erosion.

The Collapsed Tracks site (Loc. 5) exhibits only a few tracks. They occur in the upper remnant of the limestone riverbed near the bank. Both normal and

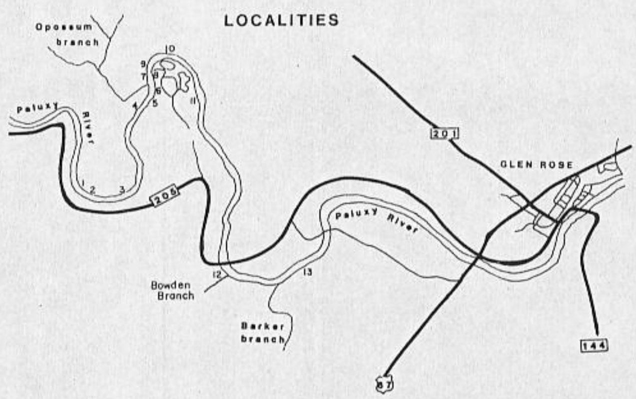


Fig. 7. Paluxy Basin track sites. Sites shown are those that occur along or in the Paluxy River west of the town of Glen Rose, Somervell County, Texas. Numbered sites extend from the River Crossing site (1) downstream to the Halbert (Lancaster Ranch) site (13).

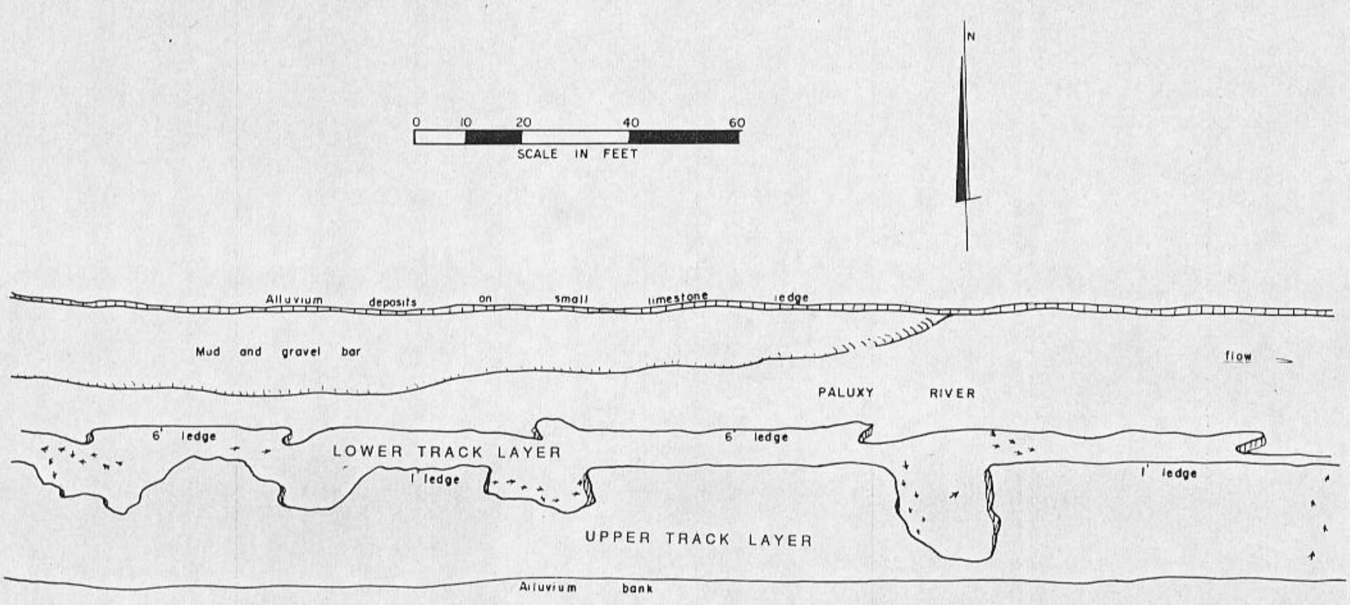


Fig. 8. McFall site sketch map. Tracks occur in two beds on the south bank of the river. The upper bed is the resistant marker horizon, and it is the highest stratigraphic track bed in the Paluxy River bed.

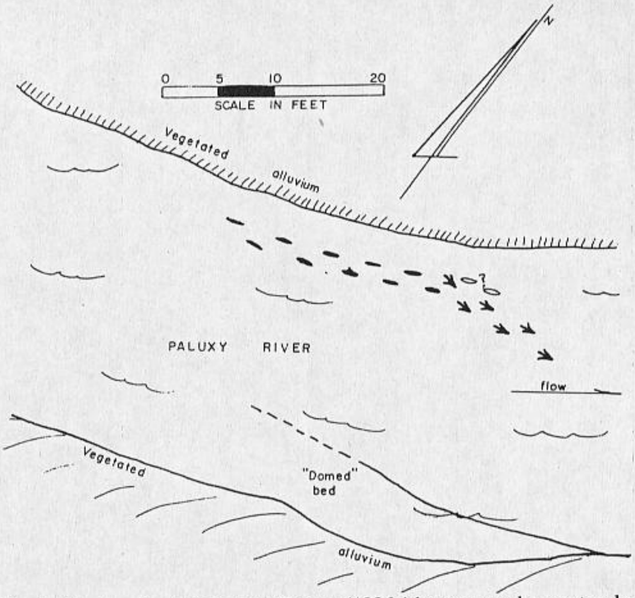


Fig. 9. Taylor site sketch map. Kuban (1986c) has mapped more tracks at this site in his work demonstrating the dinosaurian nature of these single digit tracks. The "domed" bed on the south bank of the river is a good example of the structural warping of beds common in this area.

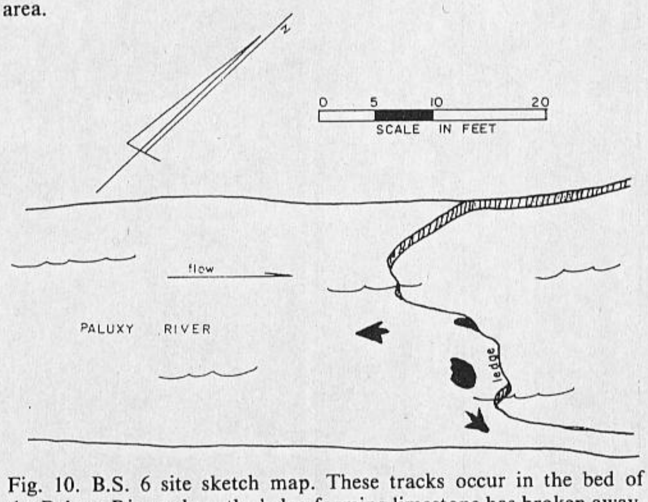


Fig. 10. B.S. 6 site sketch map. These tracks occur in the bed of the Paluxy River where the ledge-forming limestone has broken away. Probably more tracks were present here in the past, as indicated by the partial track at the edge.

"collapsed mud" tridactyl tracks are found at this site (Fig. 11).

The Blue Hole site (Loc. 6) occurs at a major point bar/cut bank along the Paluxy River where river erosion has produced a pool reported to be 30 to 35 feet deep.

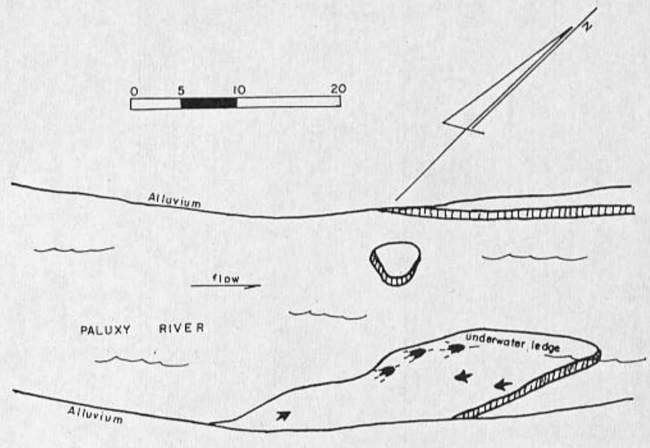


Fig. 11. Collapsed Tracks site sketch map. The tracks at this site are of both normal tridactyl and "collapsed" tridactyl tracks. They occur in a small limestone lens along the south bank in the riverbed.

The cut bank is a large cliff providing an excellent exposure of the type area Lower Glen Rose and Thorp Springs Members. Slump blocks of Thorp Springs Limestone line the cut bank side of the river, and the dinosaur tracks are exposed around these slump blocks in a remnant of the main track layer. With the exception of one sauropod track, all of the tracks at this site are tridactyl.

In the late 1930s and early 1940s Roland T. Bird of the American Museum of Natural History in New York published four articles reporting his findings of dinosaur tracks in the Paluxy River bed (Bird, 1939, 1941, 1944, 1954). Bird's main site (Loc. 7) was located within the confines of what is now Dinosaur Valley State Park (the park did not exist during Bird's work). He chose this site because it contained a number of excellent sauropod trails with some tridactyl tracks. Part of these tracks form a famous carnivore/sauropod chase scene and were excavated for exhibitions at the American Museum of Natural History and the Memorial Museum at the University of Texas (Figs. 12, 13, 14).

In the summer of 1983, during a drought and consequent low water stand, Dr. James O. Farlow mapped three sauropod trails (Loc. 8) (Fig. 15), as well as numerous other sauropod and tridactyl tracks in varying states of preservation. These tracks had been previously mapped by Fields (1980). Some tracks occur in the middle of the riverbed, but the sauropod trails are found near the eastern bank. The three sauropod

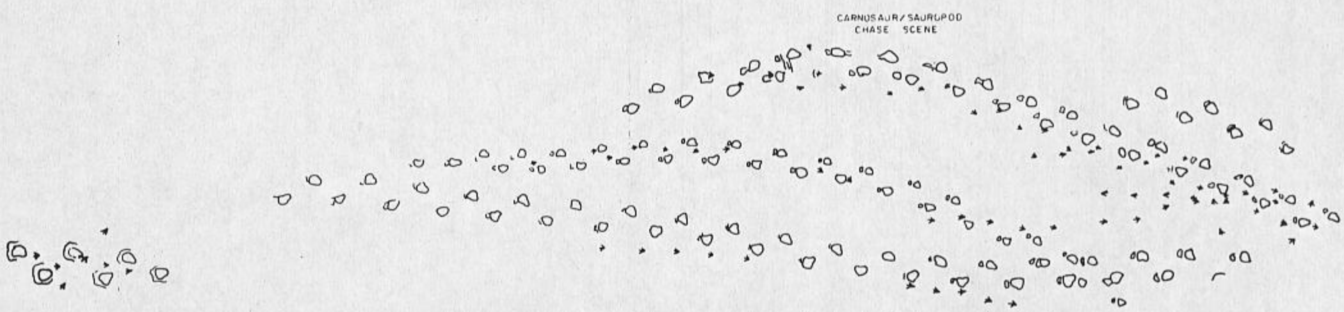


Fig. 12. Bird's site map (after R. T. Bird). This map includes the well-known carnosaur/sauropod chase scene tracks.

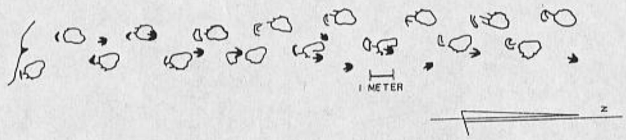


Fig. 13. Carnivore/sauropod chase scene tracks. This detail of the carnivore/sauropod chase scene tracks shows the tracks that were removed by Bird and sent to the Texas Memorial Museum and the American Museum of Natural History.

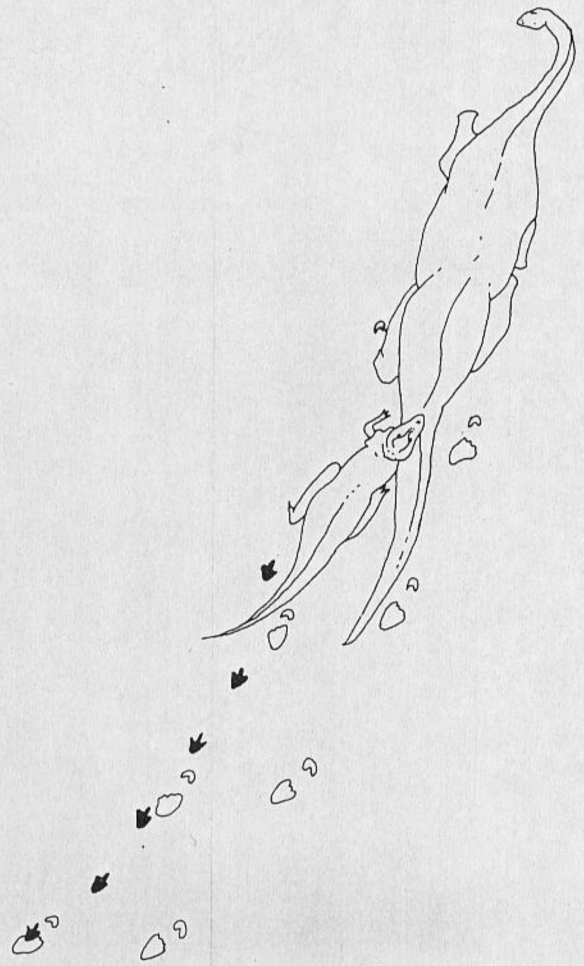


Fig. 14. Carnivore/sauropod chase scene scenario. This reconstruction demonstrates the possible events that created the carnivore/sauropod chase scene tracks (Perkins and Langston, 1979)).

trails are subparallel in the same direction and may represent part of a herd. The tracks are all deep and extremely well preserved, and they clearly show the morphologic features associated with tracks of sauropod dinosaurs (Farlow, 1987).

One of the main track sites set up for display at Dinosaur Valley State Park is the Park Crossing site (Loc. 9) (Fig. 16). These tracks occur along the northwestern bank of a large meander of the Paluxy River. The tracks are reached by crossing the river on a series of stepping stones. These tracks are usually well exposed, though occasionally they are covered during

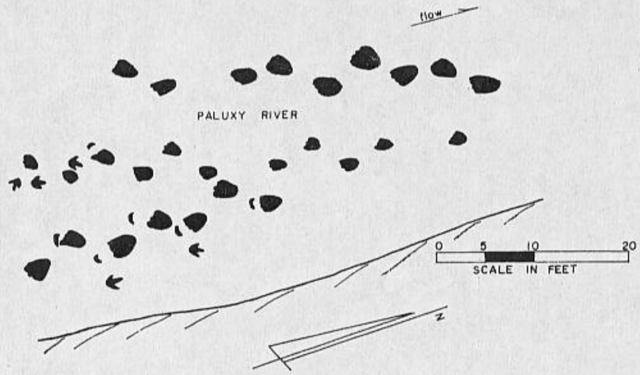


Fig. 15. Farlow's "Sauropod Section" sketch map. These three superl sauropod trails occur on the east bank of the river in the same are: from which Bird removed his carnivore/sauropod chase scene track (after Farlow, 1987).

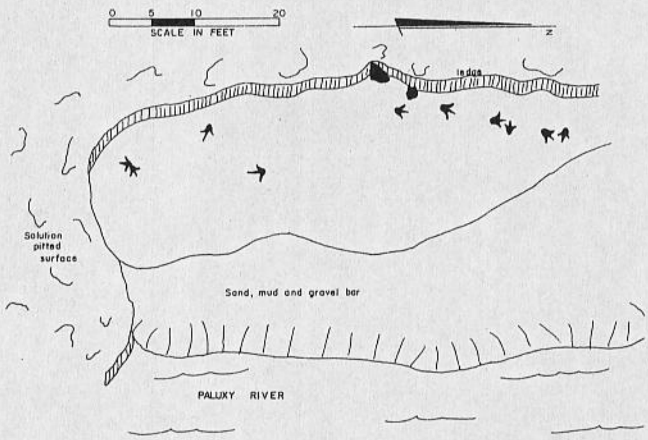


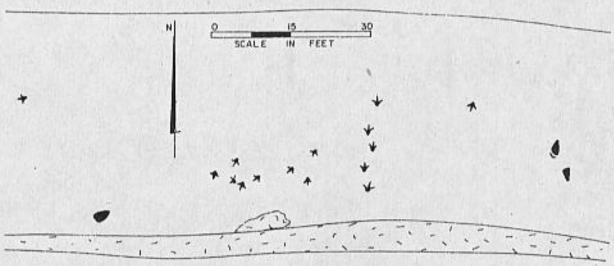
Fig. 16. Park Crossing site sketch map. This is one of two sites or display in Dinosaur Valley State Park. These tracks are rarel underwater and the park personnel keep them cleaned.

high water. They consist of a few poor sauropod track: and several good tridactyl tracks. A nearby sauropoc trail was briefly uncovered during flooding of the Paluxy

The other main display of dinosaur tracks withir Dinosaur Valley State Park is the Park Cliff site (Loc 10) (Fig. 17), occurring on the same meander but farthe downstream. The vantage point from which the track: can be observed is a cliff. At this locality the parl personnel have erected a map that depicts track type: and positions. Both tridactyl and sauropod tracks car be seen here, but the tridactyl type predominates. The best exposure is a tridactyl trackway near the middle of this locality which extends directly across the river.

The Campground site (Loc. 11) occurs near the Dinosaur Valley State Park campground. The track: are all tridactyl and are found in the riverbed. They are shallow and usually water-covered. One excellen trackway occurs near the center of the riverbed and extends upstream. Due to flooding of the river shortl after the discovery of these tracks, no map of the site was made.

The Bowden Branch site (Loc. 12) is located jus upstream from the confluence of Bowden Branch and the Paluxy River (tracks are in the Paluxy River bed).



ig. 17. Park Cliff site sketch map. This is the second of two sites n display in Dinosaur Valley State Park. These tracks can be observed ı the Paluxy River bed from an overlooking cliff.

ıll of the tracks at this site are tridactyl, and they are sually covered by water (Fig. 18). Single digit tracks ave been reported by others (Kuban, 1989a).

The Halbert (Lancaster Ranch) site (Loc. 13) contains bundant tracks but few trackways. Most of the tracks ccur in the limestone riverbed immediately upstream rom the "rapids," though some occur downstream (Fig. 9). All of the tracks at this site were made by tridactyl inosaurs. Most are deep and in fairly good condition, ut some are shallow and difficult to find.

The Comanche Peak Nuclear Power Plant site (Loc. 4) is within the reactor cavity of the facility. Because his site has been covered by construction of the reactor, he data from this site was derived from literature.)uring excavation of the reactor cavity, a series of three rackways of tridactyl tracks was exposed (Fig. 20). 'hese tracks exhibited a morphology characteristic of tridactyl carnivore tracks. Several of these tracks were removed at the time, and one was presented to the Somervell County Museum.

Isolated Sites

The North Bosque River site (Loc. 15) is the only locality for this study that occurs in the Lampasas Cut Plain outside of the Paluxy River basin. It occurs just east of the Bosque/Hamilton County border in the riverbed of the North Bosque River, up and downstream from a river bar. These tracks are all shallow and poorly preserved due to their occurrence within the confines of a nodular limestone bed. However, they occur in vast numbers. Because of their number and poor preservation, no map of the tracks was attempted.

EDWARDS PLATEAU

One famous track site is the "swimming" sauropod track site (Loc. 16) found on the Mayan Dude Ranch near Bandera (Fig. 21). This site occurs in exposed limestone on the floodplain of the Medina River (Fig. 22). These tracks have been extensively weathered. At one time a clear trackway of sauropod forefoot tracks and one partial hindfoot were visible here, apparently representing a swimming sauropod (Bird, 1944). Now the only remnants of these tracks are shallow left/right potholes, and part of the trackway appears to be covered with sand and gravel.

