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Comanchean Stratigraphy of Kent Quadrangle, Trans-Pecos Texas

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COMANCHEAN STRATIGRAPHY OF KENT QUADRANGLE, TRANS-PECOS TEXAS[1]

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ABSTRACT

At the northern end of the Coahuila platform, the thinned Comanchean sequence consists of the newly named Sixshooter group of carbonate formations underlain by the newly named Yearwood formation. The Sixshooter group consists, in descending order, of the Buda limestone, the newly named Boracho limestone composed of the newly named San Martine and Levinson members, and the Finlay limestone at the base. Beneath the Finlay is the Cox sandstone, and beneath the Cox, the Yearwood formation, which consists of an upper limestone member previously called Rustler (Permian) and a basal conglomeratic sandstone member that rests unconformably on Permian formations. The Buda and Boracho are biostratigraphically correlative with the Washita group of central Texas; similarly, the basal part of the Levinson member and all the Finlay limestone are correlative with Fredericksburg formations. Whether any part of the Cox sandstone is contemporaneous with the Trinity group is speculative. The Yearwood is probably a Trinity, though possibly a Fredericksburg, correlative.

INTRODUCTION

The Comanchean series extends as a continuous body of rock from central Texas to northern Chihuahua. One or two formations can be traced all the way, but most of the rock units of central Texas lose their lithostratigraphic identity before they reach the Mexican geosyncline in Chihuahua along the Rio Grande, which is the international boundary. The Coahuila platform just east of the geosyncline is one of the critical areas of intervening stratigraphy, and some of the more significant outcrops are in the 30′ Kent Quadrangle in Jeff Davis, Reeves, and Culberson counties, Texas, at the north end of the platform.

Physiographically the Kent Quadrangle consists of three distinct parts. On the north are the southern ends of the Rustler Hills and the Gypsum Plain (Richardson, 1904, p. 22). The southwest-central part includes the Apache Mountains, which are formed by the outcrop of the Capitan reef. The southern boundary of the Kent Quadrangle is roughly coincident with the northern front of the Davis Mountains. For purposes of convenience in mapping, the 30′ quadrangle has been subdivided into sixteen 7½′ quadrangles with names selected from local features or places. The accompanying map (Fig. 1) designates principal structural and topographic features, and the type localities of newly named stratigraphic units.

The Cretaceous outcrops near Kent were mapped in the summer of 1947 by graduate students from The University of Texas under the supervision of Hal P. Bybee and J. T. Lonsdale. DeFord and his graduate students resumed the mapping in the summer of 1949. Since then, they have mapped the areal geology

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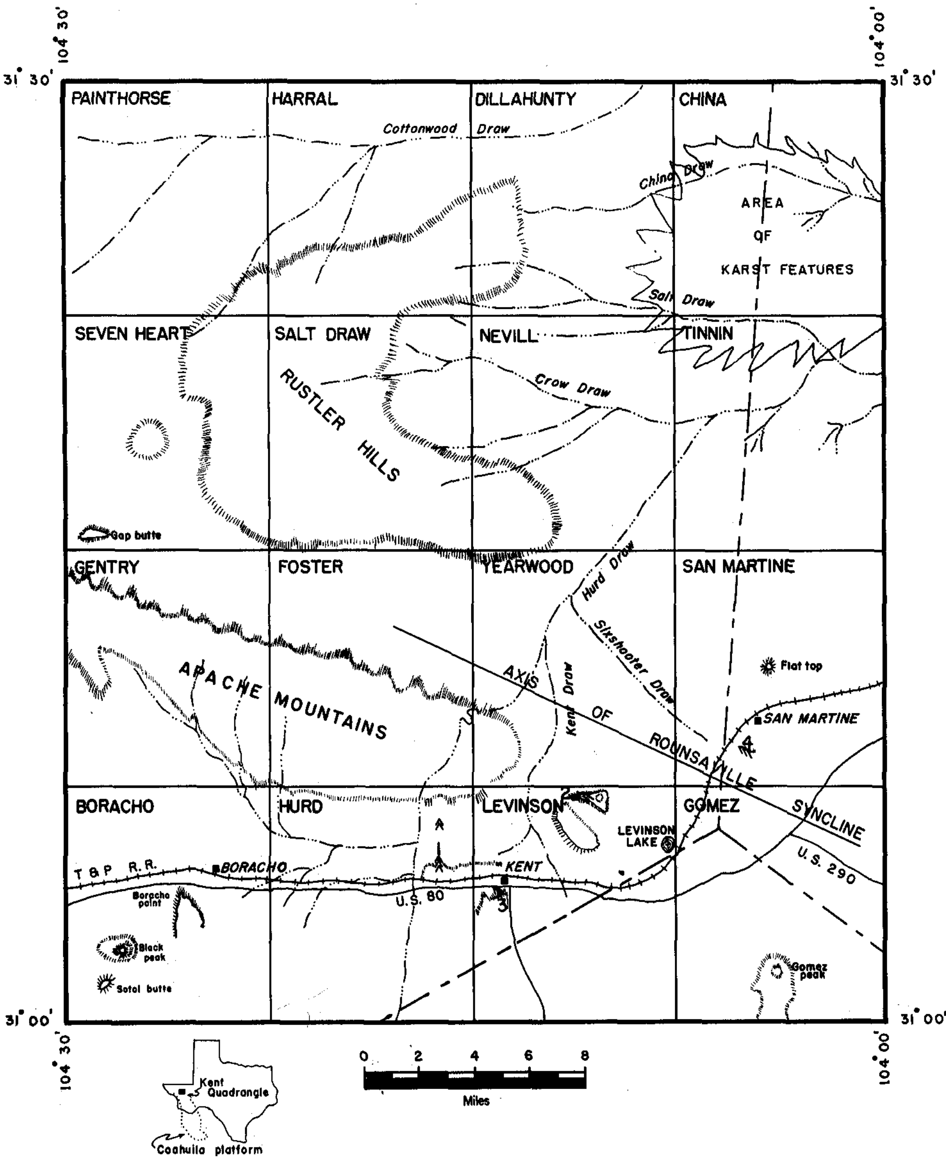

FIG. 1.—Map of Kent 30′ Quadrangle showing measured sections: MS 1, Cox sandstone, in Hurd Quadrangle; MS 2, type Yearwood formation and MS 3, type Levinson member, in Levinson Quadrangle; and MS 4, Buda limestone and type San Martine member, in San Martine Quadrangle.

and part of the structure of the Permian, Cretaceous, Tertiary, and Quaternary rocks of the Kent 30′ Quadrangle. Since 1952, Brand, working alternately for the Bureau of Economic Geology and Department of Geology, The University of Texas, has studied the biostratigraphy of Comanchean and Gulfian rocks and revised the mapping. He has been assisted by graduate students from Texas Technological College. The study of Comanchean outcrops is virtually complete, but additional field work on Permian, Gulfian, Tertiary, and Quaternary deposits is necessary.

