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**A NEW UPPER CRETACEOUS
RUDISTID FROM THE KEMP
CLAY OF TEXAS**

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FROM THE KEMP CLAY OF TEXAS

BY

LLOYD WILLIAM STEPHENSON

Shorter contributions to general geology, 1938

(Pages 1-15)



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By LLOYD WILLIAM STEPHENSON

ABSTRACT

The paper describes a new rudistid species, *Titanosarcolites oddsensis*, from the Kemp clay (Maestrichtian), the uppermost formation of the Upper Cretaceous of Texas, and the uppermost of four formations composing the Navarro group. The genus *Titanosarcolites* Trechmann (1924) is founded on a rudistid species from Jamaica, first described by Whitfield in 1897 as *Caprinula gigantea*. *Titanosarcolites giganteus* (Whitfield) has subsequently been recorded from Cuba, questionably from the Island of St. Croix, and from Chiapas, Mexico. This is the first record of *Titanosarcolites* as far north as Texas. Since the Maestrichtian age of the Kemp clay is generally accepted, the presence in it of this tropical genus tends to confirm the Maestrichtian age of the rudistid fauna of the Caribbean region, which includes in addition to this genus, *Barrettia* Woodward, *Praebarrettia* Trechmann, *Bournonia* Mac Gillavry, *Biradiolites* D'Orbigny, *Antilocaprina* Trechmann, *Tampsia* Stephenson, *Lapeirousia* Bayle, and other genera. Outside of the Caribbean region and north of it representatives of this fauna have been recorded from Guatemala (*Barrettia* and *Biradiolites*), Chiapas, Mexico (*Barrettia* and *Titanosarcolites*), and Tamaulipas, Mexico (*Tampsia*). The species *Titanosarcolites oddsensis*, here described, indicates the range of at least one member of the fauna as far north as the Gulf Coastal Plain of Texas, and fragmentary material indicates the range of this or a closely related genus in the Western Interior of the United States as far north as Montana.

INTRODUCTION

A new paleontologic link between the Upper Cretaceous series of the Gulf Coastal Plain and that of Jamaica, Cuba, and other West Indian islands, is afforded by a large rudistid shell found by me in Falls County, Tex., in November 1936. The specimen was obtained from the upper part of the Kemp clay, the uppermost formation of the Cretaceous series and the uppermost of the four formations composing the Navarro group. Though incomplete and externally poorly preserved, the specimen internally clearly reveals on polished surfaces many of the bizarre structural features of the group of rudistids to which it belongs. The shell was closely associated with numerous impure limonite-stained septarian concretions of calcium carbonate, which were weathered out of the clay. These concretions contained a few imperfectly preserved fossils, among which were recognized *Crenella serica* Conrad, *Turritella vertebroides* Morton (var.), *Den-*

talium sp., *Sphenodiscus* sp., and *Discoscaphites* sp. This associated fauna is strictly a Gulf Coastal Plain assemblage not known in the Caribbean Upper Cretaceous.

Rudistids are rare in the Navarro group of Texas. The sum total of the known rudistid material from the Navarro consists of *Durania* sp., too poorly preserved for specific identification, found in the Neylandville marl in Navarro County, a more completely preserved undescribed species of *Sawagesia?* from the Corsican marl near San Antonio, Bexar County, the large shell here described, from Falls County, and a few fragments from scattered localities.

The Falls County shell is here referred to the genus *Titanosarcolites* Trechmann. Although closely related to the genotype, *Titanosarcolites giganteus* (Whitfield), from Jamaica, it possesses distinctive specific characters and is described below under the new name *T. oddsensis*.

The recorded distribution of material referred to *T. giganteus* indicates that in places the individuals of this species made up a considerable part of the rudistid fauna of the Jamaica-Cuba region in late Upper Cretaceous time. However, according to its recorders, most of the material studied is incompletely and imperfectly preserved, and Mac Gillavry (1937, p. 86) is of the opinion that it may represent more than one species. The associated rudistid fauna is a varied one, including forms that have been referred to *Barrettia* Woodward, *Praebarrettia* Trechmann, *Bournonia* Mac Gillavry, *Biradiolites* D'Orbigny, *Antilocaprina* Trechmann, *Tampsia* Stephenson, *Lapeirousia* Bayle, and other genera. Representatives of this rudistid fauna have been recorded from Jamaica, Cuba, Haiti (Woodring and Brown, 1924, pp. 97-98), Puerto Rico? (Hubbard, 1923, pp. 34-36), the Dominican Republic (Cooke, 1921, p. 55), and the Island of St. Croix (Stanton in Vaughan, 1923, p. 305). The fauna is only meagerly represented in the recorded material from Puerto Rico, the Dominican Republic, and Haiti, and *Titanosarcolites* has not been recognized in these places.

Rudistids are primarily indigenous to tropical and semitropical seas, but they spread sparingly into temperate seas. So far as known the northern limit of the range of rudistids in the Upper Cretaceous series of the Gulf Coastal Plain is latitude 36° N. A few specimens belonging to *Durania* Douvillé or *Sauvagesia* Bayle? have been found in east-central and northeastern Texas, southwestern Arkansas, Mississippi as far north as West Point, and Alabama in the vicinity of Selma and Montgomery. One small fragment, recorded as *Caprinella coraloidea* Hall and Meek? has been found in McNairy County, Tenn. (Wade, 1926, p. 82). No authentic rudistids have been recorded from the Cretaceous of the Atlantic Coastal Plain east and northeast of Alabama. That the rudistid group strayed well into the Upper Cretaceous sea of the Western Interior is evidenced by the finding of a few small more or less fragmentary specimens in the Niobrara formation and other beds of Niobrara age and in the Pierre shale of the Montana group, at scattered localities in New Mexico, Nebraska, Kansas, Colorado, Wyoming, South Dakota, and Montana, the one farthest north being in Wibaux County, Mont., indicating a limit of range at least as far as 47° N. Most of this material is undescribed, but Logan (1898, p. 494) has described one species from the Niobrara formation, under the name *Radiolites maximus*, and Hall and Meek (1856, pp. 380-381) one species from the upper part of the Pierre shale, under the name *Caprinella coraloidea* (= *Titanosarcobolites? coraloideus*). The Niobrara material appears to belong mainly to *Durania* and that from the Montana group to *Titanosarcobolites* or a closely related genus. The specimen from Wibaux County, Mont., mentioned above, belongs to *Titanosarcobolites?*; it is from the Pierre shale exposed in the Cedar Creek anticline 20 miles southwest of old Mingusville (now Wibaux). The Wibaux County locality appears to be on the extreme northern outskirts of the range of rudistids in North America.

