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CRETACEOUS RUDISTS OF GUATEMALA

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ABSTRACT

A small assemblage of rudists was described in the 1930's from central Guatemala by MacGillavry and Mullerried. New collections from outcrops and cores in the Petén, from Rubelsanto in Alta Verapaz, and in the Barillas-San Ramón region of Huehuetenango, have yielded three stratigraphically distinct assemblages: Albian-Cenomanian, Turonian, and Santonian-Maastrichtian. The ages are confirmed by associated larger benthic foraminifers. These assemblages are similar taxonomically with those in the Caribbean and Mexico. They represent shallow, normal marine shelf environments that alternated with restricted evaporitic conditions of the central Yucatán platform.

Key words: Guatemala, rudists, Petén, Alta Verapaz, Huehuetenango, Albian-Cenomanian, Turonian, Santonian-Maastrichtian.

RESUMEN

En 1930 fue descrito un pequeño conjunto de rudistas del centro de Guatemala por Mac Gillavry y Mullerried. Colecciones nuevas de afloramientos y núcleos de Petén, de Rubelsanto en Alta Verapaz y de la región de Barillas-San Ramón en Huehuetenango, han proporcionado tres conjuntos estratigráficamente diferentes: Albiano-Cenomaniano, Turoniano y Santoniano-Maastrichtiano. Las edades se confirmaron por los foraminíferos bentónicos grandes asociados. Estos conjuntos son taxonómicamente similares a los conjuntos del Caribe y de México. Representan ambientes someros de plataforma de agua marina normal, que alternan con condiciones restringidas con evaporitas de la plataforma central de Yucatán.

Palabras clave: Guatemala, rudistas, Petén, Alta Verapaz, Huehuetenango, Albiano-Cenomaniano, Turoniano, Santoniano-Maastrichtiano.

INTRODUCTION

Throughout the Cretaceous Period, most of Guatemala was a shallow water, carbonate platform that extended eastward into Belize and northward into the Yucatán and Chiapas regions of Mexico (Bishop, 1980; Enos, 1983; Scott, 1984). This platform accumulated upon a fragment of continental crust, the Yucatán Plate, that migrated out of the proto-Gulf of Mexico during the Jurassic (Pindell and Barrett, 1990). It was in place relative to the rest of Mexico by Late Jurassic time. The southern margin of this platform is now truncated by a major Neogene strike slip fault zone that includes the Chixoy-Polochic fault system (Burkart and Self, 1985), which forms the junction between the Yucatán and Chortis blocks.

This Cretaceous carbonate platform consists of at least 3,000 m of carbonates and evaporites rimming an intraplatform basin in the Petén area where carbonates and evaporites are interbedded (Bishop, 1980). The sections are partially exposed in the Sierra de los Cuchumatanes in central Guatemala and in the Sierra Lacandón in northern Guatemala. Field work sponsored by Amoco Production Company during the mid 1980's and 1991 in Huehuetenango and in northwestern Petén yielded many new rudist specimens. An additional collection was made from cores during 1975 in the Rubelsanto area in Alta Verapaz (Figure 1).

Rudists were first reported from Guatemala north of Cobán, Alta Verapaz, by Karl Sapper (1894, 1899) and this material was described, identified and dated tentatively by MacGillavry (1934): *Thyrastylon* [*Biradiolites*] *adhaerens* (Whitefield), possibly Maastrichtian, *Praelapeirousia?* sp., Santonian, and *Sauvagesia* sp., ranging from Albian to questionably Campanian. In 1935 MacGillavry reported *Barrettia monilifera* Woodward and *Parastroma guitarti* (Palmer) from Sapper's collection west of Cobán which occurred with *Pseudorbitoides iraelski* Vaughan and Cole, a Maastrichtian marker. Additional localities near Cobán yielded *B. monilifera*, *"Biradiolites" lombricalis* (d'Orbigny) with sauvagesiids, caprinids, and corals; and in southeastern Guatemala *Toucasia* sp. cf. *T. texana* Roemer, monopleurids, caprinids, and sauvagesiids were reported by Mullerried (1939). Since these early reports, rudists have been mentioned, but not described, by geologists in mapping and structural studies. The deeply weathered and densely covered bedrock makes it difficult to do through studies and to recognize the presence of frameworks. A recent survey of the data from Guatemala reported *Toucasia texana, Barrettia monilifera,* and *Thyrastylon adhaerens* (Johnson, 1993).

Seven genera and seven species are reported here; six of the species are new to Guatemala, but three occur in the Chiapas region of Mexico (Johnson, 1993), and the others are found elsewhere in the region. They represent three stratigraphic assemblages: Albian-Cenomanian, Turonian, and Santonian-Maastrichtian, and provide data for biostratigraphic, paleoenvironmental and biogeographic studies of Guatemala, the Caribbean Province, and the Tethyan Realm (Figure 2). Guatemalan rudists must be compared with taxa from larger and more diverse collections in Cuba and Curaçao (Palmer, 1933; Rutten, 1936; MacGillavry, 1932, 1937; Chubb, 1961),

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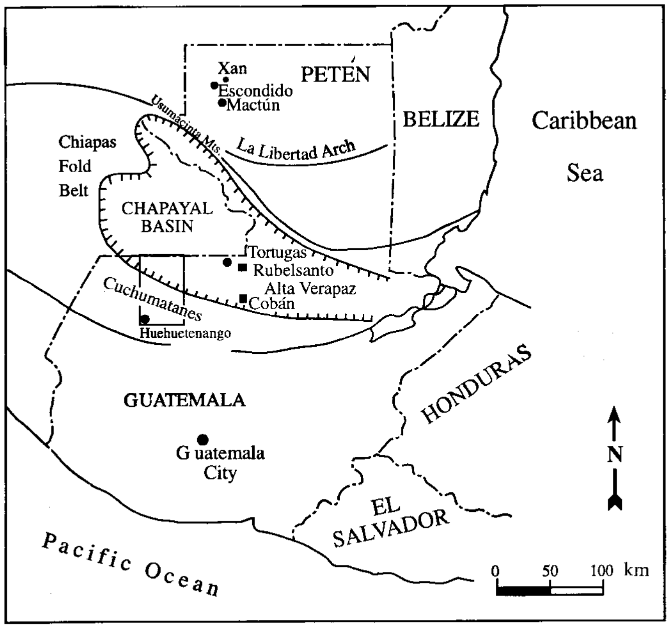

Figure 1. General location map of Guatemala showing major geological features.

in Jamaica (Chubb, 1967, 1971), and in Mexico (Palmer, 1928; Mulleried, 1930, 1931, 1933, 1934; Alencáster, 1971). The specimens illustrated here are deposited in the University of Texas Memorial Museum, Austin, Texas.

STRATIGRAPHY

Stratigraphic samples were collected in three separate areas (Figure 1). Outcrop sections in the Sierra de Los Cuchumatanes, Huehuetenango, were collected along Highway 9 north from the town of Huehuetenango to Barillas and to San Ramón. Exposures in the gorge of Río Yula San Juan-Río Ixcán were sampled during a raft run. Eastward in Alta Verapaz, cores were sampled from the Tortugas Dome and Rubelsanto oil fields. Northward in northwestern Petén outcrop and subsurface samples were collected. Thin-sections are identified by Amoco locality and sample numbers (Am).

