U.S. DEPARTMENT OF THE INTERIOR

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SOME MACROFOSSILS FROM THE CRETACEOUS (CAMPANIAN)
ANACACHO LIMESTONE OF TEXAS

BY

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1 Menlo Park, California
ABSTRACT

The Anacacho Limestone was deposited during the Campanian and represents two time intervals, one of early Campanian and one of middle Campanian age. These two intervals correspond to transgressive periods following major sea level drops near the base and top of the lower Campanian. This study focuses on the molluscan paleontology of the middle Campanian interval in the eastern part of the Anacacho exposure belt in Medina County, Texas. Molluscan assemblages in this area are indicative of inner to mid-shelf environments. No significant reef components are present. These eastern Anacacho deposits are interpreted to represent more offshore, deeper water environments than those to the southwest, where reef and lagoonal deposits have been reported. Compilation of macrofossil lists from these eastern localities has expanded the number of invertebrate species known from the Anacacho Limestone by nearly three-fold. This increase in diversity, based on a small amount of new work, suggests that many more taxa are yet to be identified, particularly in the western part of the exposure belt in Uvalde and Kinney Counties. The Anacacho fauna documented herein closely resembles that of the Snow Hill calcareous member of the Black Creek Formation in North Carolina.

INTRODUCTION

The paleontologic data presented in this report are the result of a cooperative project carried out between the Texas Bureau of Economic Geology and the U. S. Geological Survey on the New Braunfels, Texas 1:100,000 map sheet. During the course of this work, the faunas of the Anacacho Limestone and correlative Pecan Gap Chalk were investigated in order to assess their paleoecology and stratigraphic relationship. This report provides the most current and extensive invertebrate fossil information for the Anacacho Limestone. Data are almost entirely derived from material collected during a five day site visit in 1990 and from fossils studied at the Texas Memorial Museum, University of Texas, Austin, in 1992. The total number of taxa identified from these two sources far exceeds that indicated in the published literature, which forms the third source of information used to compile the faunal list below. Collections from the Anacacho Limestone that reside in the U. S. Geological Survey (USGS) collections housed at the U. S. National Museum were not reviewed for this paper. Anacacho collections housed at the USGS in Denver, Colorado, were inspected, but were found to contain only ammonites and inoceramid bivalves; the ammonites are documented by Cobban and Kennedy (in press), and are included in the list below. Somewhat surprisingly, the bivalve and gastropod material collected on the short collecting trip in 1990 was as extensive as that in the museum collections, indicating a general lack of interest in collecting the mostly poorly preserved molluscan fauna of the Anacacho Limestone.

It is evident from the literature (e.g., Luttrell, 1977; Wilson, 1984; Rodgers, 1988) that the most fossiliferous parts of the Anacacho Limestone are reefal to lagoonal facies developed around volcanic cones exposed in the western part of the outcrop area in Uvalde and Kinney Counties and also found in the subsurface in Zavala and Dummit Counties. These shallow-water western localities were not sampled in this study, which is concentrated on localities here interpreted as being deposited in more offshore, deeper-water settings in Medina and Bexar Counties. These more-eastern localities have
received the most attention in past reports referring to molluscan paleontology (e.g., Stephenson, 1937; Young, 1963; Brown, 1965; Cobban and Kennedy, in press), and, therefore, the potentially most-diverse molluscan faunas of the Anacacho Limestone are yet to be documented.

The most fossiliferous portions of the Anacacho Limestone, other than the skeletal limestones, where all fossils are highly fractured, are typically chalky limestones and marls in which aragonite is not preserved. Therefore, most of the molluscan material, other than the oysters, inoceramids, and pectens, is represented only by molds. In addition, the fossils are typically somewhat compacted and deformed to varying degrees. These preservational vagaries make positive identification difficult, particularly for the aragonitic gastropods and bivalves. This taxonomic uncertainty is reflected by the large number of comparisons to described species (cf.), rather than actual assignment to those taxa in this report. The generally poor preservation of mollusks in many Taylor-age units of Texas, may be one reason for the general lack of taxonomic studies of Campanian age bivalves and gastropods in the state.

LITHOFACIES

The Anacacho Limestone was originally described in the Anacacho Mountains of Texas by Hill and Vaughan (1898), who identified this limestone-rich interval in Kinney and Uvalde Counties, Texas, as occupying the same stratigraphic position as the less carbonate-rich Taylor marl to the east and the Upson clay to the west in Texas. The Anacacho is mainly composed of bioclastic and argillaceous limestones with subsidiary clay and marl interbeds. The unit represents a small carbonate bank (160 km east-west by 30-40 km north-south) of up to over 150 m in thickness that lapped onto and around the flanks of the Uvalde Salient (Rodgers, 1988). Skeletal carbonate material was supplied to this bank from patch reefs, beaches, and lagoons that were developed around scattered Campanian igneous intrusions and volcanoes (Luttrell, 1977; Wilson, 1986; Rodgers, 1988). The skeletal limestones are primarily composed of red and green algae, foraminifers, bryozoans, and molluscan and echinoid fragments, but yield few identifiable macrofossils (Luttrell, 1977; Rodgers, 1988). In contrast, localized rudistid patch reef and lagoonal facies apparently contain many whole macrofossils, as do the apparently more offshore argillaceous limestone and marlstone facies studied in this report. High porosity developed in the Anacacho Limestone and facies equivalents, particularly in the grainstone facies, has allowed hydrocarbon influx, providing asphalt deposits (Wilson, 1984) and petroleum reservoir rocks of economic importance (e.g., Luttrell, 1977; Thompson, 1986).