There has been some difference of opinion as to the exact position in the Upper Cretaceous series of the rudistid-bearing beds of the West Indies, some authorities placing them as low as the Cenomanian or Turonian (Hawkins, 1923, 1924; Palmer, 1933), but the prevailing opinion now seems to be that they are high Upper Cretaceous. Trechmann (1924, pp. 397-400) and Spath (1925, pp. 28-32) place the Jamaican beds in the upper Campanian or Maestrichtian, and Mac Gillavry (1937, pp. 85-92) places the Loma Yucatan limestone of Cuba in the Campanian and the overlying Habana formation, or *Barrettia* beds, in the Maestrichtian. *Titanosarcobolites giganteus* is listed from the *Barrettia* beds. Vermont (1937, pp. 36-37; 1937, p. 263) concurs with Mac Gillavry in correlating the Habana formation with the Maestrichtian.

The high stratigraphic position of *Titanosarcobolites oddsensis*, in the Kemp clay, is in harmony with the

view that the Caribbean beds carrying *Titanosarcobolites* are of Maestrichtian age. A characteristic faunal element of the Kemp clay and its age equivalents in the Coastal Plain is the genus *Sphenodiscus* Meek, represented by several species. There is general agreement among students of Upper Cretaceous paleontology that the *Sphenodiscus*-bearing beds of the Atlantic and Gulf Coastal Plain are of Maestrichtian age. One apparent exception to the restricted range of *Sphenodiscus* is the discovery by Prof. F. L. Whitney, cited by Stephenson (1933, pp. 1357-1358), of one small specimen of an undescribed species of the genus in the upper part of the Taylor marl (upper Campanian) in Travis County, Tex. One rare exception need not, however, invalidate the usefulness of the genus in correlation. After all, a genus represented by several species and many individuals in a given zone must somewhere have had an evolutionary development in earlier times.

The type specimens of *Titanosarcobolites giganteus* (Whitfield) are preserved in the American Museum of Natural History. The loan of the six specimens illustrated by Whitfield (Am. Mus. Nat. History, 9685.1-6) and permission to cut and polish two of them have made possible a critical comparison of the Texas and Jamaica material. For this privilege grateful acknowledgment is extended to Dr. Chester A. Reeds, curator of the department of geology and invertebrate paleontology, who has also kindly permitted the use of the two illustrations showing the internal structural features of Whitfield's species.

I have not seen any of the recorded rudistid material identified by Mac Gillavry, Palmer, and others from the Habana formation of Cuba but have had the privilege of cursorily examining in the Philadelphia Academy of Sciences a fine unstudied collection of rudistids and other fossils made by Sr. Emilio Alemán, under the direction of Dr. Roy E. Dickerson. Conspicuous among the rudistids were large, massive shells belonging to the genus *Parastroma* (*Orbignya* of Palmer), large more or less imperfectly preserved shells of *Titanosarcobolites*, apparently belonging to the species *T. giganteus* (Whitfield), and the shells of *Barrettia*. Dr. Dickerson kindly donated five large examples of *Titanosarcobolites* to the United States National Museum and also several smaller shells, among which is the lower valve of a well-preserved young individual possessing the typical shell structure and apertural features of the genus *Tampsia*; it may belong to *T. lopez-trigoi* Palmer or to *T. ruttenti* Vermont, both from Cuba, but it appears to be very closely related to *T. bishopi* Stephenson from Tamaulipas, Mexico. In the absence of adult shells a satisfactory comparison cannot be made with the *T. bishopi*. Cut and polished cross sections of several of the shells referred to *Titanosarcobolites* exhibit internal structure which, though badly damaged by crystallization of the calcite, is obviously more like

that of *T. giganteus* (Whitfield) than it is like that of the Texas species *T. oddensis* Stephenson.

The specimens of *Titanosarcolites giganteus* (Whitfield) received from Dr. Dickerson were collected in Pinar del Río Province at two localities: Locality A-6 (3 specimens) is 10 kilometers west from Pinar del Río on the road and trail passing through Guayabo, 600 meters west of Guayabo and 200 meters east of the great Pinar fault, which forms the contact between the San Cayetano formation (Jurassic) and the Upper Cretaceous. Locality A-12 (2 specimens) is in a field on Finca Anton Alvarez in the western part of the province, 7 kilometers northeast of San Juan y Martínez. The specimen of *Tampsia* came from an exposure in a creek in Santa Clara Province (locality P) 1 kilometer west of Central Perseverancia, a sugar mill 40 kilometers northwest of Cienfuegos; the specimen was associated with a large and as yet unstudied fauna of pelecypods, gastropods, echinoids, and corals, collected by Dr. Dickerson and Señor Alemán.

The photographs reproduced in plates 1 to 5 were taken by N. W. Shupe in the laboratory of the Geological Survey.

References to the bibliography at the end of this paper are given in parentheses by dates and pages.

DESCRIPTION OF SPECIES

Genus TITANOSARCOLITES Trechmann (1924, pp. 397-400)

Type species: *Caprinula gigantea* Whitfield (1897, pp. 194-196).

The genus *Titanosarcolites* Trechmann was erected to include those large thick-shelled subequivalve rudistids, each valve of which is traversed by a comparatively small longitudinal septate body cavity and each valve of which has a thick outer shell layer traversed by a series of relatively large tubes of irregular size and distribution and circular, oval, and irregular cross section; the tubular layer is developed around the anteroventral side. The two valves are curved in one plane with the tips turned toward each other. This large cumbersome bivalve is interpreted not to have been attached at the beak of either valve but to have lain recumbent on the sea bottom on the anteroventral side (Trechmann, 1924, p. 397; Cox, 1933, pp. 379-388).

A detailed description of the genus, with especial reference to Cuban material is given by Mac Gillavry (1937, pp. 85-92).

Both Douvillé (1927, pp. 131-133) and Mac Gillavry assign to the genus a monopleurid rather than a caprinid or radiolitid ancestry, a conclusion based on the arrangement of the cardinal apparatus. Mac Gillavry points out the relation of this apparatus to that of such genera as *Antillocaprina*, *Trechmanella*, *Hippurites*, and *Rousselia*, to all of which he ascribes a monopleurid origin.