The Hondo Creek site (Loc. 17) is located in the bed of Hondo Creek approximately one mile south of Tarpley in Bandera County on the land of W. J. Schmidt

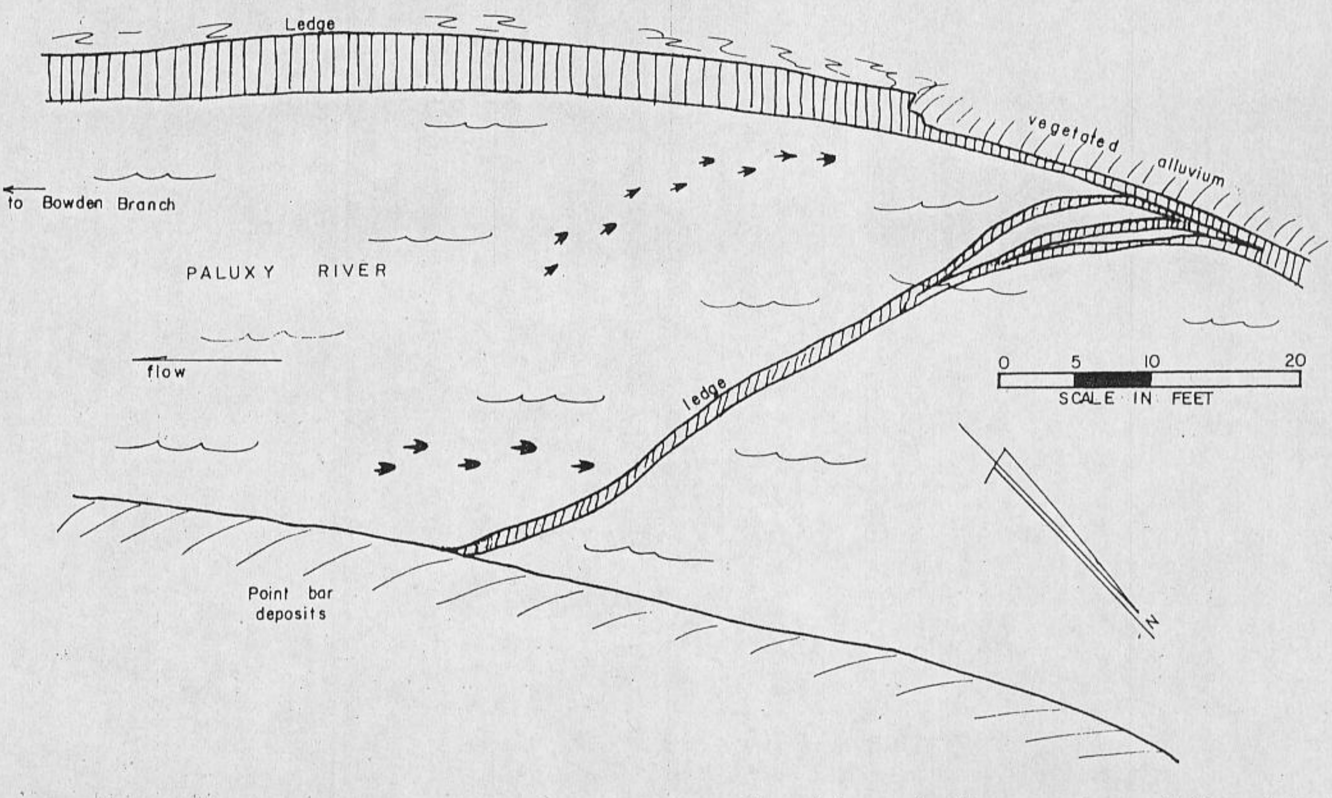


Fig. 18. Bowden Branch site sketch map. Tracks can be recognized by overall morphology and stride sequence but are highly eroded and

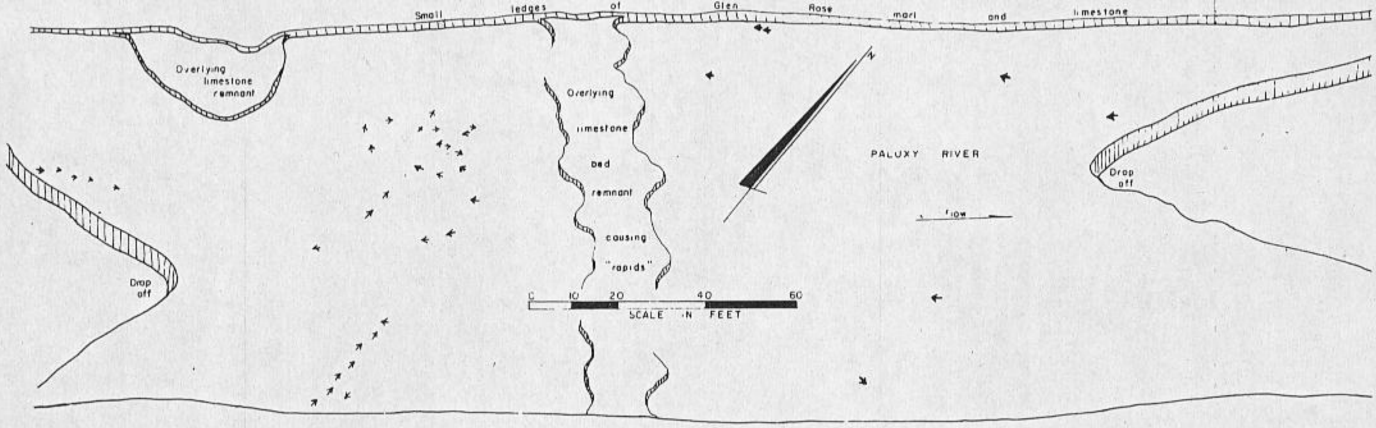


Fig. 19. Halbert's (Lancaster Ranch) site sketch map. Abundant tridactyl tracks occur at this site both upstream and downstream from a remnant limestone lens that causes a "rapids" in the riverbed.

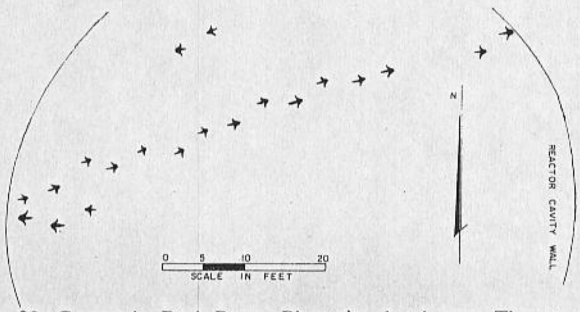


Fig. 20. Comanche Peak Power Plant site sketch map. These tracks were exposed during excavation of the reactor cavity for the power plant and are no longer available for study (map from Skinner and Blome, 1975).

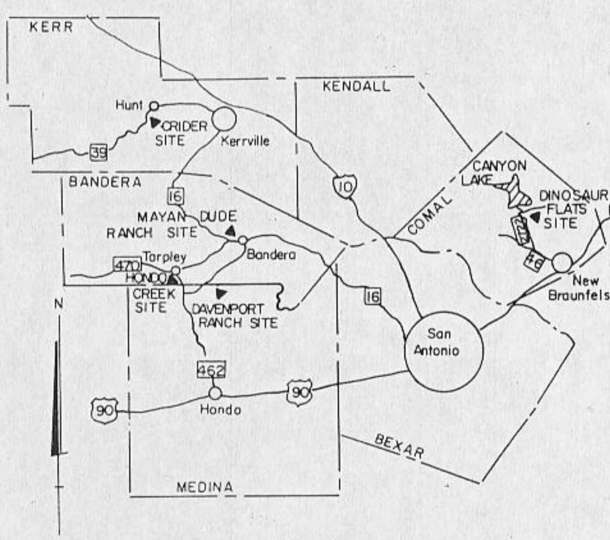


Fig. 21. Edwards Plateau Glen Rose track sites. Five sites on the Edwards Plateau are in the Glen Rose Limestone. The Crider site is in Kerr County south of Hunt on State Hwy. 39. The Dinosaur Flats site is southeast of Canyon Lake Reservoir in Comal County a few miles southwest of Sattler on FM 2673. The Mayan Dude Ranch site occurs in the town of Bandera in Bandera County. The Hondo Creek site lies in Hondo Creek about 1 mile south of Tarpley in Bandera County, and the Davenport Ranch site is in Medina County in West Verde Creek.

(Fig. 21). The tracks occur in the bed of the creek both up and downsteam from a gate and sign marking the locality. All of the numerous tracks at this site appear to be of tridactyl dinosaurs (Fig. 23). Many are elongated, distorted tracks, probably scoured by the river, while others are well-preserved tridactyl prints. Some may be collapsed tracks. Several good trackways occur at this site.

The Crider site (Loc. 18) is located in the south fork of the Guadalupe River near the town of Hunt in Kerr County, Texas (Fig. 21). The tracks occur in a limestone ledge along the west bank of the river just downstream from a small waterfall. Some possible tracks have been reported on the opposite bank in the same horizon. The track layer forms the riverbed at (and upstream from) the waterfall. All the tracks at this locality are deeply impressed and may be collapsed tracks, but the preservation of morphological features is poor.

One of the more unusual track sites in Texas is the sauropod herd track locality (Loc. 19 - the Davenport Ranch site) southwest of Bandera off FM 1077 (Fig. 21). These tracks occur in dolostones along West Verde Creek. R. T. Bird (1944) originally mapped and described this site as containing a large number of sauropod tracks representing a herd, and a smaller number of tridactyl tracks (Fig. 24). Since then many of the sauropod tracks have been covered by alluvium. However, one superb

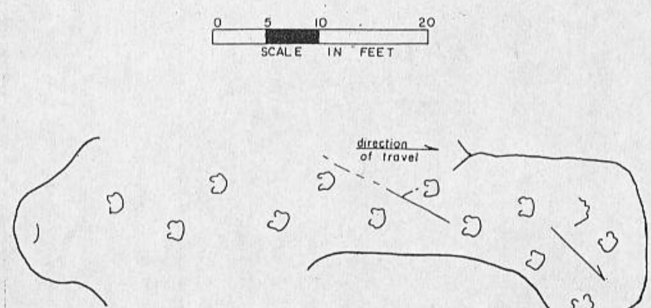


Fig. 22. Mayan Dude Ranch site track map (after Bird, 1944). This is the original appearance of the "swimming" sauropod tracks, which Bird discovered at this site. Only a stride sequence of shallow potholes can be observed at the site now.

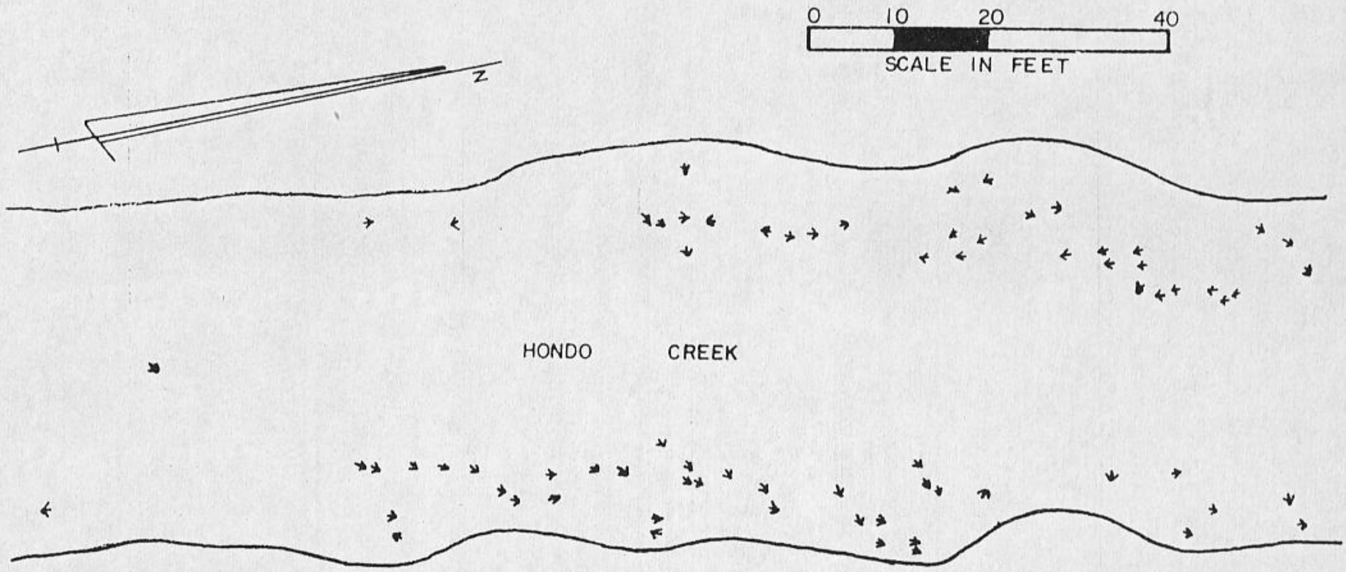


Fig. 23. Hondo Creek site sketch map. This map is based on Houston, who mapped the tracks in 1933. All tracks are of tridactyl dinosaurs.

tridactyl trail and a few other tridactyl tracks are clearly visible and extremely well preserved (Fig. 25).

One of the most prolific track sites for this study is the Dinosaur Flats site (Loc. 20) owned by Mr. and Mrs. Ken Thayer and located several miles south of Canyon Lake on FM 2673 (Fig. 21) This site was exposed during excavation, and a number of shallow tridactyl tracks were uncovered in one limestone bed. All the tracks are shallow and sometimes difficult to see. Many lengthy trackways, as well as some unusual "trails," occur together. The accompanying map (Fig. 26) shows only a portion of the total tracks, since more have been uncovered to the west.

PALUXY SAND

The Paluxy Sand is present only in the northern half of the study area. Though long recognized for its vertebrate remains, the Paluxy Sand has been recognized only recently as a track-bearing unit. Four sites for this study occur in Paluxy Sand, and several more have been reported.

The Dow site (Loc. 21) is approximately 2.5 miles south of Huckaby on FM 219 in Erath County, Texas (Fig. 27). The track site is in a gully running through fields of reddish Paluxy soils filled with abundant petrified wood. These tracks occur where headward erosion has exposed a sandstone bed for a short distance (Fig. 28). The east wall contains a caliche horizon overlain by reddish soils. All the tracks at this site are tridactyl, deeply impressed and well preserved. Unfortunately, the track layer is rather soft, so the tracks may not last long. Two intersecting trackways occur here.

The Ising site (Loc. 22) occurs in the bed of the Lampasas River in Hamilton County off FM 1047 north of Star (Fig. 27) on land belonging to Mr. and Mrs. Charlie Ising. The tracks occur in the bed on the west edge of an intermittent stream (Fig. 29). Ten tridactyl tracks occur here and form several short trackways, with a few random prints.

The Hall site (Loc. 23) occurs in Hamilton County on the lands of Mr. C. L. Hall, located just north of the town of Shive, in a draw leading down to Collard Creek (Fig. 27). The draw extends from pasture lands

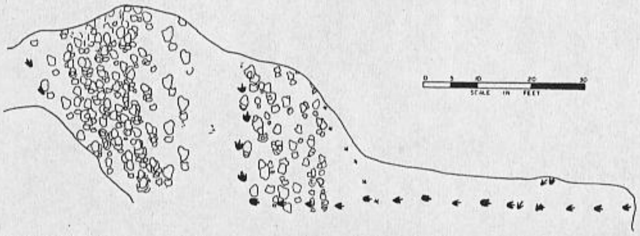


Fig. 24. Davenport Ranch site (after Bird, 1944). This is the original configuration of tracks at the site as discovered by Bird. The sauropod tracks are all oriented in the same direction and are grouped with smaller tracks in the center and larger tracks outside. These tracks may represent "herding" behavior by the sauropods.

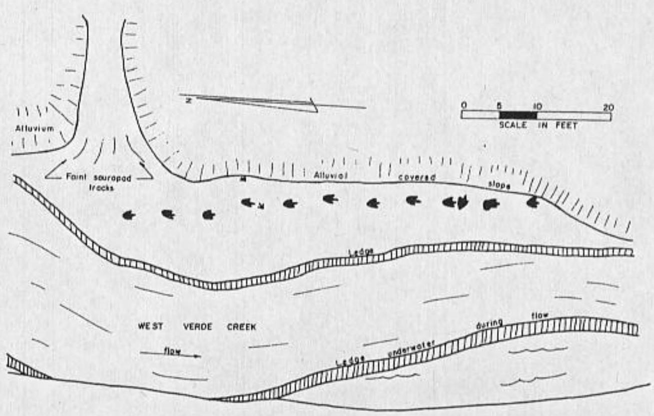


Fig. 25. Davenport Ranch site sketch map showing tracks that are still well exposed at the site. Only faint sauropod tracks are visible now, and many are apparently covered by alluvium.

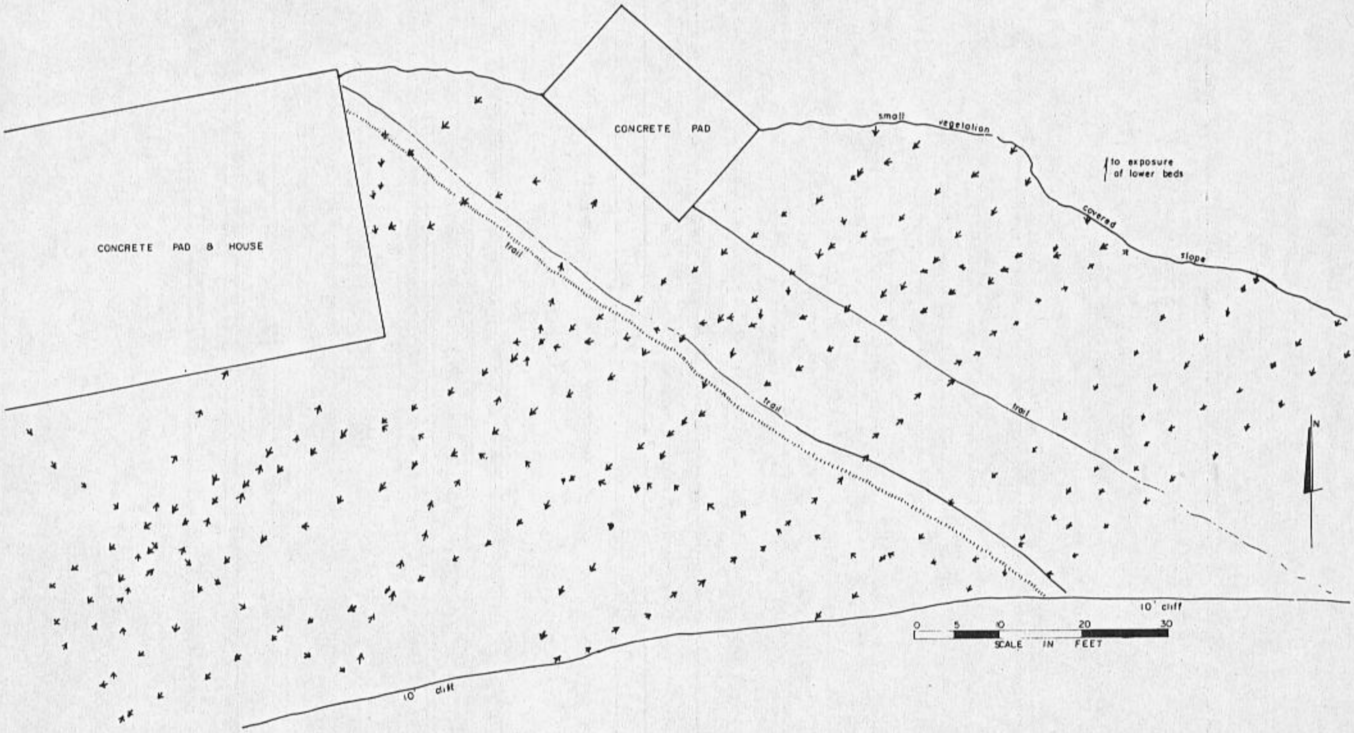


Fig. 26. Dinosaur Flats site sketch map showing most of the tracks at the Dinosaur Flats site, though more occur to the west in the same layer (Langston, unpublished map).

to a rocky, wet-weather wash. The tracks occur in a sandy layer both upstream and downstream from a large alluvial deposit. Formerly, some 54 tracks were visible at this site, but they were covered by the alluvium deposited during floodstage. The few tracks still exposed are fairly well-preserved tridactyl tracks. Some of these may be partially collapsed tracks.

The Nichols site (Loc. 24) occurs almost directly across a gravel road from the Hall site on lands of Mr. C. E. Nichols (Fig. 27). The tracks occur in the dry bed of a wet-weather wash at a point just north of a large cut bank on the east bank (Fig. 30). One good trackway and several scattered tracks, all of tridactyl dinosaurs, occur here. All these tracks are rather shallow due to erosion.

EDWARDS LIMESTONE

The only site for this study from the Edwards Limestone is the F6 Ranch site (Loc. 25) west of Junction in Kimble County, Texas (Fig. 31). This locality occurs on lands of the David Akers family in the dry bed of Copperas Creek (Fig. 32). Tridactyl tracks occur in thin, flaggy limestones, mostly on the south side of the creek. These tracks are shallow and often difficult to recognize, but generally they clearly show their distinctive tridactyl morphology. The tracks are found at various levels in the flaggy limestones (Farlow, 1981).

STRATIGRAPHIC RELATIONSHIPS OF TRACK SITES

The stratigraphic units in this study belong to the Trinity and Fredericksburg Groups of the Lower Cretaceous (Comanchean) Series.

The track-bearing formation in the Trinity Group is the Glen Rose Formation. In south-central Texas Glen Rose strata are subdivided into lower and upper Glen Rose members along a zone of *Corbula harveyi* concentration. In the type area in north-central Texas, the formation is divisible lithologically into lower Glen Rose, Thorp Springs, and upper Glen Rose members, all of which may contain tracks (Rodgers, 1965). The three members of the Glen Rose Limestone in north-central Texas may be equivalent to the upper Glen Rose member in south-central Texas (Walker, 1973; Davis, 1974).

The track-bearing units of the Fredericksburg Group are the Paluxy Sand and Edwards Limestone. Members that contain tracks include the Georges Creek and Eagle Mountain Members of the Paluxy Sand (Owen, 1979), and the Fort Terrett Member of the Edwards Formation (Rose, 1972) (Fig. 4).

The presence of the Llano Uplift and the erosional character of the varying lithologies have led to the development of two physiographic provinces in the study area: the Lampasas Cut Plain to the north and the Edwards Plateau to the south.

The Lampasas Cut Plain province is distinguished by mesas capped with flat-lying Edwards Limestone overlying gentle slopes formed by Comanche Peak Limestone and gently rolling valley floors of Walnut Clay. Typical Edwards Plateau topography consists of massive tablelands in Trinity and Fredericksburg rocks capped in places by Buda Limestone.

Because of the confusion caused by facies variations and stratigraphic nomenclatural problems, Figure 33 summarizes track sites by physiographic province and then by stratigraphic unit within each province.