STRATIGRAPHY

The Comanchean strata exposed in the Kent Quadrangle have heretofore been assigned to the Trinity, Fredericksburg, and Washita groups, but the assignment is based solely on the contained fossils. In other words, two of these groups are assemblage-zones or stages, for near Kent the "Washita-Fredericksburg" biostratigraphic boundary is not an easily recognizable lithostratigraphic boundary. The "Trinity" there is a conjectured chronostratigraphic unit, for no indubitable "Trinity" fossils have been found. DeFord and Brand prefer to consider the Trinity, Fredericksburg, and Washita stratigraphic units as central Texas groups rather than state-wide assemblage-zones or stages.

The boundaries of the Comanchean series in the Kent Quadrangle are placed at formation boundaries, although heretofore the base has not been so clearly defined. Figure 2 shows the proposed lithostratigraphic subdivisions.

YEARWOOD FORMATION

The name Yearwood, proposed for the lowermost Cretaceous formation in the Kent Quadrangle, is derived from the Yearwood (Drake) Ranch 5.2 miles (6.3 miles by road) north-northeast of Kent, Texas. The type locality is the west slope of a prominent hill in the NW. ¼ of Sec. 7, Blk. 59, T. & P. RR. Co. (MS 2, Fig. 1). Access to the type locality is by a dim ranch road southwestwardly from the ranch headquarters.

Exposures of the Yearwood formation are limited to the southern and east-central parts of the Kent Quadrangle. The upper limestone beds cap the prominent escarpment in the Levinson Quadrangle (Fig. 1) 2-4 miles northeast of Kent. They also crop out extensively along the southwest flank of the Rounsaville syncline 3.75 miles east-northeast of Kent to the west edge of the Yearwood Quadrangle where Hurd Draw emerges from the canyon in the Apache Mountains and along the south flank of the Apache Mountains east of Hurd Draw. Scattered exposures occur beneath the Cox sandstone north of the Texas and Pacific Railroad from just west of Levinson Lake westward to Boracho Station. The farthest west outcrop is in the upper slope of Sotol Butte in the southwest corner of the Boracho Quadrangle.

Lithically, the Yearwood formation consists of up to 160 feet of limestone and a sporadically distributed basal conglomerate. The basal clastic part is re-

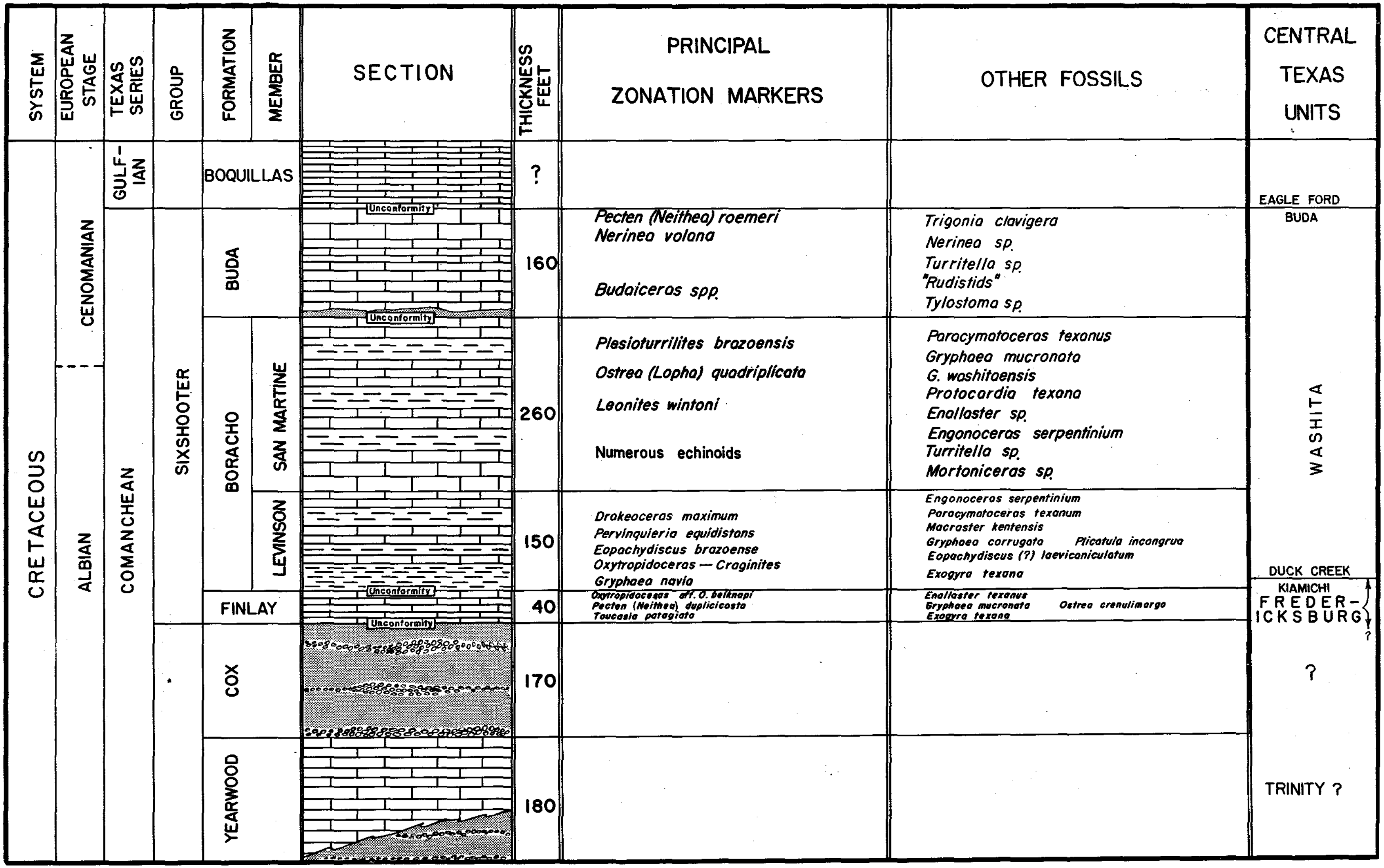

FIG. 2.—Proposed lithostratigraphic classification of Comanchean strata of Kent Quadrangle showing macrofossils and correlation with central Texas groups and European stages.

stricted to the area in the vicinity of the type locality where a maximum section of about 55 feet is recorded. Elsewhere the basal conglomerate is absent or exemplified by scattered quartz pebbles in the basal few feet of the limestone. The Yearwood rests unconformably on Permian formations: at the type locality, on Permian redbeds; in the escarpment northeast of Kent and in the low escarpment between Kent and Boracho Station, on the Tansill (Guadalupian) limestone.