Neither the cardinal apparatus nor the dentition are preserved in *Titanosarcolites oddensis*, and its reference to this genus is based on the similarity of such of its features as the longitudinal septate cavity, the longitudinal canals, and the series of large longitudinal tubes in the outer part of the shell on the anteroventral side. That this Texas shell is specifically different from *T. giganteus* is indicated by the smaller size of the septate cavity, the more sharply defined perimeter of this cavity, the much larger size of the longitudinal canals, and the larger average size of the longitudinal tubes. These differences are readily seen in the illustrations of the polished cross sections shown in plates 2-5.

In addition to the Texas specimens herein described, fragmentary material that may belong to *Titanosarcolites* has been recorded from the Upper Cretaceous of the United States under the names *Ichthyosarcolites* Desmarest and *Caprinella* D'Orbigny. However, none of these specimens has shown in the parts preserved any evidence of the presence of the thick outer shell-layer traversed by large longitudinal tubes, such as characterizes *Titanosarcolites*.

Tuomey (1854, p. 172) described three species of so-called *Ichthyosarcolites* from Noxubee County, Miss., which may have been representatives of *Titanosarcolites*, but he did not illustrate his material, his descriptions are inadequate, and his types are lost. In the collection of the National Museum is a cast of the internal septate cavity of a *Titanosarcolites*? (U. S. Nat. Mus. 12689) from Alabama, which F. B. Meek identified as belonging to "*Ichthyosarcolites cornutus*," one of the three species described by Tuomey.

Hall and Meek (1856, pp. 380-381) described one valve of a rudistid shell from Sage Creek, Nebr., from the upper part of division No. 4 (= upper part of Pierre shale), under the name *Caprinella coralloidea*; it may be a *Titanosarcolites*. The description and figures indicate a short conical, somewhat spirally twisted shell about 2.5 inches long, having an internal cavity divided into chambers by lamellae or septa convex toward the apex, spaced at intervals of 1 to 4 millimeters; the chambers are filled with matrix or secondary calcite. The shell is composed of numerous four- to six-sided longitudinal canals whose hollow interiors are interrupted at irregular intervals by thin transverse laminae. According to J. B. Reeside¹ shell fragments of this character have subsequently been found at several localities in the Pierre shale. Wade (1926, p. 82) identified a small fragment from Coon Creek, McNairy County, Tenn., as belonging questionably to Hall and Meek's species.

Titanosarcolites oddensis Stephenson, n. sp.

Plates 1, 2; plate 3, figure 1

The holotype, a left valve, is incomplete at both ends, and the outer surface is badly damaged and largely destroyed by corrosion. Scattered about over the

¹ Oral communication.

surface are the incomplete attached portions of small irregular oysters of undetermined species.

The adult shell is large, very thick, conular, rather strongly curved, traversed longitudinally by a proportionately small eccentric tubular septate body cavity. The poorly preserved outer surface of the shell appears to be longitudinally ribbed, the ribs probably being of only moderate strength. The body cavity is markedly eccentric in position as shown by the cross sections; it lies 10 to 20 millimeters within the shell a little to one side of the plane of maximum curvature of the cone. The side of the cavity has been partly crushed in mechanically, the pressure having been applied from the thinnest side of the surrounding shell; as a result the thin septa have been broken and the fragments segregated in parts of the cavity (see pl. 3, fig. 1). Before the crushing took place the cavity was probably subovate in cross section and had a maximum diameter of about 32 millimeters.

The maximum measurable thickness of the shell surrounding the septate cavity is 109 millimeters. Radially outward from the cavity the shell is divisible into three layers or bands of unequal thickness. The inner layer is 1 millimeter or less in thickness and forms a well-defined lining or boundary to the cavity; it is lamellar in structure, the lamellae lying parallel to the inner surface of the cavity; the septa, which are also lamellate, protrude inward across the cavity from this layer and are concave toward the larger end of the shell. The intermediate layer has a maximum measured thickness of about 52 millimeters and is composed of two kinds of canals. The main body of the layer is made up of longitudinal four- to six-sided thin-walled chambered canals measuring in cross section as much as 2.5 millimeters and showing no serial arrangement in any direction. The transverse laminae dividing these canals into chambers are irregularly spaced, the spaces ranging from 0.5 to 2.5 millimeters; the laminae are concave toward the larger end of the shell. As shown in the polished cross sections of the shell a subordinate part of the intermediate layer is composed of tabular or "stretched" canals, which are subdivided into rectangular spaces by much thinner transverse longitudinal walls. These tabular canals are arranged in three separate longitudinal groups whose cross sections are seen in the illustrations; a large, sharply outlined group, elongated lens-shaped in cross section, lies to the right of the septate cavity, the lower end almost touching the inner shell-layer, and the other end lying upward to the right of and obliquely away from the septate cavity; a second smaller more irregular-shaped group lies above and well away from the first group; a third group, seen only in the smaller cross section, is badly crushed, but at the smaller broken end of the shell itself this group appears as a large, broad well-defined patch similar to, but less elongated

than, the first group described. These groups of tabular canals mark the areas of muscular attachment during the successive stages of shell growth; the large crushed area to the left of the septate cavity in plate 3, figure 1, is interpreted to mark the position of the posterior myophore (*mp*) and the one to the right the anterior myophore (*ma*).

The outside shell-layer has a maximum measured thickness of 79 millimeters, and the cross section cut near the large incomplete end shows that the thickness of this layer does not fall below 50 millimeters in an incompletely preserved band extending around the anteroventral side of the shell. This layer is traversed longitudinally by many tubular cavities ranging in cross section from less than 2 millimeters to a measured maximum of 39 millimeters. The cavities have a heterogeneous arrangement and range in cross section from subcircular to elongate-ovate; some are irregular. The cavities are filled with fine brown calcareous silt matrix. They are separated from each other by proportionately thin walls of shell substance, the better preserved parts of which are seen to be canaliculate like the intermediate shell layer already described. However, the structure has been partly destroyed or obscured apparently by the recrystallization of the calcite, and much of the layer is stained with limonite and therefore appears dark in the photographs. Each cavity is lined with a calcitic layer generally less than a quarter of a millimeter thick.

The dental apparatus is not preserved in the holotype, and there is no indication of the position of the ligament.