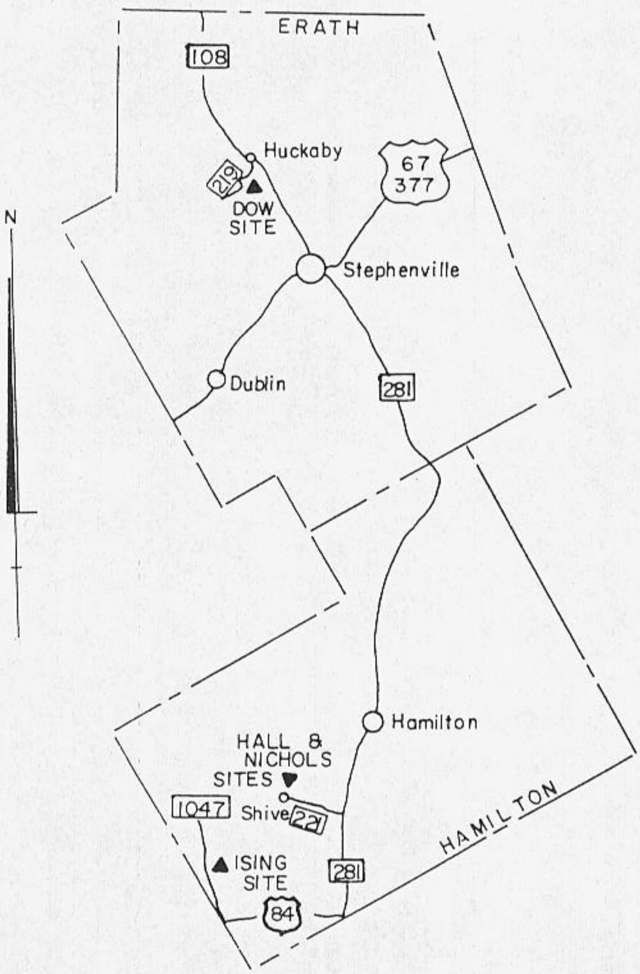


Fig. 27. Paluxy Sand track sites. Four sites for this study occur in the Paluxy Sand in Erath and Hamilton Counties. The Dow site lies in Erath County southwest of Huckaby off FM 219. The Hall and Nichols sites occur in Hamilton County just northeast of Shive. The Ising site lies approximately 5 miles north of Star off FM 1047 in

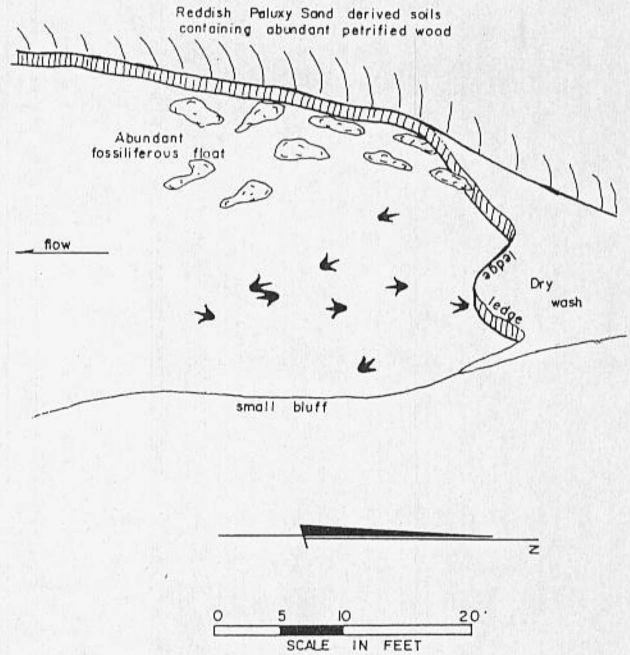


Fig. 28. Dow site sketch map. These tracks occur in a wash within a soft sand layer. Tracks are deeply impressed and well preserved, forming three good, though short, trackways.

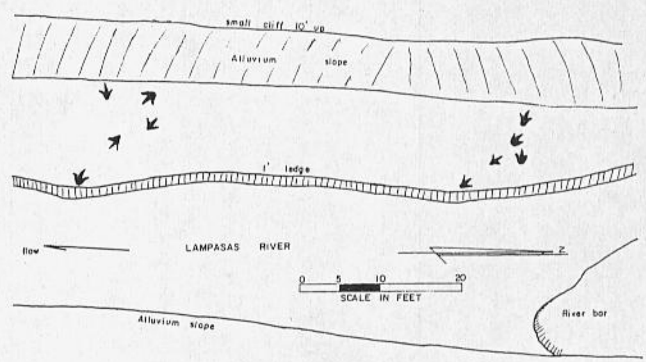


Fig. 29. Ising site sketch map. At least three short tridactyl trackways are exposed in calcareous sands on the west bank of the Lampasas River at this site. Tracks are deeply impressed and well preserved.

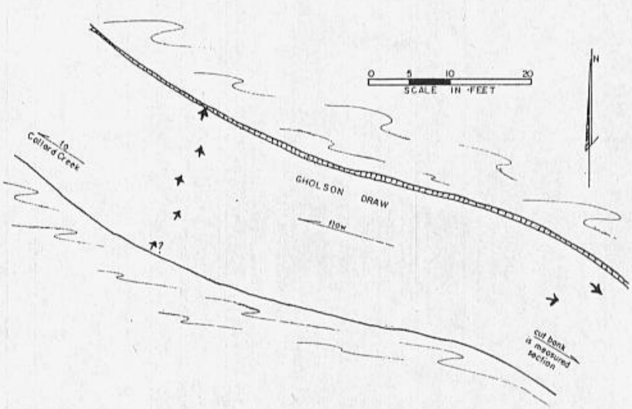


Fig. 30. Nichols site sketch map. One good tridactyl trackway and a few scattered tridactyl tracks occur in the Paluxy Sand at this site.

STRATIGRAPHY OF THE TRACK BEDS

In the Paluxy River basin (Somervell County) stratigraphic control in the type area Lower Glen Rose Limestone is based on lateral continuity of outcrops and prominent marker horizons. This level of control is not possible throughout the study area, and correlations in other areas are based on the position of regional stratigraphic marker horizons.

GLEN ROSE LIMESTONE

Lampasas Cut Plain

Paluxy River Basin

The best-known dinosaur tracks in Texas occur in the type area lower Glen Rose Limestone along the Paluxy River in Somervell County, west of the town of Glen Rose. Five distinct track layers were observed in this study (Fig. 34).

The main track layer is the only horizon that contains abundant, well-preserved sauropod tracks. It is the lowest in a sequence of five beds which form an important marker sequence. The overyling four beds include a thin gray-green nonfossiliferous shale, an indurated limestone (hardground), a "steinkern marl" containing numerous fossil casts, and a burrowed limestone with a distinctive weathering profile that resembles the curved side of a capital "B". This sequence of five beds is laterally persistent, with only minor lateral lithologic variations in individual beds.

Immediately above the marker sequence are several feet of marl. At several localities, subcircular serpulid reefs occur on the upper surface of these marls, and are apparently confined to this horizon. At the Halbert (Lancaster Ranch) site the serpulid reef layer forms the riverbed and contains abundant, well-preserved tridactyl tracks.

Above the serpulid reef layer is a 3-foot section of shale, sandy limestone, and limestone marked by lateral facies variations. The overlying 3 feet of section contain the two uppermost track layers in the lower Glen Rose member. The lower 2 feet consist of interbedded shale, sandy shale, limestone, sandy limestone, and sandstone. It contains mud cracks, rare oolitic grains, thinly laminated beds, ostracodes, miliolid foraminifera, rare mollusks, and tridactyl dinosaur tracks. The upper foot of the 3-foot section consists of a thin shale grading upward to a dense fossiliferous limestone bed, which

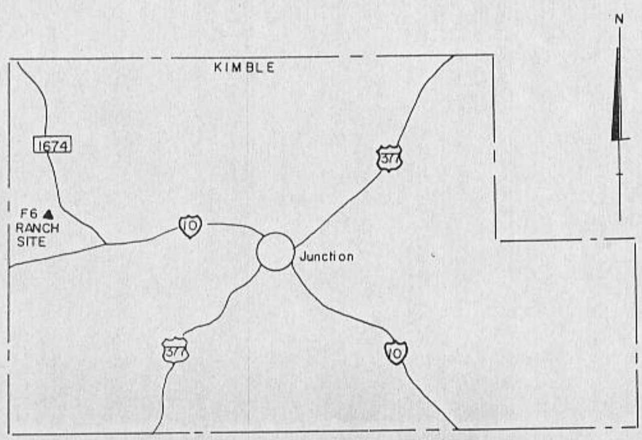


Fig. 31. Edwards Limestone track sites. The only site in the Edwards Limestone described in this study is the F6 Ranch locality located off FM 1674 north of Roosevelt and west of Junction, Texas.

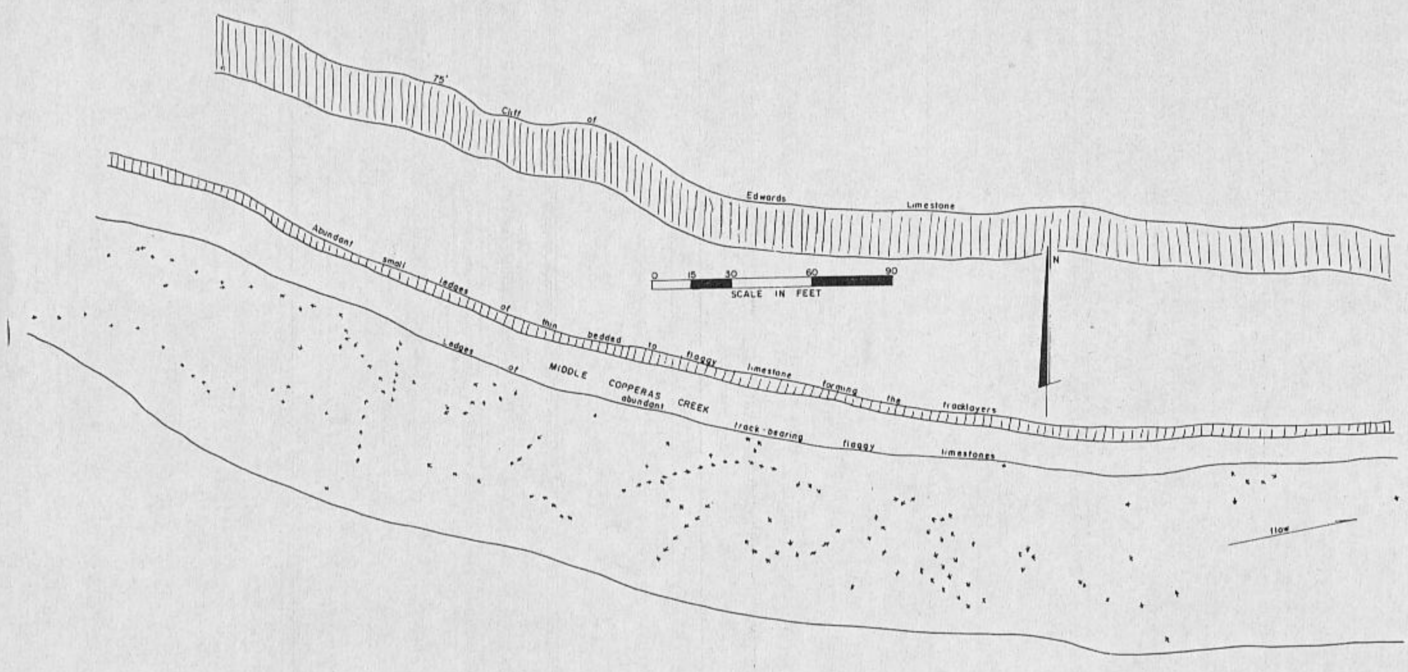


Fig. 32. F6 Ranch site sketch map. These tracks occur in the intermittent stream bed of Middle Copperas Creek. A high cliff of Fort Terrett Limestone is on the north side of the creek (after Farlow, unpublished map).

ımonly forms a prominent ledge along the banks he river. At the McFall site, this layer contains a -preserved tridactyl treadway. Laterally persistent, minent, and easily recognized, this bed forms an ellent stratigraphic marker.

he rest of the lower Glen Rose member above this consists of alternating shales, sandstones, and stones in which no tracks were observed.

he Comanche Peak Nuclear Power Plant site (Loc. has been assigned to strata of the upper Thorp ngs Member based on comparison of the provided sured section with type area Thorp Springs riptions (Mason-Johnston and Associates, Inc.).

ited Sites

ne North Bosque River site occurs in the Glen Rose estone in the Lampasas Cut Plain, outside the Paluxy River Basin. The track layer occurs approximately 100 feet below the Glen Rose Limestone/Paluxy Sand contact (Preston, 1963) in the upper Glen Rose member.

	LAMPASAS CUT PLAIN		EDWARDS PLATEAU	
ATION	MEMBER	TRACK SITES	MEMBER	TRACK SITES
RDS	X	X	Segovia	X
			Ft. Terrett	F6 Ranch
XY	Eagle Mountain	Nichols Hall Ising	X	X
	Georges Creek	Dow		
	Lake Merritt	X		
N E	Upper	North Bosque River	Upper	Crider Davenport Ranch Dinosaur Flats
	Middle (Thorp Springs)	Comanche Peak Power Plant		
	Lower	Paluxy River Sites		
	X	X	Lower	Hondo Creek Mayan Dude Ranch

. Track sites by geology and physiography.

Edwards Plateau

The Glen Rose Limestone in the Edwards Plateau is much thicker than in the Lampasas Cut Plain, due principally to the addition of beds, rather than the thickening of individual beds (Stricklin, Smith, and Lozo, 1971). On the plateau, the Glen Rose Limestone consists of more than 600 feet of limestone, dolomite, marl, and shale, divided into upper and lower members based on a thin, areally persistent "Corbula bed" (Stricklin, Smith, and Lozo, 1971) (Fig. 35).

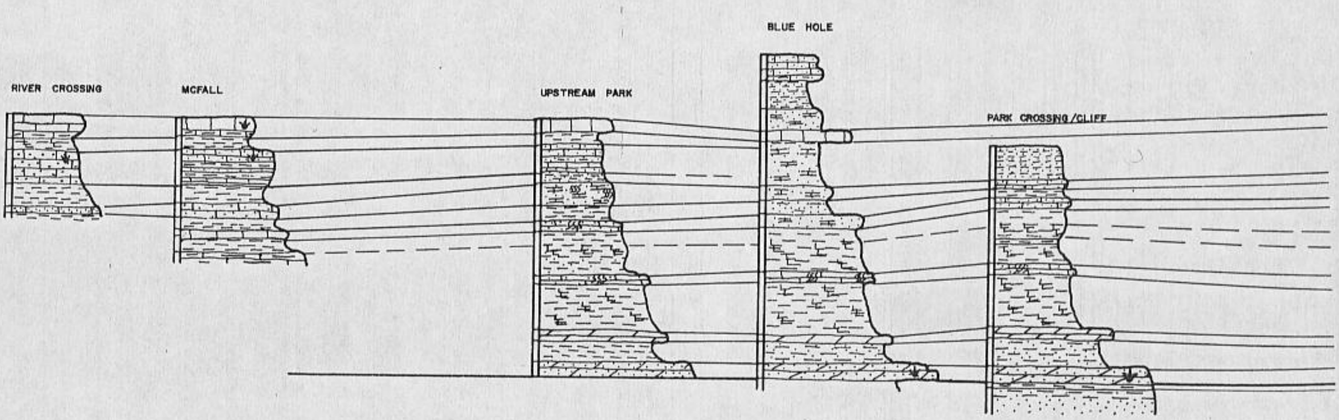
The lower Glen Rose consists of massive shell-fragment limestones with clay interbeds at the base, grading upward into dolomitic shales and dolomites, and finally into alternating beds of clay and limestone (Stricklin, Smith, and Lozo, 1971). The lower Glen Rose commonly contains rudist reefs and is capped by the "Corbula bed" (Behrens, 1965; Stricklin, Smith, and Lozo, 1971; Stricklin and Amsbury, 1974; Perkins, 1974).

The upper Glen Rose Limestone has been divided into eight units, consisting of calcareous clay, dolomite, limestone, and collapse breccia (formed by leaching of gypsum) (Stricklin, Smith, and Lozo, 1971).

For the present study, five sites occur in the Glen Rose Limestone on the Edwards Plateau. The Hondo Creek and Mayan Dude Ranch localities occur in strata of the lower member of the Glen Rose Limestone, while the Crider, Davenport Ranch, and Dinosaur Flats sites occur in the upper Glen Rose member. Stratigraphic correlations are based on the "Corbula bed" and the contact of the Glen Rose Limestone with the overlying Edwards Limestone (Fig. 35). None of the track layers can be correlated between sites.

PALUXY SAND

The Paluxy Sand is the lowermost formation of the Fredericksburg Group in the study area. It is exposed



. Cross section—type area lower Glen Rose. Note the readily identified marker beds in this figure. At this locality the main track layer is the

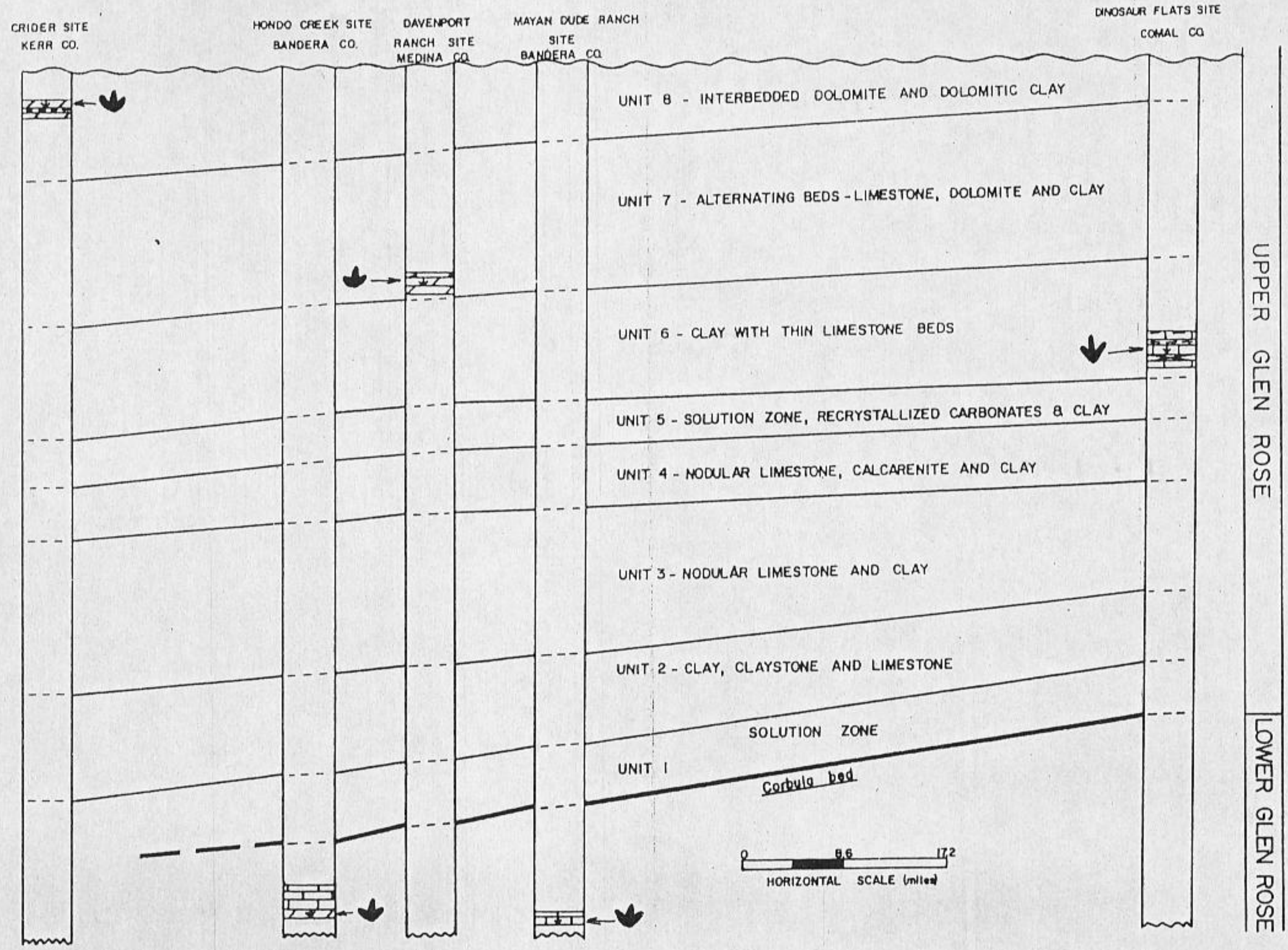
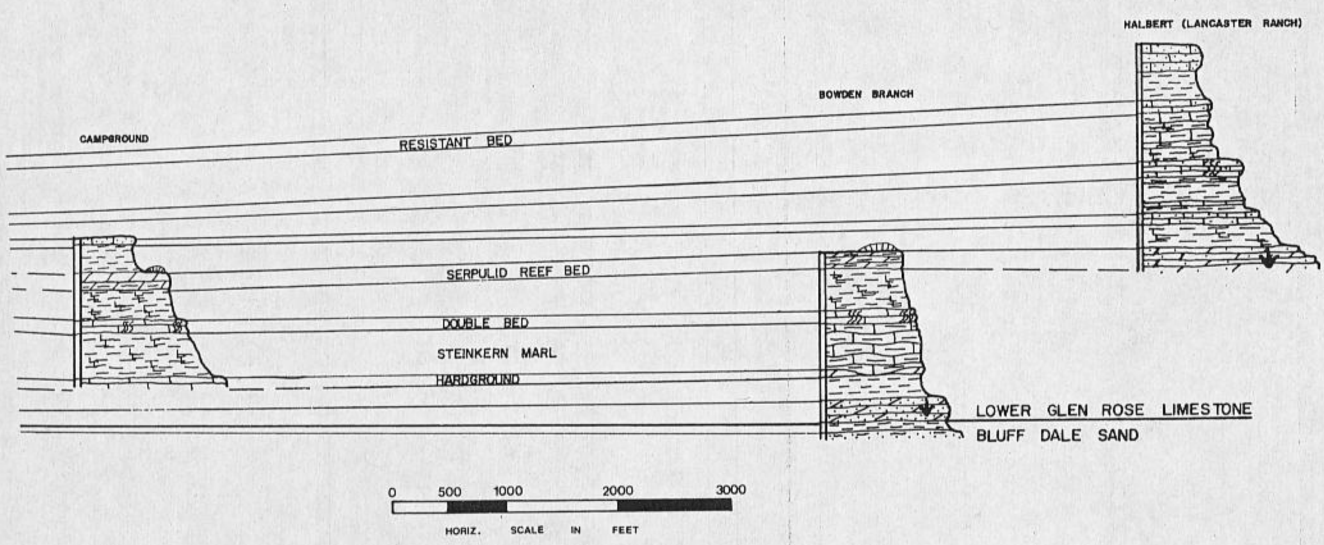


Fig. 35. Diagrammatic cross section, Edwards Plateau, showing Glen Rose nomenclature used in this report. Note the subdivision of the Glen Rose Limestone into upper and lower members at the Corbula bed and the further subdivision of the upper member into eight units (Stricklin, Smith, and Lozo, 1971). Correlations are based on position relative to the Glen Rose/Edwards contact and to the Corbula bed. Only the upper, track-bearing portion of the lower Glen Rose member is shown in this cross section. Measured sections for each site are shown, and track layers are indicated by a small tridactyl track.



lowermost bed in the lower Glen Rose Limestone. Beds that contain tracks are marked with a small tridactyl track.

only in the Lampasas Cut Plain (Atlee, 1962; Fisher and Rodda, 1966; Boone, 1968; Owen, 1979; Corwin, 1982). In the area of this investigation, the Paluxy Formation has been divided into three members. From bottom to top they are: 1) the Lake Merritt Member; 2) the Georges Creek Member; and 3) the Eagle Mountain Member (Owen, 1979). These coalesce downdip to the south where they become inseparable (Fig. 36).