The basal conglomerate consists of rounded to subangular quartz pebbles and cobbles in a matrix of fine- to medium-grained calcareous quartz sandstone. Perhaps the most distinctive feature of the formation is the presence of scattered limestone cobbles some of which contain the Permian (Guadalupian) fusuline, *Polydiexodina.* These have not been found in the Cox sandstone, a formation which, in other respects, resembles the basal conglomerate of the Yearwood formation. Locally, silicified wood occurs in the conglomerate; it is abundant on many weathered slopes.

The upper member, consisting of up to no feet of limestone, is considerably more widely distributed than the basal conglomeratic member. Lithically, it consists of light gray to grayish orange-pink, thin-bedded to massive, micro-grained limestone with thin, light gray, calcareous shale interbeds. The limestone is sparsely fossiliferous; and only poorly preserved algal remains, sporadic chara oögonia, and two poorly preserved gastropods have been found in it.

The exact age affinities of the Yearwood formation are not yet known. Adkins (1933, p. 368) and King (1949) called the limestone member, or part of it, Rustler (that is, Permian) but made no reference to the basal conglomerate and sandstone. The presence of chara oögonia in the limestone suggests a possible correlation with the "basalmost Cretaceous" in the Fort Stockton region (Adkins, 1927, pp. 33-37). In Triple Hill and in the Finlay Mountains, northwest of Sierra Blanca, the Cox sandstone overlies the Campagrande limestone, which is similar, lithically, to the Yearwood, but according to Albritton (letter dated July 1, 1957), the upper half of the Campagrande is abundantly fossiliferous at certain horizons, containing coral heads, rudistids, algal growths, and internal casts of large clams and gastropods, although the lower half is mostly non-fossiliferous.

From Texas Hill, south of Sierra Blanca, through Devil Ridge, the Indio Mountains, Pinto Canyon, and the Shafter region, the Cox sandstone overlies limestone that contains the foraminifer *Orbitolina texana* (Roemer). The absence of this species in the limestone near Fort Stockton, in the Yearwood formation, and in the Campagrande formation possibly indicates an epineritic or lagoonal environment.

The following section was measured at the type locality of the Yearwood formation. A more nearly complete section of the basal conglomerate is exposed on the eastern slope of the isolated hill in the SW. ¼ of Sec. 8, Blk. 59, T. 8, T. & P. RR. Co. Access to the section is by a dim ranch road directly south from the Yearwood Ranch headquarters.

TYPE SECTION OF YEARWOOD FORMATION, LEVINSON QUADRANGLE, MS 2 (FIG.1)

	Thickness in Feet
Top of section (top of hill)	
10. Limestone, grayish orange-pink (5YR7/2),* massive, aphanic, sparsely fossiliferous with algal bodies and several poorly preserved gastropod sections; thin (¼-in.) limonitic stringers occur throughout unit 10	17
9. Limestone, grayish orange-pink (5YR7/2), thin-bedded to massive; the lower one foot contains sporadically distributed angular limestone fragments; upper part is pauro-grained	5.6
8. Limestone, very pale orange (10YR8/2) to moderate orange-pink (sYR8/4), thin-bedded, nodular, pauro-grained; interbedded with the limestone are several moderate reddish orange (10R6/6), thin-bedded, calcareous siltstone layers, which contain scattered 1/8-1/4-in. quartz pebbles	23
7. Limestone, very pale orange (10YR8/2), massive, pauro-grained; unit 7 contains numerous algal bodies and abundant chara oögonia	17
6. Limestone, very pale orange (10YR8/2) to light gray (5Y7/2), thin-bedded, pauro-grained, with thin (¼-in.) calcite stringers	5.6
5. Limestone, grayish orange-pink (5YR7/2) to grayish orange (10YR7/4), thick-bedded to massive, pauro-grained to phaneric; basal one ft. contains numerous small (¼-in. diam.) algal bodies embedded in a phaneric matrix; upper part contains a profusion of large (diam. 1–2 in.) algal bodies, which show prominently on face of ledge	13
4. Limestone, grayish pink (5R8/2) to grayish orange-pink (10R8/2), thick-bedded, nodular, pauro-grained; upper half of unit 4 contains several thin (6-in.) beds of light brown (5YR5/6) aphanic, silty limestone; entire unit contains scattered black chert pebbles	2.8
3. Limestone, very pale orange (10YR8/2) thin- to thick-bedded, nodular, pauro-grained with narrow (1/32-in.) calcite stringers	9
2. Limestone, very pale orange (10YR8/2), massive, aphanic; algal bodies occur throughout unit 2, but are most abundant in upper 10 ft.; quartz pebbles (diam. 1/4-1/2in.)are common throughout	16
1. Conglomerate, yellowish brown, thin-bedded to massive, with numerous gray limestone interbeds; conglomerate contains particles from coarse-sand size to 3 in. in greatest diameter; larger pebbles and cobbles, composed of limestone, probably derived from Tansill and other Permian (Guadalupian) formations, for several limestone cobbles containing fusuline *Polydiexodina* have been found; smaller pebbles are composed of well rounded, black, brown, and reddish brown quartz; matrix of lenses containing limestone pebbles and cobbles is mainly calcareous, of quartz-pebble layers, mainly sandy	41
Total measured thickness of Yearwood formation	150
—Unconformity—	
Permian redbeds	

* Rock Color Chart, National Research Council, 1948.

COX SANDSTONE

In the southern part of the Kent Quadrangle the outcrop of the Cox sandstone parallels the outcrop of the Yearwood formation. The Cox also crops out widely in the eastern and northeastern parts of the Kent Quadrangle where it oversteps the Permian Castile, Rustler, and Pierce Canyon formations. It also commonly occurs, there, with younger Cretaceous formations in collapse features, which have developed in the Castile gypsum.