The greatest dimension of the incomplete holotype, measured in the longitudinal direction, is about 250 millimeters; the minimum and maximum dimensions of the largest cross section are respectively 152 and 208 millimeters; the smaller broken end of the specimen has minimum and maximum diameters of approximately 104 and 112 millimeters.

A smaller mechanically flattened specimen, incomplete at both ends, from the type locality, probably belongs to the same species and is listed as a paratype. It is 140 millimeters long; in its crushed condition it increases from about 75 millimeters in maximum diameter at the small end to 92 millimeters at the large end. The shell structure has been destroyed by recrystallization of the calcite. Two fragments from a concretion in the same formation at another locality in Falls County probably belong to this species.

Types: Holotype U. S. Nat. Mus. 75979; 1 paratype, U. S. Nat. Mus. 75980.

Distribution in Texas.—Navarro group, upper part of Kemp clay: Limonite-stained calcium carbonate concretions in a field north of the McClanahan-Odds road on the southwestward-facing slope of Big Creek Valley 1 mile west by south of Odds (Limestone County), in Falls County (Geol. Survey Coll. 17373, type locality); questionably in a field on the westward-facing slope of Big Creek Valley 1.3 miles southeast of Parsons Bridge and 3

miles southwest of Stranger, Falls County (U. S. G. S. coll. 17372).

Unidentified specimens of *Titanosarcollites*? from Texas

Specimens of *Titanosarcollites*? too incomplete for specific identification have been found at three localities in the Navarro group, as indicated below. In addition one small fragment was found in the upper part of the Taylor marl on State Highway 34, 5¼ miles northeast of Ennis, Ellis County (U. S. G. S. coll. 17378).

The most complete of the Navarro specimens was obtained in the Nacatoch sand on Postoak Creek at the north edge of Corsicana, Navarro County (U. S. G. S. coll. 518, U. S. Nat. Mus. 20903). (See pl. 3, figs. 2-4.) This specimen indicates a short, rapidly expanding, strongly curved, slightly spiral shell. Except near the apex only the part of the shell on the inner side of the curve is preserved; it is proportionately very thick and is composed of longitudinal prismatic canals of varying sizes, of which most are four- to six-sided but a few of the smaller ones may be circular or oval in cross section. The hollow interior of each of the canals is interrupted at irregular intervals by thin transverse uncurved laminae, the laminae in one canal bearing no uniform relation in position to those in adjoining canals; the canals in one group, shown just to the left of the internal cavity in plate 3, figure 3, are smaller than the others. A part of the external surface on the inner curve of the shell is nearly smooth but exhibits fine radial striations and six or seven light-colored radial lines above the beak spaced at intervals of 2 to 4 millimeters. The septa that divide the inner cavity of the shell into chambers are not preserved, having apparently been lost before fossilization. This cavity ends apically in a bluntly rounded bottom, corresponding rather closely in shape to the inner cavity shown in Hall and Meek's illustrations of *Caprinella coralloidea* (1856, pp. 380-381 pl. 1, figs. 3 a-c). The specimen cannot be satisfactorily identified with the latter species. Dimensions: Length, measured from the beak along the curve of the internal cavity to the outer margin, about 70 millimeters; maximum thickness of shell, about 28 millimeters.

One large imperfect shell fragment from the Nacatoch sand, found on the Dallas highway three-fifths of a mile west of Kaufman, Kaufman County (U. S. G. S. coll. 14098, U. S. Nat. Mus. 75981), is made up of polygonal prismatic canals like those of *Titanosarcollites*, except that the transverse septa in the longitudinal canals are not curved. (See pl. 4, fig. 1.) The shell is very thick and the canals, though of irregular size, are in general larger than those of the Corsicana specimen. The hollow canals are set off at longitudinal intervals of 0.5 to 2 millimeters by thin transverse laminae, and the intervening spaces are filled with

secondary calcite. The external tubular layer such as characterizes *Titanosarcollites*, if originally present, is wanting in the specimen as preserved. Dimensions: Greatest diameter, 106 millimeters; maximum thickness, 65 millimeters.

A small elongated, curved shell fragment was found in the Kemp clay in a creek bank on the east side of a road 3½ miles north of Powell and 10 miles northeast of Corsicana, Navarro County (U. S. G. S. coll. 9556). The fragment is composed of irregular, polygonal canals in which at longitudinal intervals of 0.5 to 1.5 millimeters are thin, transverse, uncurved laminae. The structure is similar to that of *Titanosarcollites*.

Titanosarcollites giganteus (Whitfield)

Plate 4, figure 2; plate 5

This Jamaican species was originally described by Whitfield (1897, pp. 194-196) under the name *Caprinella gigantea* and was later made the genotype of *Titanosarcollites* Trechmann (1924, pp. 397-400). It is a common fossil in Upper Cretaceous limestones interbedded in the middle part of the unit known as the Blue Mountain series, which is 3,000 feet thick. The type material came from Logie Green, Clarendon Parish, Jamaica.

By permission of Dr. Chester A. Reeds, curator of the department of geology and invertebrate paleontology, American Museum of Natural History, I have figured in this paper cut and polished surfaces of two of the better-preserved cotypes for comparison with the Texas species. The pictures show that the two species are similar in their structural make-up. In each species both the valves are conical and each valve is traversed by a proportionately small longitudinal septate body cavity; the shell of each is divisible into three parts—a thin inner lamellar layer, a thick median layer made up of small longitudinal septate canals, and a thick outer layer of the same sort but traversed by many small to large tubular cavities of irregular distribution.

A difference that serves sharply to distinguish the two species is the relative sizes of the longitudinal canals, those of *Titanosarcollites giganteus* averaging less than half the diameter of those of *T. oddensis*. The latter has a smaller body cavity, which is only about two-thirds the diameter of the former at a corresponding stage of growth. *T. giganteus* appears to be the more slender of the two species, but this feature may vary with individuals. There appears to be a somewhat different arrangement of the muscle impressions in the two species, but this also may be a variable feature among individuals; this difference may be seen by comparing my figure 1, plate 3, with Mac Gillavry's figure 1, plate 9 (1937). The polished surfaces of the types do not clearly show the positions of the muscle impressions.