CORRELATION AND AGE

Because the Anacacho Limestone was deposited around numerous volcanic highs and islands that developed through an extended period in south Texas (Ewing, 1986), its stratigraphic relationship to surrounding units is complex. Near the type area in the Anacacho Mountains, the Anacacho is conformably overlain by the San Miguel Formation and grades laterally to the west and south into the Upson Formation and the lower part of the San Miguel (Spencer, 1965; Sohl et al., 1991). To the east, along the
outcrop belt, the Anacacho thins and apparently grades into the upper part of the Pecan Gap Chalk near San Antonio. The top of the Anacacho becomes uncomformable to the east of the Anacacho Mountains, where it is overlain by the Maastrichtian Escondido or Corsicana Formations, but then again may become conformable with the upper part of the Taylor marl near the eastern limit of the Anacacho (Brown, 1965).

The relationship of the basal Anacacho Limestone to underlying units is unclear. Ammonite distributions suggest that at least two time intervals are represented by the Anacacho in the type area and probably elsewhere; a lower Campanian and a middle Campanian interval. The lower interval, corresponding to the lower Anacacho of Hazzard (1956), contains *Hoplioplacenticeras, Menabites (Delawarella),* and *Placenticeras.* These ammonites suggest a correlation to the Gober Chalk at the top of the Austin group in northeast Texas (Hazzard, 1956; Young, 1963; Cobban and Kennedy, in press). Young (1963) listed Anacacho Limestone localities containing this fauna as far east as Bexar County, at least 160 km (100 mi) east of the Anacacho Mountains. This lower unit is approximately the same age as the facies equivalent McKown Formation (Garner and Young, 1976), which is associated with the Pilot Knob volcanics near Austin, and also may correlate to the subsurface Dale lime, which lies near the Austin-Taylor contact to the east in Bastrop County (Thompson, 1986).

Hazzard (1956) placed an unconformity, representing the Austin-Taylor contact, between his lower Anacacho unit and the overlying middle Campanian Milam chalk and proposed a conformable contact between the lower Anacacho and the Big House Chalk below. In contrast, most subsequent workers (e.g., Brown, 1965; Wilson, 1984) have placed the Austin-Taylor contact at an apparent unconformity at the base of the lower Anacacho or at the base of the Upson Formation, which was included in the basal Anacacho as originally described by Hill and Vaughan (1898). In support of this latter placement, a restudy of the type Anacacho section by Longoria (1991) indicates an angular unconformity at the base of the Anacacho as originally described (=base of lower Anacacho of Hazzard, 1956). Further study of the biostratigraphy and lithostratigraphic relationships near the type Anacacho are warranted in order to clarify the placement and extent of unconformities in the section. The widespread presence of a lower Campanian ammonite fauna in an Anacacho-like facies near the base of the Anacacho Formation does suggest, however, that, at least locally, the Anacacho Limestone, as defined as a mapable lithostratigraphic unit, includes Austin-age rocks.

The upper part of the Anacacho Limestone is the most widely exposed and recognized part of the formation. It is composed of the upper Anacacho Limestone and the underlying Milam chalk of Hazzard (1956); the latter unit apparently only being developed in the Anacacho Mountains area (Rodgers, 1988). These units contain the middle Campanian ammonite assemblage described by Cobban and Kennedy (in press) and listed in this paper. This assemblage is essentially the same as that in the Pecan Gap Chalk and contains *Trachyscapheites spiniger porchi* (Adkins), tying it to the Western Interior *Baculites mclearni* to *B. asperiformis* zones (Cobban and Kennedy (1994). Cobban and Kennedy (in press) noted that the occurrence of *Bostrychoceras polyplocum* (Römer), which is found near the top of the Anacacho section on Seco Creek, suggests a slightly older age for this locality, than indicated by the other components of the upper Anacacho fauna found elsewhere. However, this older age seems unlikely since components of the "younger" fauna appears to occur in and below the beds containing *B.*
polyplocum on Seco Creek (Brown, 1965), and B. polyplocum apparently co-occurs with the entire fauna at King’s Water Hole on Hondo Creek (see Appendix A, locality M8696). The taxa reported herein all lie in the middle Campanian Anacacho interval.