The key regional horizons for correlation are the Glen Rose Limestone/Paluxy Sand contact, the prominent caliche horizon which caps the Georges Creek Member, and the Paluxy Sand/Walnut Clay contact (Amsbury, 1967; Owen, 1979). The Paluxy/Walnut contact to the south is gradational and interfingering (Moore, 1964; Owen, 1979).

The northernmost of the four Paluxy track sites is the Dow site near Huckaby in Erath County. The track layer occurs near the top of the Georges Creek Member of the Paluxy Sand. The caliche horizon above the track layer is probably the same horizon used to identify the top of the Georges Creek Member (Amsbury, 1967; Owen, 1979; Corwin, 1982).

The second and third Paluxy Sand sites are the Hall and Nichols sites near Shive in Hamilton County. These exhibit identical strata, and tracks occur in the same bed. The Glen Rose Limestone/Paluxy Sand contact is shown on the measured sections. This track layer probably occurs in the Eagle Mountain Member.

The fourth Paluxy Sand locality is the Ising site in the south Lampasas River, north of Star, in Hamilton County. The track layer occurs in the upper Paluxy Formation

EDWARDS LIMESTONE

The only site in the Edwards Limestone is the F6 Ranch site west of Junction, in Kimble County. The type section of the Fort Terrett Member occurs near abandoned Fort Terrett south of Roosevelt, along Highway 290, near the F6 Ranch locality. Track layers are correlative with the miliolid foraminifera and mollusk fragment beds of the dolomitic unit in the Fort Terrett type section (Rose, 1972) (Fig. 37).

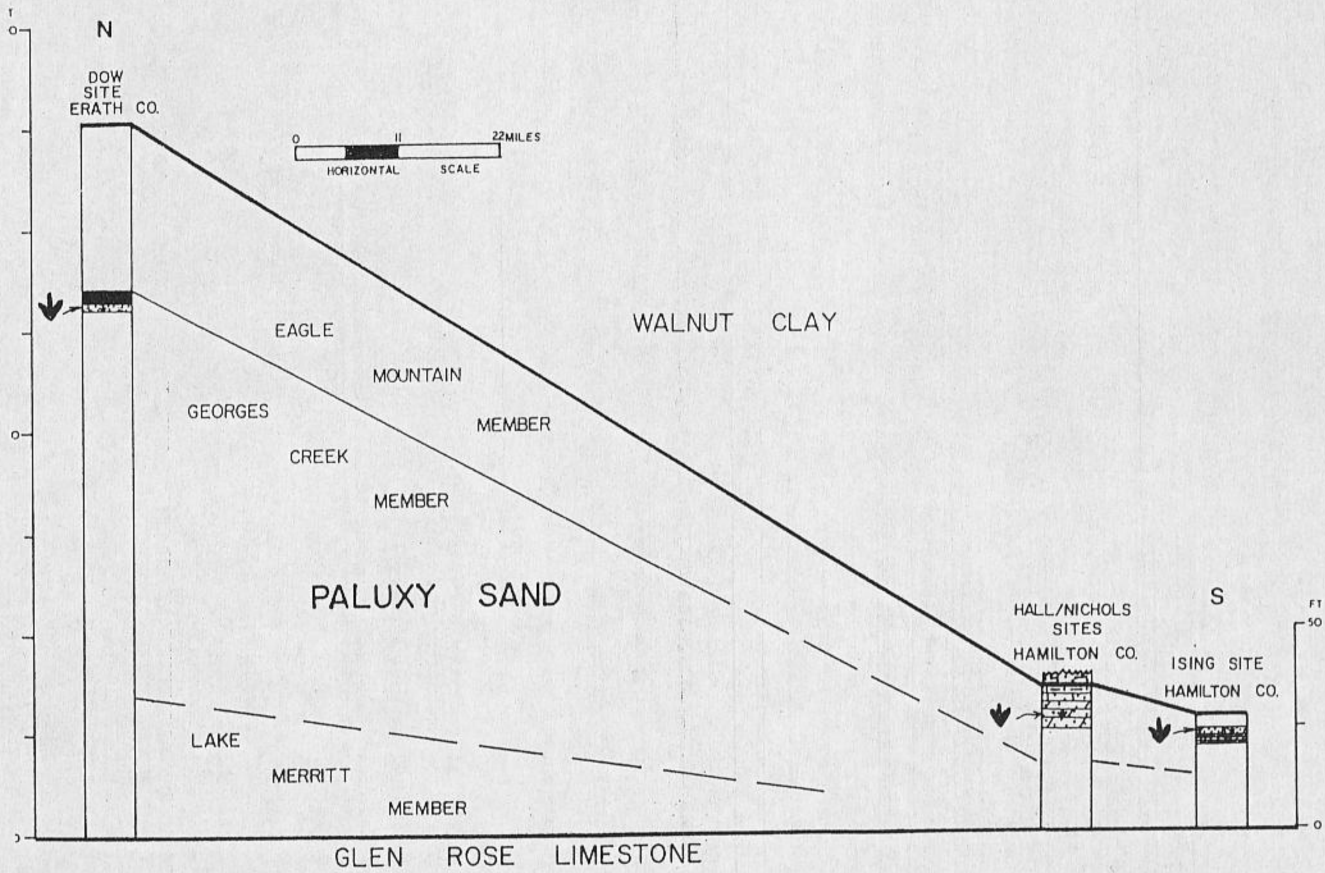


Fig. 36. Diagrammatic cross section, Paluxy Sand, here divided into the Lake Merritt, Georges Creek and Eagle Mountain Members, the latter two of which contain tracks. Note the thinning and disappearance of members as the formation thins to the south. Track sites are shown with track layers marked with small tridactyl tracks. Primary reference horizons are the top and bottom of the Paluxy Sand and a regional caliche horizon at the top of the Georges Creek Member.

DEPOSITIONAL ENVIRONMENTS OF TRACK SITE STRATA

GLEN ROSE LIMESTONE

Glen Rose Deposition

Deposition of Glen Rose sediments occurred during transgression of Early Cretaceous seas onto the stable Central Texas Platform. The base of the Glen Rose is time-transgressive to the north (Hayward and Brown, 1967; Mosteller, 1970; Stricklin, Smith and Lozo, 1971; Walker, 1973; Davis, 1974). Members present in the lower part of the formation in south-central Texas and the East Texas basin are not present in the type area of north-central Texas due to updip pinchout. Lower Glen Rose members of the basin are correlative with the Hensel and Twin Mountains sands of the outcrop.

During lower Glen Rose deposition, a high-energy, rudist reef and grainstone complex developed on a low-relief carbonate ramp. Rudist patch reefs developed along the Pearsall Arch (Bay, 1982). Shallow subtidal to tidal flat sediments formed shoreward of the reefs (Stricklin, Smith, and Lozo, 1971).

During upper Glen Rose deposition, the rate of sea-level rise began to increase resulting in vertical growth of the biohermal facies and development of a marked break in slope. This altered the carbonate ramp profile to that of a carbonate shelf (Bay, 1977, 1979). Environments ranging from tidal flats to shallow subtidal lagoons occurred behind this restrictive shelf margin (Stricklin, Smith, and Lozo, 1971; Bay, 1977, 1979). Dinosaur tracks were formed in these marginal marine, shallow subtidal to supratidal environments.

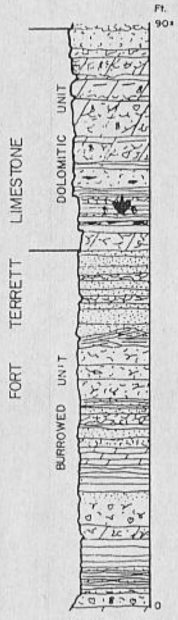


Fig. 37. Type Section Fort Terrett Member. The lower half of the Fort Terrett Member of the Edwards Limestone is shown in this section (Rose, 1972). The Fort Terrett is divided into four units, two of which are shown here: the lowermost burrowed unit and the dolomitic unit. The tracks at the F6 Ranch site (Loc. 25) occur in strata correlative to the miliolid rich beds of the dolomitic unit.

Deposition of Track-bearing Strata

Lampasas Cut Plain

During lower Glen Rose deposition in the Paluxy River Basin area, dinosaur tracks were preserved in marginal marine sediments along a shallow bay (Fig. 38). Two channel systems, one from the north and one from the northwest, supplied clastics to this bay (Boone, 1968; Aguayo, 1971). As the sea transgressed, the drowned channels became estuaries.

The Twin Mountains Sand represents the lowermost shoreward clastic equivalent of the lower Glen Rose Limestone (Rodgers, 1965) deposited in an estuary along the transgressing Glen Rose shoreline. Overlying lower Glen Rose beds represent cyclical subtidal to supratidal deposition in this estuarine environment (Nagle, 1968).

The four track layers identified in this section represent facies of the complex marginal marine deposits. The main track layer is a homogeneous, sandy dolomudstone deposited on an exposed intertidal or supratidal flat. The serpulid reef-bearing track layer represents normal marine shallow subtidal to intertidal deposition as suggested by algal laminae and well-ordered serpulids in reefal mounds (Andrews, 1964; Heckel, 1972; Trippett, 1972; Multer, 1977; Cole, 1981). The third track layer represents tidal flat sedimentation, suggested by the presence of mud cracks and restricted fauna. The uppermost track layer probably represents shallow subtidal deposition (Nagle, 1968).

The other track sites in the Lampasas Cut Plain are the Comanche Peak Nuclear Power Plant site and the North Bosque River site. Mud cracks and worm burrows in the track layer at the Nuclear Power Plant site indicate shallow water deposition (Skinner and Blome, 1975). The stratigraphic section at the North Bosque River site consists of packstones at the base, grading upward into slightly sandy, thin-bedded mudstones. Tracks are shallow and poorly preserved without pressure ridges. These beds probably represent shallow, subtidal lagoonal deposits.

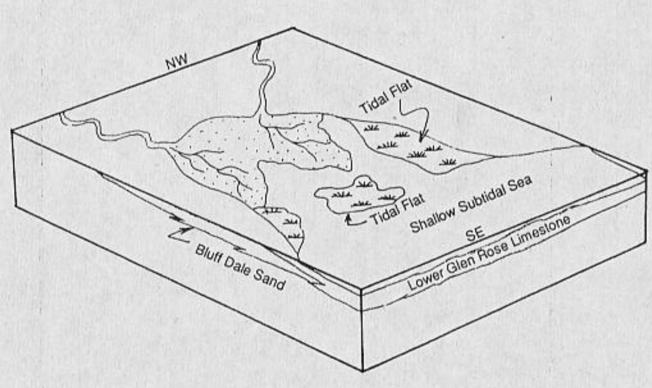


Fig. 38. Type area lower Glen Rose deposition. Tracks formed in tidal flat and shallow subtidal sediments of a bay system. The dual drainage system supplied abundant clastics to this bay, rapidly burying tracks.

Edwards Plateau

Lower Glen Rose deposition in south Texas occurred on a carbonate ramp as the sea transgressed across the craton (Fig. 39). The oldest track site, the Mayan Dude Ranch locality (Loc. 16), occurs in the reef interval in which four facies bands parallel the ancient shoreline. These facies range from oyster biostromes along the shore to oyster/monopleurid biostromes, monopleurid biostromes, and caprinid reefs seaward (Perkins, 1974). The tracks occur in the subtidal monopleurid biostrome belt. If the tracks at this site are true impressions and not "ghost track" impressions from overlying sediments (Langston, 1986), then the water was apparently deep enough to float a sauropod. This is indicated by the shallow manus prints, possibly tracks of a partially floating sauropod propelling itself with its front feet (Bird, 1944).

The Hondo Creek site (Loc. 17) is also within the reef interval (Houston, 1933; Perkins, 1974). Abundant tracks occur on a dolomitic mudstone section containing abundant oysters in erect, living position. This is a subtidal section, with tracks made in shallow water on top of monopleurid reefs (Fig. 39). Truncation, encrustation, and boring of monopleurid biostromes are common in this area (Perkins, 1974). Tracks may have been made during subaerial exposure of this bed.

The oldest track layer in the upper Glen Rose member occurs at the Dinosaur Flats site (Loc. 20) in the lower portion of Stricklin, Smith, and Lozo's unit 6, which is characterized by clay with thin, fossiliferous limestone beds. The abundance of terrigenous material in the section suggests close proximity to a drainage source or greatly increased runoff from nearby land masses. The faunal assemblage is dominated by miliolid foraminifera and ostracodes with bivalves (oyster mounds), suggesting subtidal brackish waters. The track layer represents deposition in shallow, subtidal, nearshore brackish waters (Fig. 40).

The Davenport Ranch site (Loc. 19) occurs in unit 7, which consists of alternating limestone, dolomite, and clay. The paucity of fossils, presence of mud cracks, pervasive dolomitization, and deeply impressed tracks suggest formation on a tidal flat (Fig. 41).

The youngest track site in the Glen Rose Limestone is the Crider site (Loc. 18) in unit 8 of the upper Glen Rose member near its contact with the overlying Fredericksburg Group. This section consists predominantly of sucrosic dolomudstones exhibiting birdseye texture, floating grains, laminar micritic crusts, pyrite-encrusted nodules, and deep but poorly preserved dinosaur tracks. These features all indicate tidal flat depositional environments (Fig. 41).

In summary, tracks in the Glen Rose Limestone tend to occur in strata that were deposited in shallow subtidal to supratidal environments. Intertidal and supratidal environments are most common and probably represent tidal flat facies. Subtidal tracks are less common.

PALUXY SAND

Paluxy Deposition

The Paluxy Sand on the northern portion of the Central Texas Platform forms a clastic wedge which pinches out to the south and east and represents depositional environments ranging from continental to shallow marine.

Three members are recognized from the base to the top: the Lake Merritt Member, representing strandline and nearshore deposits of the regressing/transgressing Glen Rose Sea; the Georges Creek Member, representing fluvial deposits to the north and shallow nearshore subtidal deposits to the south; and the Eagle Mountain Member, representing fluvial deposits to the north grading to tidal flat and shallow marine deposits to the south (Owen, 1979; Corwin, 1982). Subaerial exposure developed a prominent, regional caliche zone between the Georges Creek and Eagle Mountain Members (Amsbury, 1967; Owen, 1979; Corwin, 1982).

The three members of the Paluxy Sand thin and coalesce to the south and east, causing them to cease to be mappable units (Owen, 1979).

Deposition of Track-bearing Strata

In general, outcrops of Paluxy Sand at various sites are small (though the Hall and Nichols sites are notable

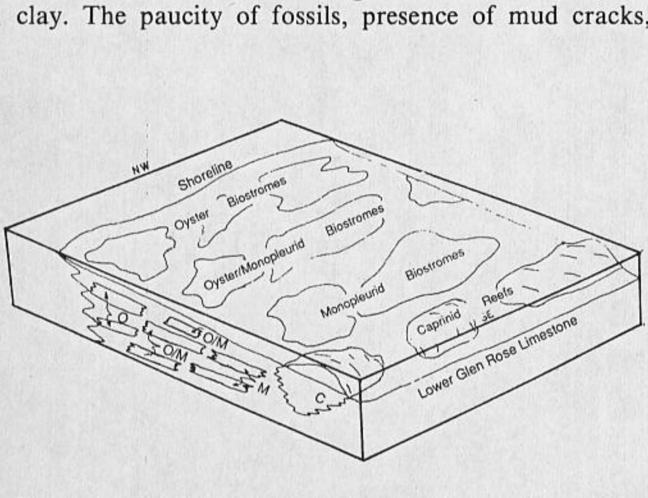


Fig. 39. Edwards Plateau lower Glen Rose deposition. Note the four facies belts paralleling the shoreline. Tracks of the Hondo Creek and Mayan Dude Ranch sites (Loc. 17 and Loc. 16) formed in the monopleurid biostrome facies belt. (O—oyster; M—monopleurid; O/M—oyster/monopleurid).

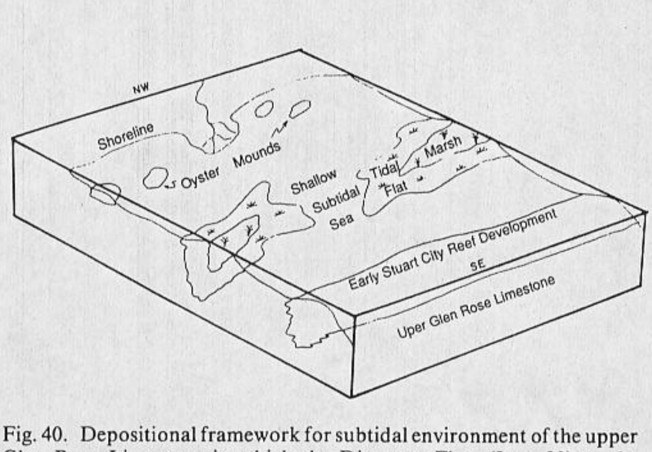


Fig. 40. Depositional framework for subtidal environment of the upper Glen Rose Limestone in which the Dinosaur Flats (Loc. 20) tracks occur. These tracks formed in an area conducive to the growth of oyster mounds and with a high clastic influx near the shoreline.

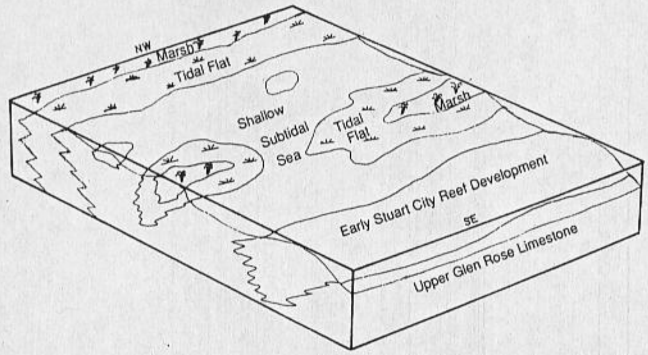


Fig. 41. Tidal flat and marsh environments during latest Glen Rose time. Deposition of tracks at the Davenport Ranch (Loc. 19) and Crider (Loc. 18) sites occurred in these tidal flat sediments.

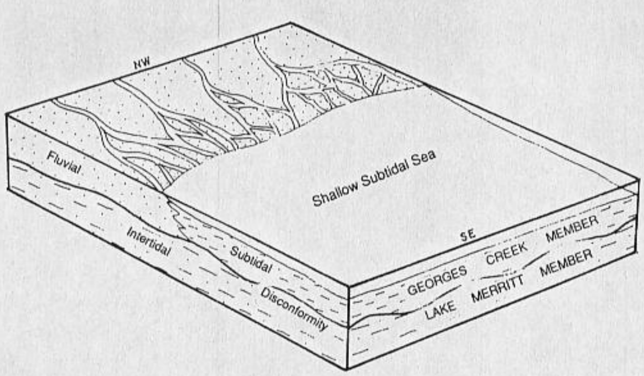


Fig. 42. Paluxy Sand continental deposition. This diagram illustrates deposition of the lower two members of the Paluxy Sand—the Lake Merritt and Georges Creek Members separated by a disconformity. Tracks occur at the Dow site (Loc. 21) in channel bar deposits of the Georges Creek Member. Regression and exposure at the end of Georges Creek deposition allowed the development of a regional caliche horizon which caps this member (Owen, 1979).

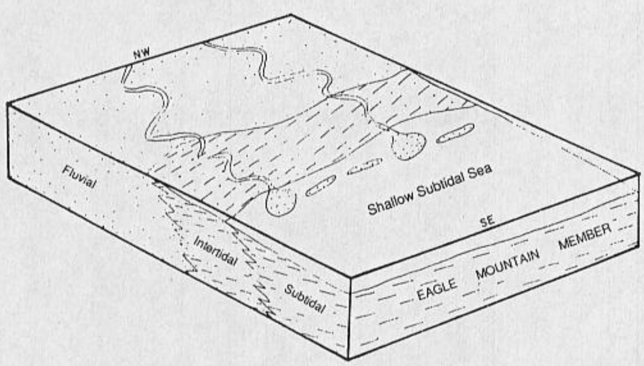


Fig. 43. Paluxy Sand intertidal deposition. Fluvial meander belt facies developed to the northwest during deposition of the Eagle Mountain Member, while intertidal and subtidal sediments were deposited to the southeast. Tracks of the Hall (Loc. 23), Nichols (Loc. 24), and Ising (Loc. 22) sites formed in the very fine-grained intertidal deposits (Owen, 1979).

exceptions). The availability of diagnostic environmenta indicators is limited.