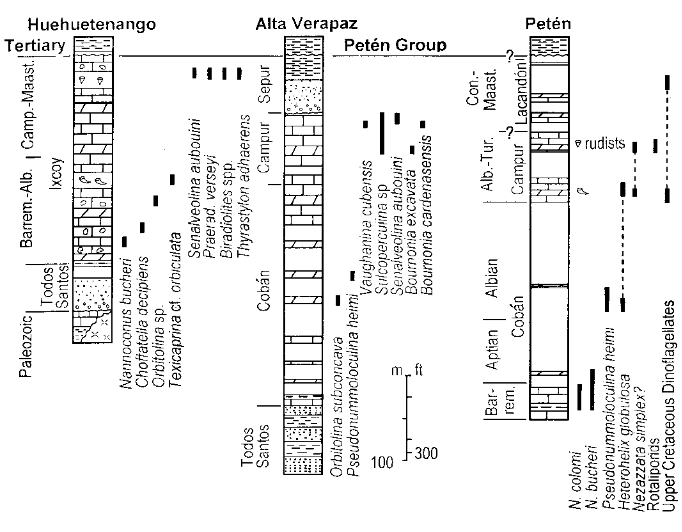

Figure 2. Generalized stratigraphic successions in Huehuetenango, Alta Verapaz and northwestern Petén departments. Fossil ranges located approximately relative to position within the succession.

HUEHUETENANGO AREA

Samples were collected in roadcuts (Figure 3) crossing anticlinal ridges composed of resistant limestone and dolomite of the Ixcoy Formation. The undivided carbonate unit between the terrigenous clastic Todos Santos Formation below and the Sepur Formation above is mapped as the Ixcoy (Figure 2) (Anderson *et al.*, 1973; Clemons *et al.*, 1974; and Bishop, 1980). The type area is the village of Ixcoy or San Juan Ixcoy.

The Ixcoy Formation is estimated to be 2,500–3,000 m thick in the Cuchumatanes (Figure 3) by Clemons and Burkart (1971) and Anderson and coworkers (1973). An accurate

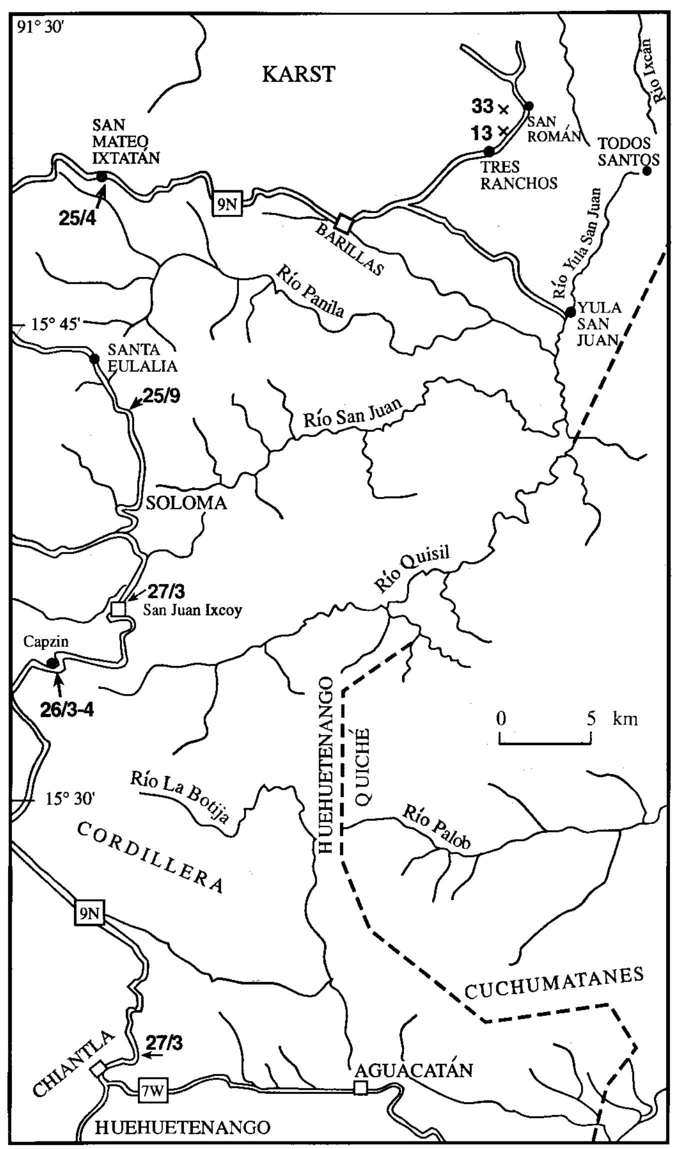

Figure 3. Detailed map of the Huehuetenango area showing rudist collection sites. Taken from Central American map ND15-4 at a scale of 1:250,000.

measurement is difficult to obtain because of structural complexities. It is confirmed that its age ranges from Aptian to Maastrichtian, based on associated foraminifers, supporting the correlation of the Ixcoy with the Cobán and Campur formations eastward (Walper, 1960; Vinson, 1962).

The section is exposed along the Río Yula San Juan-Río Ixcán south and north of the village of Yula San Juan about 16 km southeast of Barillas (Figure 3). Basement rocks exposed south of Yula San Juan are schist and gneiss with foliation striking 99–105 degrees SE-NW. The overlying Todos Santos Formation consists, in ascending order, of conglomerate with basement clasts, sandstone, gypsum, and red-gray mudstone and dolomite. The mudstone-dolomite section between the gypsum and the Ixcoy Formation is about 120-m thick. The base of the Ixcoy is placed at the base of the thick- to massive-bedded dolomite and limestone succession. Brecciated limestone and dolomite become more common just above the base of the formation in association with light-gray, medium crystalline dolomite, dolomitic limestone, and rare beds of poorly preserved foraminifers and rudists. Proceeding up section into the river gorge, dark gray limestone becomes dominant; the only breccias are caliche-cemented talus breccias of post-Cretaceous age, probably Pleistocene-Holocene. The thin-bedded, dark gray, brecciated lime mudstone and bioturbated, peloidal mudstone crop out at water level on the east bank. A Barremian-lower Aptian assemblage consists of *Choffatella decipiens* Schlumberger, *Nannoconus bucheri* Bronnimann, *Nannoconus wassali* Bronnimann, and *Globigerina hoterivica* (Subbotina). Samples from a nearby site also contained *Orbitolina* sp. (R.E. Hinote, personal communication, 1986). The lower part of the Ixcoy is partly age-equivalent with the Sligo-Pearsall formations in the U.S. Gulf Coast.

The basal Ixcoy Formation may grade downward into the Todos Santos Formation. A continuous depositional succession is suggested from tidal flats to a shallow, restricted marine shelf lagoon to a deeper marine shelf in later Aptian time. This drowning coincided approximately with the widespread intra-Aptian drowning in the Caribbean (Scott *et al.*, 1988).

The middle part of the Ixcoy Formation is intermittently exposed in roadcuts along Highway 9N between Huehuetenango and San Ramón (Figure 3) (J.H. Rosenfeld and J.L. Carney, personal communication, 1991). Medium- to thick-bedded, moderate brown-gray limestone locally contains common rudist fragments and other bivalves. The depositional environment was a shallow, open shelf.