PALEONTOLOGIC BACKGROUND

Little recent taxonomic literature exists for Campanian age macrofossils of Texas, other than papers by Cobban and Kennedy (e.g., 1993, 1994, in press) on the ammonites. Many of the taxa were named in early papers by Römer (1852), Conrad (1857, 1858), and Craigin (1893). The echinoid fauna has been dealt with in some detail by Clark (1893) and Cooke (1953). Kniker (1918) described the pectinids, and Adkins (1929) and Young (1963) provided taxonomic data of the ammonites of the Anacacho Limestone and correlative units. The Campanian bivalves and gastropods of Texas have been largely ignored, with the bulk of taxonomic papers pertinent to taxa found in the Anacacho describing faunas from other Gulf and Atlantic Coast States. Of particular importance are Whitfield (1885, 1892), Weller (1907), Gardner (1916), Stephenson (1923), Wade (1926), and Sohl (1960, 1964a,b). In addition to these monographic works, several papers noting species present in the Anacacho Limestone and correlative Pecan Gap Chalk are available; the most important of which are Brown (1965) for the Anacacho and Stephenson (1919) for the Pecan Gap.

Comparison of the bivalve and gastropod fauna from the Anacacho Limestone to those described in the above monographs indicates that the Anacacho assemblage bears a strong resemblance to that of the Snow Hill calcareous member of the Black Creek Formation of North Carolina as described by Stephenson (1923). Stephenson (1923) originally thought the Snow Hill member was late Campanian in age. However, Sohl and Owens (1991) have shown that the type Snow Hill is early Campanian in age, placing it in their Tar Heel Formation, and that Stephenson (1923) mistakenly included some taxa from their middle to upper Campanian Bladen Formation with what he thought to be his Snow Hill fauna. Both the Tar Heel and Bladen Formations contain species in common with the Anacacho Limestone.

RESULTS

This study is based on limited field work and the examination of collections at the Texas Memorial Museum. Taxa lists compiled from this work are listed in Appendixes A and B. The field work involved recollection of two of the classic eastern exposures of the Anacacho Limestone, the lower part of the Seco Creek section and the King’s Water Hole section on Hondo Creek. In addition, a locality was collected just east of Rio Medina near the Medina-Bexar County line (locality M8700, Appendix A). This locality is approximately equivalent to Texas Memorial Museum locality 800 (Appendix B). Finally, a collection was made in a pipeline ditch being excavated in a massive chalk unit mapped as the Pecan Gap Chalk less than 1 km (0.6 mi) east of the easternmost Anacacho exposure mapped on the Geologic Atlas of Texas, San Antonio Sheet (1983). This locality is apparently slightly stratigraphically lower than the Anacacho mapped in this area.
SECO CREEK SECTION

Access was only obtained to the lower part of the Anacacho section on Seco Creek, where Station I, beds "a" through "i" of Brown (1965) were collected. Brown (1965) questioned whether the calcarenitic interval from beds "a" through "d" belonged to the Austin Group or the Anacacho Limestone. None of the fossils collected from bed "b" (M8690, Appendix A) in this study are restricted to the Anacacho or the Austin. However, if the Pycnodonte in this sample is Pycnodonte (Phygraea) mutabilis (Morton), this would suggest an age younger than the Austin Group, as the species is only questionably known from rocks as old as the Austin. In addition, the Spondylus specimens from this bed have a greater number of spinose primary radial costae than is typical of Spondylus guadalupae Römer (ca. 14 versus ca. 10) of the Austin Chalk, and fewer non-spinose secondary radials (3-4 versus 4-6). The degree of variation in Spondylus guadalupae is unknown, however. It is possible that this lower calcarenitic interval represents the lower Campanian Austin-age Anacacho interval indicated elsewhere, but further collecting is needed to verify the age of these beds. The overlying fossils collected from beds "f" through "i" (M8691, Appendix A) are typical of the middle Campanian Anacacho interval elsewhere, although this is the only locality where Turritella (Sohlitella) trilira Conrad has been positively identified.

HONDO CREEK SECTION

The entire section of Anacacho Limestone exposed at King's Water Hole at Hondo Creek crossing 5 km (3 mi) north of Hondo was measured and sampled in detail. The stratigraphic section with abbreviated lithologic descriptions and fossil sample intervals is shown in Figure 1. Taxonomic occurrences are plotted in Figure 2. The taxonomic ranges shown in Figure 2 are probably environmentally controlled rather than indicative of age constraints. Age determination of the basal skeletal limestone exposed in the creek bed was not possible because no identifiable fossils were recovered. This skeletal calcarenite is very similar in character to the basal beds on Seco Creek, which may lie in the lower Campanian Anacacho interval. The first age-indicative fossil, Baculites taylorensis Adkins, was found approximately 1.5 m above the basal calcarenite. This ammonite and others found in units 4 through 8 are typical of the middle Campanian Anacacho interval.