Outside of Jamaica the species has been recorded from the Habana formation of Cuba in the Provinces of Camaguey (Douvillé, 1927, pp. 131-133; Mac Gillavry, 1937), Santa Clara (Thiadens, 1936, p. 1018), and Pinar del Río (Vermunt, 1937); questionably from the Island of St. Croix (Stanton in Vaughan, 1923), and from Chiapas, Mexico (Muellerried, 1934). The St. Croix material, which is preserved in the United States National Museum (U. S. G. S. coll. 10229), consists of one incomplete specimen whose internal structure is partly obscured by crystallization of the calcite, but the characteristic large longitudinal tubes are clearly preserved, and in a polished cross section the longitudinal canals and the outline of the septate cavity can be dimly seen; the edges of some of the septa are also faintly discernible. The specimen is probably correctly identified, but some doubt must remain as to its specific relationships. I have not seen the recorded specimens from either Cuba or Chiapas, but have seen the unrecorded material mentioned on page 2 of this paper.

On all the West Indian islands cited and in Chiapas, Mexico, *Titanosarcolites giganteus* is associated with *Barrettia* Woodward and other rudistid genera which most authorities regard as constituting a late Upper Cretaceous (Maestrichtian) fauna; one of these rudistid genera is *Tampsia* Stephenson (Palmer, 1933, pp. 100-101; Vermunt, 1937, pp. 273-274; and p. 2 of the present paper). *Barrettia* has also been recorded by Mac Gillavry from Guatemala (1935, pp. 558-559).

Tampsia was originally described from the upper part of the Mendez shale in the southern part of the State of Tamaulipas, Mexico (Stephenson, 1922, pp. 4-9), and was at that time considered on meager evidence to be of Taylor (Campanian) age. Evidence subsequently afforded by Foraminifera, identified by Helen Jeanne Plummer and J. B. Dorr and cited by Muir (1936, pp. 67-76), is interpreted to indicate the Navarro (Maestrichtian) age of the upper part of the Mendez shale.

Assuming the correctness of the identifications by the different authors cited, a faunal connection seems to be indicated between the Upper Cretaceous rudistid-bearing limestones of the Antillean region (with *Titanosarcolites*, *Barrettia*, *Tampsia*, and other genera) and the upper part of the Kemp clay of Texas (with *Titanosarcolites*), through the *Biradiolites*- and *Barrettia*-bearing beds of Guatemala, the *Barrettia*- and *Titanosarcolites*-bearing beds of Chiapas, and the *Tampsia*-bearing beds in the upper part of the Mendez shale of southern Tamaulipas, Mexico.

BIBLIOGRAPHY

1854. Tuomey, M., Description of some new fossils from the Cretaceous rocks of the Southern States: Acad. Nat. Sci. Philadelphia Proc., vol. 7, p. 172.
1856. Hall, James, and Meek, F. B., Descriptions of new species of fossils from the Cretaceous formations of Nebraska: Am. Acad. Arts Sci. Mem., n. ser., vol. 5, pp. 380-381, pl. 1, figs. 3a-f.
1897. Whitfield, R. P., Descriptions of species of Rudistae from the Cretaceous rocks of Jamaica: Am. Mus. Nat. History Bull. 9, pp. 194-196, pl. 18; pl. 19, figs. 1, 2; pl. 20; pl. 21; pl. 22, figs. 1-3.
1898. Logan, W. N., The invertebrates of the Benton, Niobrara, and Fort Pierre groups: Kansas Univ. Geol. Survey, vol. 4, p. 494, pl. 115; pl. 119, fig. 1.
1921. Cooke, Wythe, Stratigraphy and structural geology and geologic history [Dominican Republic]: Dominican Republic Geol. Survey Mem., vol. 1, p. 55.
1922. Stephenson, L. W., Some Upper Cretaceous shells of the rudistid group from Tamaulipas, Mexico: U. S. Nat. Mus. Proc., vol. 61, Art. 1, pp. 4-9, pls. 1-8.
1923. Vaughan, T. Wayland, Stratigraphy of the Virgin Islands of the United States and of Culebra and Vieques islands, and notes on eastern Puerto Rico: Washington Acad. Sci. Jour., vol. 13, p. 305.
1923. Hawkins, H. L., Some Cretaceous Echinoidea from Jamaica: Geol. Mag., vol. 60, pp. 199-216.
1923. Hubbard, Bela, The geology of the Lares district, Porto Rico: New York Acad. Sci., Scientific survey of Porto Rico and the Virgin Islands, vol. 2, pt. 1, pp. 34-36.
1924. Trechmann, C. T., The Cretaceous limestones of Jamaica and their Mollusca: Geol. Mag., vol. 61, pp. 397-400; pl. 23, figs. 1, 2; text fig. 1.
1924. Hawkins, H. L., Notes on a new collection of fossil Echinoidea from Jamaica: Geol. Mag., vol. 61, pp. 312-324.
1924. Woodring, W. P., Brown, J. S., and Burbank, W. S., Geology of the Republic of Haiti, pp. 97-98, Department of Public Works, Port-au-Prince.
1925. Spath, L. F., On Senonian Ammonoidea from Jamaica: Geol. Mag., vol. 62, pp. 28-32.
1926. Sánchez Roig, Mario, La fauna cretácica de la región central de Cuba: Soc. cubana hist. nat. "Felipe Poey" Mem., vol. 7, pp. 93-95, pl. 7.
1926. Wade, Bruce, The fauna of the Ripley formation on Coon Creek, Tennessee: U. S. Geol. Survey Prof. Paper 137, p. 82, pl. 25, figs. 13, 14.
1927. Douvillé, H., Quelques fossiles du Crétacé supérieur de Cuba: Soc. géol. France Bull., 4^e sér., tome 26, pp. 131-133, pl. 8, fig. 5.
1928. Palmer, Robert H., The rudistids of southern Mexico: California Acad. Sci. Occ. Paper 14, p. 29.
1933. Stephenson, L. W., The zone of *Exogyra cancellata* traced twenty-five hundred miles: Am. Assoc. Petroleum Geologists Bull., vol. 17, pp. 1357-1358.
1933. Palmer, R. H., Nuevos rudistas de Cuba: Rev. agricultura, vol. 14, Nos. 15 y 16, pp. 100-101, Lám. 5, figs. 1, 2.
1933. Cox, L. R., The evolutionary history of the rudists: Geol. Assoc. London Proc., vol. 44, pp. 379-388.
1934. Mac Gillavry, Henry James, Some rudists from the Alta Verapaz, Guatemala: K. Akad. Wetensch. Amsterdam Proc., vol. 37, no. 4, pp. 233-238.