The upper part of the Ixcoy Formation is exposed in the Río Yula San Juan-Ixcán gorge and in roadcuts on Highway 9N near San Román (Figure 3). Roadcuts at marker posts 417 and 419 south of San Ramón expose medium-bedded, moderate gray to brown-gray, bioclastic limestone with rudists. Cross-bedded channels, up to 5 m across, with graded radiolitid bioclasts from base to top, are exposed at 417 km post. The upper part of the Ixcoy was deposited in a variety of normal marine, shallow shelf environments. No rudist bioherms were found, but radiolitid biostromes were common. Moderately sorted, coarse-grained rudist grainstone indicates a high energy environment. Sharp, burrowed or bored contacts between packstone and wackestone indicate periodic hiatuses in deposition. Laminated mudstone with "bird's-eye" calcite blebs indicate supratidal conditions.

The Sepur Formation overlies the Ixcoy Formation in the Huehuetenango area. Clemons and Burkart (1971) applied "Sepur" to red sandstone, shale and lithoclastic limestone of Campanian-Maastrichtian age. A unit of shale, sandstone, argillic limestone and coal lithically like the Sepur is exposed above the Ixcoy Formation along the road north of San Ramón to the Río Ixcán. It is dated by palynomorphs as late Paleocene and Eocene (R.W. Hedlund, unpublished Amoco report, 1986). The late Paleocene foraminifer, *Globorotalia planoconica* Subbotina, represents zone P4 (B.A. Masters, written communication, 1986). The palynomorph assemblage with radiolaria and ostracodes and the lithologic succession indicate a shoaling-up environment from a Paleocene open marine shelf to an Eocene coastal plain with mangrove swamps (R.W. Hedlund, written communication, 1986). Well exposed sections up to 100-m thick are located about 15 km northeast of San Ramón near the villages of Esperanza and Campana. Near San Ramón these beds are overturned dipping southward on the north limb of an anticline. Detailed structural and stratigraphic studies are warranted.

Application of the name, Sepur Formation, in the Huehuetenango area for the Tertiary clastic unit above the Ixcoy Formation is not clear. In its type area at Sepur village about 20 km north of Cobán, the Sepur Formation consists of basal conglomerate and sandstone overlain by brown clay, shale, siltstone, and limestone up to 600-m thick (Sapper, 1899). Upper Cretaceous foraminifers were reported by Paul Bronnimann (*in* Vinson, 1962), Asworth (1974) and Michaud and coworkers (1992). But Sapper (1937) and van den Bold (1946) reported Paleocene-Eocene fossils from the Sepur Formation. It is possible that two different stratigraphic units are present or that Cretaceous fossils have been reworked into Tertiary strata.

RUBELSANTO AREA

In the Rubelsanto area, the Cretaceous section consists of three formations, in ascending order: the Cobán, Campur and Sepur formations (Figure 2) (Walper, 1960; Wilson, 1974; Vinson, 1962; Bishop, 1980; Michaud *et al.*, 1992). The aggregate thickness is reported to be about 4,200 m. The type sections of these three formations are within about 25 km of each other in Alta Verapaz near the town of Cobán and northeast at Finca Campur and at Sepur near the village of Lanquín. In wells and outcrops in the Rubelsanto-Chinaja area, Leigh and Buis (1976) divided the Cobán into three members. The uppermost Cobán "A" Member is characterized by thick-bedded, light gray limestone and dolomitic limestone about 620-m thick. The middle Cobán "B" Member contains thick anhydrite-carbonate cycles up to 915-m thick. The basal Cobán "C" Member consists of anhydrite and thin dolomite, shale, and limestone beds up to 1,200-m thick.

In the Tortugas area west of Rubelsanto, four core holes were sampled; no rudists were found. Coring began in the Cobán "A" Member; the Cobán "B" Member is about 475-m thick from the top of the anhydrite beds down to the base of a distinctive limestone marker bed 14–17 m thick. This basal bed contains *Orbitolina* (*Mesorbitolina*) *subconcava* Leymerie, and *Pseudonummoloculina heimi* (Bonet). Various miliolids and calcareous algae, *Thaumatoporella* and *Pycnoporidium* occur throughout. A younger marker limestone bed 13-m thick is about 250 m above the lower bed; it is a miliolid micrite. The Cobán "B" is Albian in age. The Cobán "C" Member is about 400-m thick and consists of anhydrite and dolomite. A third distinctive dolomitic limestone marker bed is near the base of the Cobán "C" overlying salt that may be intrusive. This bed contains poorly preserved indeterminate orbitolinids and miliolids.

The Cobán Formation was deposited upon a shallow carbonate platform in supratidal, intertidal, strandline, and shelf lagoon environments. Common facies are anhydrite, dolomite, orbitolinid-peloid packstone, miliolid-peloid packstone-wackestone, intraclast-peloid-miliolid packstone, peloid-ostracode-miliolid packstone-wackestone, and carbonate mudstone. The marker limestone beds represent marine flooding across the platform and may be equivalent with Aptian and Albian events recorded in the U.S. Gulf Coast (Scott *et al.*, 1988; Scott, 1993). The age of the Cobán ranges from early Aptian to Cenomanian (Michaud *et al.*, 1992).

The Campur Formation comprises about 825 m of light gray to tan, fine- to medium-crystalline, fossiliferous limestone. It was named by Vinson (1962) to include Upper Cretaceous limestones above the Cobán Formation. Its type section is on the Cobán-Sebol road about 35 km northeast of Cobán and 3–6 km south of Finca Campur. In outcrop, the Campur is thinner bedded and finer grained than the Cobán. The Campur is characterized by abundant fossils including diverse foraminifers that range from early Campanian to Maastrichtian: *Senalveolina aubouini* Fleury, *Chubbina jamaicensis* Robinson, *Sulcoperculina* sp. aff. *S. dickersoni* Palmer (Plate 1), and *Vaughanina cubensis* Palmer (Figure 4, A–B). Santonian-Campanian rudists are common. Ashworth (1974) and Michaud and coworkers (1992) also reported upper Campanian foraminifers.

The Campur was deposited in an open shelf with scattered accumulations of rudists, corals and stromatoporids. Tidal flats developed upon islands. Common facies are diverse foram-peloid and rudist-foram-peloid wackestone-packstone-grainstone, stromatoporid-coral wackestone, and some dolomite and anhydritic dolomite.

