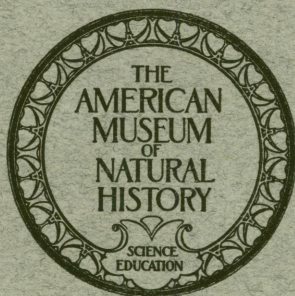


FOSSIL INVERTEBRATA FROM NORTHEASTERN BRAZIL

By CARLOTTA JOAQUINA MAURY

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Article IV. —FOSSIL INVERTEBRATA FROM NORTHEASTERN BRAZIL¹

BY CARLOTTA JOAQUINA MAURY

PLATES IX-XIX

CONTENTS

	PAGE
INTRODUCTION.....	126
STRATIGRAPHIC RESULTS OF THE STUDY OF THE BRAZILIAN COLLECTION.....	126
DISCUSSION OF THE FOSSILS BY GROUPS.....	127
I. THE MARINE CRETACEOUS MOLLUSCA AND ECHINOIDEA FROM VARIOUS LOCALITIES IN THE DOLOMITIC LIMESTONE BELT OF RIO GRANDE DO NORTE	127
DESCRIPTION OF SPECIES.....	128
CLASS MOLLUSCA.....	128
Genus <i>Arca</i> Linnaeus.....	128
Subgenus <i>Barbatia</i> Gray.....	129
<i>Arca (Barbatia) camurupimensis</i> , sp. nov.....	129
<i>Arca (Barbatia) mossoroensis</i> , sp. nov.....	130
Genus <i>Venericardia</i> Lamarck.....	130
<i>Venericardia mossoroensis</i> , sp. nov.....	130
Genus <i>Corbis</i> Cuvier.....	131
<i>Corbis maiae</i> , sp. nov.....	131
Genus <i>Cardium</i> Linnaeus.....	132
<i>Cardium jenkinsi</i> , sp. nov.....	132
<i>Cardium galateae</i> , sp. nov.....	133
<i>Cardium itapassarocanum</i> , sp. nov.....	134
<i>Cardium endymionis</i> , sp. nov.....	134
Genus <i>Cyprimeria</i> Conrad.....	135
<i>Cyprimeria riograndensis</i> , sp. nov.....	135
Genus <i>Pholadomya</i> Sowerby.....	135
<i>Pholadomya baizaleitensis</i> , sp. nov.....	135
Genus <i>Pteria</i> Scopoli.....	136
<i>Pteria camurupimica</i> , sp. nov.....	136
<i>Pteria mossoroensis</i> , sp. nov.....	137
Genus <i>Perna</i> Bruguière.....	137
<i>Perna arvoredensis</i> , sp. nov.....	137
Genus <i>Ostrea</i> Linnaeus.....	138
<i>Ostrea pendenciana</i> Maury.....	138
<i>Ostrea lagoapiatensis</i> , sp. nov.....	138
Genus <i>Modiola</i> Lamarck.....	139
<i>Modiola camurupimica</i> , sp. nov.....	139
<i>Modiola arvoredensis</i> , sp. nov.....	140
Genus <i>Tylostoma</i> Sharpe.....	140
<i>Tylostoma brasilianum</i> Maury.....	140
<i>Tylostoma rochai</i> von Ihering.....	141

¹Manuscript received by the Editor April 18, 1933.

	PAGE
Genus <i>Ampullospira</i> Harris.....	142
<i>Ampullospira</i> , sp. indet.....	142
Genus <i>Turritella</i> Lamarck.....	142
<i>Turritella natalensis</i> Jenkins.....	142
<i>Turritella euphrosynes</i> , sp. nov.....	143
<i>Turritella thaliae</i> , sp. nov.....	143
Genus <i>Melania</i> Lamarck.....	144
<i>Melania catandubica</i> , sp. nov.....	144
Genus <i>Nerinea</i> Defrance.....	144
<i>Nerinea (Plesioptygmatis) coutinhoi</i> , sp. nov.....	146
<i>Nerinea (Ptygmatis) baixadoleitensis</i> , sp. nov.....	147
<i>Nerinea (Ptygmatis) riograndensis</i> , sp. nov.....	148
<i>Nerinea</i> , sp. indet.....	149
Genus <i>Cerithium</i> Adanson.....	149
<i>Cerithium mirimense</i> Jenkins.....	150
<i>Cerithium</i> (?) <i>jacouea</i> (Jenkins).....	150
Genus <i>Clava</i> Martyn.....	151
<i>Clava (Ochetoclava) aglaiae</i> , sp. nov.....	151
Genus <i>Aporrhais</i> da Costa.....	151
<i>Aporrhais baixadoleitensis</i> , sp. nov.....	151
CLASS ECHINODERMATA.....	152
Genus <i>Cyphosoma</i> Agassiz.....	153
<i>Cyphosoma</i> , sp. indet. juv.....	153
Genus <i>Breynella</i> Gregory.....	153
<i>Breynella baixadoleitensis</i> , sp. nov.....	153
Genus <i>Toxaster</i> Agassiz.....	154
<i>Toxaster</i> , sp. indet.....	154
Genus <i>Hemiaster</i> Desor.....	155
<i>Hemiaster catandubensis</i> , sp. nov.....	155
<i>Hemiaster</i> , sp. indet.....	155
Genus <i>Lovenia</i> Agassiz.....	156
<i>Lovenia baixadoleitensis</i> , sp. nov.....	156
Genus <i>Spatangus</i> Klein.....	156
<i>Spatangus baixadoleitensis</i> , sp. nov.....	156
II. THE PLIOCENE TO RECENT FOSSILS OF THE STONE REEF, AREIA PRETA, NATAL, RIO GRANDE DO NORTE.....	157
Genus <i>Anomalocardia</i> Schumacher.....	157
<i>Anomalocardia brasiliiana</i> (Gmelin).....	157
III. THE RECENT TO PLIOCENE FOSSILS OF THE CORAL REEF, AREIA PRETA, NATAL, RIO GRANDE DO NORTE.....	158
Genus <i>Petalocochus</i> Lea.....	158
<i>Petalocochus irregularis</i> (d'Orbigny).....	158
IV. THE RECENT TO PLEISTOCENE FOSSILS OF THE SOFT SANDSTONE AND COQUINA AT THIBAU, NORTHWEST OF MOSSORÓ, RIO GRANDE DO NORTE..	159
Genus <i>Diodora</i> Gray.....	159
<i>Diodora listeri</i> (d'Orbigny).....	159
Genus <i>Arca</i> Linnaeus.....	160

	PAGE
Subgenus <i>Scapharca</i> Gray, Section <i>Argina</i> Gray.....	160
<i>Arca</i> (<i>Argina</i>) <i>campechensis</i> Gmelin.....	160
Genus <i>Divaricella</i> von Martens.....	161
<i>Divaricella quadrisulcata</i> (d'Orbigny).....	161
Genus <i>Cardium</i> Linnaeus.....	162
<i>Cardium</i> (<i>Trachycardium</i>) <i>muricatum</i> Linnaeus.....	162
Genus <i>Tivela</i> Link.....	163
<i>Tivela mactroides</i> (Born).....	163
Genus <i>Pitaria</i> Roemer.....	164
<i>Pitaria</i> (<i>Lamelliconcha</i>) <i>circinata</i> (Born).....	164
Genus <i>Anomalocardia</i> Schumacher.....	164
<i>Anomalocardia brasiliiana</i> (Gmelin).....	164
Genus <i>Strigilla</i> Turton.....	164
<i>Strigilla pisiformis</i> (Linnaeus).....	164
Genus <i>Donax</i> Linnaeus.....	165
<i>Donax striata</i> Linnaeus.....	165
Genus <i>Mulinia</i> Gray.....	166
<i>Mulinia branneri</i> Dall.....	166
Genus <i>Corbula</i> Bruguière.....	166
<i>Corbula</i> cf. <i>uruguayensis</i> Marshall.....	166
V. THE TERRESTRIAL PLEISTOCENE MOLLUSCAN FOSSILS OF THE SUBAERIAL CALCAREOUS BRECCIA OF ALMINO AFFONSO IN THE INTERIOR OF RIO GRANDE DO NORTE.....	167
Family Helicidae Keferstein.....	167
Genus <i>Drymaeus</i> Albers.....	167
<i>Drymaeus</i> , sp. indet.....	167
Genus <i>Helicina</i> Lamarck.....	168
<i>Helicina</i> , sp. indet.....	168
Genus <i>Artemon</i> Beck.....	168
<i>Artemon alminoaffonsicum</i> , sp. nov.....	169
Genus <i>Bulimulus</i> Leach.....	170
<i>Bulimulus</i> , sp. indet.....	170
VI. THE FRESHWATER TRIASSIC FAUNA OF THE RIO DO PEIXE SHALES IN THE WESTERN INTERIOR OF PARAÍBYA DO NORTE.....	170
Genus <i>Diplodon</i> Spix.....	174
<i>Diplodon lucianoï</i> , sp. nov.....	175
BIBLIOGRAPHY.....	176

INTRODUCTION

The collection described in the following report was received by the American Museum of Natural History, New York, from the Inspectoria Federal de Obras Contra as Seccas, Brazil, in April, 1925. Accession number 1100.

The material is described at the request of Dr. Chester A. Reeds, Curator of Geology and Invertebrate Palaeontology, American Museum of Natural History. The drawings are by George S. Barkentin.

Most of the fossils in the collection are from the State of Rio Grande do Norte, northeastern Brazil. But there is also a unique and most interesting minute fauna from the Rio do Peixe shales, near the city of Souza in the western interior of the adjacent State of Parahyba do Norte.

STRATIGRAPHIC RESULTS OF THE STUDY OF THE BRAZILIAN COLLECTION

The most striking and important stratigraphic results of the study of this Brazilian collection are:

FIRST.—The extension of the *Nerinea* fauna from the Rio Assú region near Pendencia, to the limestone of Jacoca, west of Natal, and concurrent proof that the limestone west of Natal is not Lower Eocene, as thought by Harris,¹ Jenkins,² and Branner,³ but is Cretaceous and a continuation of the limestone of Mossoró, São Sebastião, and Rio Assú, determined by the writer,⁴ in 1925, to be Cretaceous. The entire dolomitic limestone belt is a stratigraphic unit and is of Cretaceous age. It is probably referable to the Turonian stage.

SECOND.—The Rio do Peixe shales and sandstones appear to be Triassic rather than Cretaceous as heretofore thought. A Triassic age is suggested independently by both the freshwater minute bivalve fauna, and by the character of the reptilian tracks discovered by Dr. Luciano Jacques de Moraes⁵ and described by him in 1924. Similar minute bivalve shells are reported by Dr. J. B. Reeside, Jr., to be in Triassic material at the United States National Museum. Mr. Barnum Brown,⁶ Curator of Fossil Reptiles in the American Museum, and the best authority in the world on fossil tracks, thinks the Tridactylid Dinosaur of Dr. Moraes' report is probably Middle or Upper Triassic in age.