The Dow site (Loc. 21) in Erath County occurs ir the Georges Creek Member. The track layer is the only bed exposed, and it is a fine-grained, burrowed, calcite-cemented, quartz arenite with minor clay seams. Corwir (1982) reports similar burrowed sand units to be commor in the upper sand beds of the Georges Creek Membei in this area. Owen (1979) interprets burrowed sand units of this member to represent exposed channel bar surfaces of braided streams (Fig. 42).

The Hall (Loc. 23) and Nichols (Loc. 24) sites expose identical stratigraphic sections of the Eagle Mountain Member. The track layer formed in an intertidal to slightly supratidal environment, as evidenced by the dolomitized, unfossiliferous, burrowed, fine-grained sands containing clay (Fig. 43). Subsequent to deposition of the track layer, the sea transgressed across the area depositing intertidal to shallow subtidal sediments.

The Ising site (Loc. 22) in southwestern Hamilton County occurs in the upper portion of the Paluxy Sand. The three members could not be differentiated in this area. The lack of fossils and the pervasive dolomitization of these beds suggests an intertidal to supratidal depositional environment (Fig. 43).

EDWARDS LIMESTONE

Edwards Deposition

The only Edwards Limestone site included in this study is the F6 Ranch locality west of Junction on the Edwards Plateau (Loc. 25). In this area, the Edwards Limestone consists of two members: the Fort Terrett and the overlying Segovia.

The Fort Terrett Member contains the tracks and consists of four units, which from bottom to top are the basal nodular unit, the burrowed unit, the dolomitic unit, and the Kirschberg Evaporite unit (Rose, 1972). The basal nodular unit was deposited below effective wave base in shallow, low energy, subtidal marine waters. The burrowed unit was deposited in shallow marine water below effective wave base with essentially no clastic influx. The dolomitic unit contains massive dolomites representing shallow marine deposits and thin dolomitic beds containing stromatolites, root marks, mud cracks, and birdseye structures indicating tidal flat deposition. The Kirschberg Evaporite unit was deposited on an evaporite-dominated tidal flat (Rose, 1972).

Deposition of Track-bearing Strata

The strata at this site correlate with the dolomitic unit of the Fort Terrett Member, which consists of shallow subtidal deposits and intertidal to supratidal tidal flat sediments. The thin, flaggy, track-bearing limestones are tidal flat deposits, as indicated by the abundant mud cracks, possible algal mat surfaces, relict evaporite nodules, and sparse fauna.

PALEOECOLOGIC SIGNIFICANCE OF DINOSAUR TRACKS

One of the major goals of this study was to determine the significance of dinosaur track-bearing beds as indicators of paleoecology. Although specific relationships between track types and depositional environment offer only the broad generalization that Texas dinosaur tracks indicate marginal marine environments, trends are discernible.

The most obvious of these trends is that the well-preserved, deeply impressed and abundant sauropod trails (including tracks of front and hind feet) in tidal flat sediments indicate dense dewatered muds, typical of brief subaerial exposure. However, the Mayan Dude Ranch "swimming" sauropod trail either represents subtidal track formation or the formation of "ghost tracks"—impressions formed when dinosaurs trod across overlying sediments (Langston, 1986). Another trend is that tridactyl tracks seem to occur in both subtidal and intertidal to supratidal sediments.

Tracks in subtidal deposits are typically shallow, lack mud pressure ridges, and exhibit poor morphologic preservation, in contrast to intertidal or supratidal tracks, which tend to be deep, exhibit poor to excellent morphologic preservation, and possess mud pressure ridges. Exceptions do occur; for example, the F6 Ranch tidal flat tracks are shallow, poorly preserved, and exhibit poorly developed to absent mud pressure ridges. Inter/supratidal tracks that have been extensively eroded may exhibit subtidal features. Many of the subtidal tracks may actually be "ghost tracks." As such, the layers in which they occur would not represent true track layers.

The track-bearing beds of this study lack clear tail drag marks in association with tracks made in intertidal to supratidal sediments, indicating that dinosaurs carried their tails off the ground.

Two related observations suggested by the tracks are: (1) Sauropod tracks almost always occur in abundance, representing several individuals generally headed in the same direction, possibly travelling in herds (Bird, 1944; Farlow, 1987); and (2) Tridactyl tracks often occur in abundance but do not indicate any herding behavior, suggesting they may have travelled in loosely knit packs (Farlow, 1987).

SUMMARY AND CONCLUSIONS

1. Numerous dinosaur tracks occur in the Trinity and Fredericksburg Groups of the Lower Cretaceous Comanchean Series in Texas.
2. Individual track sites were located and mapped in the field, and each local stratigraphic section described and sampled for subsequent laboratory analysis. These individual stratigraphic sections were interpreted within the overall stratigraphy of the relevant geologic units established by previous workers to determine stratigraphic placement, depositional environments represented by the track layers, and the paleoecologic significance of the tracks themselves.
3. Trinity Group tracks occur throughout the Glen Rose Limestone of both the Lampasas Cut Plain and the Edwards Plateau. Fredericksburg Group tracks occur in the Georges Creek and Eagle Mountain Members of the Paluxy Sand in the Lampasas Cut Plain and the Fort Terrett Member of the Edwards Limestone in the Edwards Plateau.
4. Lower Glen Rose tracks formed in shallow subtidal to intertidal environments on a carbonate ramp system. Upper Glen Rose track sites formed mainly in intertidal to supratidal environments, but some sites formed under subtidal conditions.
5. A regression terminated Glen Rose deposition and allowed progradation of the continental braided stream and marginal marine tidal flat sediments of the Paluxy Sand. Tracks occur in these sediments within the Lampasas Cut Plain.
6. In south Texas, dinosaur tracks formed in sediments of an extensive tidal flat system during Edwards deposition.
7. In marginal marine settings, abundant, well-preserved, deeply impressed dinosaur tracks appear to be good indicators of intertidal/supratidal deposition.

APPENDIX I

PREVIOUS WORKS

Previous works relevant to this study include literature dealing with the Trinity and Fredericksburg strata of Texas, the dinosaur remains and tracks found in and around Texas, paleoecologic studies of the dinosaurs, and studies of modern carbonate, clastic, and mixed carbonate/clastic depositional environments. Adkins (1932), Boone (1968), Davis (1969, 1974) and Corwin (1982) provide excellent summaries of works dealing with portions of this study up to their respective times. Adkins summarized literature dealing with the Mesozoic systems in Texas, Boone provided a comprehensive listing of literature dealing with the lower Cretaceous deposits of Texas, Davis summarized works dealing specifically with the Glen Rose Limestone, and Corwin summarized the body of literature concerned with the Fredericksburg Group north of the Colorado River in Texas. The interested reader is urged to consult these publications, as only selected references in the areas summarized by these authors will be presented in the following literature review. In the interest of the historical development of knowledge, previous works will not be subdivided into categories but will be presented in strict chronological order.

The first true geologist to study Cretaceous rocks in Texas was Ferdinand Roemer. His works (1846, 1848, 1852, 1983 [reprint]) identified "Beds at the foot of the Highlands" and "Beds of the Highlands" along what is now known as the Balcones Fault scarp. His inability to recognize the fault zone caused him to incorrectly date the scarp-forming Fredericksburg rocks as younger than the Austin Chalk at the foot of the scarp.

In 1852 G. G. Shumard ascribed a Late Cretaceous age to the rocks of the Red River area and named them the Fort Washita Limestone (Thompson, 1935, p. 1509).

While accompanying the "Thirty-fifth Parallel Survey" Jules Marcou (1853) correctly identified fossils from the Cretaceous of Texas and western Oklahoma as Neocomian (Early Cretaceous) in age (Thompson, 1935, p. 1509-1510).

An assembly of the stratigraphy of Texas was attempted in 1860 by B. F. Shumard. In it he recognized and named three formations—the *Caprotina* Limestone, the Comanche Peak Group, and the *Caprina* Limestone, which correspond respectively to the present Glen Rose Limestone, Walnut Clay and Comanche Peak Limestone, and Edwards Limestone. He followed Roemer's error in mistakenly ascribing a Late Cretaceous age to these rocks (Thompson, 1935, p. 1510).

R. T. Hill (1887 a, b, c) published works dealing with the Cretaceous rocks of Texas in which he described the physiography of Texas, presented a cross section of the Cretaceous section in north-central Texas, and divided the Cretaceous strata into the Comanche and Gulf Series corresponding to the Lower and Upper Cretaceous. This was the first correct subdivision of the Cretaceous rocks of Texas. In his rock sequence Hill included the *Caprotina* Limestone in the Fredericksburg Group. At this time he recognized the presence of dinosaur remains in the basal Cretaceous sands thereafter known as the "dinosaur sands." In 1888 he removed the *Caprotina* Limestone from the Fredericksburg Group and placed it in the upper part of his newly described Trinity Group (Hill, 1888).

In 1889 Hill published a paper in the First Annual Report of the Texas Geological Survey in which he introduced the Trinity Sand and Travis Peak Sands of the Trinity Group (Hill, 1889a). In that same year he published a checklist of the Cretaceous fossils of Texas (Hill, 1889b), acccompanied by a brief description of the stratigraphy of the Cretaceous system. In 1890, Hill expanded his physiographic description of Texas in his "Classification and Origin of the Chief Geographic Features of the Texas Region."

One of Hill's most important contributions to the Comanchean geology of Texas appeared in 1891. In it he placed the Kiamichi Clay in the Washita Group, defined the top of Shumard's *Caprina* Limestone to be the top of the Fredericksburg Group, and renamed Shumard's Comanche Peak Group as the Comanche Peak Chalk. In this paper he also named the Walnut Clay for exposures around the town of Walnut Springs, the Paluxy Sand for exposures near the town of Paluxy along the Paluxy River, and substituted the name Glen Rose for his "alternating beds" (*Caprotina* Limestone). At this time he placed the Paluxy Sand in the Fredericksburg Group.

In 1892 J. A. Taff defined a Bosque division of the Cretaceous north of the Colorado River which included the Trinity Sand, Glen Rose (alternating beds) Formation, and the Paluxy Sand.

The first work dealing with the flora of the Trinity Group in Texas appeared in 1893. In it W. M. Fontaine provided descriptions and illustrations of plant remains found in the Glen Rose Limestone, notably *Frenelopsis* (a type of marsh plant).

In a joint paper by Hill and Vaughn (1898) the name Edwards Limestone was substituted for the *Caprina* Limestone and the Paluxy Sand was moved to the Trinity Group.

Hill's monographic work on the "Geography and Geology of the Black and Grand Prairies of Texas" was published in 1901. This classification of the Comanchean Series included the Travis Peak Sand, Glen Rose Limestone, and Paluxy Sand in the Trinity Group and the Walnut Clay, Comanche Peak Limestone and Edwards Limestone in the Fredericksburg Group. However, Hill recognized the difficulty in determining a clearly defined boundary between these two groups.

In 1910 Pierce Larkin published a brief article in which he described the fossilized remains of a sauropod dinosaur from sands of the Trinity Group in Oklahoma.

The first mention of dinosaur tracks in Texas was by E. W. Shuler in 1917. He described eight tracks from the Glen Rose Limestone in the bed of the Paluxy River near Glen Rose, Texas, and also described the section of rocks in which the tracks occurred. He attempted a depositional interpretation and proposed the name *Eubrontes* (?) *titanopelopatidus* sp. nov. (the lime mud strider) for the tracks.

In 1922 W. E. Wrather described dinosaur tracks from the upper Glen Rose Limestone in the southwestern corner of Hamilton County in the bed of Cottonwood Creek (a tributary of the Lampasas River). Most of the creek bed was obscured by mud and gravel, but local people placed the number of tracks present at over one hundred.

Gayle Scott (1926) provided a correlation of the Texas Cretaceous section with the European stages and showed that the Trinity and Fredericksburg Group rocks were Aptian to Albian in age.

In 1928 W. S. Adkins described and illustrated the fossils characteristic of the Cretaceous section in Texas. In that same year T. W. Stanton correlated Fredericksburg limestones from the Llano Estacado to central Texas and correlated "upper Trinity" sands north of the Glen Rose pinchout with the Paluxy Sand. In two related works, Vanderpool (1928a, b) published a detailed description and zonation of fossils from the Trinity Group and a study of the stratigraphy and regional variations of that Group.

C. N. Gould summarized the recorded findings of Comanchean reptilian bones and tracks from Kansas, Oklahoma, and Texas in 1929. The bulk of his short article is given to the description of a new track site in the northeast corner of Kinney County, Texas.

In a study of the geology of Bell County in 1930, Adkins and Arick presented detailed stratigraphic descriptions of the pre-Cretaceous through Upper Cretaceous rocks in the surface and subsurface of that county. The same year, Gayle Scott published a detailed stratigraphic analysis of the Trinity Group as it outcrops in Parker County, Texas.

In 1932 W. S. Adkins's monumental work summarizing the Mesozoic systems in Texas appeared. This was a comprehensive survey of the data and previous literature on Mesozoic stratigraphy, structure, and paleontology of Texas. He also summarized the known dinosaur track localities in Texas at that time. Also in 1932 L. D. Cartwright, Jr., analyzed the regional structure of the Edwards Plateau region and determined that the structure was controlled by the pre-Cretaceous paleoplain and the downwarping of the basin to the south and east in association with the Balcones Fault system.

The first description of tracks in Bandera County appeared in 1933. Sam H. Houston, Jr., measured, mapped, and photographed tracks occurring in the bed of Hondo Creek 26 miles north of the town of Hondo and placed the track-bearing strata in the Glen Rose Limestone.

In 1934 W. H. Curry examined the nature of the contact between the Edwards and Georgetown Formations (Fredericksburg and Washita Groups) in the Edwards Plateau region of Texas.

E. W. Shuler's second article dealing with dinosaur tracks near Glen Rose, Texas, appeared in 1935. In it he described a dinosaur track that had been removed from the Glen Rose Limestone in the bed of the Paluxy River and mounted in the bandstand in the town square of Glen Rose.

S. A. Thompson (1935) proposed a revision of the stratigraphic nomenclature of the Fredericksburg Group whereby the name Goodland Limestone would be dropped since it was synonomous with the Comanche Peak Limestone. He also proposed reducing the Edwards Limestone, Comanche Peak Limestone, and Walnut Clay from formation to member status with the three collectively forming the Gatesville Formation, but this revision was not widely accepted.

R. T. Hill's final work on the Fredericksburg Group appeared in 1937 when he removed the Paluxy Sand from the Trinity Group and made it the lowest member of the Fredericksburg Group. He based his decision on new data that indicated the Paluxy Sand was the logical beginning of a cycle of deposition. In the same year E. W. Shuler published an article dealing with dinosaur tracks at the fourth crossing of the Paluxy River near the town of Glen Rose, Texas. At this site he mapped 26 tridactyl tracks representing several species and placed the track-bearing strata in the Glen Rose Limestone. Unfortunately these tracks no longer exist.

In 1939 R. T. Bird of the American Museum of Natural History published the first of four articles about Texas dinosaur tracks entitled "Thunder in His Footsteps." This article described tracks in the Glen Rose Limestone in the bed of the Paluxy River west of Glen Rose, Texas.

R. W. Imlay (1940) described the Lower Cretaceous rocks of southern Arkansas and briefly dealt with their correlation to the Trinity Group in Texas.

In 1941 Bird's second article on Glen Rose dinosaur tracks appeared. Entitled "A Dinosaur Walks into the Museum," this article described a series of tracks and the process of their removal from the Paluxy River prior to reassembly in the American Museum of Natural History. This trackway apparently depicted a tridactyl carnivore either following or hunting a sauropod.

C. C. Albritton reported 101 tracks forming 30 distinct trackways (as well as isolated tracks) in the Glen Rose Limestone at Lake Eanes near Comanche, Texas, in 1942. These tracks were all made by the same creature, and he identified the tracks as specimens of *Eubrontes* (as named by Shuler). Unfortunately, this track site no longer exists. Also in 1942, Stephenson and others published correlations of outcropping Cretaceous rocks from the Trans-Pecos region of Texas across the Gulf and Atlantic coastal plains.

F. E. Lozo (1944) provided a summary listing and description of the foraminifera of the Trinity and Fredericksburg Groups from Bosque County northward to the Red River. He detailed the units of each group in which the fossils appeared and related them to the occurrence of macrofossils where possible.

In 1944 R. T. Bird published an article dealing with dinosaur tracks from Bandera County, Texas. He presented maps, descriptions, and photographs of two different sites. One site showed tracks of a herd of sauropods while the other showed tracks of a swimming sauropod.

In 1945 R. W. Imlay presented an analysis of the Lower Cretaceous formations in south Texas as they appeared in the subsurface.

Raymond Sidwell presented a brief article in 1947 dealing with changes in the rocks of the Trinity Group throughout north and central Texas.

In 1949 F. E. Lozo published an article in a fieldtrip guidebook detailing stratigraphic correlations of the Fredericksburg limestones throughout north-central Texas. In this study he followed Hill's inclusion of the Paluxy Sand in the Fredericksburg Group, and he divided the Walnut Clay into four unnamed members.

In 1950 J. W. Stovall and Wann Langston, Jr., described fossilized remains of a new dinosaur unearthed from the Trinity sands of Oklahoma. They presented a detailed description of these bones and proposed the name *Acrocanthosaurus atokensis* for the specimen.

Stead (1951) outlined a foraminiferal zonation of the Glen Rose Limestone based on outcrop studies in Travis, Hays, and Comal Counties in central Texas. A second zonation of the Glen Rose Limestone of central Texas was presented by Whitney in 1952. He emphasized the faunal differences between the lower and upper Glen Rose Limestone.

In 1954 R. T. Bird published his last account of Texas dinosaur tracks. This article presented little new information; instead, it was a combination of his three previous articles "popularized" for National Geographic Magazine. In this same year Don Frizzell published a comprehensive listing, description, and illustrations of the various foraminifera of Cretaceous age in Texas.

J. M. Forgotson, Jr. (1956) studied the subsurface Trinity Group of the Gulf coastal plain. He provided regional correlations of the formations of the Trinity Group and a detailed analysis of the Ferry Lake Anhydrite Member of the Glen Rose Limestone. In that same year, Getzendaner (1956) provided a description of the Trinity Group in Texas and nearby states and in particular analyzed the stratigraphy and depositional environments of the various members of the Group. Also in 1956, Lozo and Stricklin's study of the outcropping basal Cretaceous rocks in cental Texas appeared. This work provided a description of the stratigraphy, depositional environments, and regional variations of the Lower Cretaceous rocks below the Glen Rose Limestone.

In 1957 Forgotson published another article on the Trinity Group throughout the Gulf coastal plain. He subdivided the Trinity Group into four members below the Glen Rose Limestone and correlated time-stratigraphic units in this group from Florida to Texas.

J. F. Jamieson (1959) described the stratigraphy and depositional environments of the Fredericksburg Group in central Texas.

In 1959 F. E. Lozo edited the most comprehensive study of the Edwards Formation in Texas to date. It contained a series of papers all individually authored by F. E. Lozo, H. F. Nelson, Keith Young, O. B. Shelburne, and J. R. Sandidge. Of these five papers, the three which have relevance to this work include Lozo, Nelson, and Young.

Lozo (1959) studied the stratigraphy of the entire Fredericksburg Group in north-central Texas and considered this group to be a depositional cycle initiated by clastic deposition (Paluxy Sand) and terminating with pure carbonate deposition (Edwards Limestone). Nelson (1959) provided a detailed study of the Edwards Limestone in central Texas. He divided the formation into three facies including rudist reefs, inter-reef sediments, and primary dolomite. He also studied the lower and upper contacts of the Edwards and determined that the upper contact was unconformable and it indicated a period of subaerial exposure. Young (1959) analyzed the fauna of the Edwards Limestone in Bosque and Hill Counties. He interpreted depths for Edwards deposition from about 25 feet at the base to intertidal at the top of the formation.

R. C. Douglass (1960) studied the occurrence of the foraminiferal genus *Orbitolina* in North America and stated its value as a marker fossil of the Trinity Group. He zoned the Glen Rose Limestone based on the occurrence of *Orbitolina texana* (Roemer) and *Orbitolina minuta* (Douglass).

In a popular study of the fossils of Texas, W. H. Matthews III (1960) described the occurrence of dinosaur tracks near the town of Glen Rose, Texas, and identified the major fossils of Paleozoic through Cenozoic age in Texas.

H. D. Holloway (1961) studied the basal Trinity and Paluxy Sand Members of the Trinity Group in the subsurface of McLennan County, Texas, and he evaluated their use as groundwater aquifers.

W. A. Atlee (1962) analyzed the stratigraphy, regional relationships and depositional environments of the Paluxy Sand. He interpreted deposition ranging from shallow marine to fluvial and possibly eolian environments.

R. J. Dunham's classic work on the classification of carbonate rocks appeared in 1962. His classification is based on the relative amounts of mud and grains present in the rocks, and it is the classification system used in this study.

Also in 1962, E. R. Henningsen described the diagenesis due to groundwater flow through the Trinity Sand aquifers in central Texas.

J. M. Forgotson, Jr. (1963) studied the Trinity Group in detail throughout the Gulf Coast area. He analyzed the paleotectonic history of the region and utilized this in describing the depositional history of the Trinity Group.

P. B. Andrews (1964) studied the occurrence of serpulid worm reefs in Baffin Bay, Texas. He correlated growth patterns of the reefs with salinity variations of the bay waters.

In 1964 Lozo and Smith analyzed the Comanchean stratigraphy of south-central Texas and proposed a nomenclature revision whereby the area was divided into three regions, each with its characteristic stratigraphy. They outlined the stratigraphy of each region and proposed new names for the units.