Where the Cox sandstone overlies the Yearwood formation the contact is distinctly disconformable. Blocks of Yearwood limestone, up to one foot in greatest dimension are common in the basal few feet of the Cox. Moreover, the top few feet of Yearwood limestone contains stringers and pockets of Cox sandstone, which presumably were deposited in small solution features in the Yearwood.

Lithically, the Cox consists of massive beds of quartz-pebble conglomerate, and fine- to medium-grained sandstone with a few silty marl interbeds. Priddy (1956) found no significant mineralogical differences between the Cox of the Kent area and the type Cox near Sierra Blanca. A limestone bed, containing *Actaeonella dolium* Roemer, *Exogyra texana* Roemer, and *Engonoceras* sp., in the upper part of the typical Cox, is missing at Kent. Its absence as well as the lack of any invertebrate fossils from the Cox near Kent precludes the possibility of biostratigraphic correlation with the type Cox. The Cox at Kent may be correlative with the Trinity group, for its contact with the overlying Finlay formation is disconformable, and the basal Finlay contains faunal elements similar to those in the lower part of the Fredericksburg group, but the correlation is speculative.

TOP PART OF COX SANDSTONE MEASURED BY DEHLINGER (1951) AND JANSZEN IN PROMINENT POINT IN SE. ¼, SEC. 21, BLK. 60, T. 8. ABOUT 3/4 MILE NORTH OF TEXAS AND PACIFIC RAILROAD, MS 1 HURD QUADRANGLE (FIG.1)

	Thickness in Feet
Finlay formation	
—Disconformity—	
Cox sandstone	
16. Siltstone, thin-bedded, moderate red (5R5/4) to moderate orange-pink (5R8/4), calcareous	3.4
15. Quartz sandstone, light gray (N7), hard, massive, slightly calcareous, cross-bedded in upper part; quartz grains subrounded	17
14. Sandy siltstone, pale red-purple (5RP6/2), thin-bedded, well indurated	28
13. Silty sandstone, pale yellowish brown (10YR6/2), thin-bedded, friable	3.4
12. Quartz sandstone, moderate yellowish brown (10YR5/4) to very pale orange (10YR8/2), massive, friable, fine-grained, cross-bedded; quartz grains subrounded.	30
Total thickness at this locality	82

The basal part of the Cox sandstone is well exposed in a small knoll approximately a mile north of the foregoing section, where the contact with the underlying limestone member of the Yearwood formation is exposed; S. ½, Sec. 16, Blk. 8, T. & P. RR. Co. The projection of bed 11 passes under bed 12, and probably the actual total thickness is several feet greater than the calculated total (Dehlinger, 1951).

	Thickness in Feet
Top of knoll	
Cox sandstone	
11. Quartz sandstone, light gray (N7), massive, fine-grained; cement is calcareous	3.0
10. Silty sandstone, pale yellowish orange (10YR8/6), moderately hard; siliceous cement.	4.3
9. Quartz sandstone, yellowish gray (5Y8/2), massive, friable; calcareous cement	3.8
8. Sandy siltstone, moderate grayish yellow (5Y8/3), thin-bedded, calcareous	10.0
7. Quartz sandstone, pale yellowish brown (10YR6/2), friable, calcareous.	7.3
6. Quartz sandstone, grayish orange (10YR7/4) to pinkish red (5R7/2), friable; grains subrounded	12.0
5. Quartz sandstone, very pale orange (10YR8/2), friable, calcareous; grains well rounded	1.2
4. Quartz sandstone, pale yellowish brown (10YR6/2), friable, calcareous; contains thin bands of pea gravel (1/8-1/4-in. diameter)	1.2
3. Quartz sandstone, pale yellowish brown (10YR6/2), friable; grains subrounded; cement calcareous	1.2

	Thickness in Feet
2. Silty sandstone, very pale orange (10YR8/2), friable, calcareous	2.0
1. Pea gravel, dusky brown (5YR2/2) to light brown (5YR5/6), loosely consolidated, grains subrounded to subangular; matrix is friable, pale yellowish brown sandstone (10YR5/4)	2.1
Total thickness at knoll	48
Total measured thickness of Cox sandstone	130

—Disconformity—
Limestone member of Yearwood formation

SIXSHOOTER GROUP

The name Sixshooter, proposed for a group of three carbonate formations, is derived from Sixshooter Draw in the eastern part of the Yearwood Quadrangle (Fig. 1). The Sixshooter group comprises, in ascending order, the Finlay limestone, the Boracho limestone, and the Buda limestone; it is best exposed in the southern part of the Kent Quadrangle along U. S. Highway 80. It is likely to prove a useful subsurface unit in the northern part of the Coahuila platform in Trans-Pecos Texas, especially where its component formations can not readily be differentiated.

FINLAY LIMESTONE

The Finlay limestone in the Kent Quadrangle consists of approximately 40 feet of sandstone, arenaceous limestone, and coarse-grained massive limestone. The best exposures near Kent are in the upper part of the prominent escarpment north of the Texas and Pacific Railroad, but the Finlay limestone caps the Cox sandstone throughout the quadrangle. In all exposures, the Finlay is sandstone in the basal few feet, separated from the Cox sandstone by an obscure disconformity. In well exposed sections, the disconformity is marked by a distinct discontinuity in bedding showing as much as 12 inches of channeling in the upper surface of the Cox. In the upper 3-4 feet of Cox is an oxidized zone containing red and purple, variegated sandstone. At the top of the Cox, scattered limonite concretions indicate pre-Finlay subaerial exposure.

In the vicinity of Kent, the basal Finlay contains several feet of sandstone, whereas the upper part is composed almost entirely of thin-bedded to massive coarse-grained limestone. In the Nevill, Tinnin, Dillahunty, and China quadrangles (Fig. 1), the upper part contains sandstone interbeds.

The Finlay limestone is the lowermost Cretaceous formation to which biostratigraphic zonation can be applied. The basal few feet contain several distinct beds of coquinoid, arenaceous limestone from which the following fossils probably indicative of a correlation with the Walnut formation have been collected: *Gryphaea mucronata* Gabb, *Ostrea crenulimargo* Roemer, and *Exogyra texana* Roemer. The overlying limestone strata are characterized by *Toucasia* aff. *T. patagiata* (C. A. White), *Pecten (Neithea) duplicicosta* (Roemer), and by *Oxytropidoceras* aff. *O. belknapi* (Marcou). Detailed study of faunal sequences in the

Finlay in the northeastern part of the area is hardly feasible, because most exposures are associated with collapse structure in the Castile gypsum. The aforementioned species, however, can be identified in most exposures.