¹ Harris, G. D. Communicated and quoted as a footnote in Jenkins' report.

²Jenkins, O. P. 1913. Geology of the Region about Natal, Rio Grande do Norte, Brazil. *Proceedings American Philosophical Society*, LII, pp. 431-466.

³Branner, J. C. 1919. Mappa Geologica do Brazil. *Bulletin Geological Society of America*. The entire belt of limestone from Aracaty, Ceará, to Natal is mapped as Eocene.

⁴Maury, C. J. 1924-1925. Fósseis Cretaceos do Rio Grande do Norte. *Monographias do Serviço Geologico e Mineralogico do Brasil*, IV, pp. 495-551, Rio de Janeiro.

⁵Moraes, L. J. de. 1924. Serras e Montanhas do Nordeste. *Inspectoria Federal de Obras Contra as Seccas, Publicação 58, Serie I. D. Capitulo 3*, pp. 41-49, Pls. xxvii-xxxiii, diagrams 1, 3, sections 20, 21, Rio de Janeiro.

⁶Communicated by letter dated March 8, 1933.

DISCUSSION OF THE FOSSILS BY GROUPS

Because of the very diverse stratigraphic horizons represented by the material in this collection, it seems clearest to discuss the fossils by groups under the different horizons to which they are assigned and the localities from which they were obtained, as follows:

I. The marine Cretaceous Mollusca and Echinoidea from various localities in the dolomitic limestone belt of Rio Grande do Norte.

II. The Pliocene to Recent fossils of the stone reef, Areia Preta, Natal, Rio Grande do Norte.

III. The Recent to Pliocene fossils of the coral reef, Areia Preta, Natal, Rio Grande do Norte.

IV. The Recent to Pleistocene fossils of the soft sandstone and the coquina at Thibau, on the coast, northwest of the city of Mossoró, Rio Grande do Norte.

V. The terrestrial Pleistocene fossils of the subaërial calcareous breccia at Almino Affonso, in the southwestern interior of Rio Grande do Norte.

VI. The freshwater Triassic fauna of the Rio do Peixe shales and sandstones near Souza, in the western interior of Parahyba do Norte.

I. THE MARINE CRETACEOUS MOLLUSCA AND ECHINOIDEA FROM
VARIOUS LOCALITIES IN THE DOLOMITIC LIMESTONE BELT OF
RIO GRANDE DO NORTE

The principal fossiliferous localities are near Mossoró, São Sebastião, and Assú, in the northwestern part of the State; Baixa Verde, in the south-central area; and Itapassaroca, Jacoca, and Arvoredo, in the southeastern part of the State, westward of the port of Natal.

Usually the matrix is a magnesian limestone, sometimes, as at Baixa Verde, almost a true dolomite.

But there is a curious siliceous phase at Baixa do Leite, in the northwestern part of the State, southeast of the port of Macau, near the contact of the Cenozoic coastal belt with the Cretaceous limestone belt. Many of the fossils from Baixa do Leite are in a whitish, partly chalcedonized material in which mineral replacement has taken place. This matrix contains *Nerinea* (*Ptygmatis*) *baixadoleitensis*, and the presence of the genus *Nerinea* proves it to be of Cretaceous age like the normal limestone.

At Camurupim, near Mossoró, many molds and imprints of fossils are in weathered boulders, very hard, very heavy and highly siliceous. Unfortunately all the species are long-ranging and index fossils pointing

to a definite horizon are lacking, but tentatively they are assigned to the Cretaceous.

At Olho d'Agua da Catanduba, near Angicos, in the central part of the State, fossiliferous boulders lie strewn upon the surface of the limestone. These also are provisionally assigned to the Cretaceous.

DESCRIPTION OF SPECIES

Class MOLLUSCA

Genus **ARCA** Linnaeus

In a siliceous boulder from Camurupim, are many imprints and molds of shells. The most interesting are two imprints referable to the Arcidae. One shows a complete left valve, the other, the upper part of a right valve. These are described as separate species because the form and ribbing appear unlike. In general aspect both valves resemble two North American Cretaceous shells which are externally similar but differ in hinge characters. One is *Nemodon eufalensis* described by Gabb,¹ in 1860, as *Arca (Macrodon) eufalensis* and referred by Dr. Whitfield,² in 1885, to Conrad's³ *Nemodon*, 1869. Dr. Dall⁴ included *Nemodon* in the Arcidae under *Barbatia*, but Dr. Gardner⁵ places it under the Parallelodontidae. *Nemodon* is characterized by its long hinge teeth, and seems best retained as a separate genus. The other North American shell which resembles the Brazilian valves is *Arca (Barbatia) uandi* Gardner⁶ from the Matawan formation of Delaware, although ours are only half as large.

Our imprints show no hinge characters, and as far as external form is concerned they might be either *Nemodon* or *Barbatia*. But Dr. Sheldon remarks that *Nemodons* seem to have only fine radial sculpture, their ribs being much less distinct than Gabb's figure would lead one to suppose. Our valves show stronger ribbing, especially posteriorly, and for this reason and because their general aspect seems nearer to *Barbatia uandi* than to any other described species, they are herein described as *Barbatias*.

The figured type of *Barbatia disclusa* White⁷ was from Rio Pirabas, Pará, measured 29×12 mm., and is Lower Miocene in age. The Sergipe molds included by Dr. White are dissimilar forms and are Middle Albian.

¹Gabb, W. M. 1860. Journal Academy Natural Sciences, Philadelphia, 2d Ser., IV, p. 398, Pl. LXVIII, fig. 39.

²Whitfield, R. P. 1885. United States Geological Survey, Monographs, IX, pp. 83-86.

³Conrad, T. A. 1869. American Journal of Conchology, V, p. 97.

⁴Dall, W. H. 1898. Transactions Wagner Free Institute Science, III, p. 615.

⁵Gardner, Julia A. 1916. Upper Cretaceous, Maryland Geological Survey, p. 540.

⁶Gardner, Julia A. 1916. Upper Cretaceous, Maryland Geological Survey, p. 539, Pl. XXI, figs. 5, 6.

⁷White, C. A. 1887. Archivos do Museu Nacional do Rio de Janeiro, VII, p. 62, Pl. v, figs. 14, 15.

Arcas, especially Scapharcas, are abundant in the Lower Miocene of Rio Pirabas and the Estação Agronomica, in the State of Pará.¹

Arca orestis Rathbun is from the Lower Eocene of Pernambuco. *Meekia commemorata* White from the same horizon is probably a species of *Bathyarca*.

In the Old World the Arcidae seem to have developed advanced types earlier; but in the New World the higher Arks do not appear before the Tertiary. *Barbatia*, however, is an ancient subgenus, and true *Barbatias* go back into the Cretaceous. The shell in *Barbatia* is equivalve, with hinge teeth numerous, small and vertical beneath the umbones, larger and more oblique distally. The type of the subgenus is *Arca barbatia* Linnaeus.

All the subgenera of *Arca* are marine except *Scaphula* Benson which is freshwater in habitat. Members of the various subgenera are widely distributed in the warmer seas of today, living from between tides to abyssal depths. The Recent Brazilian Arcas were discussed by the writer² in an earlier publication.

Subgenus **BARBATIA** Gray

***Arca (Barbatia) camurupimensis*, sp. nov.**

Plate XI; Figure 1

The following description is based on the imprint in the rock of a left valve. An artificial cast reproduces the form and sculpture of the original mollusk.

Shell small, subrhomboidal in outline, with the anterior end short, rounded, and the posterior end produced and obliquely truncate. Basal margin sinuated by a mesial sulcation which is conspicuous only near the ventral border of the valve. Umbonal slope rounded. Beaks at about the anterior fourth of the total length of the shell. Hinge line very long and straight, slightly exceeding three-quarters of the shell's entire length. Dentition unknown. The whole surface was sculptured with fine radiating ribs of which marginal traces are preserved. Anteriorly and posteriorly the ribs are stronger. At the anterior end about five broader ribs can be discerned, while two broader ribs are in the center of the posterior dorsal area and terminate in the middle of the oblique marginal truncation. There is a faint indication that the ribs tend to be divided in this species. Length of shell 16 mm., height 8 mm.

As already noted under the discussion of the genus *Arca*, the nearest affinity of this species, judging by the known characters, is *Barbatia uandi* Gardner.

¹Maury, C. J. 1924-1925. Fósseis Terciários do Brasil com Descrição de Novas Formas Cretáceas. Monographias do Serviço Geológico e Mineralógico do Brasil, IV, pp. 407-411. Pls. XI, XIII, Rio de Janeiro.

²Maury, C. J. 1924-1925. Fósseis Terciários do Brasil. Monographias do Serviço Geológico e Mineralógico do Brasil, IV, pp. 222-223.

LOCALITY.—Camurupim, near Mossoró, Rio Grande do Norte. In a siliceous boulder containing many traces of marine shells.

HORIZON.—The species are long-ranging and indecisive stratigraphically. Provisionally referred to the Turonian stage of the Cretaceous, although the boulder horizon may be slightly younger than the main mass of the limestone.

Arca (Barbatia) mossoroensis, sp. nov.

Plate XI; Figure 2

In the same locality and in a similar matrix to that in which *Barbatia camurupimensis* was found, is the imprint of a right valve of a related species. This imprint is tipped so that the base of the valve is not shown.

An artificial cast shows that the shell was small, with the posterior end bluntly pointed. The umbonal slope is rather markedly angulate. The surface is sculptured with radial ribbing, the ribs upon the central area being so fine as to be thread-like. But on the posterior area the ribs are conspicuously developed, four or five being especially strong. All the ribs as far as one can see are entire, whereas the preceding species tended to have divided ribs. The beak is situated at about the anterior fourth of the total length of the shell. Length 12 mm., height 6 mm.

LOCALITY.—Camurupim, near Mossoró, Rio Grande do Norte. In a siliceous boulder.

HORIZON.—Provisionally referred to the Turonian stage of the Cretaceous, but the boulder horizon may be slightly younger than the main mass of limestone.

Genus **VENERICARDIA** Lamarek

Venericardia mossoroensis, sp. nov.

Plate XII; Figure 5

In a siliceous boulder of heavy, massive material is the imprint of a shell which in form and sculpture resembles species of *Venericardia*. Very similar forms have been described also under the closely related genus *Cardita*. The essential difference between these genera lies in the development of the lateral hinge teeth, but in the species now described the hinge is unknown. It is tentatively referred to *Venericardia* because of its cordate form.