Relatively diverse assemblages of deep- to shallow-infaunal bivalves, epifaunal bivalves, gastropods, and ammonites are found at this section, where the marlstone and chalk beds are typically more fossiliferous than the limestones. Infaunal bivalves are the most diverse and common in the lower, more marly units 3 through 5, where the deep infaunal bivalve, Panopea n. sp. aff. decisa Conrad, is typically found in life position. Also, in the lower part of the section, Pycnodonte and ammonites tend to be concentrated near the tops of the limestone beds. Higher in the section (units 11 through 14)
### ANACACHO LIMESTONE AT KING'S WATER HOLE, HONDO CREEK, TEXAS

<table>
<thead>
<tr>
<th>METERS</th>
<th>UNIT</th>
<th>LOCALITY NUMBER</th>
<th>LITHOLOGIC COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>14</td>
<td>M8699</td>
<td>Chalky, very well-indurated limestone. Zones of abundant <em>Pycnodonte</em> and other shell debris.</td>
</tr>
<tr>
<td>8</td>
<td>13</td>
<td>M8698</td>
<td>Chalky limestone. Common to abundant <em>Pycnodonte</em>.</td>
</tr>
<tr>
<td>7</td>
<td>12</td>
<td>M8697</td>
<td>Marly limestone. Abundant <em>Pycnodonte</em>.</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>9</td>
<td>M8695</td>
<td>Marly limestone.</td>
</tr>
<tr>
<td>3C</td>
<td>8</td>
<td>M8694</td>
<td>Chalky, slightly platy limestone. Areas of abundant <em>Pycnodonte</em>.</td>
</tr>
<tr>
<td>3B</td>
<td>7</td>
<td>M8693</td>
<td>Marly limestone above and below 35 cm chalky limestone bed. <em>Baculites</em> near base, other fossils concentrated in limestone bed.</td>
</tr>
<tr>
<td>3A</td>
<td>6</td>
<td>M8692</td>
<td>Marly limestone.</td>
</tr>
<tr>
<td>2</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Figure 1.** Stratigraphic section of the Anacacho Limestone exposed at King's Water Hole on Hondo Creek. Lithologic units, fossil locality numbers, and an abbreviated lithologic description are plotted against the lithologic column.
Figure 2. Molluscan fossil distributions in the exposed Anacacho Limestone section at King’s Water Hole on Hondo Creek, Texas.

_Pycnodonte_ accumulations become more abundant as other taxa become less common and shell breakage increases.

These data suggest an open marine, shelf-depth habitat with relatively stable benthic conditions during the deposition of units 2 through 10, followed by increased current or wave activity during deposition of units 11 through 14. It is possible that the lower marly and chalky interval corresponds to the Milam chalk to the west and the overlying limestone interval to the upper Anacacho, but further work is needed to verify this tentative correlation.
EASTERN LOCALITIES

Locality M8700, in a cut on Road 1957, 3.2 km (2 mi) east of the town of Rio Medina, contains a molluscan fauna typical of the middle Campanian Anacacho Limestone interval (Appendix A). The basal bed exposed at this locality is a hard chalk of at least one meter in thickness. Most of the fossils listed from this locality were found in the overlying two-meter-thick marlstone bed. Above, the top of the exposed section is capped by a oyster-rich skeletal calcarenite bed of more than a meter in thickness. This section contains the most diverse gastropod assemblage identified in the Anacacho. The bivalve assemblage is very similar to that from the nearby Texas Memorial Museum locality 800 (Appendix B).

The fossils at locality M8702 were collected from material excavated from a three-meter-deep pipeline trench on Road 1957, 0.4 km (0.25 mi) west of junction of Road 151 in San Antonio. The white chalk exposed at this locality was mapped as Pecan Gap Chalk on the Geologic Atlas of Texas, San Antonio Sheet (1983), and apparently immediately underlies the easternmost exposure of Anacacho Limestone 1 km to the west. In contrast, Stephenson (1937, p. 136) considered white chalk exposed 13 km (8mi) to the east at the Cementville cement pit to lie in the Anacacho Limestone. Although no age-indicative ammonites were found at M8702, the molluscan assemblage is consistent with those found in middle Campanian Taylor-age rocks elsewhere. At least seven of the fourteen taxa found at this locality have not been identified from the Anacacho Limestone to the west, suggesting some facies control on the fossil distributions.

COMPARISONS WITH TEXAS MEMORIAL MUSEUM COLLECTIONS

In general, taxa in the Anacacho Limestone collections studied at the Texas Memorial Museum were well represented in the collections gathered during the field work of this project. Only four species (indicated by single asterisks in Appendix C) of the approximately 17 molluscan species identified in the museum collections (Appendix B plus several ammonites not listed) were not found in the field collections, the latter of which contain a total of about 45 species. Museum collections were largely lacking from the western exposures of the Anacacho Limestone in Uvalde and Kinney Counties, which apparently are more fossiliferous than the eastern part studied herein. This suggests the potential for a much expanded taxa list when the western area is studied in detail.