No complete section of the Finlay limestone is exposed within the Kent Quadrangle, but partial sections including the lower, sandy part of the formation and the basal part of the upper limestone member can be seen in the escarpment north of Kent. In the SW. ¼ of Sec. 24, Blk. 59, and the NE. ¼ of Sec. 26, Blk. 60, T. 8, T. & P. RR. Co., fossiliferous beds crop out.

Hatley (1955, pp. 9-12) has reported the following microfauna from the Finlay limestone.

Foraminifera	Ostracoda
Ammobaculites viriosus Loeblich and Tappan	*Cythereis mahonae* Alexander
Lituola subgoodlandensis (Vanderpool)	*Cytheropteron* sp.
Ramulina muricatina Loeblich and Tappan	

The following macrofossils have been collected by Brand from localities in the Kent Quadrangle.

Enallaster texanus (Roemer)	*Pecten (Neitkea) duplicicosta* Roemer
Holectypus planatus Roemer	*Ostrea crenulimargo* Roemer
Gryphaea mucronata Gabb	*Toucasia* aff. *T. palagiata* (C. A. White)
Exogyra texana Roemer	*Oxytropidoceras* aff. *O. belknapi* (Marcou)
Lunatia pedernales (Roemer)	

BORACHO LIMESTONE

The name Boracho, proposed for the formation including all the strata between the underlying Finlay limestone and overlying Buda limestone, is derived from Boracho Station on the Texas and Pacific Railroad approximately 10½ miles west of Kent. With the exception of the basal part of the lower member, the Boracho is essentially a homogeneous limestone and marl sequence. Exposures of the formation in the Boracho vicinity are, for the most part, south of U. S. Highway 80; at Boracho Point, 2 miles west of Boracho station, a nearly complete section is exposed, but even there, as in most localities, the lowermost beds of the formation are concealed by colluvium or Quaternary gravel.

Levinson limestone member.—The name Levinson, proposed for the lower member of the Boracho limestone, is derived from Levinson Lake (Fig. 1) just north of the Texas and Pacific Railroad in the Levinson Quadrangle. The type locality is the area south of Kent, which is part of the Boracho outcrop south of U. S. Highway 80 that extends from the vicinity of Levinson Lake westward to Boracho Point. The Levinson member also crops out north of Flattop in the San Martine Quadrangle and in the west wall of Sixshooter Draw. Ail these hillside outcrops exhibit a characteristic ridge-and-gully pattern that reminds one of an inverted jello mold. Scattered exposures occur in the collapse features in the northeastern part of the Kent Quadrangle.

The basal contact of the member is not exposed in the type area, but a small outcrop in the north bank of Crow Draw in the NE. ¼ of Sec. 29 and the SW. ¼ of Sec. 28, Blk. 59, T. 6, in the Nevill Quadrangle seems to show a disconformable contact with the underlying Finlay limestone. The Levinson member there is considerably thinner than in exposures near Kent, and sandstone interbeds are common in the lower shaly part. The basal beds have yielded the Fredericksburg forms *Oxytropidoceras acutocarinatum* auctorum (non Shumard) and *Gryphaea navia* Hall. The beds containing these *pre-Craginites* fossils are presumably correlative with part of the covered unit 1 of the type section of the Levinson member.

Although the shale outcrops are obscure, the lower part of the member is dominantly shaly. Its fossils are correlative with those in the Kiamichi and Duck Creek formations of north Texas. The upper part is composed of limestone, bearing fossils correlative with those in the Fort Worth limestone.

The base of the type section of the Levinson member is 0.3 mile west of Kent in the ditch on the north side of U. S. Highway 80; it continues south of the highway in the west wall of the large earthen stock tank, and thence to an abandoned rectangular concrete water tank on top the hill 0.1 mile south of the Kent tourist court. This is "Water-Tank Hill." The rest of the type section is 0.1 mile south of the Kent school house, in a high escarpment, up which it extends to the base of the prominent limestone ledge that caps the escarpment. This is "Cross Hill," so called because of the large cross erected by some Christian sect on its flat summit.

TYPE SECTION OF LEVINSON MEMBER OF BORACHO LIMESTONE, MS 3, LEVINSON QUADRANGLE (FIG.1)

	Thickness in Feet
San Martine member of Boracho limestone	
21. Limestone, forms prominent ledge capping "Cross Hill"	35
—Conformable contact—	
Levinson member of Boracho limestone	
20. Limestone, yellowish gray (5Y7/2), thin- to thick-bedded, aphanic, with thin (1–3-in.) dusky yellow (5Y6/4) marl interbeds; both limestone and marl are fossiliferous; fauna includes *Engonoceras serpentinium, Paracymatoceras texanum,* and numerous gastropod and pelecypod casts	11
19. Limestone and marl as in unit 20. In unit 19 about 4 ft. below top is 1½-ft. bed of hard, aphanic limestone, which contains numerous specimens of *Engonoceras serpentinium;* other forms include *Gryphaea mucronata* (throughout unit 19) and *Protocardia texana* (abundant in *Engonoceras* layer)	12
18. Limestone, yellowish gray (5Y7/2) to dusky yellow (5Y6/4), thin- to thick-bedded, nodular, argillaceous limestone with marly interbeds; at base is a 2-ft. bed of aphanic, hard limestone, which contains numerous *Gryphaea mucronata* and *Engonoceras;* the echinoid *Macraster kentensis* occurs sporadically in unit 18.	15
17. Limestone, yellowish gray (5Y7/2) with thin, light olive-gray (5Y5/2) interbeds; sparsely fossiliferous	13
16. Limestone, yellowish gray (5Y7/2), thin- to thick-bedded, aphanic with interbeds of yellowish gray, nodular, argillaceous limestone and dusky yellow to dark yellowish brown silty marl; limestone beds are sparsely, but marly layers abundantly fossiliferous; horizon 3 feet below top of unit 16 is marked by *Macraster kentensis* and *Goodhallites* sp.; other forms from marly layers include *Cyprimeria texana, Protocardia texana, Gryphaea mucronata,* and *Engonoceras serpentinium*	17
15. Limestone, yellowish gray (5Y7/2), thick-bedded, aphanic, with hard, dusky yellow (5Y5/2), marly interbeds; upper 3 ft. contains the ammonite *Drakeoceras maximum* to top of covered interval	5
From here section is continued downward on north slope of "Water-Tank Hill" 0.1 mile south of tourist court at Kent. Section continues below first occurrence of *Drakeoceras maximum.*	