C. H. Moore, Jr. (1964) studied the Fredericksburg Group in central Texas. He concentrated on the Walnut Clay and divided it into six members. He also showed the north to south regional variations of Fredericksburg rock units and determined the depositional history for this group.

E. W. Behrens (1965) conducted a detailed analysis of a portion of the Glen Rose Limestone in south-central Texas. He recognized three facies—a *Corbula* facies, a steinkern facies, and a mudstone facies—and determined the depositional history of this unit based on the sequence of these facies.

In 1965 R. W. Rodgers completed a master's thesis detailing the stratigraphy and depositional history of the Glen Rose Limestone in its type area near the town of Glen Rose, Texas. He divided the formation into three units based on lithology and faunal content.

Fisher and Rodda (1966) revised and standardized the nomenclature of the basal Cretaceous units in Texas north of the Colorado River. They mapped the occurrence and regional variations of the members of the Trinity Group, in particular outlining the stratigraphic relations of a dip section containing basal Trinity Sand (Twin Mountains Sand), Glen Rose Limestone, and Paluxy Sand. In this same year, Moore and Martin examined the occurrence of the Paluxy Sand in Travis, Burnet, and Williamson Counties. They studied the stratigraphy and depositional history of this unit and determined that it had formed in marginal marine environments.

In 1967 D. L. Amsbury presented a paper for the Geological Society of America in which he recognized laterally continuous caliche zones in the Paluxy Sand and suggested that they could be used as marker horizons within this unit. In that same year the Baylor Geological Society published its first edition of the Valley of the Giants field trip guidebook, which provided a detailed description of a dinosaur track site along the Paluxy River near Glen Rose.

Also in 1967, in two separate works, Fisher and Rodda (1967a, b) examined the Edwards Limestone and the Lower Cretaceous sands of Texas. They divided the Edwards Formation into three facies, designated the Kirschberg lagoon for the limited area of evaporite occurrence, and described two types of dolomite present in this formation, stratal dolomite and massive dolomite. In their study of the Lower Cretaceous sands of north and central Texas they divided this area into four regions based on regional stratigraphic variations of the section from the basal Cretaceous sands up through the Paluxy Sand. They also analyzed the various sand units for their suitability for industrial use.

Robert Font (1967) studied the basal Cretaceous sands in central Texas and determined the topography of the pre-Cretaceous paleoplain surface. In that same year Wayne M. Halbert described a dinosaur track site in the Paluxy River just downstream from Barker Branch. He measured, mapped, and photographed the tracks; and he analyzed the track dimensions as well as the stride length of the various trackways. In this way the presence of tracks made by at least three and possibly four different creatures was determined: tridactyl carnivore, tridactyl herbivore, sauropod, and a problematical four-toed track. At about the same time William Trippet and G. D. Howell also produced studies located within the type area of the Glen Rose Limestone in the Paluxy River basin. Trippet (1967) analyzed the stratigraphy of the pre-Thorp Springs Member (lower Glen Rose) of the Glen Rose Limestone and provided measured sections, cross sections, and a depositional history of this unit. Howell (1967) studied the relationship between the geomorphology and lithology of the Glen Rose Limestone within the Paluxy River basin.

Also in 1967, the Permian Basin Section of the Society of Economic Paleontologists and Mineralogists published a work dealing with the "Comanchean (Lower Cretaceous) Stratigraphy and Paleontology of Texas." In this work, Hayward and Brown (1967) provided a summary of the current knowledge of the stratigraphy and depositional history of the Comanchean rocks of central Texas. Also appearing in this work were R. W. Rodgers's master's thesis on the Glen Rose Limestone in central Texas and two articles by Keith Young. Young summarized knowledge of the Comanchean Series in south-central Texas in one article and provided ammonite zonations of the Comanchean in his second article (1967a, b).

C. H. Moore, Jr. (1967) studied the regional stratigraphic relationships and depositional history of the Edwards Limestone and related rock units in west central Texas. Paul Tasch (1967) concurred with the Albian age for the Paluxy Sand and reported the occurrence of conchostracans from this sand unit.

In 1968 four important works dealing with the Trinity Group appeared. These include works by P. A. Boone, J. D. Van Camp, L. G. Kessler II, and J. S. Nagle. In a detailed study of the basal Trinity sands of central Texas, Boone also provided a map and description of the pre-Cretaceous Wichita paleoplain in that area and stated the significance of this surface in affecting deposition of most of the Trinity Group sediments. Van Camp analyzed the Glen Rose Limestone/Paluxy Sand contact in central Texas and determined that the contact was conformable in both a gradational and interfingering nature. He also stated that any hiatus between the Trinity and Fredericksburg Groups had to occur within the Paluxy Sand due to its conformable contact with the Glen Rose. Nagle's intricately detailed analysis of the lower Glen Rose Limestone in the type area in the Paluxy River west of Glen Rose, Texas, pinpointed seven depositional cycles in this unit and provided correlations of some of the cycles. Kessler studied the palynology of the lower Glen Rose Limestone in Somervell County and determined depositional environments of the rocks based on palynomorph distribution.

Also in 1968, L. F. Laporte presented an analysis of some recent carbonate environments and their application to the geologic record.

In 1969 K. W. Davis presented a compendium of previous literature dealing with the Glen Rose Limestone up to that time. W. A. Trippet II (1969) studied the Bluff Dale Sand and its depositional history and concurred with Rodgers's (1965) interpretation of this sand as the clastic shoreward facies of the lower Glen Rose Limestone. Ronny Thomas (1969) presented a regional stratigraphic analysis of the Glen Rose Limestone in Hood, Somervell, and Erath Counties, providing descriptions, cross sections and a depositional history of the unit throughout this area. Fisher and Rodda (1969) provided a detailed study of the deposition and diagenesis of the Edwards Limestone in central Texas concentrating on the dolomitization of the unit. An analysis of the morphology, sequence, and diagnostic features of a modern carbonate tidal flat on Andros Island in the Bahamas was presented by E. A. Shinn, R. M. Lloyd, and R. N. Ginsburg in 1969.

In 1970 W. E. Swinton published *The Dinosaurs*, a comprehensive summary of the known data concerning these creatures at that time. In a section dealing with the sauropod dinosaurs he definitely placed them in an aquatic rather than terrestrial environment. He also described the paleoecology of other types of dinosaurs.

M. A. Moseller (1970) determined the stratigraphy and depositional history of the Comanchean rocks in the subsurface of east-central Texas along the Texas craton/East Texas basin transition. Also in 1970, the Baylor Geological Society published two guidebooks dealing with the Cretaceous rocks of central Texas. "Thee Guidebook" (1970a) was a two-day field trip guide through the North American section of the Cretaceous as exposed in central Texas. "The Lampasas Cut Plain" (1970b) dealt with the stratigraphy and geomorphology of the physiographic province for which the book was named.

In 1971 J. E. Aguayo studied the Glen Rose Limestone in north-central Texas in the vicinity of the type area near Glen Rose. He detailed the stratigraphy and depositional history of this unit, provided regional cross sections, and outlined the paleotopography of the area during deposition based on his stratigraphic analysis. In a related study to the south, Boyd V. Dreyer (1971) examined the stratigraphy and depositional history of the entire Trinity Group as it appeared in outcrop on the northeast side of the Llano Uplift in central Texas. He described the significance of the uplift in providing a paleohigh and local source for basal Cretaceous clastic units around the Llano region.

B. F. Perkins (1971) and Perkins and Stewart (1971) published two sections in a guidebook to the trace fossils of the Texas Cretaceous section. In these sections they summarized the occurrence of dinosaur tracks in Texas and presented maps, descriptions, and an analysis of tracks in the Paluxy River west of Glen Rose in the Glen Rose Limestone.

In a detailed work on the Trinity Group of south-central Texas, F. L. Stricklin, C. I. Smith, and F. E. Lozo (1971) described the stratigraphy of the basal Cretaceous units from the basal clastic units up through the Glen Rose Limestone. They provided regional cross sections showing the stratigraphic relationships of the various units of the Trinity Group.

R. T. Bakker (1971) stirred a great deal of controversy with his suggestion that sauropod dinosaurs were actually terrestrial creatures and not aquatic at all. He examined the physical features of these creatures and then argued for a lifestyle resembling that of elephants and giraffes.

Keith W. Davis continued his studies of the Glen Rose Limestone in north-central Texas with a report on the biostratigraphy of that unit in 1972. To the north of Davis's study area, W. A. Trippet II (1972) examined the paleoecology and depositional history of several serpulid worm reefs exposed in the lower Glen Rose Limestone along the Paluxy River near Barker and Bowden Branches.

The most comprehensive work dealing with the Edwards Limestone in south-cental and south Texas to date appeared in 1972. In it P. R. Rose described the surface and subsurface stratigraphy of the Edwards Limestone, proposed stratigraphic subdivisions and named them, and detailed the depositional history of this unit in its southern extent.

In an interesting study of several dinosaur track sites in North America, J. H. Ostrom (1972) statistically analyzed individual trackways and noted the improbably large occurrence of parallel to subparallel directions of travel. He interpreted these data as suggesting that at least some types of dinosaurs might have exhibited herding behavior.

Two important studies of depositional environments and paleontology appeared in 1972. In the first, B. F. Perkins and W. Jack Turney described the distribution of mollusks in Florida Bay and related this to environmental conditions that could potentially be applied to ancient rocks. In the second, J. Keith Rigby and Wm. Kenneth Hamblin edited a work for the Society of Economic Paleontologists and Mineralogists dealing with the recognition of ancient sedimentary environments. Relevant articles in this work include those by P. H. Heckel, J. D. Howard, F. J. Lucia, and H. E. Reineck. Heckel presented an analysis of distinctive sedimentary structures and paleontologic associations indicative of shallow marine environments. Howard described the use of trace fossils in recognizing shoreline deposits in the ancient rock record. Lucia provided a listing, description, and explanation of diagnostic features of evaporite/carbonate shorelines, and Reineck described the morphology and structures of modern clastic tidal flats.

In 1973 J. S. Bain explored the regional relationships of the Cretaceous/pre-Cretaceous contact in north-central Texas, and, most importantly, constructed a detailed map of the paleotopography of the pre-Cretaceous Wichita Paleoplain in that area.

In two related works in 1973, the Baylor Geological Society published a revision of its "Valley of the Giants" guidebook through the Paluxy River basin in Somervell County, and W. A. Trippet II completed work detailing the physical resources of Somervell County and including a geologic map of the county.

Two regional analyses of the Glen Rose Limestone appeared in 1973. James F. Burkholder and David N. Lumsden provided a detailed petrographic analysis of the Glen Rose in the subsurface of south Texas. In it they divided the formation into five different depositional facies, outlined the depositional history of the unit, and described its thickening off of the San Marcos platform into the ancient Maverick basin. C. A. Walker (1973) studied the stratigraphy of the Glen Rose Limestone in Coryell and Lampasas Counties in comparison with previous studies to the north and south, and described the environmental facies of the unit that appeared in his study area.

H. F. Nelson (1973) authored a guidebook exploring the reef-like nature of the Edwards Limestone and the inter-reef and associated sediments of this formation.

Three related works dealing with the Glen Rose Limestone in central Texas appeared in 1974. In the first, A. A. Brown described the occurrence of celestite in the Glen Rose Limestone in central Texas. He determined the complete absence of any primary celestite, all of it being secondary in origin replacing either anhydrite or dolomite in various forms. However, it is still intimately related to depositional parameters and only occurs in supratidal sabkha sediments. K. W. Davis described the stratigraphy and depositional environments of the Glen Rose Limestone in Hamilton and Comanche Counties in central Texas. He divided this unit into four depositional facies based on his outcrop studies, and, in a regional comparison of the Glen Rose to the north and south, he determined that the entire section of Glen Rose Limestone in the type area to the north probably correlated only to the upper Glen Rose Limestone in the south. Both Brown and Davis reported dinosaur tracks from the Glen Rose Limestone. G. D. Howell provided an environmental inventory of Hamilton County in which he constructed a detailed geologic map of the county.

R. W. Scott (1974) analyzed the depositional significance of Lower Cretaceous bay and shoreface benthic communities in Cretaceous rocks of New Mexico, Colorado, Oklahoma, and Kansas. He described the occurrence of five distinctive faunal associations characteristic of specific depositional environments.

In 1974 the Society of Economic Paleontologists and Mineralogists ran a field trip to the Trinity sediments of south-central Texas. In the guidebook the occurrence of dinosaur tracks in the Glen Rose Limestone along Hondo Creek was reported.

Geoscience and Man, v. 8 (School of Geoscience, Louisiana State University) was devoted to "Aspects of Trinity Division Geology in Texas." Articles of relevance to the present work which appeared in this issue include those by David L. Amsbury; Richard F. Inden; Wann Langston, Jr.; Bob F. Perkins; and F. L. Stricklin, Jr. and D. L. Amsbury. Amsbury discussed the stratigraphy and depositional history of the basal Cretaceous rocks below the Glen Rose Limestone on the San Marcos platform. Inden outlined a depositional model for a portion of the Trinity Group and described the relevant lithofacies in central Texas. Langston summarized the knowledge of nonmammalian Comanchean tetrapods. He provided a list and description of all significant dinosaur bone finds in Texas and the surrounding states and described the dinosaurs that they represented. He also discussed the occurrence of dinosaur tracks in Texas and described several of the trackways. Perkins discussed the paleoecology and depositional history of a rudist reef in the Glen Rose Limestone of Bandera County, Texas, and he described the occurrence of dinosaur tracks in the Glen Rose Limestone along Hondo Creek. Stricklin and Amsbury described a section of the middle portion of the Glen Rose Limestone south of the Llano Uplift. In it they recognized a shallow marine to supratidal sequence of sedimentary structures, and they reported the occurrence of dinosaur tracks associated with the supratidal facies.

Bobby H. Bammel (1975) studied the Thorp Springs Member of the Glen Rose Limestone in north-central Texas. He divided the unit into facies based mainly on faunal content and interpreted the depositional history of these rocks. Terry C. Jackson (1975) provided a physical inventory of Bosque County in which he mapped in detail the surface geology of the county. Mark Thomas Owen (1975) studied the Paluxy Sand in Erath, Hood, and Somervell Counties in north-central Texas. He described the stratigraphy and depositional history of the unit within these counties.

M. R. Gallup (1975) and M. R. Gallup and Wann Langston, Jr. (1975) summarized and described the remains of dinosaurs and associated vertebrates from north-central Texas in the collection of the Field Museum of Natural History.

S. A. Skinner and Charles Blome (1975) described dinosaur tracks that had been exposed during excavation of the nuclear reactor crater at the Comanche Peak Nuclear Power Plant in Somervell County, Texas. They stated that all tracks were of the tridactyl carnivore *Acrocanthosaurus* and briefly described the geologic section exposed within the crater. They did not determine in which specific member of the Glen Rose Limestone these tracks occurred, and the site is now covered by the nuclear reactor making future study impossible.

W. A. S. Sarjeant (1975) explained the methods of formation and preservation of vertebrate trace fossils and described the appropriate field methods for examining and collecting data on such.

In 1976 J. C. Brothers examined the marginal Glen Rose Limestone in north-central Texas and determined the stratigraphy and depositional environments represented by these rocks. Sidarous (1976) correlated the works of Walker (1973) and Davis (1974) dealing with the Glen Rose Limestone in Comanche, Coryell, Lampasas, and Hamilton Counties, Texas.

Rebecca Narramore (1976) studied five track sites in Coryell, Hamilton, and Somervell Counties, all in rocks of the Glen Rose Limestone. She described the morphology of the tracks, their subaqueous environment of deposition, and remarked upon the lack of tail drag marks in every case.

Richard Hazelwood (1977) mapped and described the Wichita Paleoplain in central Texas. He described the sequence of events that led to the formation of the erosional surface as well as the initial Cretaceous deposition, and showed the influence of the Llano Uplift on the local areas of the paleoplain.

R. W. Scott (1977) described several paleocommunities from the Lower Cretaceous of the western interior and explored their use as depositional environment indicators.

Charles A. Caughey (1977) examined the Paluxy Sand in northeast Texas in terms of its economic resources—oil, gas, and groundwater. He also detailed the stratigraphy and depositional environments represented by this sand unit.

The morphology and recharge potential of playa lakes in the Edwards Plateau region of Texas was investigated by James Roy Pool (1977).

In 1977 H. G. Multer published a revision of his guide to the carbonate rock environments of Florida and the Bahamas. In it he described the occurrence of serpulid reefs of varying morphologies off the east coast of Florida in the intertidal to shallow subtidal zone.

Also in 1977, D. G. Bebout and R. G. Loucks edited the Texas Bureau of Economic Geology report "Cretaceous Carbonates of Texas and Mexico—Applications to Subsurface Exploration." Articles of relevance in this work include those by D. G. Bebout and R. A. Schatzinger; Edward McFarlin, Jr.; T. A. Bay, Jr.; C. A. Achauer; T. J. Petta; A. W. Cleaves; R. W. Scott and E. J. Kidson; and A. D. Jacka. Bebout and Schatzinger presented regional cross sections of the Cretaceous section in south Texas. McFarlin explored the correlation between the transgressive/regressive cycles in the strata of the Gulf Coast and eustatic sea level changes. Bay described the stratigraphy of the Trinity and Fredericksburg Groups in Texas and Mexico, proposed carbonate depositional models to fit each unit, and described the depositional history of the respective units. Achauer described the facies and diagenesis of a Glen Rose patch reef with the dominant diagenetic processes being subaerial exposure and freshwater diagenesis shortly after deposition. Petta (1977) described the diagenetic sequence of events that occurred in a Glen Rose rudist patch reef complex in Bandera County in detail. Diagenetic processes occurred in three phases: (1) marine connate water dissolution; (2) early freshwater dissolution; and (3) late freshwater precipitation of cements. Cleaves (1977) described and mapped a facies mosaic of the middle Glen Rose Limestone in Blanco and Hays Counties. Near the Llano Uplift the sequence is dominated by repetitive cycles of subtidal to supratidal deposition, while away from the uplift the rocks reflect mostly subtidal deposition. Scott and Kidson (1977) analyzed the depositional systems represented by rocks of the Trinity and Fredericksburg Groups in west Texas. Jacka (1977) provided a description of the subtidal to supratidal facies cycles of deposition seen in the Fort Terrett Formation of the Edwards Group near the town of Junction, Texas. He also described in intricate detail the processes of diagenetic alteration that the rock unit had undergone, concentrating on the formation of porosity.

In a guidebook to portions of the lower Cretaceous of central Texas, R. G. Loucks and others (1978) described outcrops of the Glen Rose Limestone and the Walnut Clay and presented depositional interpretations of these rocks as tidal facies.

In 1978 Sam F. Harrill described and mapped the paleogeomorphology of the Wichita Paleoplain in the subsurface of Hamilton County. His findings were at variance with nearby surface studies of the paleoplain.

Paul Marchand and S. A. Wood both presented studies of the Twin Mountains Sand in 1978. Marchand described the depositional systems of the sand, which ranged from fluvial sands to delta muds and clays to foreshore sands. Wood described the contact of the Twin Mountains Sand and the Glen Rose Limestone as being conformably interfingering.

The Baylor Geological Society published "The Paluxy Basin" field trip guidebook in 1978. This guidebook was an extensive revision of the former "Valley of the Giants" guidebook. It retained many of the former stops, but the dinosaur track locality was moved to Dinosaur Valley State Park.

R. C. Selley (1978) presented an analysis of ancient sedimentary environments and their recognition in the geological rock record.

In 1979 the Baylor Geological Society published a guidebook for the Southwestern Association of Student Geological Societies annual field trip. This guidebook demonstrated the unconformable nature of the Cretaceous/pre-Cretaceous contact and explained how it had formed. That same year C. D. Givhan completed an in-depth study of the paleotopography and paleogeology of the Wichita Paleoplain surface in central Texas.

M. T. Owen expanded his study of the Paluxy Sand begun in 1975, and in 1979 this expanded work was published as a Baylor Geological Studies Bulletin. In this work he divided the Paluxy Sand into three members and detailed the depositional histories they represented from shallow subtidal to supratidal environments. He also identified a regional exposure surface within the Paluxy Sand.

B. F. Perkins and Wann Langston, Jr. published a guidebook for the 12th Annual Meeting Fieldtrip of the American Association of Stratigraphic Palynologists in 1979. This guidebook consisted of two parts dealing with different aspects of the Glen Rose Limestone in the type area along the Paluxy River near Glen Rose, Texas. The first part, by Perkins, described the various types of fauna and flora found in the lower Glen Rose Limestone at four localities. The second part, by Langston, consisted of an analysis of the dinosaur tracks found in the lower Glen Rose Limestone. It illustrated the types of tracks found, the dinosaurs that made them, and the depositional environments they represented. Also in 1979, Alan Charig published a book investigating dinosaurs in the light of all the new data, some of which had suggested that some dinosaurs might have been warm-blooded.

In 1980 R. Jay Parker described the geomorphic processes that had evolved the characteristic landscapes of the Glen Rose prairie in north-central Texas. He showed the intimate relationship between lithology and geomorphology in this area.

Morris (1980) presented a fairly detailed listing of reported track sites along the Paluxy River in the lower Glen Rose Limestone west of the town of Glen Rose, Texas.

Two analyses of modern depositional environments which proved relevant to this study are those by Morton and McGowen (1980) and Reineck and Singh (1980). Morton and McGowen studied the various depositional environments represented on the Texas coast, and Reineck and Singh comprehensively described clastic depositional sedimentary environments.

Martin Shields (1981) studied the fauna of the Glen Rose Limestone in the type area and identified several paleocommunities representing various depositional environments.