The imprint is of a left valve partly filled with matrix, but the sculpture is shown around the margins and has been restored over the younger part of the valve in the drawing.

The shell is small, suborbicular and subcordate in form, evenly convex, with the beak situated near the anterior end. Hinge line rather long, slightly sloping. The entire surface of the shell is sculptured with about nineteen radial ribs, crenulated by concentric growth lines. The crests of the ribs are rather sharp but they broaden and are somewhat terraced laterally. Thread-like, interpolated riblets tend to develop in the interspaces. Length of shell 13 mm., height 10 mm.

At first glance this species suggests Tertiary relationships, but very similar Cretaceous species have been described. *Venericardia wenoensis* Adkins from the base of the Weno formation in the Texas Cretaceous is an example. In describing that species, Adkins remarked that it resembles the Eocene *Venericardia alticostata* Conrad but has the ribs more strongly imbricate.

Specimens from the Cretaceous of southern India figured by Stoliczka as *Cardita jacquinoti* d'Orbigny, bear a rather striking resemblance to our Brazilian shell, and show tricarinate or terraced ribs, but the crests are not so markedly crenulate as in our shell.

Dr. Rathbun's Brazilian species, *Cardita wilmoti* from the white limestone of São José, Pernambuco, shows some resemblance to this Rio Grande do Norte species. Very beautiful Lower Miocene Venericardias have been described by the writer from Rio Pirabas, State of Pará.

The present species appears to be an ancestral precursor of the great Tertiary race of Venericardias, and to have inhabited Cretaceous seas, as did also the Indian *Cardita jacquinoti* and the North American *Venericardia wenoensis*.

LOCALITY.—Camurupim, near Mossoró, Rio Grande do Norte. In a siliceous boulder.

HORIZON.—Provisionally referred to the Cretaceous, but the species are not stratigraphically decisive, and the boulder horizon may be slightly younger than the main mass of the Turonian limestone.

Genus **CORBIS** Cuvier

The genus *Corbis* is remarkable for its exquisitely fine and decorative sculpture, the subcircular or transversely elliptical valves being ornamented with sharp concentric lamellae, and with short, fine, closely-set radial striae in the interspaces.

Triassic species of *Corbis* are questioned, but this lovely genus has been an inhabitant of warm seas from Jurassic to Recent time.

Corbis maiiae, sp. nov.

Plate XII; Figure 3

In the collection is a single, incomplete imprint in the rock matrix of a shell showing the characteristic sculpture of *Corbis*.

The substance of the original shell was thin, as the narrow space between its imprint and internal mold proves. The form was broadly elliptical, and the beaks small and low. In its central portion the valve was very gently convex, the internal cavity being shallow. The surface is ornamented with about fourteen concentric, sharp, narrow ridges; and in each interspace are very fine radial striae, numbering

four or five to a millimeter over the central part of the valve. Hinge characters unknown. Estimated length of entire shell about 19 mm., height 9 mm., semidiameter about 3 mm.

In size and general aspect this species may be compared with *Corbis alapetitei* Pervinquièr¹ from the Cenomanian of North Africa.

Corbis maiae is the first species of the genus ever found in the rocks of Brazil. It is named for the most beautiful of the Pleiades.

LOCALITY.—Baixa do Leite, south of Macau, on the margin of the limestone belt, in material which has become partly chalcidized by mineral replacement.

HORIZON.—Associated Nerineas prove this Cretaceous. It is tentatively referred to the Turonian.

Genus **CARDIUM** Linnaeus

Triassic Cardiums are somewhat doubtful, but the genus has certainly inhabited Jurassic to Recent seas.

Cardium jenkinsi, sp. nov.

Plate XII; Figure 1

Cardium (Criocardium) soaresanum JENKINS, 1913, Geology of the Region about Natal, Brazil. Proceedings American Philosophical Society, LII, No. 211, p. 19, Pl. xx, figs. 2, 2a.

Not *Cardium soaresanum* RATHBUN, 1874, Cretaceous Lamellibranchs of Pernambuco, Brazil. Proceedings Boston Society Natural History, xvii, p. 253.

Not *Cardium (Criocardium) soaresanum* C. A. WHITE, 1887, Contribuições à Paleontologia do Brasil. Arquivos do Museu Nacional do Rio de Janeiro, VII, p. 90, Pl. vi, figs. 6, 7, 8. English edition, Washington, 1888.

Not *Cardium (Criocardium) soaresanum* BRANNER, 1902, Geology of the Northeast Coast of Brazil, Bulletin Geological Society of America, XIII, p. 47.

In our Itapassaroca material are molds of two left valves and of one right valve of a *Cardium* specifically identical with the *Cardium* described and figured by Mr. Olaf Jenkins from Itapassaroca, in 1913, as *Cardium soaresanum* Rathbun. That species was described by Dr. Rathbun from material brought back from Pernambuco by Professor Hartt in the early seventies and was never figured by Rathbun. Thirteen years later, Dr. C. A. White illustrated other specimens that had been obtained from Maria Farinha, Pernambuco, in the yellowish limestone which is of Lower Eocene age.

Critical comparison proves that the Itapassaroca *Cardium* is not identical with *Cardium soaresanum*, which is a larger species, with a higher beak, a much thicker, more inflated form, more numerous ribs, and with the height exceeding the length. The outline also is different. *Cardium soaresanum*, well illustrated in White's figure 6 of the left side, is subovate, the posterior basal margin being somewhat produced

¹Pervinquièr, L. 1912. Carte Géologique de la Tunisie. Direction Générale des Travaux Publics. Études de Paléontologie Tunisienne, II, p. 257, Pl. xix, figs. 19 a-b, 20 a-b.

and dipping down in the region of the umbonal slope. The *Itapassaroca Cardium*, as shown by our molds and by Jenkins' figure 2, which represents a right valve, has the basal margin evenly rounded, and the outline of the shell is subcircular.

Large specimens of *Cardium soaresanum* measured 22 mm. in length and 23 mm. in height, and White's figure 8 is 22×25 mm. and figure 6, 17×18 mm., showing that the height exceeds the length. The diameter of White's figure 7, drawn from the same specimen as figure 6, is 14 mm.

Jenkins' *Itapassaroca Cardium* molds measured 12×12 mm. and 6 or 7 in diameter. Ours are 11×11 , semidiameter less than 4 mm. The species has the length equal to or even slightly exceeding the height, and the shell is flatter, the diameter being proportionately less. Our molds show only traces of the ribbing, but Jenkins' specimens had 22 ribs. Our illustration is a composite of Jenkins' and our specimens.

This *Itapassaroca Cardium* is small, 11 or 12 mm. in both height and length, and 6 or 7 mm. in diameter. The form is subcircular, and the ribs number about 22.

Mr. Jenkins based his correlation of the *Itapassaroca* limestone with the Maria Farinha Lower Eocene limestone upon the presence of *Cardium soaresanum* in both formations. But the new collection proves that the *Itapassaroca Cardium* is not the same species as Rathbun's Lower Eocene *soaresanum*, and the correlation is invalidated.

This little *Cardium* from *Itapassaroca* is now named in honor of Mr. Olaf Jenkins, who was a member of the Stanford University Expedition to Brazil, in 1911, and found this species not only in limestone in the railway cut half a kilometer beyond *Itapassaroca* at kilometer 45; but also in the quarry at Jacoca, four kilometers southwest of Ceará-Mirim; and near Alvoredo north of Macahyba; and near Desterro north of Macahyba,—all these localities being exposures of the magnesian limestone in the region west of Natal, Rio Grande do Norte.

LOCALITY.—*Itapassaroca*, Rio Grande do Norte Central Railway, exposed in a cut. In buff-colored dolomitic limestone which effervesces only slightly with dilute hydrochloric acid.

HORIZON.—Proved to be Cretaceous by associated *Nerinea* species. Provisionally referred to the Turonian stage.

***Cardium galateae*, sp. nov.**

Plate XI; Figure 3

In a siliceous boulder containing also a crystal-lined geode, is the imprint of a delicate shell that appears to be a small *Cardium*.

The imprint is of a right valve, and an artificial cast shows that the form was subcircular, slightly oblique, gently convex, with a rather low beak, and with the posterior area somewhat compressed and marked off by a narrow umbonal ridge. All the surface except the younger part of the shell is sculptured with exceedingly fine radial ribs. Hinge characters not known. Length of shell 8 mm., height 7 mm.

Cardium scrobiculatum Stoliczka from the Cretaceous of southern India resembles this Brazilian shell in general form and type of sculpture.

LOCALITY.—Camurupim, near Mossoró, Rio Grande do Norte.

HORIZON.—The species are not decisive stratigraphically. Provisionally referred to the Turonian stage of the Cretaceous, although the boulder horizon may be slightly younger than the main mass of limestone.

***Cardium itapassarocanum*, sp. nov.**

Plate XI; Figure 7

The shell is represented by an internal mold showing both valves in place.

The form of this species is high, short, and much inflated. In general outline it resembles the Cretaceous *Cardium perinfaustum* Maury from Rio Assú, near Pendencia, Rio Grande do Norte, but that species has very broad ribs, while in this shell the ribbing is closely-set. The general form is also somewhat like the two Lower Miocene species, *Cardium paraense* White and *C. pessoai* Maury, both from Rio Pirabas, State of Pará. But the shell now described is from Cretaceous limestone which carries the *Nerinea* fauna. The ribs cannot be counted but where preserved are seen to be narrow, closely-set, and numerous. Length of shell 41 mm., height 44 mm., diameter 38 mm.

LOCALITY.—Itapassaroca, near Macahyba, to the westward of Natal, Rio Grande do Norte. In magnesian limestone. The mold is stained yellowish and reddish with iron oxide, for the limestones west of Natal are ferruginous.

HORIZON.—Associated *Nerineas* prove this Cretaceous and not Lower Eocene as called heretofore. Tentatively referred to the Turonian stage.

***Cardium endymionis*, sp. nov.**

Plate X; Figure 4

Shell of medium size for the genus, subovately cordate, inflated, rather high in proportion to its length, with prominent, full, incurving beaks. The type specimen is an internal mold with both valves in place, the right being the more perfectly preserved. Beaks subcentral. Posterior area marked off with a rounded umbonal slope beyond which the surface slopes somewhat steeply to the posterior truncated margin. Anterior margin rounded. The ribs are clearly preserved anteriorly, and almost obliterated traces indicate that the total number was about thirty-four. These were originally roughened with vaulted scales now worn down but giving the ribs a crenulated aspect. Height of shell 45 mm., greatest length 37 mm., diameter 36 mm.