DEVELOPMENT OF THE ANACACHO LIMESTONE
AND EUSTATIC SEA LEVEL HISTORY

The two Campanian time intervals preserved in the Anacacho Limestone apparently reflect eustatic sea-level changes. The lower Campanian interval probably correlates to the Scaphites hippocrepis II or III zones in the Western Interior region, and the middle Campanian interval is coeval with the B. asperiformis zone and possibly part of the Baculites mclearni zone (Kennedy and Cobban, 1993; Cobban and Kennedy, in press). These two preserved time intervals correspond to transgressive periods following
major sea-level drops near the base and top of the lower Campanian (at 80 and 85 Ma on Haq et al. 1987; see Elder and Kirkland, 1994, fig. 2). In the east Texas basin, these also are times of maximum carbonate development during deposition of the Gober and Pecan Gap Chalks. Therefore, the development and preservation of the Anacacho limestone beds during a time interval typified by marly sedimentation in southwest Texas, is probably the combined result of decreased siliciclastic input, due to eustatic sea level rise, and the prolonged buildup of reefs and carbonate banks around volcanic highs present during these periods of sea-level rise. In contrast, the sea-level fall events are represented by unconformities.

CONCLUSIONS

Ammonite distributions in the Anacacho Limestone indicate that the formation represents two time intervals, one in the early Campanian and one in the middle Campanian, separated by an unconformity. These two time intervals correspond to transgressive events following major sea level drops at the base and top of the lower Campanian. This study is focused on the molluscan paleontology of the middle Campanian interval in the eastern part of the exposure area of the Anacacho in Medina County. The molluscan assemblage in this area, which mostly is derived from marly and chalky beds, is indicative of inner to mid-shelf environments and contains no significant reef components. These beds are interpreted to represent more-offshore, deeper water facies than those to the southwest, where reef and lagoonal deposits have been reported (Luttrell, 1977, Rodgers, 1988).

The Anacacho invertebrate fauna has been largely ignored, particularly the bivalve and gastropod components. Macrofossil lists compiled herein, based mainly on four days of collecting plus review of the Texas Memorial Museum collections, have expanded the number of invertebrate species known from the Anacacho Limestone by nearly three-fold, from approximately 22 indicated in the literature to the 58 listed in Appendix C. This increase in diversity, based on such a small amount of new work, suggests that many more taxa are yet to be identified, particularly in the western part of the exposure belt in Uvalde and Kinney Counties. When the Anacacho fauna listed here is compared to the few well-documented middle Campanian molluscan assemblages of the Gulf and Atlantic coastal regions, it most closely resembles the fauna of the Snow Hill calcareous member of the Black Creek Formation documented by Stephenson (1923) in North Carolina.

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APPENDIX A

Locality and fossil information for Anacacho Limestone and Pecan Gap Chalk collections made during 1990 field work.

USGS Mesozoic Locality: M8690.
Medina County, Texas, San Antonio 1:250000 quadrangle.
Marl interbed (bed "b" of Brown, 1965) in calcarenitic limestone in Seco Creek on Road 1796, ca. 3.2 km (2 mi) north of D'Hanis.
Latitude: 29 degrees 21.70' N; Longitude: 99 degrees 17.00' W;
Collector: W. P. Elder, 1990; Field Identifier: 90ET-3A.
Stratigraphic unit: Anacacho Limestone?

TAXA PRESENT

BIVALVES

*Spondylus* aff. *guadalupae* Römer
*Exogyra* cf. *ponderosa erraticostata* Stephenson
*Pycnodonte (Phygraea) aff. mutabilis* (Morton)
*Lyriochlamys?* sp.

ECHINOID

*Phyllobrissus cubensis* (Weisbord)

USGS Mesozoic Locality: M8691.
Medina County, Texas, San Antonio 1:250000 quadrangle.
Marls overlying limestone (beds "f" through "i" of Brown, 1965) in Seco Creek on Road 1796, ca. 3.2 km (2 mi) north of D'Hanis.
Latitude: 29 degrees 21.70' N; Longitude: 99 degrees 17.00' W;
Collector: W. P. Elder, 1990; Field Identifier: 90ET-3B.
Stratigraphic unit: Anacacho Limestone

TAXA PRESENT

AMMONITE

*Baculites* sp.

BIVALVES

*Panopea* n. sp. aff. *decisa* Conrad
Pycnodonte (Phygraea) mutabilis (Morton)
Cardioid

GASTROPOD

Turritella (Sohlitella) trilira Conrad

USGS Mesozoic Locality: M8692 to M8699.
Medina County, Texas, San Antonio 1:250000 quadrangle.
Anacacho Limestone at King's Water Hole. Hondo Creek crossing 5 km (3 mi) north of Hondo. See Figure 2 for stratigraphic positions of sampled units at localities M8692 to M8699.
Latitude: 29 degrees 23.50' N; Longitude: 99 degrees 9.15' W;
Collector: W. P. Elder, 1990; Field Identifier: 90ET-4.
Stratigraphic unit: Anacacho Limestone

Unit 2; USGS Mesozoic Locality: M8692.

TAXA PRESENT

BIVALVE

Granocardium (Criocardium) dumosum (Conrad)

Unit 3; USGS Mesozoic Locality: M8693.