	Thickness in Feet
14. Limestone, light gray (N7) to light olive-gray (5Y5/2) thin- to thick-bedded, slightly argillaceous, aphanic, with medium gray (N6) marly shale interbeds; unit 14 includes eight subequal limestone beds with thin marl interbeds; limestone is fossiliferous, especially more argillaceous beds; fauna includes *Drakeoceras* sp., *Goodhallites* sp., and numerous pelecypod casts.	8.5
13. Limestone, light olive-gray (5Y6/1), thin- to thick-bedded, aphanic, argillaceous, sparsely fossiliferous; thin layers are nodular and more argillaceous than more persistent thick beds; unit 13 forms the first conspicuous ledge midway in hill.	3.8
12. Shale, dark gray (N3) to moderate yellowish brown (10YRs/4), thinly laminated, slightly silty, sparsely fossiliferous; fauna includes *Plicatula incongrua* and *Gryphaea mucronata*	6
11. Limestone, dusky yellow (5Y6/4) to medium gray (N5), thin- to thick-bedded, aphanic, argillaceous, fossiliferous; fauna includes *Plicatula incongrua, Gryphaea mucronata* (small individuals), *Protocardia texana,* and numerous gastropod and pelecypod fragments; an impression of ammonite genus *Goodhallites* presumably slumped from unit 11 was found on slope below it	1.3
10. Shale, medium gray (N5) to medium dark gray (N4), thinly laminated, slightly silty; weathers to paper-thin laminae.	20
9. Limestone, moderate yellowish brown (10YR5/4), nodular to thick-bedded, argillaceous, aphanic, with thin medium gray marl interbeds; limestone is fossiliferous; fauna includes *Pervinquieria equidistans, Gryphaea corrugata,* and *Pecten (Neithea)* sp.	2
8. Shale, light gray (N7), slightly calcareous, faintly laminated with several thin (1–2-in.) interbeds of dusky yellow (5Y6/4), argillaceous limestone; sparsely fossiliferous.	15
7. Limestone, pale yellowish brown (10YR6/2), nodular, slightly argillaceous; in middle of unit 7 is a o.6-ft. bed of medium gray shaly marl; limestone is fossiliferous: fauna includes *Pervinquieria equidistans, Engonoceras* sp., *Plicatula incongrua,* and *Gryphaea corrugata*	1.5
6. Shale, grayish olive (10Y4/2) to dark gray (N3), faintly laminated, slightly silty with several thin (1/4-1/2-in.) dusky yellow, argillaceous limestone interbeds	5.5
5. Limestone, dusky yellow (5Y6/4) to grayish red purple (5RP4/2), unevenly thin-bedded with dusky yellow marl interbeds; contains fragments of *Pervinquieria "trinodosum," Gryphaea corrugata,* and fragments of uncoiled ammonites probably referable to genus *Hamites*	1.1
From here the section is continued downward from first appearance of *Pervinquieria equidistans* in west wall of earthen stock tank 0.1 mi. west of Kent school house.	
4. Shale, moderate yellow (5Y7/2), thinly laminated; with thin (3-in.) interbeds of moderate yellow argillaceous limestone; fossiliferous: fauna includes *Eopachydiscus brazoense and E. laevicanicitlatum*	3.9
From here section is covered to highway level; it is continued in roadside ditch on north side of highway 0.2 mi. west of Kent.	
3. Covered.	4
2. Shale, moderate yellow (5Y7/6), thinly laminated and thin moderate yellow limestone interbeds; macrofossils scarce, but a fragment of *Craginites* aft. *C. serratescens* was found.	3
Total measured thickness of Levinson member.	149
1. Covered, thickness estimated.	20
Approximate thickness of Levinson member.	169

—Disconformity (observed in Crow Draw; not exposed here)—
Finlay limestone

Hatley (1955, pp. 9-12) has reported the following microfauna from the Levinson member.

Foraminifera

Reophax eckernex Vieaux
R. incompata? Loeblich and Tappan
Haplostiche texana (Conrad)
Ammobaculites subcretaceus Cushman and Alexander
Flabellammina longiuscula Alexander and Smith
F. washitensis Alexander and Smith
Triplasia acutocarinata (Alexander and Smith)
Spiroplectammina alexanderi Lalicker
S. goodlandana Lalicker
S. longa Lalicker
S. nuda Lalicker
Textularia duckcreekensis Tappan
T. losangica Loeblich and Tappan
T. rioensis Carsey
T. washitensis Carsey
Gaudryina cushmani Tappan
Clavulinoides sp. A.
Trochammina truncata Tappan
Darbyella subcretacea Tappan
Lenticulina gaultina (Berthelin)
Lenticulina sp. A.
Saracenaria sp. A.
Marginulina cf. *M. diversicostata* Liszka
M. tenuissima Reuss
M. sp. A.
Dentalina communis d'Orbigny
D. cylindroides Reuss
D. debilis (Berthelin)
D. hammensis (Franke)
D. raristriata (Chapman)
D. stratifera (Tappan)
Nodosaria barkeri Vieaux
N. oklahomensis Tappan
Vaginulina kochii Roemer var. *kochii* Roemer = *Citharina kochii* (Roemer) var. *kochii* (Roemer)
V. kochii (Roemer) var. *striolata* Reuss = *Citharina kochii* (Roemer) var. *striolata* (Reuss)
V. recta Reuss = *Citharina recta* (Reuss)
V. triplema Reuss = *C. tripleura* (Reuss)
Palmula leai Loeblich and Tappan
Frondicularia ungeri Reuss
F. plana var. *plana* Loeblich and Tappan
Lagena apiculata Reuss
L. cf. *L. hispida* Reuss
Globulina exserta (Berthelin)
Pyrulina longa Tappan
Ramulina abscissa Loeblich and Tappan
R. muricatina Loeblich and Tappan
R. sp. A.
Bullopora cervicornis (Chapman)
Loxostomum sp. A.
Valvulineria asterigerinoides Plummer
Globigerina planispira Tappan
Globigerina washitensis Carsey
Anomalina petita Carsey

Ostracoda

Cytherella ovata (Roemer)
C. scotti Alexander
C. *comanchensis* Alexander
Cytherelloidea williamsoniana (Jones) var. *stricta* Jones and Hinde
Bairdia harrisiana Jones
Paracypris siliqua Jones and Hinde
P. dentonensis Alexander
P. alta Alexander
Cytheridea washitaensis Alexander
C. graysonensis Alexander
Cythere concentrica (Reuss)
Cythereis nuda (Jones and Hinde)
C. *worthensis* Alexander
C. dentonensis Alexander
C. ornatissima (Reuss)
C. sp. A.
Cytheropteron rugosolatum Alexander
C. sp. A.