J. O. Farlow (1981) examined a series of dinosaur tracks exposed in the Fort Terrett Formation of the Edwards Group just west of the town of Junction, Texas. Using the measured sizes, strides, and paces of the tracks, Farlow estimated speeds for these dinosaurs ranging from 1.8 to 11.9 meters per second.

In the same year Halstead and Halstead (1981) and Stout, Preiss, and Service (1981) presented comprehensive reviews of the dinosaurs and their life habits. The latter work is highly imaginative in style.

Brian D. Anderson (1982) examined the various facies of the Trinity Group of central Texas in a study of the variations occurring along the margin of the craton and basin. Corwin (1982) provided a detailed study of the stratigraphy of the Fredericksburg Group north of the Colorado River in Texas. She summarized and centralized the data for each member of the group and then correlated the various proposed depositional systems to provide a regional synthesis of the depositional history of the Fredericksburg Group. Watson (1982) studied the relationship between geology and geomorphology in the Edwards Plateau region of Texas. She summarized the stratigraphy of the area, divided the region into several areas based on the nature and extent of dissection that had taken place, and then proposed a detailed sequence of formation of the present Edwards Plateau.

A. R. Bay (1982) identified three cycles of shoal-water complexes in the Glen Rose Limestone in the subsurface on the Pearsall arch. He identified three major depositional facies within each cycle: (1) open marine shelf, (2) shoal-water complex, and (3) protected lagoon.

R. H. Sams (1982) published a brief article dealing with newly discovered dinosaur tracks in Comal County, Texas. He identified more than 200 tracks in this preliminary report. These tracks were located in the Glen Rose Limestone.

David Lambert produced a popular book dealing with the subject of dinosaurs in 1982. This work dealt with all types of dinosaurs generally, and though it did not mention the specific species of dinosaurs identified in the present study, it still proved useful for general information.

Peter A. Scholle and Darwin Spearing edited a compilation of works dealing with sandstone depositional environments for the American Association of Petroleum Geologists in 1982. Relevant articles include: Clifton, who provided a summary of estuarine deposits; Coleman and

Prior, who summarized the various types of deltaic deposits; and Weimer, Howard and Lindsay, who described the depositional processes active in clastic tidal flat settings.

J. Michael Hawthorne (1983) detailed the stratigraphy and depositional environments of the dinosaur tracks present in the lower Glen Rose Limestone in the type area along the Paluxy River near the town of Glen Rose, Texas. He identified several track-bearing layers and demonstrated their stratigraphic relationships. He also provided a summary of the types of tracks found in Texas, and the dinosaurs interpreted to have made them.

Also in 1983, a field trip guidebook by the Baylor Geological Society detailed the geologic section of Cretaceous rocks found in central Texas.

A compendium of carbonate depositional environments, edited by Peter A. Scholle, Don G. Bebout, and Clyde H. Moore, was published by the American Association of Petroleum Geologists in 1983. Relevant articles include: a description of carbonate deposition in the beach environment by Richard F. Inden and Clyde H. Moore; an analysis of carbonate deposition in reefal environments by Noel P. James; and a detailed outline of carbonate tidal flat environments by Eugene A. Shinn.

In 1984 Martin Shields completed a regional study of the Glen Rose Limestone in its surface and subsurface occurrence. He provided descriptions of the stratigraphy, deposition, and diagenesis of the Glen Rose as well as numerous dip and strike cross sections.

Jeffrey G. Pittman (1984) described the geology of the Dequeen Formation of Arkansas, which is equivalent to the Glen Rose Limestone of Texas. He reported great numbers of dinosaur tracks within the Dequeen unit, as well as the presence of large amounts of evaporites. Interpreted environments ranged from subtidal to supratidal.

In 1985 Jeffrey G. Pittman presented a talk to the South-Central Section of the Geological Society of America that dealt with a new trackway of sauropod dinosaur tracks that he had located, mapped, measured, and photographed from the Dequeen Formation of Arkansas.

In 1985 R. T. Bird's memoirs were published posthumously. His description of a lifetime of hunting fossils included accounts of his work with the dinosaur tracks in Texas.

In 1986 the First International Symposium on Dinosaur Tracks and Traces was held in Albuquerque, New Mexico. Relevant abstracted papers include Farlow, Hawthorne, and Langston (1986); Kuban (1986 a, b); Langston (1986); and Pittman (1986). Farlow, Hawthorne, and Langston discussed the stratigraphy, depositional significance and behavioral and locomotive significance of Texas dinosaur tracks. Langston described "ghost track" impressions formed in lower sediments as dinosaurs trod upon overlying sediments. The other papers were published in *Dinosaur Tracks and Traces* (Gillette and Lockley, 1989) and are summarized below.

J. O. Farlow (1987) published a guidebook to the dinosaur tracks in and along the Paluxy River near Glen Rose, Texas, which includes a brief history of the tracks and their geologic and paleontologic significance.

Numerous papers presented at the First International Symposium on Dinosaur Tracks and Traces in 1986 were published together as *Dinosaur Tracks and Traces* (Gillette and Lockley, 1989). Relevant papers include Farlow, Pittman, and Hawthorne (1989); Kuban (1989 a, b); Pittman (1989); and Pittman and Gillette (1989). Farlow, Pittman, and Hawthorne provided a detailed study of the sauropod tracks in Texas and the surrounding states. Kuban summarized his work with elongated dinosaur tracks in the type area Glen Rose Limestone of Texas and also discussed the significance of unusual weathering colorations associated with these same tracks. Pittman outlined his stratigraphic correlations of dinosaur track-bearing strata in Texas and Arkansas, and Pittman and Gillette described an extensive sauropod trackway from the Dequeen Formation of Arkansas.

APPENDIX II

DESCRIPTIVE GEOLOGY OF TRACK SITES

McFALL SITE

Unit *Description*

9. TRACK LAYER. Calcarenite, miliolid-ostracode-bivalve packstone; echinoderm fragments, gastropods and algal grains also present; very resistant, hard limestone which is shaley at base, ferroan calcite.
8. Calcareous shale.
7. TRACK LAYER. Calcarenite, slightly sandy ostracode-bivalve packstone at the top overlying interbedded sandy limestones of similar character and shales; abundant ripplemarks, ferroan calcite.
6. Gray blocky shale.
5. Calcarenite/calcirudite, slightly sandy bivalve-miliolid-ostracode packstone; serpulids, echinoderm fragments and gastropods also present, bioturbated, ferroan calcite.
4. Shale.
3. Calcarenite, silty/sandy *Ophiomorpha*-bivalve-ostracode-miliolid packstone; bivalves, ostracodes, foraminifers, serpulids and algal fragments also present, *Ophiomorpha* filled with orange silty clay.
2. Silty/sandy gray green shale.
1. Nodular limestone (dolomite?).

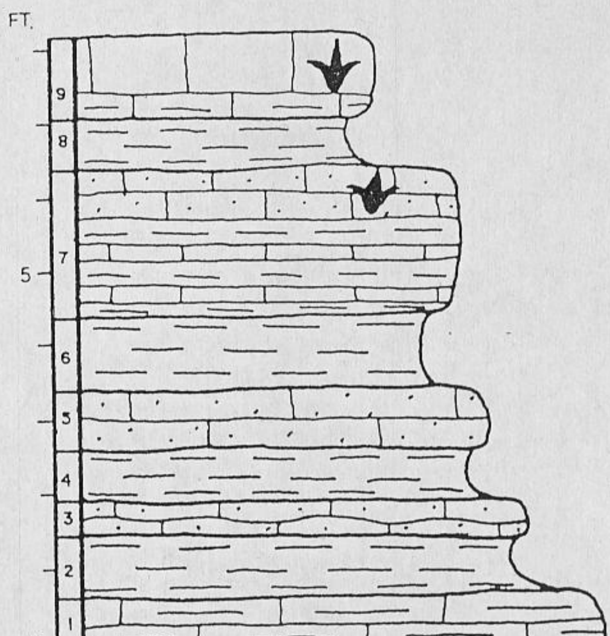


Fig. 44. McFall site measured section. Note that tracks occur in two layers at this site. This is the only site where tracks occur in the resistant bed marker horizon (upper track layer).

PARK CROSSING SITE

Unit *Description*

12. Intermixed and interbedded sand, shale and sandy shale
11. Calcarenite, sandy *Ophiomorpha* lime mudstone; burrows filled with orange silty clay are common but poorly preserved, ferroan calcite.
10. Sandy shale.
9. Calcarenite, sandy bivalve-ostracode wackestone; *Ophiomorpha* common, burrows filled with orange silty clay, ferroan calcite.
8. Slightly sandy gray green shale with calcareous resistant section near the middle, bivalves in resistant section, carbonized plant stems in 3" shale below resistant section, horizontal burrows in lowest portion.
7. "Double Bed", Calcarenite/calcirudite, *Ophiomorpha*-bivalve wackestone; ostracodes, miliolids and gastropods also present, burrow fill is ferroan dolomite cemented orange silty clay, matrix is ferroan calcite.
6. "Steinkern Marl", Calcareous sandy shale with abundant steinkerns of diverse bivalves and gastropods, Porocystis, serpulids, horizontal burrows.
5. Calcarenite/calcirudite, sandy algal-mollusk-ostracode-echinoderm packstone; hardground, oysters encrusting upper surface, borings abundant, bore fill ferroan dolomite, matrix ferroan calcite, oyster shells calcite, fauna dominated by bivalves.
4. Blue gray sandy shale, serpulids, fossilized wood, agglutinated foraminifera rare.
3. TRACK LAYER. Calcarenite, very sandy homogeneous dolomudstone; rare pyrite, ferroan dolomite.
2. Sandy shale, ostracodes, agglutinated foraminifera rare, wood fragments, vertebrate bone fragments.
1. Fine to medium sand grading up to silt, ostracodes, rare agglutinated foraminifera, wood fragments, vertebrate bone fragments.

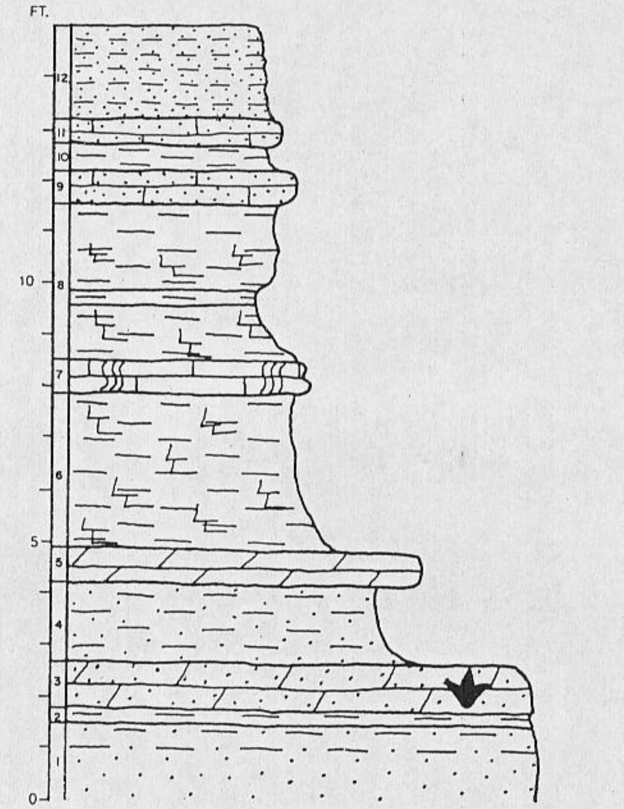


Fig. 45. Park Crossing site measured section. This outcrop exposes the five bed marker sequence used for stratigraphic control in the Paluxy basin. The tracks are in the lowest bed of this sequence, the main track layer.

PARK CLIFF SITE

Unit *Description*

9. Calcarenite, sandy bivalve-ostracode wackestone; *Ophiomorpha* common, burrows filled with orange silty clay.
8. Slightly sandy gray green shale with calcareous resistant section near the middle, bivalves in resistant section, carbonized plant stems in thin shale directly below resistant section, horizontal burrows in lowest portion.
7. "Double Bed", Calcarenite/calcirudite, *Ophiomorpha*-bivalve wackestone; ostracodes, miliolids and gastropods also present, burrow fill is ferroan dolomite cemented orange silty clay, matrix is ferroan calcite.
6. "Steinkern Marl", Calcareous sandy shale with abundant steinkerns of diverse bivalves and gastropods, Porocystis, serpulids, horizontal burrows, echinoderm fragments.
5. "Hardground", Calcarenite/calcirudite, sandy algal-mollusk-ostracode-echinoderm packstone; oysters encrusting upper surface, boring abundant, bore fill is ferroan dolomite, matrix is ferroan calcite, oysters are calcite.
4. Blue gray sandy shale, serpulids, wood fragments, rare agglutinated foraminifera.
3. TRACK LAYER. Calcarenite, sandy homogeneous dolomudstone; rare pyrite, ferroan dolomite.
2. Sandy shale, ostracodes, rare agglutinated foraminifera, wood fragments, vertebrate bone fragments.
1. Fine to medium sand grading up to silt, ostracodes, wood fragments, vertebrate bone fragments.

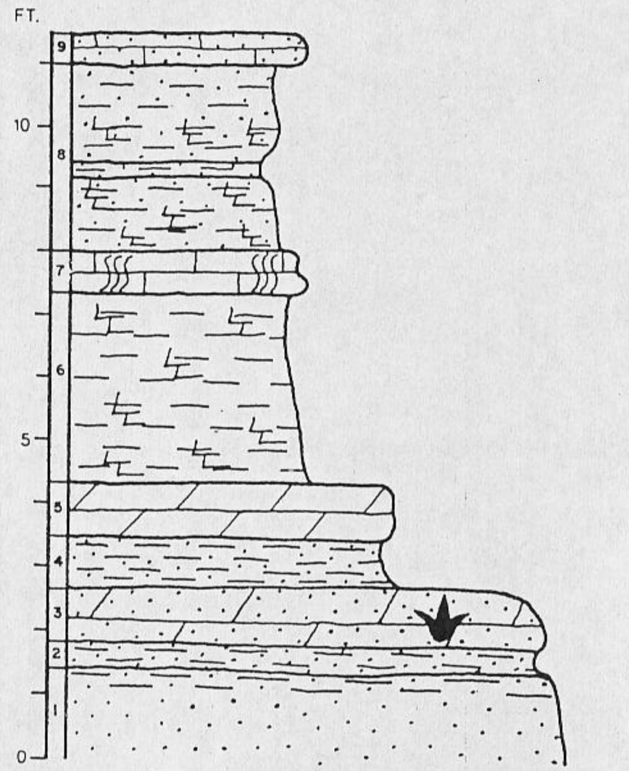


Fig. 46. Park Cliff site measured section. This section exposes the five-bed marker sequence used to maintain stratigraphic control in the Paluxy basin. Tracks occur in the lowest of these five beds, the main track layer.

BOWDEN BRANCH SITE

Unit — *Description*

9. Dolomitic (?) nodular limestone at base grading up to fine silty limestone (dolomitic?). Abundant large serpulid reefs on upper surface, carbonized wood fragments, isolated serpulids, rare bivalve steinkerns.
8. Gray green shale with occasional marl stringers.
7. "Double Bed", Calcarenite/calcirudite, *Ophiomorpha*-bivalve packstone; ostracodes, miliolids and gastropods also present, small serpulid reef on upper surface, burrow fill is ferroan dolomite cemented orange silty clay, matrix is ferroan calcite.
6. "Steinkern Marl", Nodular limestone with abundant steinkerns of diverse bivalves and gastropods, Porocystis, serpulids, echinoderm fragments, horizontal burrows.
5. "Hardground", Calcarenite/calcirudite, sandy algal-mollusk-ostracode packstone; oysters encrusting upper surface, abundant borings, laterally discontinuous as it thickens and thins, bore fill is ferroan dolomite, matrix ferroan calcite, oyster shells calcite, slightly cross-bedded.
4. Gray green shale.
3. TRACK LAYER. Calcarenite sandy dolomudstone; rare bivalves and serpulids, bored on upper surface, weathers into 3 units with tracks in upper unit, ferroan dolomite.
2. Gray green shale.
1. Fine-grained sand and silt.

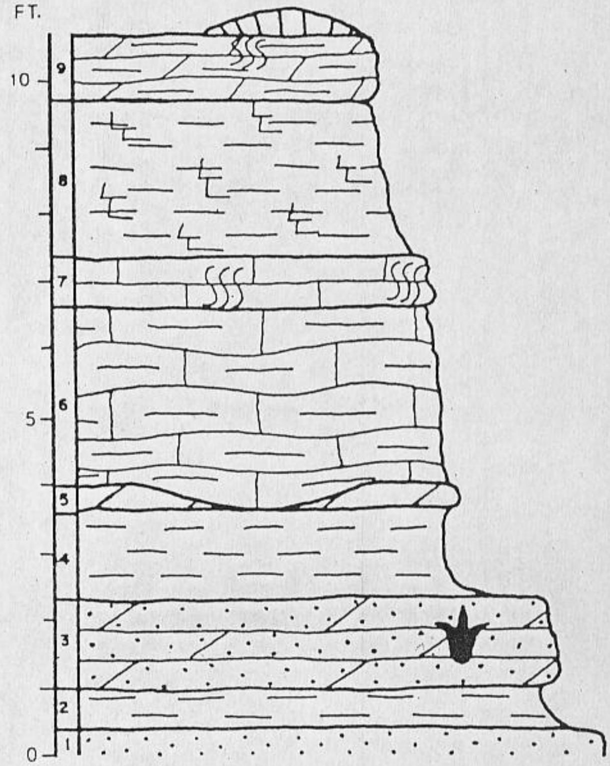


Fig. 47. Bowden Branch site measured section. The measured section for this site exposes the farthest downstream occurrence of the five-bed marker horizon in the Paluxy basin. Tracks occur in the main track layer. Abundant serpulid reefs occur at this site.

HALBERT (LANCASTER RANCH) SITE

Unit — *Description*

13. Bioturbated sandy mudstone, serpulids.
12. Calcareous shale.
11. Calcarenite, sandy miliolid-bivalve-ostracode packstone; gastropods, algae, echinoderm, and brachiopod fragments also present, shale partings at base, some burrow mottling, ferroan calcite.
10. Alternating calcareous shale and marly limestone in 3 tiered layers.
9. Calcarenite, well-sorted ostracode-miliolid-grainstone, coated grains abundant, bivalves also present, ferroan calcite with minor ferroan dolomite.
8. Shale.
7. Calcarenite, very sandy ostracode packstone; bivalves, algae and miliolids also present, ferron calcite.
6. Calcareous shale.
5. Calcarenite, slightly sandy ostracode-miliolid packstone; bivalves, gastropods, algae, echinoderm fragments, blackened organics and brachiopod fragments also present, wispy clay laminae, ferroan calcite.
4. Calcareous shale.
3. Calcarenite, very sandy miliolid-ostracode dolowackestone; bivalves also present, burrowed, calcite areas intermixed with ferroan dolomite areas, sand is fine to very fine grained.
2. Calcarenite, locally silty to sandy miliolid-ostracode-brachiopod packstone; bivalves, gastropods, algal plates, echinoderm fragments, organics and brachiopod spines also present, *Ophiomorpha* filled with ferroan dolomite cemented silt to fine sand and clay, all fossils except miliolids and brachiopod spines replaced by rhombic ferroan dolomite, matrix ferroan calcite.
1. TRACK LAYER. Calcilutite, silty to sandy ostracode-oyster laminated mud/wackestone at base to calcarenite, silty to sandy molluscan wackestone at top; algal laminations associated with dinosaur tracks which occur in the middle of this unit, laminations are interbedded calcite and ferroan dolomite, burrows filled with ferroan dolomite cemented silt and sand, blackened organics abundant, rare foraminifera, ferroan dolomite with minor ferroan and nonferroan calcite.

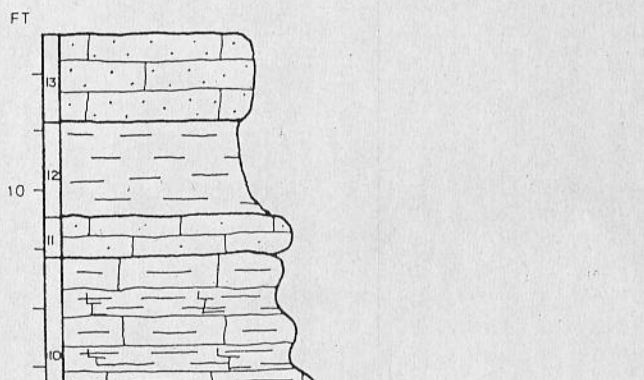


Fig. 48. Halbert's (LR) site measured section. This section is best exposed either upstream at Barker's Branch or downstream at the road crossing of the Paluxy River. Tracks occur in the same layer which contains serpulid reefs upstream.

COMANCHE PEAK NUCLEAR POWER PLANT SITE

The Comanche Peak Nuclear Power Plant site is located within the reactor cavity. Because this site has been covered by construction of the reactor, the data from this site are derived from literature and not from field observation.

During excavation of the reactor cavity, an excellent exposure of three trackways of tridactyl tracks were exposed. These tracks were excellently preserved and exhibited a morphology characteristic of tridactyl carnivore tracks. Several of these tracks were removed at the time, and one was presented to the Somervell County Museum.

The outcrop of Glen Rose Limestone in the walls of the reactor cavity was measured and described by Skinner and Blome (1975). Analysis of the measured section provided by these authors indicates that all three members of the Glen Rose Limestone were found in the cavity walls. The tracks apparently occurred in limestone of the middle Glen Rose, or Thorp Springs Member of the Glen Rose Limestone.