TAXA PRESENT

AMMONITE

Baculites taylorensis Adkins

BIVALVES

Pycnodonte (Phygraea) mutabilis (Morton)
Protocardia (Pachycardium) spillmani (Conrad)
Neithea (Neithea) quinquecostata (Sowerby)
Cymella cf. ironensis (Stephenson, 1923)
Nucula cf. stantoni Stephenson
Leptosolen aff. biplicatus (Conrad)
Lima reticulata Forbes
Idonearca sp.
Granocardium (Criocardium) sp.
Nemodon n. sp. aff. martindalensis Stephenson
Panopea n. sp. aff. decisa Conrad
Inoceramus (Endocostea) cf. balticus Böhm
Pterotrigonia sp.
Lucinid?

GASTROPOD

Drepanochilus? aff. corbetensis Stephenson

OTHER

Nautiloid?
Scaphopod

Unit 4; USGS Mesozoic Locality: M8694.

TAXA PRESENT

AMMONITE

Trachyscaphites spiniger porchi (Adkins)

BIVALVES

Neithea (Neithea) quinquecostata (Sowerby)
Lima reticulata Forbes
Pycnodonte (Phygraea) mutabilis (Morton)
Syncyclonema? burlingtonensis (Gabb)
Nemodon? sp.

GASTROPODS

Pyropsis aff. perlata Conrad
Euthriofusus? aff. convexus (Wade)
Naticid
Unit 5; USGS Mesozoic Locality: M8695.

TAXA PRESENT

   BIVALVE

   *Granocardium (Criocardium) dumosum* (Conrad)

Unit 6; USGS Mesozoic Locality: M8696.

TAXA PRESENT

   AMMONITES

   *Baculites taylorensis* Adkins
   *Pachydiscus (Pachydiscus) travisi* (Adkins)
   *Bostrychoceras polyplicum* (Römer)

   BIVALVES

   *Exogyra ponderosa erraticostata* Stephenson
   *Protocardia (Pachycardium) spilimanii* (Conrad)
   *Idonearca* sp.
   *Panopea* n. sp. aff. *decisa* Conrad
   *Pinna* cf. *laqueata* Conrad
   *Inoceramus (Endocostea) balticus* Böhm
   *Lucina* cf. *giebula* Conrad
   Trigoniid

   GASTROPODS

   *Pyropsis* aff. *perlata* Conrad
   *Gyrodes* aff. *major* Wade

Unit 8; USGS Mesozoic Locality: M8697.

TAXA PRESENT

   AMMONITES

   *Baculites taylorensis* Adkins
   *Eubostrychoceras reevesi* (Young)
   *Trachysphinctes spiniger porchi* (Adkins)
BIVALVES

*Exogyra ponderosa erraticostata* Stephenson
*Exogyra spinifera* Stephenson
*Protocardia (Pachycardium) spillmani* (Conrad)
*Idonearca* sp.
*Pinna cf. laqueata* Conrad
*Inoceramus (Endocostea) balticus* Böhm
*Lima reticulata* Forbes
*Pycnodonte (Phygraea) mutabilis* (Morton)
*Neithea (Neithea) quinquecostata* (Sowerby)
*Trigonarca?* sp.
*Camptonectes cf. bellisculptus* (Conrad)
*Spondylus* sp.
*Barbatia?* sp.
*Rudistid*
*Pterotrigonia* sp.

GASTROPOD

*Napulus?* sp.

Unit 9; USGS Mesozoic Locality: M8698.

TAXA PRESENT

BIVALVES

*Lima reticulata* Forbes
*Pycnodonte (Phygraea) mutabilis* (Morton)
*Camptonectes cf. bellisculptus* (Conrad)

Unit 14; USGS Mesozoic Locality: M8699.

TAXA PRESENT

BIVALVES

*Pycnodonte (Phygraea) mutabilis* (Morton)
*Idonearca* sp.
*Protocardia (Pachycardium) spillmani* (Conrad)
ECHINOID

Irregular echinoid

USGS Mesozoic Locality: M8700.
Medina County, Texas, San Antonio 1:250000 quadrangle.
Road 1957, 3.2 km (2 mi) east of Rio Medina in road cut on hill.
Latitude: 29 degrees 25.90' N; Longitude: 98 degrees 51.35' W;
Collector: W. P. Elder, 1990; Field Identifier: 90ET-5.
Stratigraphic unit: Anacacho Limestone

TAXA PRESENT

AMMONITE

*Baculites taylorensis* Adkins

BIVALVES

*Pycnodonte* sp.
*Protocardia (Pachycardium) spillmani* (Conrad)
*Neithea (Neithea) quinquecostata* (Sowerby)
*Idonearca* sp.
*Paranomia? cf. scabra* (Morton)
*Exogyra* sp.
*Crassatella cf. newkirkensis* (Stephenson) ?
*Syncyclonema? burlingtonensis* (Gabb)
*Liopistha alternata* Weller
*Inoceramid

GASTROPODS

*Capulus aff. cuthandensis* Stephenson
*Paladmete? aff. cancelleria* (Conrad)
*Turritella?* sp.
*Graphidula?* sp.
*Gyrodes* sp.
*Euspira cf. rectilabrum* (Conrad)

ECHINOIDS

*Phyllobrissus cubensis* (Weisbord)
*Proraster dalli* (Clark)
*Salenia hondoensis* Cooke
USGS Mesozoic Locality: M8702.
Bexar County, Texas, San Antonio 1:250000 quadrangle.
Pipeline excavation on Road 1957, 0.4 km (0.25 mi) west of junction of Road 151.
Latitude: 29 degrees 26.40' N; Longitude: 98 degrees 40.25' W;
Stratigraphic unit: Pecan Gap Chalk

TAXA PRESENT

AMMONITE

Baculites sp.