This species is referable to the subgenus *Trachycardium* Moersch which first appeared in the Upper Cretaceous seas, and is represented in the fauna of today by the type of the subgenus, *Cardium* (*Trachycardium*) *isocardia* Linnaeus, which ranges from Cape Hatteras southward through the Antilles to Trinidad and Venezuela.

Our species is an ancestral precursor of *Cardium isocardia* and of the allied Jamaican Miocene species, *Cardium* (*Trachycardium*) *lingua-leonis* Guppy.

Cardium amphitrites and *C. soperi* Maury from Rio Assú near Pendencia, Rio Grande do Norte, are both very much longer in proportion

to their height. *C. riograndense* from Rio Assú is smaller and more finely ribbed, while *C. perinfaustum* has very distant ribs. This *Cardium* is thus unlike any yet described from Rio Grande do Norte.

LOCALITY.—São Sebastião. Kilometer -30 Mossoró-São Sebastião Railway, Rio Grande do Norte.

HORIZON.—Cretaceous. Tentatively referred to the Turonian stage.

Genus **CYPRIMERIA** Conrad

Cyprimeria riograndensis, sp. nov.

Plate IX; Figure 1

There is a single large internal mold in the collection, which in size and form suggests a large member of the Veneridae.

The general outline is subcircular to subovate, and the specimen, which is the mold of a right valve, is considerably inflated especially in the region of the umbonal slope. The beak projected only slightly above the hinge area. Dentition unknown. Length of shell 70 mm., height 68 mm., semidiameter 22 mm.

Comparison shows that this species resembles somewhat *Cyprimeria major* Gardner¹ from the Monmouth formation of the Senonian Cretaceous of Maryland, North America, especially the specimen illustrated as Figure 3 on Plate xli. But the Brazilian shell was rounder and proportionately shorter, as the length is not much greater than the height. The type of *Cyprimeria major* measured 86 mm. in length; 76 mm. in height; and 23 mm. in semidiameter. As in *C. major*, the convexity of our Brazilian species is unusually high for the genus *Cyprimeria* which characteristically is more flattened. This genus is characteristic of, and limited to, the Cretaceous.

LOCALITY.—Baixa do Leite, south of Macau, Rio Grande do Norte. In whitish, partly chalcidized material that has undergone mineral replacement.

HORIZON.—Proved with certainty to be Cretaceous by the *Nerinea* fauna which this formation carries. Tentatively referred to the Turonian stage.

Genus **PHOLADOMYA** Sowerby

The family Pholadomyidae includes the single genus *Pholadomya* which is strictly marine in habitat, and ranges from the Lower Lias to the Recent faunas. It is a dying genus with but two living forms, one in the West Indian waters and one in the Japanese seas.

Pholadomya baixaleitensis, sp. nov.

Plate X; Figure 3

Shell rather small, transversely oblong, very short anteriorly, produced and somewhat compressed posteriorly, inflated in the umbonal region. The right valve appears a little flatter in the posterior dorsal area than the left, but this may be due to

¹Gardner, Julia A. 1916. Upper Cretaceous. Maryland Geological Survey, p. 689, Pl. xl, figs. 11, 12; Pl. xli, figs. 1-4; Pl. xlii, fig. 1; Pl. xliii, fig. 1.

crushing. Substance of the shell thin. Valves gaping strongly in the anterior ventral region, but only very slightly gaping, if at all, posteriorly. The valves are both ornamented with three types of sculpture: (1) coarse, irregularly spaced, concentric growth ridges somewhat undulating in aspect; (2) weak, but definitely visible, obsolescent, radial riblets on the anterior and central area of the valves; (3) closely spaced, fine, sharp, diagonal lines developed on the posterior third of the shell. These diagonals slope upwards, are parallel to one another, and at variance in direction with both the concentrics and the radials. They are not V-shaped as in *Goniomya*, but resemble the diagonals on some *Cercomyas* as in *Cercomya excentrica* Agassiz. But the form of the shell is absolutely unlike that of the genus *Cercomya*, which, moreover, is limited in range to the Jurassic.

In size and general form our shell resembles a Texan Cretaceous unnamed species figured by Adkins¹ as *Homomya* sp., but *Homomya* and all other members of the family Panopaeidae gape widely posteriorly, which is not the case in this Brazilian shell.

The presence of the radials and the very slight posterior gape of the valves indicate that this shell is referable to the genus *Pholadomya*. And its true kinship is with such forms as *Pholadomya roemeri* Whitfield from the Cretaceous of New Jersey, although that species has very much stronger radials.

Pholadomya marahuana Maury² from the Upper Albian of Algodões, northeast of Marahú, State of Bahia, differs entirely in form and sculpture from the species now described.

LOCALITY.—Baixa do Leite, southeast of Macau, Rio Grande do Norte.

HORIZON.—Proved Cretaceous by associated Nerineas. Tentatively referred to the Turonian stage.

Genus **PTERIA** Scopoli

Pteria camurupimica, sp. nov.

Plate X; Figure 2

The clearest specimen is an internal mold of a left valve which shows the characteristic form of *Pteria*, a wing, and of the still more graceful but synonymous name *Avicula*, a little bird. Upon another block there is also an imprint of the shell.

The mold shows that the shell was small, very oblique, ovate, gently inflated, with small, acute beaks rising slightly above the cardinal line. Anterior ear small but well defined. Hinge line long, narrow. The mark of the large, subcentral adductor muscle scar is clearly shown on the mold, and also the imprint of the pallial line. Length about 9 mm., height, measured obliquely, 10 mm., semidiameter 2 mm.

The imprint is of the exterior of a right valve and shows that the surface of this species was entirely smooth except for occasional, delicate concentric growth lines.

¹Adkins, W. S. 1928. Handbook of Texas Cretaceous fossils. University of Texas Bulletin No. 2838, Pl. xv, fig. 2.

²Maury, C. J. 1924-1925. Fosséis Cretaceos do Estado da Bahia. Monographias do Serviço Geológico e Mineralógico do Brasil, IV, pp. 562-563, Pl. xxii, fig. 5. Rio de Janeiro. (By error named *algodoensis* in explanation of plates.)

The genus *Pteria* is exceedingly ancient. Species of Silurian age are somewhat questioned, but it was certainly established in the Devonian, and has continued on into our modern fauna, being widely distributed in both tropic and temperate seas. The pretty little pearly shell now described was a leading member of the associated fauna, as it has left a considerable number of traces.

LOCALITY.—Camurupim, near Mossoró, Rio Grande do Norte. In a very hard, massive siliceous boulder.

HORIZON.—The species are indecisive stratigraphically, but tentatively referred to the Cretaceous, although it is possible that the boulder horizon may be slightly younger than the main mass of the limestone which is referred to the Turonian stage.

***Pteria mossoroensis*, sp. nov.**

Plate X; Figure 1

Associated with the *Pteria* just described, is an imprint in the siliceous boulder of the left valve of a shell which in some respects recalls *Lima*, but the long posterior auriculation suggests affinity with *Pteria* to which it is provisionally assigned.

An artificial cast shows that this shell was small, oblique, roundly ovate, with a small but distinct anterior ear. The earlier part of the valve is smooth but elsewhere the surface is ornamented with exceedingly delicate radial ribs so fine as to be visible only with a lens. This sculpture and the difference in form readily differentiate this species from the associated *Pteria* which is smooth. The length and height of the shell are subequal, both measuring about 9 mm.

LOCALITY.—Camurupim, near Mossoró, Rio Grande do Norte. In a siliceous boulder.

HORIZON.—Species stratigraphically indecisive. Tentatively referred to the Cretaceous, although the boulder horizon may be slightly younger than the main mass of Turonian limestone.

Genus **PERNA** Bruguière

The genus *Perna* of Bruguière (*Pedalion* of Solander) appeared in the Triassic and has lived on to Recent time.

***Perna arvoredensis*, sp. nov.**

Plate XI; Figure 6

Associated with the finely-ribbed, trigonal *Modiola*, is the internal mold of a left valve of one of the Pernidae. Since the hinge characters are concealed, one cannot be sure whether the shell was *Perna* or *Gervilleia*; for the basic distinction between these genera is the absence of dental ridges beneath the ligament pits in *Perna* and their presence in *Gervilleia*. But provisionally the specimen is referred to *Perna*.

The shell is of medium size, subquadrate in form, with a wide hinge, bearing internally a row of ligament pits. In front of the narrow, pointed beak is a small well defined anterior ear, marked by growth lines. Faint concentric growth lines also appear on the posterior dorsal margin, but elsewhere the mold shows no traces of sculpture, and is smooth except for the imprint of a large adductor muscle scar. The living shell was lined with a thick layer of mother-of-pearl. The posterior end of the mold is broken away, but the estimated length of the shell when entire is 28 mm., height 26 mm.

LOCALITY.—Arvoredo, near Macahyba, to the westward of Natal. In whitish, magnesian limestone.

HORIZON.—This limestone is the same formation as the outcrops at other localities near Macahyba, and westward of Natal, and is proven to be Cretaceous by the presence of *Nerinea* in the Jacoca quarry. It is provisionally referred to the Turonian stage.

Genus *OSTREA* Linnaeus

Devonian species referred to *Ostrea* are questioned, but the genus is known with certainty from the Carboniferous to the Recent faunas.

Ostrea pendenciana Maury

Ostrea pendenciana MAURY, 1924-1925, Fosseis Cretaceos do Rio Grande do Norte, Monographias do Serviço Geologico e Mineralogico do Brasil, IV, p. 546, Pl. xxii, fig. 8.

Shell large, ovate to subtrigonal. Convex valve inflated with rather distant, loosely and irregularly fluted, concentric lamellae. Beaks in old shells elongated and pointed, straight or slightly curved. Operculate valve nearly flat, or a little sinuous, marked only with concentric growth ridges. Estimated length of type when entire, 120 mm., width 75 mm. Type locality Rio Assú, near Pendencia, Rio Grande do Norte.

In the present collection is a worn and broken convex valve of *Ostrea pendenciana*. All the concentric lamellae are abraded, but their basal ridges are shown and the valve has the characteristic high, rather narrow form, and pointed beak of this species. This incomplete shell measures 80 mm. in height and 52 mm. in greatest width. The height when perfect was about 100 mm.

LOCALITY.—Near São Sebastião. Kilometer -30 Mossoró-São Sebastião Railway.

HORIZON.—Cretaceous. Tentatively referred to the Turonian stage.

Ostrea lagoapiatensis, sp. nov.