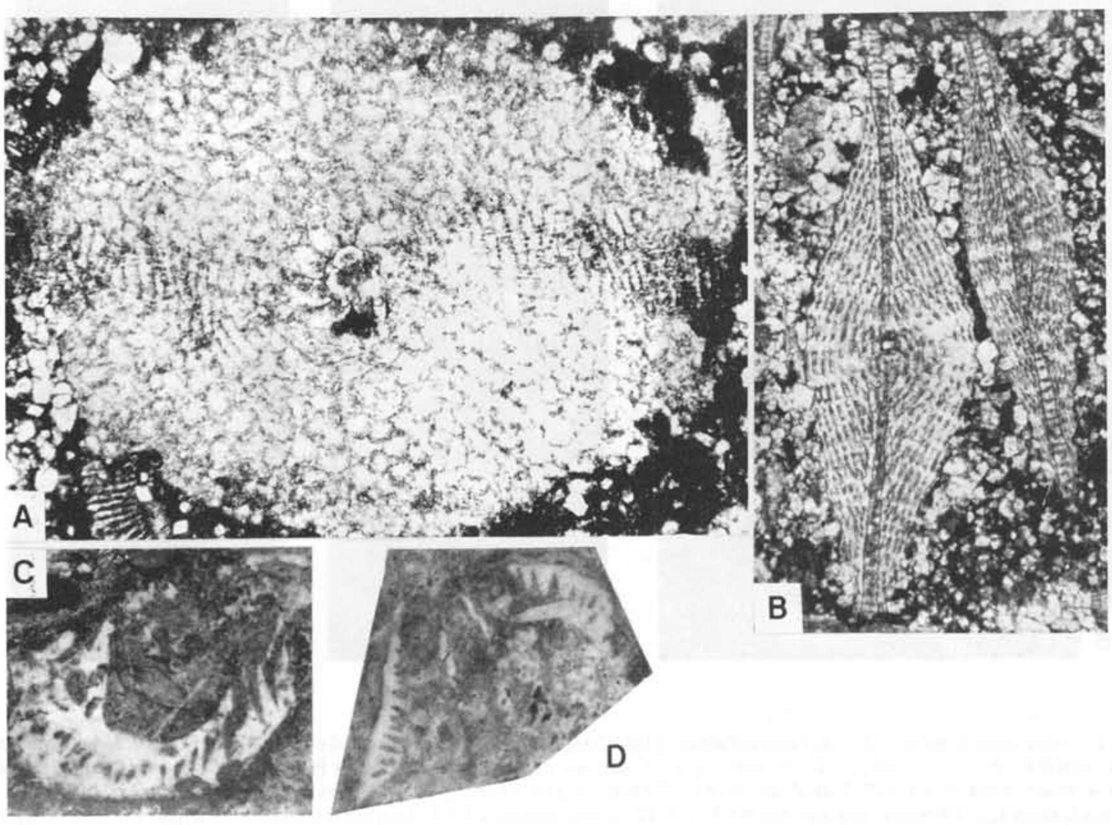

Figure 4. A, B—*Vaughanina cubensis* Palmer, 1934. Campur Formation, Los Rápidos core (Am 8062-24), 1,700 ft (518.3 m) below core top. *A*, horizontal section, x 25.7; *B*, axial sections, x 32. C, D—*Planocaprina*? sp. Ixcoy Formation, Huehuetenango area. *C*, sample 9-25-9, x 1.5; *D*, sample 9-25-4, x 1.5.

Plate 1. Figures 1, 2—*Sulcoperculina* sp. aff. *S. dickersoni* Palmer, 1934. Campur Formation, La Felicidad core. *1,* 172 ft below core top (Am 8063-3), x 13. *2,* 133 ft below top (Am 8063-2), x 71. Figures 3, 4—*Accordiella* sp. cf. *A. conica* Farinacci 1962. Campur Formation, Los Rápidos core. *3,* Equatorial section, 452–453 ft below core top (Am 8062-6), x 28. *4,* axial section, 54–55 ft below top (Am 8062-2), x 20. Figures 5, 6—*Senalveolina aubouini* Fleury, 1984. Campur Formation, La Felicidad core, 133 ft below core top (Am 8063-2). *5,* Equatorial section, x 28. *6,* Tangential section, x 28. Figures 7–10—*Chubbina jamaicensis* Robinson, 1968. Campur Formation, La Felicidad core. *7,* Equatorial section, 133 ft below core top (Am 8063-2), x 28. *8,* Tangential in coiling plane, 95 ft below (Am 8063-1), x 28. *9,* Tangential sections in axial plane, 95 ft below top (Am 8063-1), x 28. *10,* Axial section, 133 ft below top (Am 8063-2), x 28.

NORTHWESTERN PETÉN

The Cretaceous section in northwestern Petén is represented in two wells and in several outcrops. This part of the Yucatán Platform is north of the La Libertad Arch, which trends E-W to NW across north-central Guatemala north of the Rubelsanto area (Figure 1) (Bishop, 1980). Clastics of the Todos Santos Formation overlie basement rocks, and above the Todos Santos is a transitional unit of sandstone, shale, dolomite, and anhydrite, and a dolomite unit informally called the "Hillbank" (Bishop, 1980, p. 39). Above this is a thick section of limestone, dolomite, and anhydrite called the Cobán and Campur formations with Albian to Turonian fossils (Bishop, 1980).

Cretaceous strata crop out in the western end of the La Libertad Arch in the Usumacinta Mountains. The section near the village of Lacandón (Figure 3) (17°7' N, 91°17' W) consists of detrital carbonates up to 1,800 m thick (S.M. Millan, written communication, 1985). Vinson (1962) defined the Lacandón Formation for light colored, sucrosic calcarenites, lime mudstone, algal limestones, dolomites, and minor amounts of oolitic and brecciated limestone overlying the Campur Formation and laterally equivalent with the Sepur Formation. But Ashworth (1974) retained Sepur Formation for Campanian-Maastrichtian limestone, conglomerate, sandstone, and shale that unconformably overlies the Campur Formation. Ashworth and Michaud and coworkers (1992) reported from the Sepur in Alta Verapaz a diverse foraminiferal assemblage: *Vaughanina cubensis* Palmer, *Vaughanina guatemalensis* Bronnimann, *Pseudorbitoides* sp., *Lepidorbitoides minima* Douvillé, *Orbitoides palmeri* Gravell, *Acervulina cenomaniana* (Seguenza), *Sulcoperculina globosa* Cizancourt, *Siderolites* sp. cf. *S. skourensis* (Pfender), *Globotruncana ganseri* Bolli, *Globotruncana stuarti* (de Lapparent), and *Globotruncana trincarinata* (Quereau). This mixed assemblage indicates the presence of a Campanian-Maastrichtian carbonate platform and a deeper shelf. Either a dramatic facies change exists or the assemblages are in vertical succession; but none of these fossils are known yet from the Lacandón area. It appears difficult and uncertain to extrapolate lithostratigraphic units from the Usumacinta Mountains to the cordilleras of Alta Verapaz where the stratigraphy is much better understood than in the Petén.

In this study, rudists were collected at two outcrops in the Petén (Figure 5): (1) in the Sierra La Pita on a trail south from El Ceibo to Laguna El Repasto (17°13' N, 90°58'30" W), and (2) at the landing strip southeast of Laguna El Repasto (17°11' N, 90°59'30" W). Along the El Ceibo trail, light colored chalky limestone is poorly exposed. Radiolitid and other bioclasts are common. One very well preserved and entire specimen of *Distefanella lombricalis* (d'Orbigny) was collected from an exposure on the trail. At the quarry southeast of the Laguna El Repasto airstrip, limestone blocks in various structural attitudes are exposed. These massive bedded rocks are clearly slumped and brecciated, probably as a result of karstification. Calcarenite with radiolitids, miliolids and orbitoid foraminifers are common; laminated micrites with "birds-eye" fabric and non-laminated micrites are also present. Fossils in thin-section suggest an age span from Albian to Turonian.