BIVALVES

Neitha (Neitha) quinquecostata (Sowerby)
Syncyclonema? burlingtonensis (Gabb)
Granocardium (Criocardium) dumosum (Conrad)
Legumen cf. ellipticum Conrad
Crassatella? cf. conradi (Whitfield)
Lucina aff. parva Stephenson
Nemodon aff. punctus? Stephenson
Cymella cf. ironensis (Stephenson, 1923)
Inoceramus (Endocostea) balticus Böhm
Pterotrigonia cf. maroinensis (Stephenson)

GASTROPODS

Arrhoges? sp.
Turritella (Sohlitella) quadrilira Johnson
Naticid
APPENDIX B

Bivalves and Gastropods identified in Texas Memorial Museum collections from the Anacacho Limestone and Pecan Gap Chalk.

<table>
<thead>
<tr>
<th>Taxon</th>
<th>Locality</th>
<th>Formation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crassatella cf. newkirkensis (Stephenson)</td>
<td>800</td>
<td>Anacacho</td>
</tr>
<tr>
<td>Exogyra spinifera Stephenson</td>
<td>800</td>
<td>Anacacho</td>
</tr>
<tr>
<td>Neitheia (Neithia) quinquecostata (Sowerby)</td>
<td>800</td>
<td>Anacacho</td>
</tr>
<tr>
<td>Plicatula cf. clarki Stephenson</td>
<td>800</td>
<td>Anacacho</td>
</tr>
<tr>
<td>Pycnodonte (Phygraea) mutabilis (Morton)</td>
<td>800</td>
<td>Anacacho</td>
</tr>
<tr>
<td>Inoceramus (Endocostea) balticus Böhm</td>
<td>K630</td>
<td>Anacacho</td>
</tr>
<tr>
<td>Pycnodonte (Phygraea) mutabilis (Morton)</td>
<td>K653</td>
<td>Anacacho</td>
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<tr>
<td>Inoceramus (Endocostea) balticus Böhm</td>
<td>UT-18225</td>
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</tr>
<tr>
<td>Graphidula? sp.</td>
<td>UT-42122</td>
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</tr>
<tr>
<td>Granocardium (Criocardium?) cf. conradi (Stephenson)</td>
<td>UT-42135</td>
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</tr>
<tr>
<td>Paranimia? aff. scabra (Morton)</td>
<td>UT-42151</td>
<td>Anacacho</td>
</tr>
<tr>
<td>Trachycardium? cf. vaughani (Stephenson)</td>
<td>UT-42369</td>
<td>Anacacho</td>
</tr>
<tr>
<td>Exogyra ponderosa erraticostata Stephenson</td>
<td>WSA 6318</td>
<td>Anacacho</td>
</tr>
<tr>
<td>Protocardia (Pachycardium) spillmani (Conrad)</td>
<td>K629</td>
<td>Anacacho</td>
</tr>
<tr>
<td>Volutid</td>
<td>R 17592</td>
<td>Anacacho</td>
</tr>
<tr>
<td>Volutomorpha aff. conradi (Gabb)</td>
<td>R-17615</td>
<td>Anacacho</td>
</tr>
<tr>
<td>Pholadomya ingens Cragin</td>
<td>UT-33050</td>
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</tr>
<tr>
<td>Syncyclonema? burlingtonensis (Gabb)</td>
<td>UT-42113</td>
<td>Anacacho</td>
</tr>
<tr>
<td>Inoceramus (Cordiceramus) sp.</td>
<td>UT-17325</td>
<td>Pecan Gap</td>
</tr>
<tr>
<td>Inoceramus (Endocostea) balticus Böhm</td>
<td>UT-17325</td>
<td>Pecan Gap</td>
</tr>
<tr>
<td>Ostrea plumosa Morton</td>
<td>UT-46930</td>
<td>Pecan Gap</td>
</tr>
<tr>
<td>Exogyra spinifera Stephenson</td>
<td>UT-46957</td>
<td>Pecan Gap</td>
</tr>
<tr>
<td>Exogyra spinifera Stephenson</td>
<td>UT-31801</td>
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<tr>
<td>Neithea (Neithia) quinquecostata (Sowerby)</td>
<td>UT-8917</td>
<td>Pecan Gap</td>
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<tr>
<td>Inoceramus (Endocostea) balticus Böhm</td>
<td>WSA 18830</td>
<td>Pecan Gap</td>
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<tr>
<td>Ostrea plumosa Morton</td>
<td>UT-31796</td>
<td>Pecan Gap</td>
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<tr>
<td>Inoceramus (Endocostea) cf. balticus Böhm</td>
<td>UT-46932</td>
<td>Pecan Gap</td>
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</tbody>
</table>
APPENDIX C

List of macrofossils from the middle Campanian part of the Anacacho Limestone. List is compiled from field and museum collections and the literature. Taxa present in Texas Memorial Museum collections but not found during field work are prefixed by "*". Taxa only known from literature are prefixed by "**". Taxa known only from locality M8690, which may be older than middle Campanian, are prefixed by "?".