Plate IX; Figures 2, 3

In the collection are many fragments of adult valves, and several very young entire valves of an *Ostrea* which was of subovate form and became very thick and massive with age. One valve is nearly flat and sculptured only with rather distantly spaced concentric growth ridges. The opposite valve is more convex and bears a scar of attachment near the beak. The convex valve is much thickened in old shells and tends to develop a sculpture of coarse, flattened, tooth-like processes that are very striking and characteristic. Fragments preserved of the umbonal region show that the beaks were wide, thick and heavy. All the specimens indicate that the internal cavity

was shallow. With the material so broken, it is difficult to estimate the height, but the shell seems to have attained an altitude of about 100 mm.

This species is broader and less inflated than *Ostrea pendenciana* Maury, with a wide beak, and toothed scales never developed on the Pendencia shell.

LOCALITY.—Lagôa do Piató, northwest of the town of Assú, Rio Grande do Norte. The position of this lagôa is shown in Dr. Moraes' map of the state, published in 1924.¹

HORIZON.—The northern end of this lagôa is near the contact of the Cretaceous limestone with the underlying, unfossiliferous sandstone belt. The material from the Lagôa do Piató is indecisive stratigraphically. Except for the *Ostrea* just described, which itself is fragmentary, there are only the following doubtful specimens; an internal mold, perhaps an oyster, in light buff-colored limestone which effervesces freely with dilute hydrochloric acid; incomplete internal molds of two indeterminable Pelecypods; an internal mold, possibly one of the Pernidae, in cream white to light buff limestone that effervesces freely; three indeterminable fragmentary Gastropod molds, one in heavy, massive grayish limestone with pockets of crystalline calcite; two incomplete internal molds possibly of *Ampullospira* Harris (*Prisconatica* of White) but too uncertain; a curious irregular structure 40 mm. long, suggesting possibly a *Teredo* tube, like the North American, Cretaceous *Teredo irregularis* Gabb, but too incomplete for comparison; and finally a calcareous seaweed, probably a species of *Lithothamnium*.

Genus **MODIOLA** Lamarck

North American authors tend to use the generic name *Volsella* of Scopoli, 1777, rather than *Modiola* of Lamarck, 1801. Scopoli's generic name has priority but is heterogeneous by its author's definition, and the European custom is herein followed and preference given to Lamarck's *Modiola*.

This exceedingly ancient genus was living in the Devonian seas and has continued on without interruption to the marine fauna of today. The subgenus *Brachydontes* Swainson includes species in which the entire surface of the shell is radially sculptured.

Modiola camurupimica, sp. nov.

Plate XI; Figure 4

An excellent imprint of a pretty little *Modiola* lies in the hard matrix of the same siliceous boulder in which is the impression of a *Barbatia* shell.

The *Modiola* imprint is of a right valve, and an artificial cast shows the form to be ovate, evenly inflated, with the beak non-terminal, as is characteristic of this genus. About eighteen simple, fine, sharply defined riblets extend radially from the umbonal area to the posterior dorsal and ventral margins of the valve. The ribbing passes over the umbonal slope, covering slightly more than a quarter of the ventral area of the

¹Moraes, Luciano J. de. 1924. Serras e Montanhas do Nordeste. Ministerio da Viação e Obras Publicas. Inspectoria Federal de Obras Contra as Secas. Publicação No. 53, Serie I. D. Mappa No. 2, Rio de Janeiro.

valve, and then suddenly ceases. Thus the central and anterior regions are without radial sculpture and are smooth. Length of shell 11 mm., greatest height 7 mm.

This species resembles *Modiola maroimensis* White from the Middle Albian Cretaceous of Coqueiro, State of Sergipe. But our species is smaller, with stronger ribs, and the ribbing extends further forward.

LOCALITY.—Camurupim, near Mossoró, Rio Grande do Norte. In a fossiliferous, siliceous boulder.

HORIZON.—The species are long-ranging and not decisive stratigraphically. Provisionally referred to the Cretaceous, although possibly this boulder horizon is slightly younger than the main mass of Turonian limestone.

***Modiola arvoredensis*, sp. nov.**

Plate XI; Figure 5

Partly buried in a matrix of hard, magnesian limestone is the mold of the left valve of a small *Modiola* which is very unlike *M. camurupimica*.

The shell is rather small, subtrigonal in form with a very conspicuous, sharply angulate umbonal ridge extending from the umbonal region to the posterior basal margin. Beak narrow, non-terminal. The exposed anterior and central area of the valve up to the umbonal ridge is sculptured with extremely fine and delicate radial ribbing. The ribs are very closely set, thread-like, with narrower, linear interspaces. Beyond the umbonal ridge the lower part of the valve is concealed in the rock, but on a portion of the upper part finer ribbing can be seen with a lens. Whether this ribbing continues over the entire surface cannot be determined from the specimen in hand. If the whole surface be ribbed, the species is referable to the subgenus *Brachydontes*. Length of shell 16 mm., estimated greatest width 11 mm. The strongly angulated umbonal ridge at once differentiates this species from other *Modiolas* in the collection.

LOCALITY.—Arvoredo, near Macahyba, westward of Natal, Rio Grande do Norte. In whitish magnesian limestone.

HORIZON.—Proved to be Cretaceous by the presence of *Nerinea* in the quarry at Jacoca where the same limestone is exposed. Tentatively referred to the Turonian stage.

Genus *Tylostoma* Sharpe

***Tylostoma brasilianum* Maury**

Tylostoma brasilianum MAURY, 1924-1925. Fosséis Cretaceos do Rio Grande do Norte. Monographias do Serviço Geológico e Mineralógico do Brasil, IV, p. 532, Pl. XXIII, fig. 6.

Tylostoma brasilianum MAURY, 1934. O Cretaceo de Sergipe. Monographias do Serviço Geológico e Mineralógico do Brasil, XI, Pl. XVII, fig. 1. (In press, 1934.)

Shell very large, subglobose, with about six whorls. Estimated entire height of type specimen 111 mm., width 88 mm.

The type of this species was from Mossoró. In a later monograph I restricted this species to the Rio Grande do Norte fauna, and named the allied but stratigraphically older Sergipe form *Tylostoma sergipense*. For comparison with *T. sergipense*, I figured, by courtesy of the American

Museum of Natural History, a very fine specimen of *T. brasilianum* which is in the present collection.

This specimen measures 93 mm. in height and 73 mm. in width, and shows unusually well the greatly thickened outer lip which is generally broken off. In addition to this fine mold, there are two small, imperfect molds, one 36×37 mm., the other 23×25 mm. These seem to be internal molds of young shells of this species.

LOCALITY.—Near São Sebastião. Kilometer -30 Mossoró-São Sebastião Railway, Rio Grande do Norte.

HORIZON.—Cretaceous. Tentatively referred to the Turonian stage.

***Tylostoma rochai* von Ihering**

Tylostoma rochai VON IHERING, 1907, Mollusques Fossiles du Tertiaire et Crétacé Supérieur de l'Argentine. *Anales del Museo Nacional de Buenos Aires*, serie 3, tome 7, p. 40, text-figure 2.

A large *Tylostoma*, of the group of *Tylostoma torrubiae* Sharpe from the Turonian of southwestern Europe, was described by Dr. von Ihering, and named in honor of Sr. Francisco da Rocha of Ceará by whom the specimen was collected in Rio Grande do Norte. The type of *Tylostoma rochai* measured 108 mm. in height and 77 mm. in greatest width. The last whorl was nearly three-quarters of the entire height. The spire was fairly high with profoundly canaliculated sutures, and the suture of the last whorl on approaching the aperture ascended so as to cover part of the penultimate whorl.

Dr. von Ihering compared his *Tylostoma rochai* with the Sergipe molds referred by Dr. C. A. White, in 1887, to *Tylostoma torrubiae* Sharpe and said the Sergipe molds had more volutions. He also differentiated the Sergipe molds from the European and named them *Tylostoma whitei*.

Since the Sergipe molds have been shown by the writer¹ to be of Middle Albian age while the Rio Grande do Norte molds are Turonian, it seems best on stratigraphic grounds to adopt these distinguishing specific names, keeping in mind that both *Tylostoma rochai* and *T. whitei* are of the group of the European *T. torrubiae* Sharpe.

In the present collection are several molds which appear to be young and adolescent specimens of *Tylostoma rochai* von Ihering.

Tylostoma crandalli Maury² from Mossoró, Rio Grande do Norte, is much more squarely-shouldered than *T. rochai* von Ihering. It is of the group of the European species, *T. ovatum* Sharpe, but attains a very much greater size.

¹Maury, C. J. O Cretaceo de Sergipe. Monographias do Serviço Geologico e Mineralogico do Brasil, XI (In press, 1934.)

²Maury, C. J. 1924-1925. Fosséis Cretaceos do Rio Grande do Norte. Monographias do Serviço Geologico e Mineralogico do Brasil, IV, pp. 532-535, Pl. xxiii, figs. 4, 5.

LOCALITY.—Near São Sebastião. Kilometer -30 Mossoró-São Sebastião Railway, Rio Grande do Norte.

HORIZON.—Cretaceous. Tentatively referred to the Turonian stage.

Genus **AMPULLOSPIRA** Harris

Ampullospira, sp. indet.

In the collection are two incomplete internal molds of a shell in form resembling a Sergipe mold referred by Dr. C. A. White, in 1887, to *Prisconatica praelonga* Deshayes from the Neocomian of France. M. Cossmann later assigned the Brazilian specimen to the genus *Ampullospira* Harris and gave the distinctive name *A. whitei* to the Sergipe mold.¹

Our fragmentary molds are larger than the Sergipe species, which is from a Middle Albian horizon, and were a different species but are too incomplete to figure and describe.

LOCALITY.—Lagôa do Piató, near Assú, Rio Grande do Norte.

HORIZON.—As noted at length under the description of *Ostrea lagoapiatensis* in this bulletin, the material from this locality is indecisive stratigraphically.

Genus **TURRITELLA** Lamarek

The occurrence of *Turritella* in Jurassic faunas is somewhat doubtful, but the genus was definitely established in the Cretaceous seas and has continued on in the Recent fauna, although it has disappeared from the Brazilian coast, in the fauna of today.

Turritella natalensis Jenkins

Turritella natalensis JENKINS, 1913, Geology of the Region about Natal, Brazil. Proceedings American Philosophical Society, LII, No. 211, p. 21, Pl. xx, figs. 6, 6a.

Turritella natalensis MAURY, 1924-1925, Fosséis Terciários do Brasil com Descrição de Novas Formas Cretáceas. Monographias do Serviço Geológico e Mineralógico do Brasil, IV, pp. 82, 83, 470, 471, Pl. III, fig. 7.