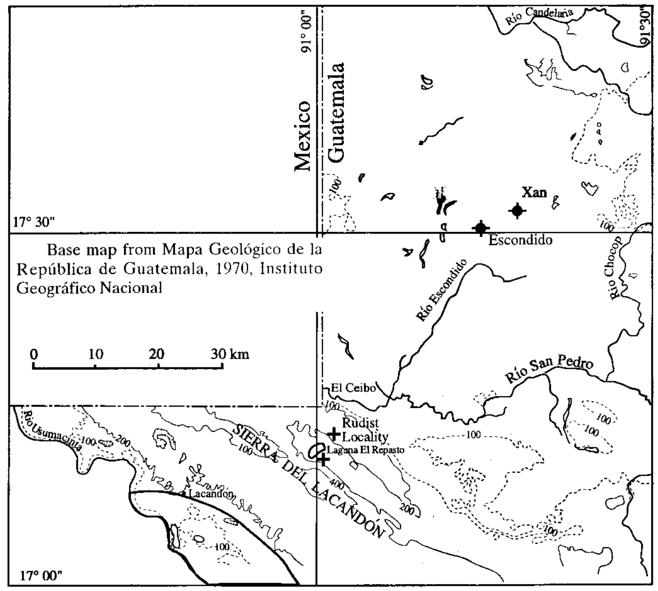

Figure 5. Detailed map of northwestern Petén Department showing rudist localities and key wells. Taken from Mapa Geológico de la República de Guatemala, 1970, Instituto Geográfico Nacional, by S. Bonis, O. Bohnenberger and G. Dengo.

The Lacandón area is marshy with numerous sinkhole lakes. Few outcrops are exposed through the jungle that covers the steep-sided ridges and valleys. A clear understanding of the stratigraphy in this area will be very difficult to ascertain from outcrop studies because of poor exposures, rugged terrain, karstification, and complex structure.

Wells about 50 km northeast, however, provide a very detailed stratigraphic succession (Figures 2, 4). The Cretaceous section is more than 4,270 m thick in the TEGI Escondido No. 1 well (17°30'17" N, 90°45'39" W). Interbedded anhydrite, dolomite, limestone, and salt are present in that order of abundance. Maastrichtian to Barremian fossils document the age span. Depositional environments varied from intraplatform basin to shallow open platform to restricted platform interior. Rudist packstone is present in the nearby TEGI Xan No. 1 well (17°31'48" N, 90°42'5" W). The lithologic succession is similar to that of the Cobán Formation in Alta Verapaz, but the Upper Cretaceous section contains more anhydrite than the Campur Formation. North of the La Libertad Arch a satisfactory lithostratigraphic nomenclature is yet to be developed.

BIOGEOGRAPHY

The Guatemalan rudist assemblages have yet to be placed within a precise chronostratigraphic framework because they have been collected from poorly known sections.

However, the assemblages represent generalized faunas from the Albian-Cenomanian, Turonian, and Santonian-Maastrichtian. The taxa are clearly related to a Mediterranean Tethys fauna with ties to Cuba, Jamaica, Hispanola, Puerto Rico, and Mexico (Johnson, 1993). Johnson lists 10 cosmopolitan and eight Caribbean endemic genera from northern Guatemala, southern Mexico and Belize region. A migration route across the Atlantic through the Caribbean was demonstrated by Johnson (1993). An east-to-west migration of Maastrichtian rudists was postulated by Skelton and Wright (1987) and also of Aptian rudists (Skelton, 1982). Foraminifers and calcareous algae followed a similar route (Masse and Rossi, 1987).

The Yucatán Plate during most of Cretaceous time was positioned between the Equator and paleolatitude 20° N (Pindell and Barrett, 1990) and in the Caribbean Province of the Tethyan Realm (Kauffman, 1973). Kauffman and Johnson (1988) proposed that the central zone of the Tethys was warmer and more saline than normal sea water and called it the "Supertethys" climatic zone. This zone explained the apparent separation of rudist-dominated assemblages in the central part of the Tethys and coral-dominated assemblages in the more marginal regions. Johnson (1993) documented the diversity increase of rudists across the western Tethyan Realm. However, comparable data for the corals, which are notoriously poorly preserved, is not available. Climate modeling (E. Barron, personal communication, 1994; R. Oglesby, personal communication, 1994) seems to substantiate that the central Tethyan zone was warmer and more saline than the marginal areas and at values higher than are considered "normal" today. The actual model values depend on the carbon dioxide partial pressure used in the model, which cannot be constrained very narrowly at this time. Finally, the presence of evaporites upon the Yucatán block is not necessarily evidence of a warmer, more saline climatic zone because evaporites are developed in the interior of this shallow platform, where circulation was restricted. Furthermore, evaporitic deposits formed in the marginal areas in Sonora and Texas, as well. This new rudist data from Guatemala neither supports nor disproves the hypothesis of a "Supertethys" climatic zone.

SYSTEMATIC PALEONTOLOGY

Order Hippuritoida Newell, 1965
Superfamily Hippuritacea Gray, 1848
Family Caprinidae d'Orbigny, 1850

Genus *Texicaprina* Coogan, 1973

Texicaprina sp. cf. *T. orbiculata* (Palmer, 1928)

1928 *Sabinia orbiculata* Palmer, p. 72–73, pl. 13, figs. 2, 3; MacGillavry, 1937, p. 140.

1973 *Texicaprina orbiculata* (Palmer) Coogan, p. 59; 1977, Coogan, p. 60, 64.

Discussion—Several-cross sections of a large curved caprinid were photographed by J.H. Rosenfeld and J.L. Carney, 1991, on Highway 9 between Soloma and San Mateo Ixtatan (Figure 3; localities 25-4, 25-9). The specimens are very similar to *Texicaprina orbiculata* (Palmer, 1928). The outer wall of the RV is more than 10 mm thick in places and it is filled with small oval pallial canals. The outermost row of pallial canals is very small and pyriform. The accessory cavity is pear-shaped. *T. orbiculata* is much larger than *Texicaprina vivari* (Palmer, 1928) and has a thick wall separating the body cavity from the oval accessory cavity. One Guatemalan specimen is 83 mm wide and 50 mm in the dorsal-ventral direction.

The genus is known from middle-upper Albian strata in Texas, offshore Louisiana, Mexico, Cuba, and Trinidad. This species was first described from middle Cretaceous strata at Paso del Río, Colima, Mexico. In Guatemala these specimens are from the Ixcoy Formation.

Genus *Planocaprina* Palmer, 1928

Planocaprina? sp.
(Figure 4, C, D)

Discussion—Fragments of a small, about 27 mm wide, caprinid having one row of pyriform pallial canals with radial plates that bifurcate, only along the anterior side appear to be closest to species in this genus. Specimens were found with *Texicaprina* at roadcut localities 25-4 and 25-9 in the Ixcoy Formation (Figure 2) by J.H. Rosenfeld and J.L. Carney. The genus is known from Aptian and lower Albian strata, so its occurrence with *Texicaprina* would be a range extension. More complete specimens need to be collected. These specimens occur with *Chondrodonta* sp. with radial ribs at locality 25-9 (Figure 2).

Family Radiolitidae Gray, 1848
Subfamily Radiolitinae Gray, 1848

Genus *Praeradiolites* Douvillé, 1902

Praeradiolites sp. cf. *P. verseyi* Chubb, 1956a
(Plate 2, figure 1; Figure 6, A)

1956a *Praeradiolites verseyi* Chubb, p. 14–15, pl. 2, figs. 4–6; Chubb, 1956c, p. 7; Chubb, 1971, p. 185–186, pl. 35, figs. 2–4, text-fig. 5.

Material—Several specimens in cross-section on polished surface of limestone from outcrops of the Ixcoy Formation.