1934. Muellerried, F. K. G., Sobre el hallazgo de paquidontos gigantes en el cretácico de Chiapas: *Inst. biología, México Anales*, tomo 5, no. 1, pp. 81-82.
1935. Schuchert, Charles, *Historical geology of the Antillean-Caribbean region*: New York, J. Wiley & Sons, 811 pp.; especially pp. 426, 429, 481, and 512.
1935. Mac Gillavry, Henry James, Remarks on rudistids: *K. Akad. Wetensch. Amsterdam Proc.*, vol. 38, no. 5, pp. 558-565.
1936. Thiadens, A., Rudistids from southern Santa Clara, Cuba: *K. Akad. Wetensch. Amsterdam Proc.*, vol. 39, no. 8, p. 1018.
1936. Muir, John M., *Geology of the Tampico region, Mexico* (published by Am. Assoc. Petroleum Geologists), 280 pp. (especially pp. 67-76).
1937. Mac Gillavry, Henry James, *Geology of the Province of Camaguay, Cuba, with revisional studies in rudist paleontology*: Dissertation, Univ. Utrecht, 1937, pp. 85-92, pl. 2, figs. 1-7, 10, 11; pl. 3, fig. 3; pl. 9, fig. 1. (Appears also as No. 14 of the Physiographic and Geologic series of the Geographic and Geologic Communications.)
1937. Vermunt, L. W. J., *Geology of the Province of Pinar del Río, Cuba*: *Geog. geol. Mededeel. Phys.-Geol., Reeks*, no. 13, pp. 36-37.
1937. Vermunt, L. W. J., Cretaceous rudistids of Pinar del Río Province, Cuba: *Jour. Paleontology*, vol. 11, no. 4, pp. 263, 273-274.

PLATES 1-5

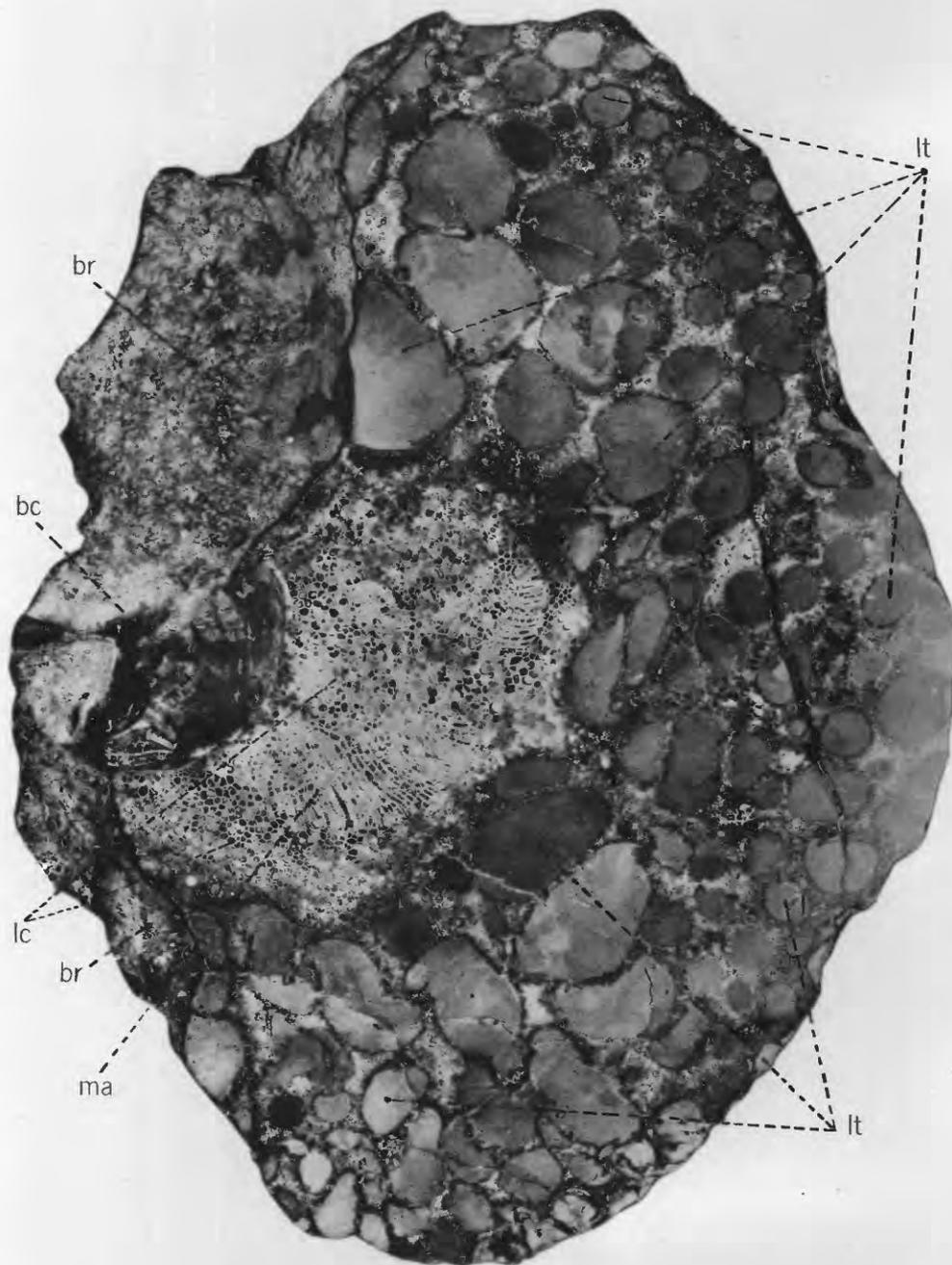
PLATE 1

Titanosarcolites oddensis Stephenson. Anteroventral view of holotype, left valve (U. S. Nat. Mus. 75979), about $\frac{2}{3}$ natural size. Openings of matrix-filled longitudinal tubes are in view on upper, weathered surface of shell; crosscuts show position of polished surfaces figured in plates 2 and 3.