Shell turreted, long and slender, with sixteen to twenty-two whorls in mature specimens. The volutions increase very gradually in diameter, resulting in a tapering, graceful form. Young shells very acutely pointed and very slender. Each whorl of the mature shell is handsomely ornamented with one strong row of beads just beneath the suture, a second, weaker row at the center, and a third row of medium-sized beads near the base of the volution. But in younger stages the lowest row of beads is hardly developed, and even in fully grown specimens this third row may be inconspicuous or almost absent. The uppermost row is the strongest and most constant of the three. There is, indeed, some variability in the sculpture and in some cases the beads become almost spinose and number six to eight on half a volution. The type specimens were about 35 mm. long; the longest recorded attained 50 mm. The diameter of the last whorl is 6 to 7 mm.

¹Maury, C. J. 1934. O Cretáceo de Sergipe. Monographias do Serviço Geológico e Mineralógico do Brasil, XI, Pl. xxiv, figs. 19-21. (In press, 1934.)

Mr. Jenkins' types were from Itapassaroca, and in the material in the collection now studied this *Turritella* is the dominant member of the fauna from Itapassaroca.

LOCALITY.—Itapassaroca, in a cut on the Rio Grande do Norte Central Railway. In buff-colored dolomitic limestone.

HORIZON.—Proved to be Cretaceous, and not Lower Eocene, by the presence of the *Nerinea* fauna in the Jacoca quarry where the same limestone formation outcrops.

***Turritella euphrosynes*, sp. nov.**

Plate XIV; Figure 1

In the collection is the imprint in the matrix of a turreted shell which although incomplete shows the sculpture very beautifully. The shell was a *Turritella*, for the internal mold of half the last volution remains and shows no marks of any internal plications, which would have been present in a *Nerinea*.

The sides of the whorls are so straight and the suture so little impressed that it is difficult to define the limits of the volutions. The ornamentation consists of three or four primary spiral threads with one or two very delicate secondary spirals in the interspaces between the primary threads. The secondaries are seen only with a lens. The sculpture is very trim and exquisite. The shell is known only from its impression in the limestone from which an artificial cast has been made for description and illustration. The imprint is of the three lower whorls only and is 11 mm. in height and 7 mm. in greatest width. Estimated height of the entire shell about 23 mm.

In general aspect this species bears a slight resemblance to *Turritella tippana* Conrad from the Upper Cretaceous of Mississippi and New Jersey, but the North American shell is three times as large and details of sculpture are unlike.

LOCALITY.—Baixa do Leite, about 11 kilometers southeast of the city of Macau, Rio Grande do Norte, at the contact of the Cretaceous limestone with the overlying Cenozoic belt of sands and clays. The matrix is cream white, oxidizing to buff color, and is filled with molds and imprints of shells of which only a few are sufficiently well preserved to be identifiable.

HORIZON.—Fortunately *Nerineas* can be identified with absolute certainty in this material. Their presence proves the pre-Tertiary age of the formation, which is referred to the Turonian stage of the Cretaceous, with the rest of the limestone mass.

***Turritella thaliae*, sp. nov.**

Plate XIV; Figure 2

We have also the internal mold of a slender, delicate *Turritella* which is mineralized by replacement but still preserves clear traces of the ornamentation of the original shell.

This mold includes ten whorls and shows that the shell was rather small and delicately tapering with the sides of the volutions flat. Suture distinct, clearly defined and very slightly shouldered beneath. The ornamentation is so fine as to be visible only with a lens and consists of delicately crenulated spirals which are more strongly developed on the upper and lower thirds of the whorls than on the central area. In the

interspaces between these very finely nodose spirals are still finer secondary spirals. Length of incomplete shell with ten whorls 21 mm., greatest width 6 mm.

LOCALITY.—Baixa do Leite, southeast of Macau, Rio Grande do Norte.

HORIZON.—Cretaceous. Tentatively referred to the Turonian stage.

Genus **MELANIA** Lamarck

Melania catandubica, sp. nov.

Plate XIV; Figure 6

In an extremely hard and heavy siliceous boulder are many imprints and some internal molds of a molluscan shell. Judging from the form, the sculpture, and the character of the aperture, this appears to have been a non-marine species, and to represent one of the Melaniidae. This family inhabits fresh, or more rarely brackish waters in the warm zones of the Americas, Africa, Europe, and Asia. Its stratigraphic range is from the Upper Jurassic to the living faunas of today.

Provisionally this Brazilian shell is referred to the genus *Melania*.

An artificial cast of the most perfect imprint shows the shell to have been of turreted form comprising about nine whorls. The suture is clearly marked, linear, with a conspicuous, rather squarely shouldered band beneath. On the final volution this subsutural shoulder is strongly tuberculate. The tubercles are short, spinose, and on the figured specimen number seven to half a volution, but they vary in number and strength. One specimen has five strong spines to half a volution. On several imprints the tubercles are absent. Aperture oval, rounded anteriorly. Height of type specimen 29 mm., greatest width 14 mm.

Living *Melania* shells are covered with a thick, dark horny epidermis as a protection from erosion due to acids derived from decaying vegetation in rivers and streams which they inhabit. Dead shells are frequently carried by the flowing currents to the seashore and there deposited.

LOCALITY.—Olho d'Água da Catanduba lies in the limestone belt, in the general vicinity of the city of Lages, in the interior of the State of Rio Grande do Norte. Dr. Luciano Jacques de Moraes of the Geological Survey of Brazil, who collected this material, states that the siliceous boulders, containing the fossils at this locality, lie strewn upon the surface of the limestone.

HORIZON.—The genus *Melania* is of long range and not stratigraphically distinctive. The horizon is provisionally referred to the Cretaceous, but this boulder phase may be slightly younger than the main mass of Turonian limestone.

Genus **NERINEA** Defrance

The family Nerineidae of Zittel includes shells of turreted, pyramidal, or ovate form, characterized by the presence of strong plications developed on the columella and outer lip and extending throughout the interior of the shell. More than five plications are very rare, usually there are three, more rarely four, two, and one.

Species as old as the Triassic are open to some question but the Nerineidae were abundant during the Jurassic and Cretaceous. At the close of the Cretaceous they utterly vanished. They are therefore most valuable index fossils. All are strictly marine in habitat. The origin and line of descent of these curious shells remain a mystery. The systematic position of *Nerinea* is thus unsettled, although M. Cossmann regards these forms as best placed under the Opisthobranchiata.

Sharpe, in 1850, divided *Nerineas* into four subgenera: *Nerinea*, s.s.; *Nerinella*; *Ptygmatis*; and *Trochalia*. Huddleston recognized six sections among the English Jurassic forms, naming them *Uniplicatae*, *Biplicatae*, and so on, in his monograph in volume 43 of the Palaeontographical Society of London. Other subdivisions may be mentioned as: *Itruvia* Stoliczka; *Cryptoplocus* Pictet and Campeche; *Aptyxis* Zittel; *Diozptyxis* Cossmann; *Mrhilaia* Pervinquière; *Plesioptygmatis* Böse; and *Gonzagia* Maury.

Species of *Nerinea*, *Nerinella*, *Ptygmatis*, *Plesioptygmatis*, and *Gonzagia* are described and figured by the writer from Brazil. *Nerinella* is best regarded as a separate genus, characterized by the very long slender shell. *Nerinella itaporangica* Maury, from Sergipe, is a Brazilian example.

The geological range of *Nerinea*, *sensu stricto*, is Bajocian to Senonian inclusive; that of *Ptygmatis* is Bathonian to Senonian inclusive; and that of *Nerinella* is Hettangian to Senonian inclusive. At the close of the Senonian all three perished. Formations in which they occur therefore cannot be younger than Senonian. This proves with absolute certainty the pre-Tertiary age of the Jacoca limestone westward of Natal, and of the Baixa do Leite formation in which the genus is also present.

The oldest Brazilian *Nerinea* yet recorded is *Nerinea riachuelana* Maury¹ from the Middle Albian of Porto do Pedrinho, Riachuelo, Sergipe. The only *Nerinea* hitherto described from Rio Grande do Norte, Brazil, is *Nerinea (Gonsagia) brasiliana* Maury,² from Rio Assú, near Pendencia, in the Turonian limestone. To this are now added several extremely interesting forms in the present collection from Rio Grande do Norte.

The *Nerinea* fauna was not only present in the Cretaceous seas of Brazil, for it is found also in Cretaceous formations of Peru,³ Mexico,⁴

¹Maury, C. J. 1934. O Cretaceo de Sergipe. Monographias do Serviço Geologico e Mineralogico do Brasil, XI, Pl. xii, fig. 14. (In press, 1934.)

²Maury, C. J. 1924-1925. Fósseis Cretaceos do Rio Grande do Norte. Monographias do Serviço Geologico e Mineralogico do Brasil, IV, pp. 542-545, Pl. xxii, figs. 1, 9.

³Lisson, C. I. 1924. Edad de los Fósiles Peruanos y Distribución de sus Depósitos. Tercera Edición, pp. 137, 144, 147, 151, Lima.

⁴Böse, E. 1906. Instituto Geológico de México. Boletín Núm. 24, pp. 65-67, Pl. xv, figs. 3-13, 1923. Boletín Núm. 42, p. 197, Pl. xiii, figs. 10-16.

Texas,¹ and in the far northern Hornby Island, British Columbia, Canada.² This fauna swept upwards from Brazil to Central and North America on the west coast. *Nerineas* have never been found in the east coast Cretaceous of North America.

As far as our present knowledge goes, *Nerineas* were in Peru much earlier than in Brazil. *Nerinea bathonica* has been recorded by Dr. Lisson from the Peruvian Jurassic.

***Nerinea (Plesioptygmatis) coutinhoi*, sp. nov.**

Plate XIII; Figures 4, 5

In the collection is an internal mold which though fragmentary is illuminating stratigraphically. It comprises the ultimate and penultimate whorls of a *Nerinea* which appears most closely allied to a Mexican form which constitutes the type of Böse's subgenus *Plesioptygmatis*. The Mexican shell was collected along the railway from Tampico to San Luis Potosí, between Cárdenas and Escontria, in a Lower Senonian horizon. But while our Brazilian species resembles this Mexican shell in internal structure, the exterior is different and the whorls of our shell are very much more deeply excavate.

One side of our specimen was skilfully ground away by Mr. Hill at the American Museum of Natural History, so as to present on the aboral surface a median longitudinal section showing the structure of the internal plications. The substance of the internal mold is very hard and appears chalcedonized and takes a very high polish. This material is faun-colored while the columella and its plications are filled with small transparent crystals.

The section shows that the columella in each whorl bears centrally two plications and a third is situated high above the others at the suture. In the section these plications appear as thornlike outgrowths on either side of the central axis, but they actually formed two continuous spiral folds encircling the columella, with the third fold on the upper part of the inner lip. The columella in our section seems discontinuous, but this is due to the fact that the section at all points is not quite central, for it was feared if the grinding were carried further the single specimen might go to pieces.