Description—Cross-sectional outline of attached right valve is ovate, about 50 by 65 mm maximum outside diameter and 28 by 45 mm maximum inside diameter. The ligament is a short bar about 1 mm wide and 3–4 mm long. The outer wall layer is of rectangular radial and concentric laminae that vary in width from

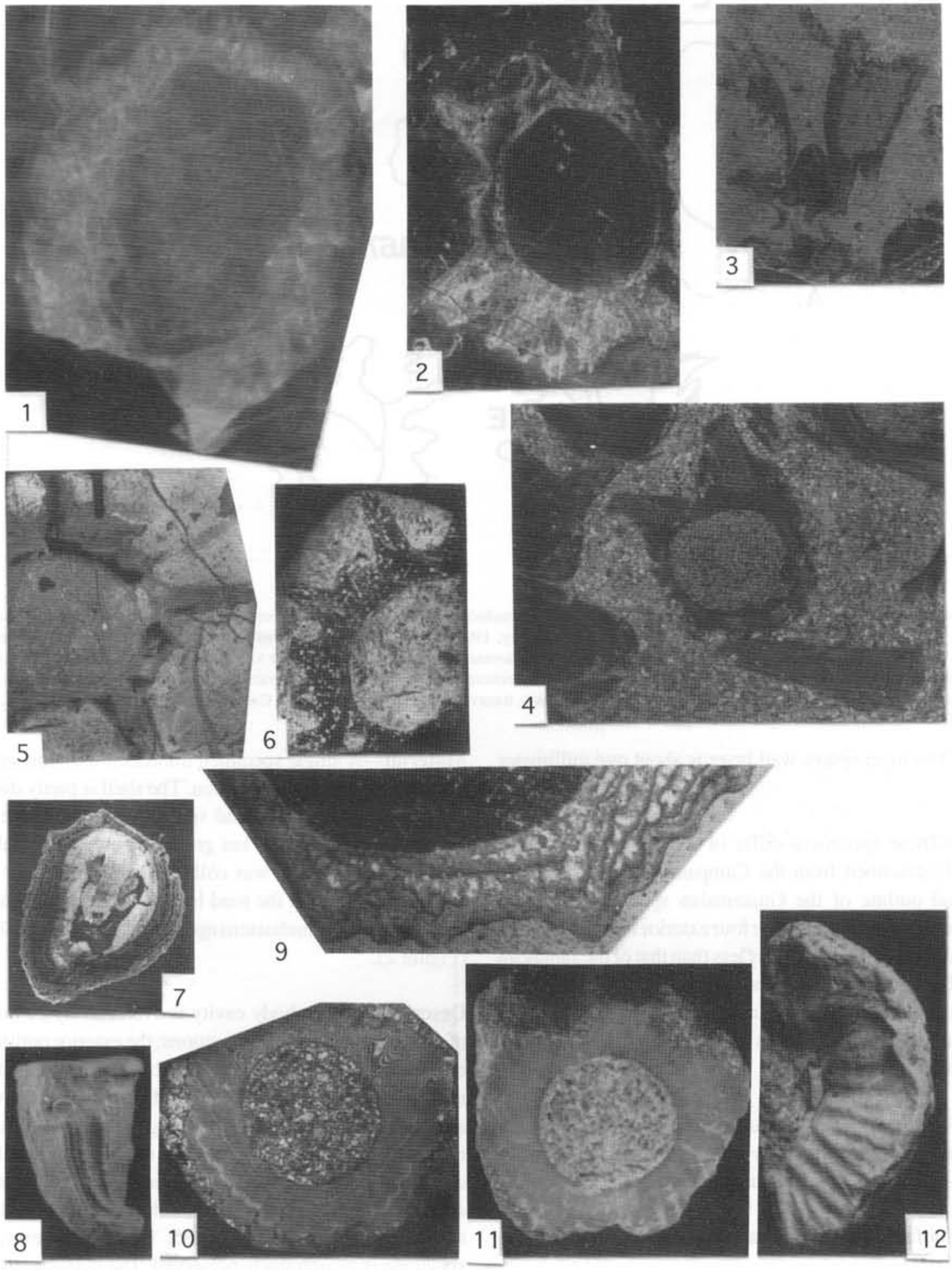

Plate 2. Figure 1—*Praeradiolites* sp. cf. *P. verseyi*, upper Ixcoy Formation, Huehuetenango locality 9-26-3A, x 1. Figure 2—*Biradiolites jamaicaensis*, upper Ixcoy Formation (Am 14270-30), San Ramón, Huehuetenango, x 1. Figures 3, 4—*Bournonia excavata*, Campur Formation, Los Rápidos core, 47 ft from top (Am 8062-1), Rubelsanto Field. *3*, Longitudinal and transverse sections, x 1. *4*, Transverse section, x 2. Figures 5, 6—*Bournonia cardenasensis*. *5*, From upper Ixcoy Formation (Am 14270-13), San Ramón, Huehuetenango, x 1. *6*, From Campur Formation, La Felicidad core, 1816–1817 ft from top (Am 8063-30), x 1. Figures 7–9—*Distefanella lombricalis*. El Ceibo-Laguna del Repasto trail (Am 10378-3), NW Petén. *7*, Cross section of RV-AV commissural view showing E and S bands and shell microstructure, x 1.5. *8*, Exterior ventral view showing E and S bands, x 1. *9*, Close-up of postero-ventral corner showing fine costae in S band, x 7. Figures 10–12—*Thyrastylon adhaerens*. Upper Ixcoy Formation (Am 14270-30), San Ramón, Huehuetenango. *10, 11*, Cross sections of RV-AV commissural view showing E and S bands and costae, x 1. *12*, Commissural shelf of RV-AV showing pallial ridges, x 1.

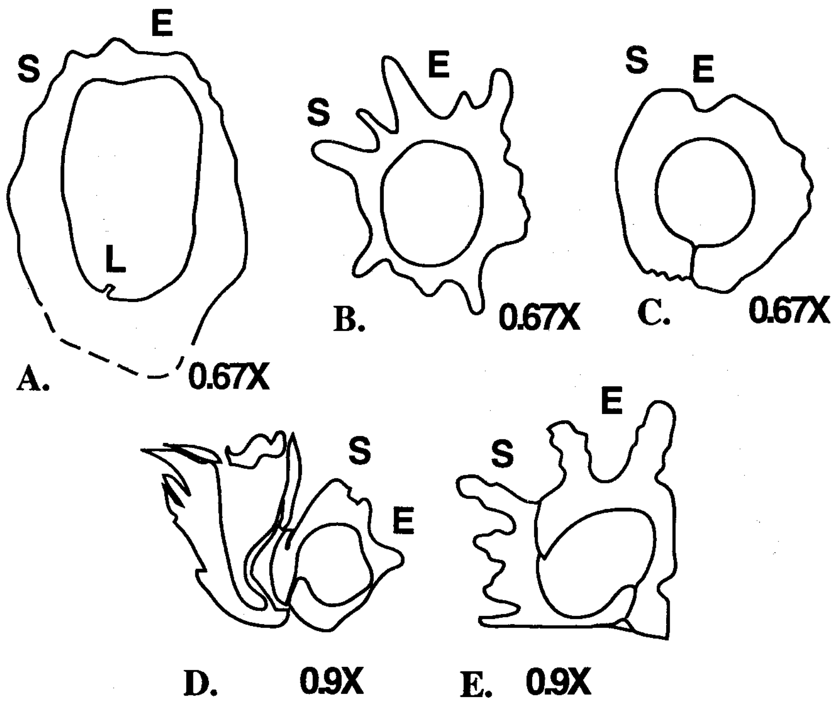

Figure 6. Cross-sections of rudist species reduced to different scales. *A, Praeradiolites* sp. cf. *P. verseyi*, transverse section of lower valve, upper Ixcoy Formation, Huehuetenango locality 9-26-3A, collected by J.H. Rosenfeld and J.L. Carney, 1991. *B, Biradiolites jamaicaensis*, transverse section of lower valve, upper Ixcoy Formation (Am 14270-13), San Ramón, Huehuetenango. *C, Thyrastylon adhaerens*, transverse section of lower valve, upper Ixcoy Formation (Am 14270-30), San Ramón, Huehuetenango. *D, Bournonia excavata*, longitudinal and transverse sections of lower valve with upper valve in place, Campur Formation, Los Rápidos core, 453 ft from top (Am 8062-6), Rubelsanto Field. *E, Bournonia cardenasensis*, transverse section of lower valve, Campur Formation, La Felicidad core, 1816–1817 ft from top (Am 8063–31A), Rubelsanto Field.