AN UPPER CRETACEOUS RUDISTID





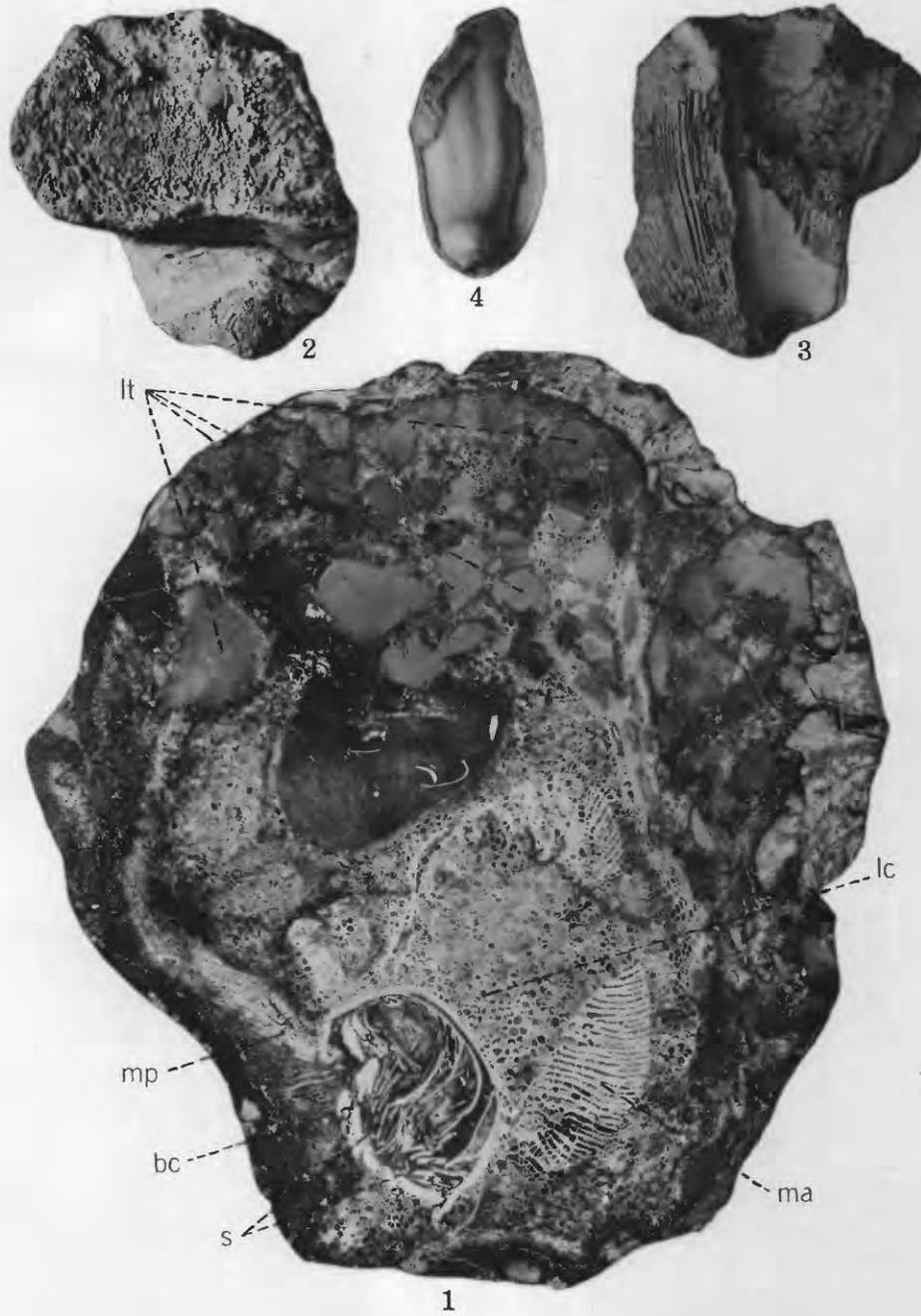
AN UPPER CRETACEOUS RUDISTID

PLATE 2

Titanosarcolites oddensis Stephenson. Larger, up-facing cut and polished surface of holotype, about $\frac{1}{2}$ natural size; *bc*, body cavity; *lc*, longitudinal canals; *lt*, longitudinal tubes; *ma*, anterior myophore; *br*, areas to left of irregular black line show broken surfaces of shell not included in polished surface.

PLATE 3

- FIGURE 1. *Titanosarcolites oddensis* Stephenson. Smaller up-facing cut and polished surface of holotype, about $\frac{1}{20}$ natural size; *bc*, body cavity; *s*, fragments of septa in body cavity; *lc*, longitudinal canals; *ma*, anterior myophore with "stretched" canals; *mp*, posterior myophore with "stretched" canals, badly crushed; *lt*, longitudinal tubes.
2. *Titanosarcolites?* sp. (U. S. Nat. Mus. 20903). Incomplete specimen showing incurved beak and broken, distal ends of longitudinal canals. Natural size.
 3. Opposite side of same specimen showing body cavity and longitudinal canals.
 4. Gutta-percha squeeze of body cavity shown in figure 3.