No parietal plication is present in this shell. For there is no indication whatever of any fold on the wall opposite the columella. We have to do with a very different structure from that of the other *Nerineas* in this collection, all of which have a very strongly developed knife-like, parietal plication.

Comparison shows that the internal structure revealed by our section resembles Böse's³ section of his *Nerinea (Plesioptygmatis) burckhardtii*, as shown in his figure 5, but that species may bear a small parietal plication, more often obsolete.

¹Adkins, W. S. 1928. University of Texas Bulletin No. 2838, p. 185.

²Whiteaves, J. F. 1903. Canadian Geological Survey, I, pt. 5, p. 363.

³Böse, E. 1906. Instituto Geológico de México. Boletín Núm. 24, pp. 65-67, Pl. xv, figs. 3-13.

Externally the volutions of our shell were centrally very profoundly excavated, and encircled by a prominent basal ridge which shows traces of having been handsomely beaded. A less pronounced ridge borders the upper edge of each whorl. The concave whorls resemble those of such forms as *Nerinea guinchoensis* Choffat,¹ and are not infrequent in species of *Nerinea*, *sensu stricto*. Böse's² figures of a Mexican *Nerinea* from the Emscherian of Tenantitlán, recorded as *Nerinea* cf. *incavata* Bronn, are somewhat like the exterior of our shell, especially his figures 15 and 16. But the internal structure of our species shows its kinship is with *Nerinea* (*Plesioptygmatis*) *burckhardtii* Böse, and not with *N. incavata* Bronn.

Cossmann thought Böse's subgenus *Plesioptygmatis* merely a form of *Ptygmatis*, but Böse defended the validity of his subgenus and held that it differs in certain characters from *Ptygmatis*. At least provisionally, our species is placed under *Plesioptygmatis*.

The single internal mold which constitutes the type includes the last two whorls and measures 23 mm. in height and 16 mm. in greatest width measured across the heavy ridge at the base of the last whorl.

This very interesting species is dedicated to Dr. Silva Coutinho who was the first to find Cretaceous fossils in the State of Rio Grande do Norte. Dr. Coutinho discovered fossiliferous outcrops, in 1886, on Rio Mossoró, as recorded by Dr. Orville A. Derby in 1887.

LOCALITY.—Near São Sebastião. Kilometer -30 Mossoró-São Sebastião Railway.

HORIZON.—Cretaceous. Tentatively referred to the Turonian stage.

***Nerinea* (*Ptygmatis*) *baixadoleitensis*, sp. nov.**

Plate XIII; Figure 1

From Baixa do Leite is the internal mold of a *Nerinea* which is very different both in external form and in internal structure from *Nerinea* (*Plesioptygmatis*) *coutinhoi* from São Sebastião.

The mold of the species now described is small, with the whorls increasing rapidly in diameter, resulting in a broadly conic or pyramidal form. Except for this pyramidal shape the exterior of the shell is unknown, for its substance is entirely dissolved away. But every whorl of the interior mold is divided into two equal parts by a rather wide and deep sulcation, more conspicuous than the linear suture between the whorls. The cause of this central furrow is clearly shown at the aperture. For a very strong parietal plication was developed on the interior wall of each volution of the shell, and at the aperture this is seen as a strong median fold within the outer lip. As is frequently the case in the subgenus *Ptygmatis*, this internal parietal plication at its free end enlarges and tends to bifurcate into two small lobes. Opposite to this fold on the outer lip are two folds and alternating furrows upon the columella, and a third plication may lie just beneath the suture, but is not clearly shown. Estimated height of entire mold 12 mm., greatest width nearly 5 mm.

¹Choffat, P. 1886. Recueil d'Études Paléontologiques sur la Faune Crétacique du Portugal. Espèces Nouvelles ou Peu Connues, I, Pl. III, fig. 16. Lisbon.

²Böse, E. 1923. Instituto Geológico de México. Boletín Núm. 42, p. 197, Pl. XIII, figs. 10-16.

The mold just described lies in a whitish matrix, and beside it is a *Nerinea* mold of much more slender and tapering form. There is also the internal mold of a *Turritella* which is readily distinguished by the absence of any marks of internal plications which are totally undeveloped in the latter genus.

Comparison of our *Ptygmatis baixadoleitensis* with European forms shows that it resembles in miniature both *Nerinea* (*Ptygmatis*) *requieniana* d'Orbigny and *N. (Ptygmatis)* *carentonensis* Cossmann,² both from the Turonian of Châteauneuf. The figure of *P. carentonensis* shows one strong fold within the outer lip enlarging at its free end, and two strong columellar folds, and the shape of the shell is pyramidal. Our Brazilian species seems a smaller related form from the New World, for its characters approach quite closely to Cossmann's type.

To a less degree our species resembles the Texan *Nerinea pellucida* from the Middle Albian of Austin, Texas, described by Cragin.³

LOCALITY.—Baixa do Leite, southeast of Macau, near the contact of the Cenozoic coastal belt with the Cretaceous limestone belt of Rio Grande do Norte. In a whitish, siliceous, partly chalcidized matrix.

HORIZON.—Cretaceous. Provisionally referred to the Turonian stage.

***Nerinea (Ptygmatis) riograndensis*, sp. nov.**

Plate XIII; Figure 2

Associated with *Ptygmatis baixadoleitensis* are several very fragmentary internal molds of a *Nerinea* easily differentiated from that species by a more elongate and slender form.

The best of these molds retains at the aperture the marks of the internal plications of the shell. Each whorl of the mold is divided by a narrow furrow, equalling in width the suture line, and at first glance easily confused with it. In this species the plication on the internal wall of the shell was narrow and knife-like and impressed itself upon the internal mold as a narrow groove.

D'Orbigny⁴ figures an internal mold of his *Nerinea renauxiana* which shows the whorls cut into two equal parts by the parietal plication which is seen at the aperture inside the outer lip. This condition corresponds to that of our molds.

At the aperture the mold chosen as type of the species now described has undergone mineral replacement, but the parietal plication is defined by a difference in shade, and the free end does not expand. On the columella are two strong folds and alternating grooves.

¹d'Orbigny A. 1896. In, Cossmann, M. 1896. Essais de Paléoconchologie Comparée, II, Pl. IV, fig. 2.

²1896. *Loc. cit.*, Pl. IV, fig. 3.

³Cragin, F. W. 1893. Contribution to the Invertebrate Paleontology of the Texas Cretaceous. Geological Survey of Texas, Fourth Annual Report, p. 226, Pl. XLII, fig. 5.

⁴d'Orbigny, A. 1842. Paléontologie Française. Terrains Crétacés, II, Atlas, Pl. CLVII, fig. 3.

LOCALITY.—Baixa do Leite, southeast of Macau, Rio Grande do Norte. In whitish, partly chalcidized material.

HORIZON.—Cretaceous. Referred provisionally to the Turonian stage.

Nerinea, sp. indet.

Plate XIII; Figure 3

Turritella (?) *jacoquea* JENKINS (*pars*), 1913, Geology of the Region about Natal, Rio Grande do Norte, Brazil. Proceedings American Philosophical Society, LII, No. 211, p. 21, Pl. xx, fig. 7a. (Exclude fig. 7 to which the name *jacoquea* is now restricted.)

The internal mold illustrated by Mr. Jenkins' figure 7a and refigured herein, I am certain is a *Nerinea* mold. Dr. John B. Reeside, Jr., concurs in this view and says he has no doubt that these double- or sometimes multiple-coiled casts are internal molds of *Nerinea*. They have been illustrated by a number of authors.

Mr. Jenkins described this double, or paired, coil of the whorls of this mold which he thought the internal mold of the shell illustrated in his figure 7, and named *Turritella* (?) *jacoquea* Jenkins. But that is very much broader at the base, and its systematic position uncertain as diagnostic characters are not shown.

It is very clear that Mr. Jenkins' mold illustrated by his figure 7a was a *Nerinea* with a knife-like internal parietal plication which cut the whorls of the mold into two equal parts, but no traces are preserved of plications upon the columella of the original shell. Hence it is not possible to make comparisons with our *Nerinea* (*Ptygmatis*) *riograndensis* which has two columellar folds. The nature of the plications on the columella of Mr. Jenkins' shell is unknown, but the parietal fold has left its mark and proves the shell was *Nerinea*. This is of extreme importance stratigraphically. It proves with absolute certainty the pre-Tertiary age of the limestones of Jacoca and other localities westward of Natal, which were referred by Jenkins, Harris, and Branner to the Lower Eocene.

LOCALITY.—Quarries at Jacoca, four kilometers southwest of Ceará-Mirim, Rio Grande do Norte. In sandy limestone. Stanford University Expedition, 1911.

HORIZON.—Cretaceous. Tentatively referred to the Turonian stage.

Genus CERITHIUM Adanson

Cerithium is recorded rather doubtfully from the Jurassic, but has been established from the Cretaceous to the Recent inclusive.

Cerithium mirimense Jenkins

Plate XIV; Figure 3

Cerithium (?) *mirimense* JENKINS, 1913, Geology of the Region about Natal, Rio Grande do Norte, Brazil. Proceedings American Philosophical Society, LII, No. 211, p. 20, Pl. xx, figs. 8, 8a.

Shell rather small, turreted, comprising about eight volutions which form a tapering, acutely pointed spire and widen to a relatively large, convexly rounded body whorl. The sculpture consists of strong, conspicuous longitudinal riblets which are more or less discontinuous, and sometimes alternating in position from whorl to whorl. These riblets number about five to half a volution. The whorls are also ornamented with clearly-cut spiral threads which on earlier whorls number about four but increase in later stage of the shell's growth to six or seven. The spirals cross the longitudinal riblets. The largest of the type specimens was nearly 15 mm. in length and 6 or 7 mm. in greatest diameter.

The best mold in the present collection measures 11×5 mm., and the imprint of a younger shell which shows the sculpture very well is only 6×4 mm., but a fragmentary imprint of a spire is nearly 10 mm. high and with the body whorl would have measured 14 or 15 mm.

Mr. Jenkins' figure 8 of his type was a composite drawing and our drawing is based partly on our material and partly on his type. One of our molds indicates the presence of a short, reflexed anterior canal, and the general aspect of this species suggests that it is referable to the genus *Cerithium*. Numerous impressions in the limestone prove that this little Cerite was abundant on the shores of the Turonian sea of Rio Grande do Norte.

LOCALITY.—The type specimens were collected by the Stanford University Expedition to Brazil, in 1911, in a railway cut half a kilometer beyond Itapassaroca, at kilometer 45. Our specimens are also from Itapassaroca, Rio Grande do Norte Central Railway. In buff-colored magnesian limestone.

HORIZON.—Cretaceous. Tentatively referred to the Turonian stage.