6 to 16 mm. The inner sparry wall layer is about one millimeter thick.

Discussion—These specimens differ in some ways fr m those Chubb (1971) described from the Campanian in Jamaica. The cross-sectional outline of the Guatemalan specimens is more ovate than "roundly triangular." The four exterior folds in the shell wall are less distinct. The diameter is less than that of the Jamaican specimens. The ligament is shorter than in Chubb's specimens. Nonetheless, these specimens have the general features of Chubb's species and a new species is not warranted on the basis of this material.

Occurrence—Found in the Campanian Barrettia Limestone near St. James, Jamaica and in the Ixcoy Formation near Capzin—locality 26-3—(Figure 3), Huehuetenango, Guatemala.

Subfamily Biradiolitinae Douvillé, 1902

Genus *Biradiolites* d'Orbigny, 1850

***Biradiolites jamaicensis* Trechmann, 1924**
(Plate 2, figure 2; Figure 6, B)

1924 *Biradiolites jamaicensis* Trechmann, p. 404, pl. 24, figs. 5, 5, a, 6, 6, a, and 7; Chubb, 1956c, p. 8; 1971, p. 186–187, pl. 35, figs. 8–12; Pons, 1977, p. 78, pl. 81, figs. 1–3.

Material—A single specimen imbedded in indurated limestone is exposed in transverse section. The shell is partly dissolved and replaced by radial-axial and sparry calcite and lime mudstone. The matrix is moderate tan gray, fine-crystalline calcite with a few bivalve clasts. It was collected from the upper part of the Ixcoy Formation on the road between San Ramón and Barillas, Km post 419, Huehuetenango, Guatemala—Am 14270-13—(Figure 2).

Description—The body cavity is ovate, 23 by 29 mm across in minimum and maximum directions; the exterior outline is marked by 10 to 11 angular costae of variable lengths separated by deep angular intercostae. Two sets of three costae on the ventral side are much longer than the intervening costae; they are up to 16–18 mm long from the inside margin of the body cavity. One set comprises the siphonal bands; the ridge separating the two bands appears to have a single ridge as compared with the double ridge shown by Chubb (1971, pl. 35, fig. 8); however, the Ixcoy specimen is incompletely preserved. The maximum shell diameter across costae is 60 mm; this is greater than the Jamaican specimens, which are 25 to 42 mm across and have an inside diameter of 16 by 15 mm.

The wall structure is poorly preserved but in places a polygonal cellular structure is well developed. The cells are from 0.5 to 1.0 mm across. In places, a thin outer lamellar layer is preserved. Trechmann (1924) described the cells as "coarse and irregular in section."

Occurrence—In Jamaica this species is common in the Maastrichtian *Titanosarcolites* Limestone in several inliers (Chubb, 1971). In the Pyrennes, Pons (1977) found a single specimen in the Santonian limestone at Collades des Basturs.

Genus *Bournonia* Fischer, 1887

***Bournonia excavata* d'Orbigny, 1847**
(Plate 2, figures 3, 4; Figure 6, D)

1847 *Agria excavata* d'Orbigny, p. 215, pl. 556; Toucas, 1907, p. 27, pl. 2, figs. 11, 11, a, 12, 13, 13, a.
1981 *Bournonia excavata* (d'Orbigny) Sánchez, p. 88, provides prior synonymy.

Material—Cross-sections on core slabs from the Los Rápidos core hole at depths of 47 to 453 ft (14.3–138.1 m) (Am 8062-1, 6), and from the La Felicidad core hole at depths of 1,208 to 1,800 ft (368.2–548.6 m) (Am 8063-20) (Figures 1–3). It also occurs in the Lacandón area (Am 10378-3).

Description—Lower attached right valve is small and conical; its cross sections are ovate to quadrangular. Two strong siphonal ridges with rectangular to rounded cross sectional profiles have open-spaced, concentric laminae. The E band is wider than the S band. Antero-dorsal part of wall thickens into rounded ridge; exterior outline is variable; interior outline of body cavity is ovate to quadrate. Wall consists of a thick outer lamellar-prismatic layer and a thin inner spar layer. Lamellae of the outer layer are separated by short cross partitions where lamellae are separate.

Occurrence—This species is common in Santonian strata in southern France and northern Spain. This is the first report of this species in the Caribbean Province. It occurs in the Campur Formation at Rubelsanto with the Campanian-Maastrichtian foraminifers, *Accordiella* sp. cf. *A. conica* Farranacci, *Senalveolina aubouini* Fleury, *Sulcoperculina* sp., and rotaliid foraminifers. It was also collected in the limestones exposed in the Lacandón area, Petén.

***Bournonia cardenasensis* (Böse, 1906)**
(Plate 2, figures 5, 6; Figure 6, E)

1906 *Biradiolites cardenasensis* Böse, 1906, p. 59–60, pl. 11, fig. 3; pl. 12, fig. 3; Myers, 1968, p. 45, pl. 4, figs. 1–4.
1906 *Biradiolites potosianus* Böse, p. 60–61, pl. 5, figs. 2, 3; pl. 11, fig. 4; pl. 12, fig. 5.
1924 *Bournonia barretti* Trechmann, p. 405, pl. 26, figs. 2, 2, a; Chubb, 1971, p. 194, pl. 40, figs. 4, 5.
1971 *Bournonia cardenasensis* (Böse) Alencáster, p. 43–45, pl. 7, figs. 5–7; pl. 19, figs. 2–4.

Material—Cross-sections on core slabs from the La Felicidad core hole at a depth of 1,816–1,838 ft (553.5–560.2 m) (Am 8063-29, 30, 31A), Rubelsantö, Alta Verapaz, Guatemala (Figures 1–3).

Description—The lower attached right valve is conical to cylindrical, curved to erect; its cross-section is elliptical to reniform; it is ornamented by 13–15 strong, angular, unequal costae crossed by distinct growth lamellae. Three larger costae separate the E and S grooves; the E groove is deep, rounded; the S groove is flat and lined with fine longitudinal ribs. The upper free left valve is plano-convex; the umbonal apex is subcentral; thin radial costae match the costae of the lower valve. Wall microstructure consists of a thick outer layer with strongly folded concentric lamellae; short radial partitions separate lamellae but are not continuous across the lamellae. The thinner middle layer of prismatic calcite had elliptical canals. The inner spar layer is thin and discontinuous.