Macrofauna

Detailed studies of the macrofauna are not yet complete, but the following forms appear to characterize the Levinson member in most of its exposures in the southern part of the Kent Quadrangle.

Enallaster sp.
Macraster kentensis
Macraster elegans Shumard
Gryphaea navia Hall
G. *corrugata* Gabb
*G. *washitaensis* Hill
G. mucronata Gabb
G. tucumcarii (Marcou)
**Ostrea* (*Arctostrea*) *carinata* Lamarck
Pecten (*Neithea*) sp.
Plicatula incongrua Cragin
Tylostoma sp.
Aporrhais sp.
Oxytropidoceras acutocarinatum auctorum (non Shumard)
Engonoceras serpentinium (Cragin)
Eopachydiscus brazoense (Shumard)
Pervinquieria equidistans (Cragin)
Drakeoceras maximum (Lasswitz)
Goodhallites (?) *austinensis* (Roemer)

* Reported by Moyer, 1952.

San Marline limestone member.—The name San Martine, proposed for the upper member of the Boracho limestone, is derived from San Martine Station

(Fig. 1) on the Texas and Pacific Railroad 10.5 miles east-northeast of Kent. The well exposed type section of the member is in the northwest face of a hill a mile south of San Martine Station and 1,500 feet south of the railroad. The type section may be reached by the Stocks Ranch road, which branches northward from U. S. Highway 80 approximately 7.2 miles east of Kent, or by the road to San Martine, which branches northward from the highway 3.2 miles east of Davis Mountain filling station at the junction of U. S. Highways 80 and 290.

Paralleling the Levinson member, the San Martine member crops out widely in the southern part of the Kent Quadrangle. In the Tinnin and China quadrangles (Fig. 1) it is present in many collapse features; in these, however, the contact between it and the overlying Buda limestone is difficult to place, and it is probably practical to map only two units there: the Cox sandstone and the Sixshooter group.

The basal 30-40 feet of the San Martine member consists of nodular to thick-bedded, slightly argillaceous, aphanic limestone, providing a unit that is manifestly useful in surface mapping. The section above this prominent basal unit resembles the upper part of the Levinson member; it forms a gentler slope in the medial part of the outcrop. The upper part, lithically similar to the lower, rather massive part, forms the steep slope beneath the Buda caprock in most outcrops.

TYPE SECTION OF SAN MARTINE MEMBER OF BORACHO LIMESTONE, MEASURED AND DESCRIBED BY MOYER (1952, PP. 29-31), LOWER PART OF MS 4, SAN MARTINE QUADRANGLE (FIG. 1)

	Thickness in Feet
Buda limestone, cliff-former	
37-44 Limestone	122
—Unconformity—	
San Martine limestone member	
36. Limestone, light olive-gray (5Y6/1), poorly bedded, nodular, contains *Plesioturrilites brazoensis,* forms slope	11
35. Limestone, yellow-gray (5Y8/1), slightly argillaceous, fossiliferous; forms ledge; fauna includes *Pecten* (*Neithea*) sp. and *Gryphaea.*	0.9
34. Limestone, light olive-gray (5Y8/1), argillaceous; contains *Plesioturrilites brazoensis.*	17
33. Limestone, yellowish gray (5Y8/1), clastic, with arenaceous layers at base	1.3
32. Limestone, yellowish gray (5Y8/1), thick-bedded, nodular; forms retreating slope; fossiliferous; contains *Plesioturrilites brazoensis* and *Kingena wacoensis.*	17
31. Limestone, yellowish gray (5Y7/2), aphanic, argillaceous, nodular	6
30. Limestone, very pale orange (10YR8/2), nodular, thick-bedded	13
29. Limestone, very pale orange (10YR8/2), phaneric; forms 2–4-ft. resistant ledges	8
28. Limestone, yellowish gray (5Y7/2), aphanic, nodular; contains *Gryphaea* sp.	35
27. Limestone, yellowish gray (5Y7/1), aphanic, slightly argillaceous; forms thick, nodular ledge with abundant *Gryphaea* near top	12
26. Limestone, yellowish gray (5Y7/2), argillaceous, nodular	23
25. Limestone, yellowish gray (5Y7/2), hard, thick-bedded; contains *Ostrea (Lopha) quadriplicata, Pecten* (*Neithea*) sp., and *Gryphaea.*	0.7
24. Limestone, yellowish gray (5Y7/2), aphanic; forms slope underlain by alternating nodular and thin-bedded strata	30
23. Limestone, yellowish gray (5Y7/2), aphanic, nodular; contains abundant *Gryphaea washitaensis.*	18
22. Limestone as above; contains *Leonites wintoni* and *Mortoniceras* sp.	27
21. Limestone, light olive-gray (5Y6/1), aphanic, hard	1.6
20. Limestone, grayish orange-pink (5YR7/2), argillaceous; forms slope	2.9
19. Limestone, yellowish gray (5Y7/2), slightly argillaceous, aphanic, thin-bedded to massive, nodular, fossiliferous; its base is prominent mapping horizon at base of	

	Thickness in Feet
San Martine member; fauna includes *Holectypus planatus, Globater parryi, Tetragramma* sp.; weathered beds near top are covered by profusion of echinoids from upper beds	35
Total thickness of San Martine member	259
Thickness of MS 4	381

—Conformable contact—
Levinson member of Boracho limestone

Stennett (1956, Table 1), has reported the following microfauna from the San Martine member.