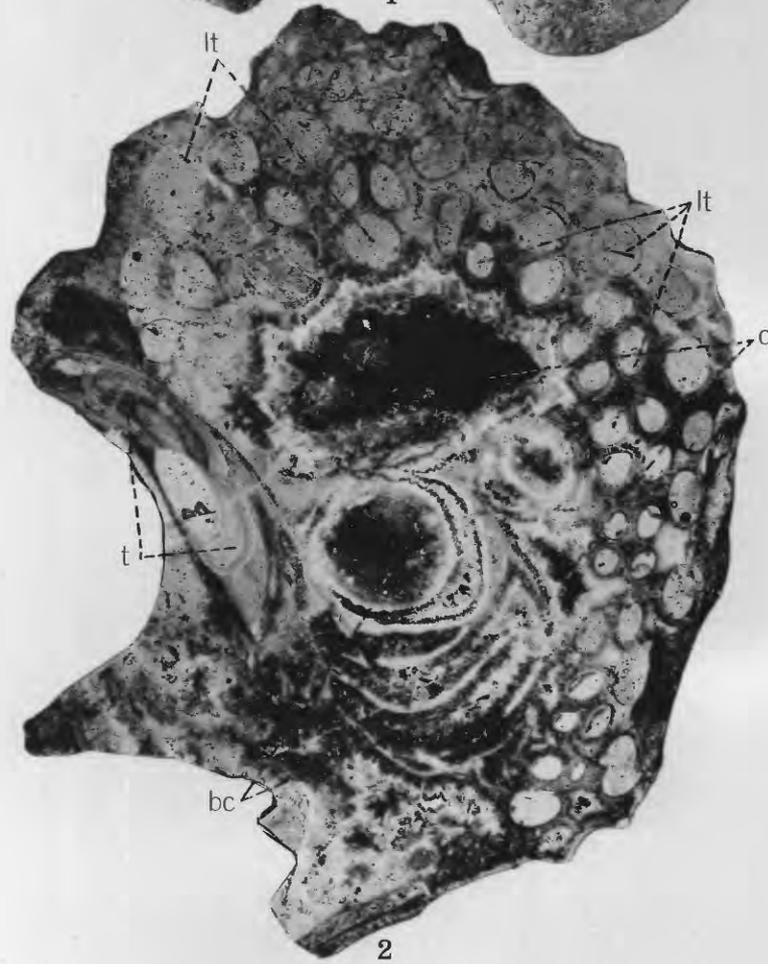


AN UPPER CRETACEOUS RUDISTID





1



2

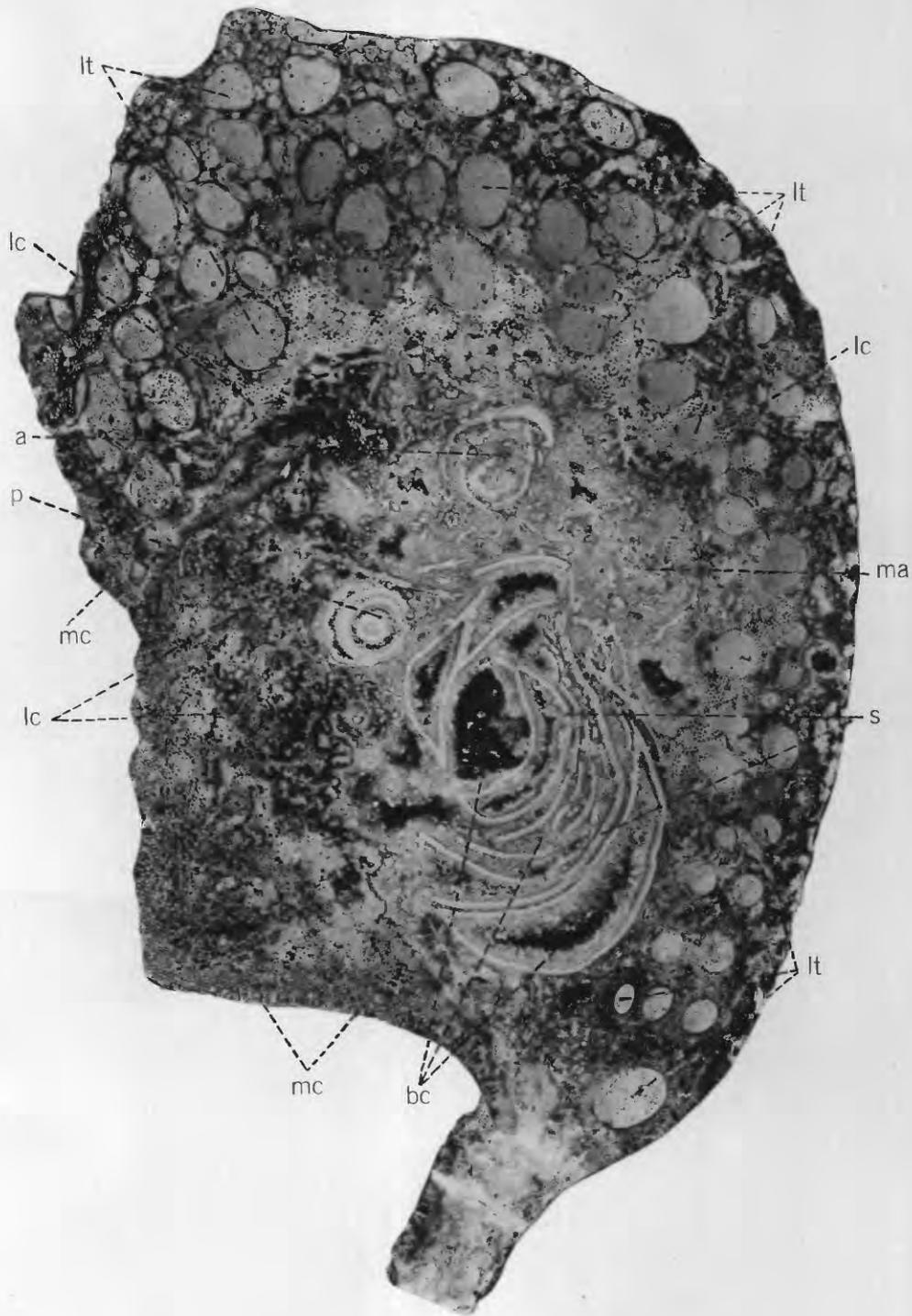
AN UPPER CRETACEOUS RUDISTID

PLATE 4

- FIGURE 1. *Titanosarcolites?* sp. (U. S. Nat. Mus. 75981). Incomplete specimen showing body cavity and broken ends of longitudinal canals, about $\frac{1}{2}$ natural size. Outside tubular layer, if originally present, has been destroyed.
2. *Titanosarcolites giganteus* (Whitfield) (Am. Mus. Nat. Hist. 9685.2). Up-facing cut and polished surface ($\frac{1}{2}$ natural size) of a cotype, a left valve, figured in Am. Mus. Nat. History Bull., vol. 9, pl. 19, fig. 1, and pl. 20; *bc*, septate body cavity partly filled with calcite crystals; *l*, longitudinal tubes filled with matrix; *t*, tube of boring organism that has penetrated deeply into shell; *c*, solution(?) cavities lined with calcite crystals. Whitfield's statement that this specimen has been split longitudinally and retains only the inner half of the shell is incorrect; only crests of larger ribs have been broken away.

PLATE 5

Titanosarcolites giganteus (Whitfield) (Am. Mus. Nat. Hist. 9685.3). Down-facing surface of cut and polished cross section (about $\frac{1}{10}$ natural size) of a cotype, a right valve, figured in Am. Mus. Nat. History Bull., vol. 9, pl. 21; *bc*, septate body cavity lined and partly filled with calcite crystals; *s*, septa in body cavity; *lc*, longitudinal canals; *mc*, "stretched" marginal canals; *lt*, longitudinal tubes filled with matrix; *a*, anterior alveole; *p*, posterior alveole; *ma*, anterior myophore.



AN UPPER CRETACEOUS RUDISTID



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