Discussion—Böse (1906) separated *B. potosianus* from *B. cardenasensis* by the presence of two wide, flat, smooth bands in *B. potosianus*. However, the side with the bands is the same as the smoother, less folded side of *B. cardenasensis* according to Alencáster (1971). Böse's specimens of both species came from the same site in the state of San Luis Potosí. *B. barretti* has all the external features of *B. cardenasensis* and cannot be differentiated by other characters.

Occurrence—*B. cardenasensis* has been found in Upper Cretaceous limestones in Chiapas and San Luis Potosí, Mexico and in the *Titanosarcolites* Limestone or the Guinea Corn Formation in Jamaica (Alencáster, 1971; Chubb, 1971). This species occurs in the uppermost *Tampsia floriformis* zone in the Cárdenas Formation in San Luis Potosí, which Myers (1968) considered Maastrichtian because it overlies the *Arcostrea aguilerae* (Böse) zone with *Exogyra costata* (Say). In Guatemala, *B. cardenasensis* occurs in the Campur Formation at Rubelsanto with rotaliid foraminifers and dasyclads.

Genus *Distefanella* Parona, 1901

***Distefanella lombricalis* (d'Orbigny, 1842)**
(Plate 2, figures 7–9)

1842 *Radiolites lombricalis* d'Orbigny, p. 183; 1847, p. 214, pl. 555, figs. 4–7.
1907 *Biradiolites lombricalis* (d'Orbigny) Toucas, p. 99, pl. 19, 1–16; Mullerried, 1932, p. 237–242, fig. 1.
1910 *Biradiolites lumbricalis* (sic) (d'Orbigny) Douvillé, p. 73, pl. 1, fig. 5.
1913 *Distefanella lumbricalis* (sic) (d'Orbigny) Douvillé, p. 413–415, fig. 3; Chubb, 1959, p. 742, 748; Chubb, 1962–63, p. 18; Polšak, 1967, p. 180–181, fig. 4; Sánchez, 1981, p. 95–96, provides prior synonymy.

Material—A single free articulated specimen was collected from a low cutbank in weathered limestone on the trail to Laguna El Repasto about 4.5 km south of El Ceibo, Petén, Guatemala (17°13' N, 90°58'30"W) (Figure 5).

Description—The lower attached right valve is elongated, cylindrical to conical, much higher than wide, straight to slightly curved; the apex is curved or spiral. The cross-section is rectangular to ovate. It is ornamented by numerous, fine, longitudinal costae. The E band is slightly convex with 6–7 faint rounded costae. The interband has three angular costae and two grooves. The S band is concave, less than half as wide as the E band, and has 4–5 faint rounded costae.

Measurements—The Guatemalan specimen is 26.5 mm high, 18.2 mm by 21.8 mm in diameter; the E band is 7.1 mm wide, the interband is 2.4 mm wide, and the S band is 4.0 mm wide.

Discussion—This Guatemalan specimen differs from European ones by its short, conical form and its numerous longitudinal ribs. The form of the French specimens illustrated by Toucas (1907) is variable and includes some short, spiralled valves. The spacing of the longitudinal costae on the French specimens and on the specimen from Oaxaca, Mexico (Mullerried, 1932) is much wider than in the Guatemalan specimen, which has seven ribs in 10 mm dorsal to the siphonal bands. However, the designation of a new species on the basis of this character and a single specimen seems ill-advised. The internal features of the genus shown by Polšak (1968) are also seen on the Guatemalan specimen. The teeth and lamellae have been dissolved away leaving only the internal mold.

Occurrence—*Distefanella lombricalis* characterizes middle and upper Turonian strata in France, Spain, Italy, North Africa, Lebanon, Syria, the former Yugoslavia, and Mexico. Its presence in the Lacandón region indicates that part of this limestone section is middle-upper Turonian.

Genus *Thyrastylon* Chubb, 1956

***Thyrastylon adhaerens* (Whitefield, 1897)**
(Plate 2, figures 10–12; Figure 6, C)

1897 *Radiolites adhaerens* Whitefield, pars, p. 188–189, pl. 10, fig. 1; pl. 12, fig. 1.
1934 *Biradiolites adhaerens* (Whitefield) MacGillavry, p. 234–237, pl. 1, figs. 1–3; text-figs. 4, 7, 8.
1956b *Thyrastylon adhaerens* (Whitefield) Chubb, p. 36–37, pl. 6, figs. 1–3; pl. 7, figs. 5–9; 1971, p. 190–191, pl. 38, figs. 1–6, provides prior synonymy.

Material—Five broken and incomplete specimens in rudist grainstone were collected from the upper Ixcoy Formation on Panorama Trail, 3 km northwest of San Ramón, Huehuetenango, Guatemala (Figure 3).

Description—The lower attached right valve is conical to cylindrical, commonly distorted by a large attachment surface; the exterior surface is ornamented by low, rounded, longitudinal costae, 4–5 per 10 mm, and concentric, wavy growth rugae about 10 mm apart. The commissural margin is wavy, with a low rim around the body cavity and locally around the outer edge; the radial pallial ridges bifurcate or intercalate, four per 10 mm. The E band is deeply rounded, about 10 mm wide with seven fine longitudinal costae. The interband is broadly rounded, about 12 mm wide with a shallow longitudinal groove. The S band is shallow, about 7 mm wide. In cross-section the bands are indicated by deep infolding of the concentric lamellae that correspond with the deeply invaginated grooves. The interior body cavity is oval, 20 by 22 mm in diameter; there is no evidence of grooves for the teeth. The wall microstructure consists of a thin, inner, prismatic layer about 0.5 mm thick and a wide outer layer of concentric lamellae or funnel plates, that are separated by short septa, some of which are aligned between several successive lamellae, about six-eight septa per 0.10 mm distance. The outer diameter is up to 43 mm by 46 mm; the height is greater than 50 mm.

Discussion—Trechmann (1924) separated two species from *T. adhaerens*. *Thyrastylon coryi* has a smaller attachment area and the left valve is highly domed compared with *T. adhaerens*. *Thyrastylon semiannulosus* has conspicuous concentric growth rings and a small attachment scar. One of the Guatemalan specimens has distinct growth rings, but it is considered to be a phenotypic variation within the species. A comparison of type specimens is needed to determine the validity of *T. semiannulosus* and of *Radiolites annulosus* Whitefield (1897); both may be synonyms of *T. adhaerens*.

Thyrastylon chubbi Alencáster (1971) has a plano-concave free left valve and narrow, shallow siphonal bands; otherwise it is very similar to *T. adhaerens*.

Occurrence—The genus is distinctively Caribbean but it also is reported from Iran (Cox *et al.*, 1969). This species is common in Jamaica from the Titanosarcolites beds, which now are mapped in the Jerusalem Mountain Inlier as the Guinea Corn Formation, Maastrichtian (E.G. Kauffman, personal communication, December, 1994). It also occurs in Cuba (MacGillavry, 1937, p. 39). It was first reported in Guatemala at San Diego, Río San Isidoro, Alta Verapaz (MacGillavry, 1934); the stratigraphy of this site is unknown. *Thyrastylon chubbi* is abundant in the Campanian-Maastrichtian Ocozocuatla Formation in southern Chiapas, Mexico (Alencáster, 1971). In Huehuetenango it occurs with *Senalveolina aubouini*, *Chubbina jamaicaensis*, rotaliids, and nummoloculinids.

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