Foraminifera

Reophax decheri Tappan
R. incompta Loeblich and Tappan
Haplostiche texana (Conrad)
Ammobaculites dentonensis Tappan
A. subcretaceus (Cushman and Alexander)
Flabellammina alexanderi Cushman
Triplasia acutocarinata (Alexander and Smith)
Spiroplectammina longa Lalicker
S. nuda Lalicker
Ammobaculoides gainesvillensis Loeblich and Tappan
Textularia rioensis Carsey
T. washitensis Carsey
Siphotextularia washitensis Loeblich and Tappan
Gaudryinella delrioensis Plummer
Eggeretta graysonensis (Tappan)
Placopsilina minima Tappan
Lenticulina cyprina (Vieaux)
L. gaultina (Berthelin)
Saracenaria bononiensis (Berthelin) var. *striatolipa* Tappan
S. cushmani Tappan
Marginulina paucicosta Tappan
M. tenuissima Reuss
Dentalina communis (d'Orbigny)
D. cylindroides Reuss
D. debilis (Berthelin)
D. hammensis (Franke)
D. striatifera (Tappan)
Nodosaria barkeri Vieaux
Pseudoglandulina sp. cf. *P. mutabilis* (Reuss)
P. scotti Tappan
Lingulina furcillata Berthelin
L. lamellata Tappan
L. nodosaria var. *semiornata* Reuss
Citharina complanata var. *complanata* (Reuss)
C. complanata (Reuss) var. *perstriata* (Tappan)
C. kochii (Roemer) var. *kochii* (Roemer)
C. kochii (Roemer) var. *striolata* (Reuss)
Lagena apiculata (Reuss)
Lagena sp. cf. *L. hispida* Reuss
L. sulcata (Walker and Jacob)
Enantiomarginulina similis Bullard
Paleopolymorphina ozawai Tappan
Globulina exserta (Berthelin)
G. *lacrima* (Reuss) var. *lacrima* (Reuss)
G. *lacrima* (Reuss) var. *subsphaerica* (Berthelin)
Pyrulina cylindroides (Roemer)
P. longa Tappan
Pseudopolymorphina roanokensis Tappan
Ramulina abscissa Loeblich and Tappan
R. sp. A.
Gümbelina washitensis Tappan
Gümbelitria harrisi Tappan
Bulimina nannina Tappan
Neobulimina minima Tappan
Virgulina minuta Cushman
Tristix excavata (Reuss)
T. quadrata (Vieaux)
T. subquadrata (Tappan)
Spirillina minima Schacko
Patellina subcretacea Cushman and Alexander
Valvulineria sp. A.
Gyroidina loetterlei Tappan
Eponides acria Loeblich and Tappan
Globigerina delrioensis Carsey
G. *washitensis* Carsey
G. sp. A.
Globorotalia sp. A.
Globorotalites sp. A.
Anomalina petita Carsey
Planomalina apsidostroba Loeblich and Tappan

Ostracoda

Cytherella ovata (Roemer)
C. scotti Alexander
C. comanchensis Alexander
Cytherelloidea reticulata Alexander
C. obliquirugata (Jones and Hinde)
Bairdia harrisiana Jones
B. comanchensis Alexander
Paracypris siliqua Jones and Hinde
Cytheridea washitaensis Alexander
C. graysonensis Alexander
Cythere concentrica (Reuss)
C. triplicata (Roemer)
C. sp. A.
Cythereis mahonae Alexander
C. nuda (Jones and Hinde)
C. paupera (Jones and Hinde)

C. *worthensis* Alexander
C. *dentonensis* Alexander
C. *ornatissima* (Reuss)
C. *sandidgei* Alexander
C. *subovala* Alexander
C. *burlesonensis* Alexander
C. sp. A.

The following forms are macrofossils characteristic of the San Martine member.

Enallaster bravoensis (Böse)
Enallaster sp.
Holectypus planatus Roemer
Globater parryi (Hall)
Gryphaea washitaensis Hill
Ostrea (*Lopha*) *quadriplicata* (Shumard)
Protocardia texana (Conrad)
Cyprimeria washitaensis Adkins
Lima pecosensis Stanton
Lima sp.
Trigonia sp.
Pecten (*Neithea*) *texanus* (Roemer)
Tylostoma sp.
Aporrhais sp.
Paracymatoceras texanum (Shumard)
Leonites wintoni (Adkins)
Plesioturrilites brazoensis Roemer
Mortoniceras sp.
Engonoceras serpentinium (Cragin)

BUDA LIMESTONE

Although Buda is a central Texas name, the formation can be readily traced all the way to western Trans-Pecos Texas, and there is little doubt that it was once a single continuous body of rock. The Buda limestone is probably the most prominent Cretaceous unit in the Kent Quadrangle, for it is the caprock of buttes and of the high escarpments formed by the infaces of the gently dipping cuestas. Most outcrops are, therefore, in steep cliffs and are exceptionally well exposed. The boundary between the Buda limestone and the underlying Boracho limestone is disconformable. The Del Rio (Grayson) is missing; it may be represented by the unconformity or locally perhaps by sandstone in the lower part of the Buda limestone.

The lower part of the Buda consists of clastic limestone; local cross-bedding is common. In the southwestern part of the Kent Quadrangle, a distinct basal conglomerate containing quartz pebbles, phosphatic nodules, and abraded shark teeth overlies the San Martine member. Locally, the basal part of the Buda is hard fine- to medium-grained quartzitic sandstone, and sandstone float covers the slope below. Above the basal layers, the Buda consists of aphanic, slightly argillaceous limestone which is lithically similar to the upper part of the San Martine member. In areas where basal conglomerate is absent, the base of the Buda is established with difficulty.

The upper part of the Buda consists of thin-bedded to massive, hard, light gray limestone, which rings when struck by the hammer. The thin-bedded layers contain a profusion of "miliolid" foraminifers. Weathered surfaces are marked by sections of the gastropod *Nerinea volana* Cragin and fragments of the pelecypod *Pecten* (*Neithea*) *roemeri*. Locally, the Buda contains nodules of hard, gray chert.

The following section of the Buda limestone, measured by Moyer (1952, p. 29), overlies the type section of the San Martine member of the Boracho limestone. The section is incomplete, but probably only a few feet of section beneath the base of the Boquillas limestone is missing.

MEASURED SECTION OF BUDA LIMESTONE, UPPER PART OF MS 4,
SAN MARTINE QUADRANGLE (FIG.1)

	Thickness in Feet
Top of hill	
Buda limestone	
44. Limestone, coquinoid, grayish orange (10YR7/4), hard, fine- to medium-grained; contains *Nerinea volana*	18
43. Limestone, very pale orange (10YR8/2), nodular, medium-grained, with gray chert nodules; contains *Nerinea volana*	17
42. Limestone, very pale orange (10YR8/2), clastic, medium-grained; contains solution pits ½ in. in diameter	22
41. Limestone, yellowish gray (5Y8/1), aphanic, nodular	24
40. Limestone, very pale orange (10YR8/2), coquinoid; forms blocky ledges 1 ft. thick	18
39. Limestone, yellowish gray (5Y8/1), hard; contains argillaceous nodules	9
38. Limestone, yellowish gray (5Y8/1), coquinoid, hard	13
37, Limestone, very pale orange (10YR8/2), fine- to medium-grained; contains *Budaiceras* spp.	1
Total measured thickness of Buda limestone	122
—Unconformity—	
San Martine member of Boracho limestone	
1-36. Limestone	259
Total thickness of MS 4	381

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