**TAXA**

<table>
<thead>
<tr>
<th>TAXA</th>
<th>Literature Source</th>
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<tbody>
<tr>
<td><strong>Ammonites</strong></td>
<td></td>
</tr>
<tr>
<td>Bostrychoceras polyplocum (Römer)</td>
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</tr>
<tr>
<td>Baculites taylorensis Adkins</td>
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</tr>
<tr>
<td>Eubostrychoceras reevesi (Young)</td>
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<tr>
<td><strong>Lewyites clinensis</strong> (Adkins)</td>
<td></td>
</tr>
<tr>
<td>Pachydiscus (Pachydiscus) travisi (Adkins)</td>
<td></td>
</tr>
<tr>
<td><strong>Bivalves</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Atreta cretacea minor</strong> (Stephenson)</td>
<td></td>
</tr>
<tr>
<td>Barbatia? sp.</td>
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</tr>
<tr>
<td>Camptonectes cf. bellisculptus (Conrad)</td>
<td></td>
</tr>
<tr>
<td>Crassatella cf. newkirkensis (Stephenson) ?</td>
<td></td>
</tr>
<tr>
<td>Cymella cf. ironensis (Stephenson, 1923)</td>
<td></td>
</tr>
<tr>
<td><strong>Durania</strong> sp.</td>
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</tr>
<tr>
<td>Exogyra ponderosa erraticostata Stephenson</td>
<td></td>
</tr>
<tr>
<td>Exogyra spinifera Stephenson</td>
<td></td>
</tr>
<tr>
<td>Granocardium (Criocardium) dumosum (Conrad)</td>
<td></td>
</tr>
<tr>
<td>Granocardium (Criocardium?) cf. conradi (Stephenson)</td>
<td></td>
</tr>
<tr>
<td>Idonearca sp.</td>
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<tr>
<td>Inoceramus (Endocostea) balticus Böhm</td>
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<tr>
<td>Leptosolen aff. biplicatus (Conrad)</td>
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<tr>
<td>Lima reticulata Forbes</td>
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<tr>
<td>Liopistha alternata Weller</td>
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<tr>
<td>Lucina cf. glebula Conrad</td>
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<tr>
<td><strong>Lyriochlamys</strong> sp.</td>
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</tr>
<tr>
<td><strong>Monopleura</strong> sp.</td>
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<tr>
<td>Neithe (Neithe) quinquecostata (Sowerby)</td>
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<tr>
<td>Nemodon n. sp. aff. mrtindalensis Stephenson, 1941</td>
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</tr>
<tr>
<td>Nucula cf. stantoni Stephenson</td>
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<tr>
<td>Panopea n. sp. aff. decisa Conrad</td>
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</tr>
<tr>
<td>Paranomia? cf. scabra (Morton)</td>
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<tr>
<td><strong>Pholadomya ingens</strong> Cragin</td>
<td></td>
</tr>
<tr>
<td>Pinna cf. laqueata Conrad</td>
<td></td>
</tr>
</tbody>
</table>

21
* Plicatula cf. clarki Stephenson  
Protocardia (Pachycardium) spillmani (Conrad)  
Pterotrigonia sp.  
Pycnodonte (Phygraea) mutabilis (Morton)  
? Spondylus aff. guadalupae Römer  
Spondylus sp.  
Syncyclonema? burlingtonensis (Gabb)  
** Requieniid Rodgers (1988)  
* Trachycardium? cf. vaughani (Stephenson)  
** Venericardia uvaldana Stephenson Stephenson (1947)

Gastropods

Capulus aff. cuthandensis Stephenson  
Drepanochilus? aff. corbetensis Stephenson  
Euspira cf. rectilabrum (Conrad)  
Euthriofusus? aff. convexus (Wade)  
Graphidula? sp.  
Turritella (Sohlitella) trilira Conrad  
Gyrodes aff. major Wade  
Napulus? sp.  
Paladmete? aff. cancelleria (Conrad)  
Pyrops aff. perlata Conrad  
* Volutomorpha aff. conradi (Gabb)

Echinoids

** Echinochorys texanus (Cragin) Brown (1965)  
Phyllobriussus cubensis (Weisbord)  
Proraster dalli (Clark)  
Salenia hondoensis Cooke

Other

Nautiloid?  
Scaphopod  
** Terebratulina cf. filosa Conrad Stephenson (1937)