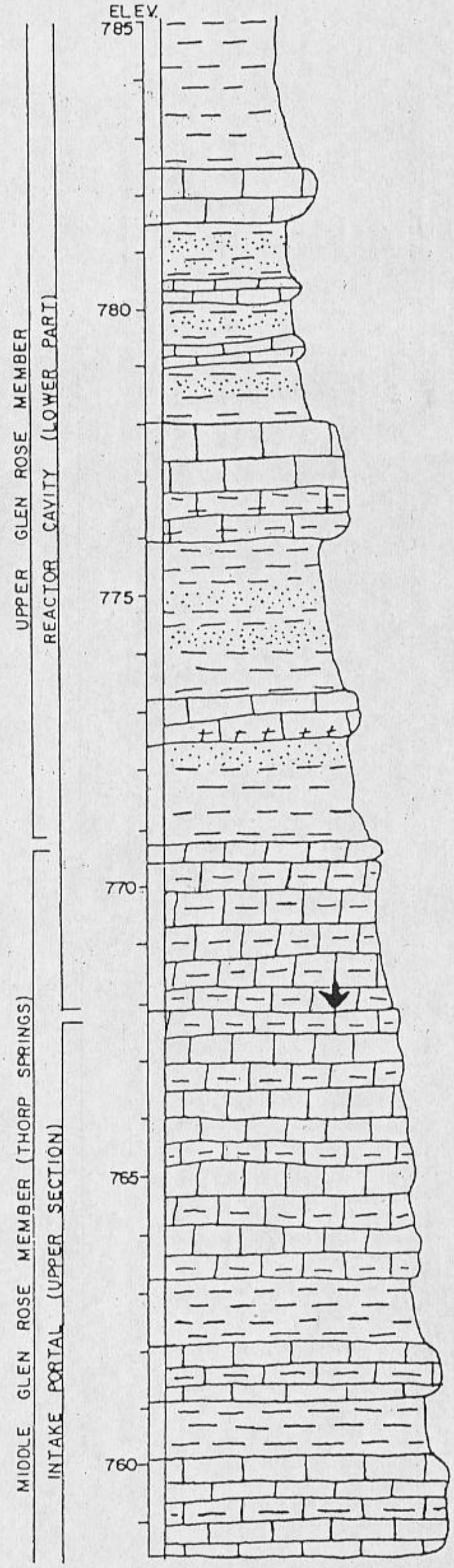


Fig. 49. Comanche Peak Power Plant site measured section. This section is a portion of the total section exposed in the excavations during construction. Tracks appear to occur in the Thorp Springs Member of the Glen Rose Limestone (section by Mason, Johnston and Associates, Inc., 1975).

MAYAN DUDE RANCH SITE

'nit *Description*

4. Calcarenite, molluscan flaggy mudstone at base grading up to nodular limestone and topped by calcarenite, molluscan mudstone; calcite, horizontal burrows.
3. Calcarenite, bivalve-echinoderm-serpulid wackestone; miliolids also present, highly dissolutioned, many molds, galleried burrows (?) or dissolution features (?), pyrite, calcite.
2. Calcirudite, rudistid packstone to calcarenite, bivalve wackestone; highly dissolved—many molds, rudists locallized possibly in mound, extensive borings on upper surface, rare echinoderms and serpulids also present, pyrite.
1. TRACK LAYER. Calcarenite, bivalve-echinoderm-serpulid wackestone; miliolids also present, top half characterized by abundant galleried burrows while bottom half is completely bioturbated, highly dissolved—many molds, pyrite.

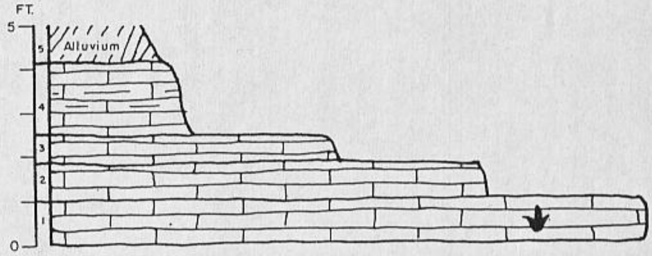


Fig. 50. Mayan Dude Ranch site measured section. Section is from the lower Glen Rose Limestone and tracks occur in a pure limestone underlying apparent rudistid reef deposits.

HONDO CREEK SITE

'Jnit *Description*

10. Calcarenite, steinkern packstone; mollusk steinkerns, bivalves, orbitolinids, miliolids, possible echinoderm fragments, steinkern mudlumps contain smaller shells, massive resistant layer, upper surface bored and oyster encrusted, *Ophiomorpha* burrows, calcite.
9. Calcarenite, ostracode-miliolid-echinoderm-bivalve mud/wackestone; possible faint cross beds, massive resistant bed, calcite.
8. Calcarenite/calcirudite, bivalve-gastropod-serpulid-echinoderm-orbitolinid wackestone; rudists in central portion of bed, serpulids as colonies encrusting other clasts and as isolated tubes, orange silty clay in lower 6" gives shaley character, calcite.
7. Calcarenite, echinoderm-bivalve-miliolid-ostracode wacke/packstone; extremely resistant extensively burrowed layer, burrows are open, calcite.
6. Calcarenite/calcirudite, bivalve-gastropod-miliolid-ostracode packstone; echinoderm fragments and rare algae also present, nodular appearance but resistant, calcite.
5. Orange silty clay.
4. Calcarenite/calcirudite, gastropod-bivalve-miliolid-orbitolinid wacke/packstone; echinoderm fragments and algae also present, sulfurous smell when struck with hammer, horizontal burrows, calcite.
3. Calcarenite, silty bivalve (monopleurids)-echinoderm-ostracode-miliolid wackestone; monopleurids in erect living position, horizontal burrows, calcite.
2. TRACK LAYER. Calcilutite, argillaceous dolomudstone, monopleurids present, upper surface highly bioturbated—vertical burrows and horizontal worm trails, dolomite.
1. Calcilutite dolomudstone.

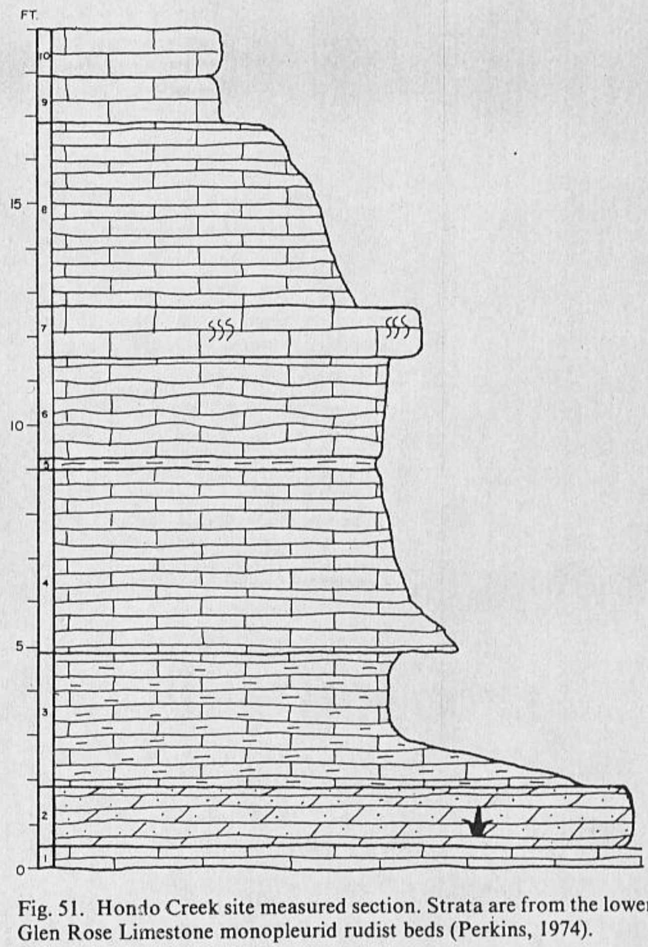


Fig. 51. Hondo Creek site measured section. Strata are from the lower Glen Rose Limestone monopleurid rudist beds (Perkins, 1974).

DAVENPORT RANCH SITE

Unit *Description*

9. Calcilutite, nonferroan sucrosic dolomudstone; massive.
8. Calcilutite, nonferroan sucrosic dolomudstone; massive, minor gypsum, extremely rare molds of ostracodes and bivalves.
7. Shale, mudcracks.
6. TRACK LAYER. Calcilutite, nonferroan sucrosic dolomudstone; massive.
5. Minor TRACKS, Calcilutite, nonferroan sucrosic dolomudstone; massive, minor bioturbation.
4. Calcilutite, nonferroan sucrosic dolomudstone; massive, minor bioturbation.
3. Calcareous shale.
2. Calcilutite, nonferroan sucrosic dolomudstone; massive, possible burrow.
1. Calcareous clay, total thickness unknown.

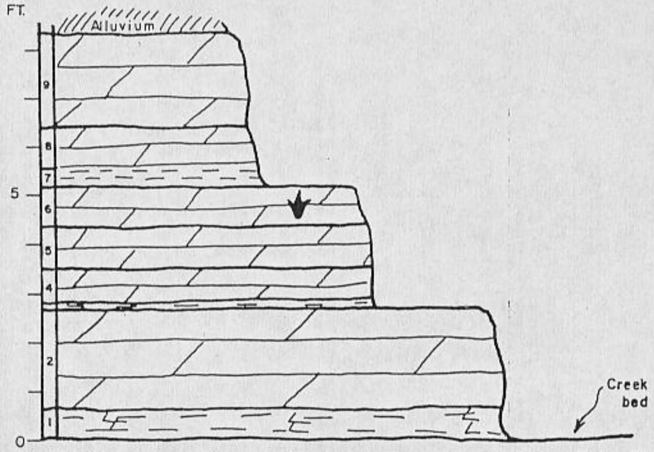


Fig. 52. Davenport Ranch site measured section. Entire section is upper Glen Rose Limestone, essentially featureless, massive dolomudstones.

DINOSAUR FLATS SITE

Unit *Description*

9. Nodular limestone, unknown thickness
8. Calcarenite, bivalve-miliolid pack/grainstone; alternating thin resistant limestones and marly limestones, calcite, rare laminations.
7. Calcarenite, miliolid-bivalve packstone; ostracodes present, nodular limestone at base with increasing shaley character upwards, calcite.
6. Marly limestone, abundant steinkerns of bivalves and gastropods, calcite.
5. TRACK LAYER. Calcarenite, miliolid-ostracode-oyster wacke/packstone; rare bivalves and foraminifera present, oyster mound approximately 8-10 feet in diameter, worm trails on upper surface, calcite.
4. Calcirudite/calcarenite, bivalve-miliolid-ostracode wacke/packstone; calcite.
3. Calcarenite, miliolid-ostracode-biserial foraminifera packstone; calcite, highly bioturbated.
2. Calcarenite, miliolid packstone; rare bivalves present, calcite, minor bioturbation.
1. Calcarenite, miliolid-bivalve packstone; rare foraminifera, ostracodes, gastropods, and echinoderms present, calcite.

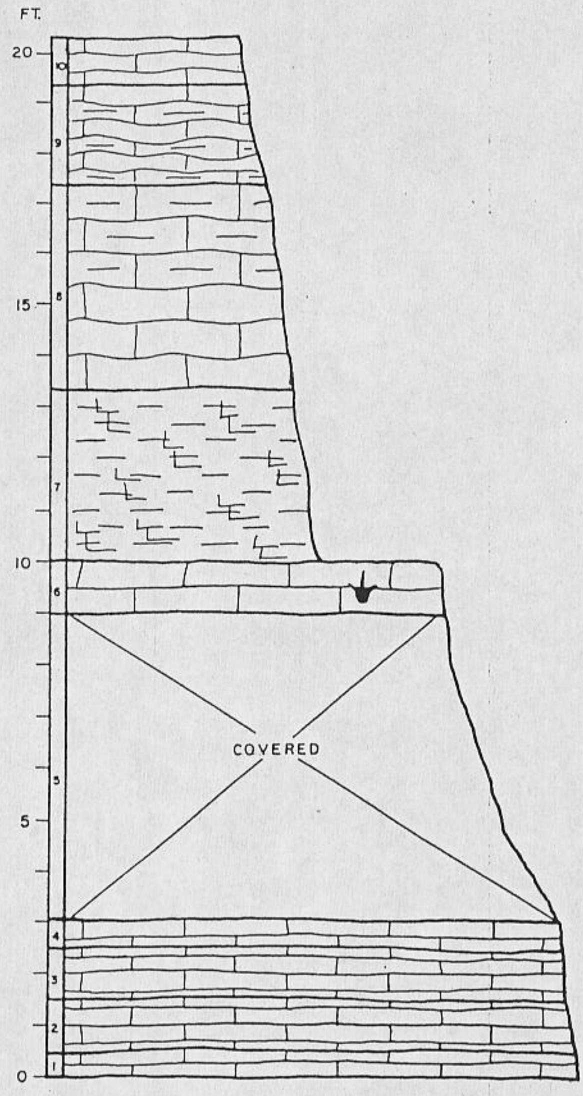


Fig. 53. Dinosaur Flats site measured section. Entire section is upper Glen Rose Limestone. Abundant poorly preserved tridactyl tracks occur in a fossiliferous limestone layer along with several oyster mounds.

DOW SITE

Unit *Description*

2. White caliche profile.
1. TRACK LAYER. Sandstone; very fine to fine-grained, calcite cement with minor ferroan dolomite, well sorted, quartz arenite, bioturbated, well-preserved deeply impressed dinosaur tracks.

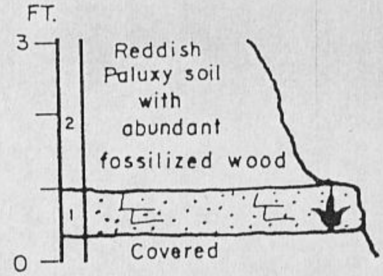


Fig. 54. Dow site measured section. The track-bearing sand layer occurs underneath reddish, fossilized wood-filled Paluxy soils on one side of the wash, and under a well-developed caliche horizon on the other side. This caliche horizon marks the top of the Georges Creek Member in which the tracks occur.

ISING SITE

Unit *Description*

4. TRACK LAYER. Siltstone/Sandstone; silt to very fine sand, ferroan dolomite cemented very well-sorted quartz arenite.
3. Ferroan dolomite cemented silty sandy clay.
2. Siltstone/Sandstone; silt to very fine sand, ferroan dolomite cemented very well-sorted quartz arenite.
1. Ferroan dolomite cemented silty sandy clay.

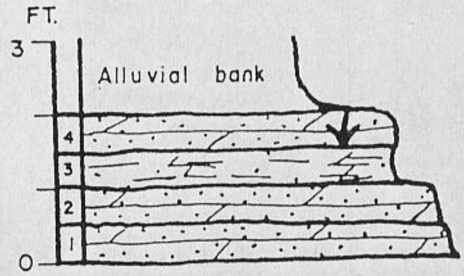


Fig. 55. Ising site measured section. Tracks occur in calcareous, fine-grained sands of the Paluxy Sand. Due to the southern pinchout and coalescence of the Paluxy Sand Members, these strata could not be assigned to a specific member.

NICHOLS SITE

Unit *Description*

11. Calcarenite, silty ostracode-foraminifera-bivalve packstone; horizontal burrows, ferroan calcite.
10. Calcareous shale.
9. Calcarenite/calcirudite, silty shaley bivalve-ostracode-foraminifera wackestone; horizontal burrows filled with calcite cemented silt to very fine sand, ferroan calcite.
8. Calcarenite/calcirudite, silty sandy bivalve-ostracode wacke/packstone; laminated at base, foraminifera also present, horizontal burrows filled with calcite cemented silt to very fine sand, ferroan calcite.
7. Calcarenite, silty-sandy ostracode-foraminifera wackestone; bivalves also present, steinkerns, burrows filled with ferroan dolomite cemented silt to very fine sand, ferroan calcite.
6. Calcarenite, ostracode-echinoderm-bivalve packstone; abundant orange silty clay filled *Ophiomorpha*, ferroan calcite.
5. Ferroan calcite cemented orange silty clay.
4. Calcarenite, miliolid-ostracode-echinoderm packstone; foraminifera, bivalves, gastropods and algae also present, very resistant, ferroan calcite.
3. Siltstone/Sandstone; silt to very fine sand, calcite and dolomite cemented, very well-sorted quartz arenite, ostracodes and rare bivalves, burrows, ferroan dolomite and calcite.
2. TRACK LAYER. Siltstone/Sandstone; silt to very fine sand, ferroan dolomite cemented very well-sorted quartz arenite, rare ostracodes and foraminifera, bioturbated.
1. TRACK LAYER. Siltstone/Standstone; silt to very fine sand, ferroan dolomite cemented very well-sorted quartz arenite, rare ostracodes and foraminifera, bioturbated.

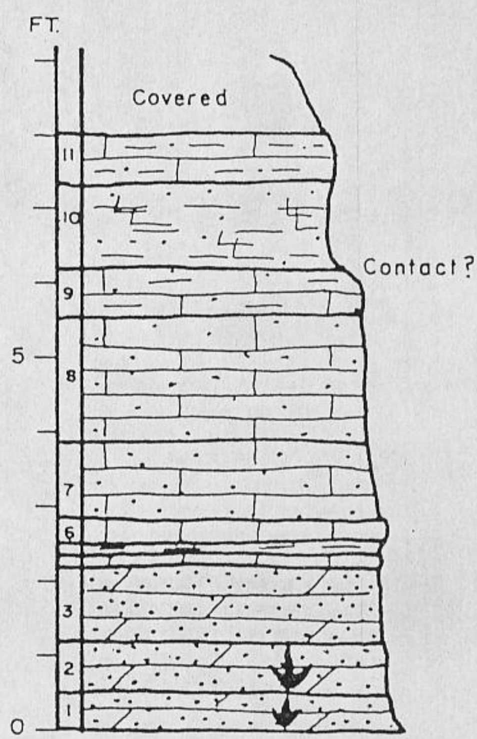


Fig. 56. Nichols site measured section. This section is nearly identical to that at the Hall site. Tracks occur in the same dolomitic sand layer, probably in the Eagle Mountain Member of the Paluxy Sand. The Paluxy Sand/Walnut Clay contact is exposed in this section, but due to its interfingering and gradational nature, it could not be pinpointed exactly.

F6 RANCH SITE

Unit *Description*

10. Thick massive resistant carbonates, bedding from 6" to 2'.
9. Calcilutite, lime mudstone; non-ferroan calcite.
8. Calcilutite, lime mudstone; non-ferroan calcite.
7. Calcilutite, lime mudstone; rare burrows, chert nodules common, non-ferroan calcite.
6. Calcilutite, lime mudstone; rare bivalves and algal laminae, laminar micritic crusts, exposure surface?.
5. Calcilutite, lime mudstone; rare bivalves and echinoderm fragments, chert nodules common.
4. Calcilutite, lime mudstone; rare bivalves and echinoderm fragments, chert nodules common.
3. Calcilutite, lime mudstone; rare burrows, rare bivalves and echinoderm fragments, chert nodules common.
2. Calcilutite, lime mudstone; chert nodules common.
1. TRACK LAYERS. Calcarenite, foraminifera-ostracode packstone at base grades up to calcarenite, ostracode-miliolid wackestone in middle and grades up to calcilutite, lime mudstone at top; thin bedded flaggy limestone (¼" to 2" flags), rare gastropods, bivalves and foraminifera also present, worm trails and mudcracks common in and near track layers, small calcite filled voids—former evaporite nodules.

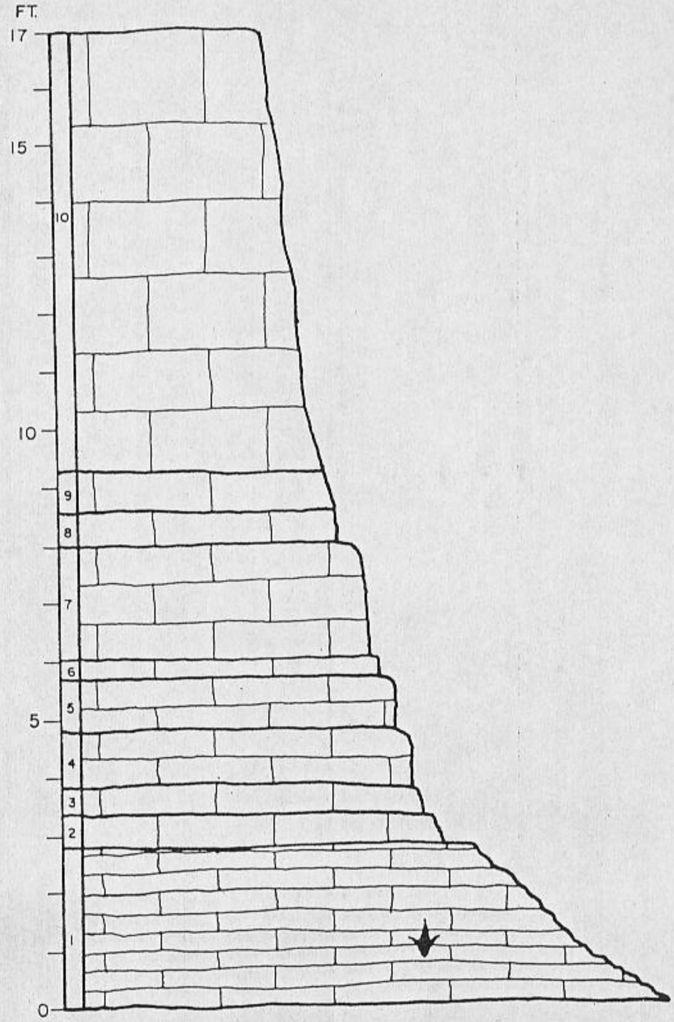


Fig. 57. F6 Ranch site measured section. A portion of the cliff outcrop including the track layers in the creekbed is shown here. Tracks occcur in flaggy, miliolid limestones of the dolomitic unit of the Fort Terrett Member.

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