Cerithium (?) *jacouea* (Jenkins)

Plate XIV; Figure 4

Turritella (?) *jacouea* JENKINS (*pars*), 1913, Geology of the Region about Natal, Rio Grande do Norte, Brazil. Proceedings American Philosophical Society, LII, No. 211, p. 21, Pl. xx, fig. 7. (Exclude fig. 7a which is *Nerinea*, sp. indet.).

Shell broadly conic, consisting of eight or nine volutions, which are gently convex, and apparently, judging from traces on the molds, a narrow band ornamented the center of each whorl. Height 25 to 30 mm., greatest width 15 mm. Internal structure unknown.

This was referred by Mr. Jenkins with a query to *Turritella*, but its form is rather broad, and it seems more like a Cerite. *Cerithium tenouk-lense* Coquand from the Cenomanian of Algeria, well illustrated by Pervinquier, ¹ has a nodose line of ornamentation on the center of every

¹Pervinquier, L. 1912. Carte Géologique de la Tunisie. Direction Générale des Travaux Publics. Études de Paléontologie Tunisienne, II, p. 16, Pl. I, figs. 20, 21a, 21b.

whorl, but is not as broad as Mr. Jenkins' shell. However, a related species, *Cerithium sancti-arromani* Thomas and Peron, also figured by Pervinquière,¹ has the broadly conic form of *jacouea*. For these reasons the shell is provisionally referred to *Cerithium*, but fuller knowledge of its internal structure may indicate that its affinity is with *Ptygmatis*.

LOCALITY.—Quarries at Jacoca, four kilometers southwest of Ceará-Mirim, Rio Grande do Norte. In sandy limestone.

HORIZON.—Cretaceous. Tentatively referred to the Turonian stage.

Genus **CLAVA** Martyn

Clava (**Ochetoclava**) **aglaiae**, sp. nov.

Plate XIV; Figure 5

In the collection is the imprint of about five whorls of a turreted, slender shell, and at the base the vestige remains of a short, reflexed anterior canal. An artificial cast shows the sculpture resembles that of the genus *Clava*.

The genotype of *Clava*, *sensu stricto*, is *Clava rugata* Martyn, living in the Indo-Pacific seas, which has a long anterior canal. For the American fossil and recent species, all of which possess a short canal, Dr. Woodring² has proposed the subgenus *Ochetoclava*, typified by *Cerithium gemmatum* Hinds, living on the West coast of Central America and Mexico. As far as can be judged by the imprint, our species is referable to that subgenus.

The sculpture on each adult whorl consists of three primary strongly nodose spirals, alternating with a finer secondary thread in each interspace. The basal secondary thread of every whorl is more prominent. The secondaries are very fine, visible only with a lens. The imprint measures 10 mm. in height and 4 mm. in greatest width. The entire shell probably attained 15×5 mm.

LOCALITY.—Baixa do Leite, southeast of Macau, Rio Grande do Norte.

HORIZON.—Cretaceous. Tentatively referred to the Turonian stage.

Genus **APORRHAI** da Costa

The genus *Aporrhais* of da Costa (*Chenopus* Philippi) first appeared in the Jurassic and has continued on to the fauna of today. Its greatest development was in the Jurassic and Cretaceous seas.

Aporrhais baixaleitensis, sp. nov.

Plate XVI; Figure 4

In the collection is an incomplete but very striking internal mold of an *Aporrhais*.

Two and one-half volutions of the spire, and the upper part of the body whorl are preserved. The whorl preceding the penultimate volution retains clearly traces of

¹Pervinquière, L. 1912. *Loc. cit.*, Pl. I, fig. 27.

²Woodring, W. P. 1928. Carnegie Institution of Washington, Publication No. 385, p. 334.

strong, rather narrow vertical ribbing, the ribs numbering six to a quarter of a volution. The last volution suddenly changes the plane of its coiling on the aboral side of the shell and swings sharply upwards, so as to cover more than half of the preceding whorl as the aperture is approached. The fragmentary mold measures 40 mm. in height and 38 mm. in greatest width. The shell when entire measured approximately 80×40 mm.

This specimen is very unlike any described from Brazil. The only other Brazilian Cretaceous member of the family Aporrhaidae yet known is the small Middle Albian shell, *Anchura infortunata* White, from Porto do Barcos, Sergipe.

The Rio Grande do Norte *Aporrhais* represented by the internal mold now described had the general aspect of *Aporrhais olisiponensis* Choffat,¹ described in 1886 and figured in 1902, from both the Lower and the Upper Turonian of Alcantara, Portugal. This European species has the vertical ribbing on the whorls of the spire, and the sharply up-rising last volution, as in our Brazilian form; and the outer lip, which is not preserved in our specimen, is expanded into a broad wing. This affords still another instance of affinity between the Rio Grande do Norte Cretaceous species and the Turonian species of southwestern Europe.

LOCALITY.—Baixa do Leite, southeast of Macau, Rio Grande do Norte.

HORIZON.—Cretaceous. Tentatively referred to the Turonian stage.

CLASS ECHINODERMATA

In the present collection from Rio Grande do Norte are a number of fossil echinoderms, but with the exception of one very choice specimen, all are very imperfect.

Dr. Hubert Lyman Clark of the Museum of Comparative Zoology and Dr. Robert Tracy Jackson have kindly looked over these echini. It is noteworthy that they find none are identical specifically with the fossil echinoderms already described by the writer² from Baixa Verde, São Sebastião, and Rio Upanema, all in the State of Rio Grande do Norte. Nor are any like those from Parahyba do Norte,³ nor like those from Sergipe.^{4, 5} There is, however, a very fragmentary *Toxaster* which bears some resemblance to a Pernambuco echinid described by Dr. White

¹Choffat, P. 1902. Recueil d'Études Paléontologiques sur la Faune Crétacique du Portugal, I. Espèces Nouvelles ou Peu Connues, Pl. v, figs. 1, 3, Lisbonne.

²Maury, C. J. 1924-1925. Fósseis Cretáceos do Rio Grande do Norte. Monographias do Serviço Geológico e Mineralógico do Brasil, IV, pp. 500-505, 508-511, 518-521, Pl. xxiv, figs. 9-13. Rio de Janeiro.

³Maury, C. J. 1930. O Cretáceo da Parahyba do Norte. Monographias do Serviço Geológico e Mineralógico do Brasil, VIII, pp. 112-123, Pl. v, figs. 1-7.

⁴White, C. A. 1887. Contribuições á Paleontologia do Brasil. Archivos do Museu Nacional do Rio de Janeiro, VII, pp. 246-263, Pls. xxvii, xxviii.

⁵Maury, C. J. 1934. O Cretáceo de Sergipe. Monographias do Serviço Geológico e Mineralógico do Brasil, XI. (In press, 1934.).

as *Toxaster altiusculus*, but it is too incomplete for any definite comparison. It is probably an allied form as the horizon is different. Dr. White, in 1887, also mentioned imperfect specimens of a *Toxaster*, resembling *T. altiusculus*, from the State of Parahyba do Norte. Evidently several species of the group of *Toxaster altiusculus* were represented in the Cretaceous seas of Parahyba do Norte and of Rio Grande do Norte. The type of *Toxaster altiusculus* White is from the Lower Eocene of the yellowish limestone of Maria Farinha, State of Pernambuco.

Dr. Clark regards the echinoderms in the present collection as Cretaceous. This accords with the evidence furnished by the Mollusca from the limestone formation which proves with absolute certainty a Cretaceous age.

Genus **CYPHOSOMA** Agassiz

Cyphosoma, sp. indet. *juv.*

Several small, poorly preserved, regular echini which may be young specimens of the genus *Cyphosoma* Agassiz (*Phymosoma* Desor) are in the collection. But they cannot be identified even generically with certainty because diagnostic characters are not shown. They are too imperfect to illustrate.

Associated with these is a larger, crushed unidentifiable spatangoid.

LOCALITY.—Camurupim, near Mossoró, Rio Grande do Norte.

HORIZON.—The Mollusca from this locality are long-ranging and not stratigraphically distinctive, and these echini add no evidence. Tentatively referred to the Cretaceous, although this boulder horizon in which the fossils occur may be slightly younger than the main mass of Turonian limestone.

Genus **BREYNELLA** Gregory

Dr. H. L. Clark, of the Museum of Comparative Zoology, does not consider the genus *Breynella* of Gregory valid and suggested referring our species with a question to the genus *Oligopodia* of Duncan. But I am tentatively placing our species under *Breynella*, because Zittel limits the range of *Oligopodia* to the Recent fauna of New Zealand, and because our species is closest to the Eocene form, *Breynella gregoryi* Twitchell, of which the type is in the American Museum of Natural History.

Breynella baixadoleitensis, sp. nov.

Plate XV; Figures 2, 3

Test ovate-elliptical in marginal outline, the sides being nearly straight centrally, or following almost an ellipsoidal curve, broadening only slightly posteriorly. Posterior end roundly truncated. Anterior end ovately rounded. Upper surface gently and broadly convex, the highest point or apex of the test being situated a little posterior to the center. Under surface flattened, slightly concave very near the margins

of the peristome. Ambulacral areas narrow, inconspicuous, not sunken but flush with the surface, delicately petal-like. The petals are open at their ends and owing to the perfect state of preservation of the test, very delicate little rows of ambulacra are seen to extend from the ends of the petals around the test to the margin of the peristome on the under surface. While such extensions do not often show, they are the normal condition, for the petals are merely the expanded upper ends of the ambulacra. On approaching the border of the peristome in our specimen, the ambulacra are expanded and appear to form a floscelle, although the anterior ambulacrum does not show the bulb-like expansion as clearly as the other four.

The apical system is situated about five millimeters anterior to the center of the test. Peristome obscurely pentagonal, also excentric anteriorly in position but slightly less in front of the center than the apical system. Periproct oblong-elongate, lying in the upper central portion of the posterior truncation. Length of test 29 mm., greatest width 24 mm., greatest height 17 mm.

This species is quite near *Breynella gregoryi* Twitchell, but differs in the shape of the test and the form of the petals. Dr. Clark says our specimen also resembles *Oligopodia epigonus*, a living species, but differs markedly in the shape of the peristome.

The type of *Breynella gregoryi*, the nearest ally of our species, is in the American Museum of Natural History, and was collected at the Santee Canal, South Carolina, in a formation of Eocene age. This was first referred to by Gregory,¹ in 1892, as *Breynella* sp., and in 1915 it was given its specific name in honor of Dr. Gregory by Twitchell.²

Our Brazilian Cretaceous species would seem to have been ancestral to *Breynella gregoryi* Twitchell. The latter species may have been a northern migrant in the Eocene sea from the Brazilian Cretaceous stock. It is also an interesting fact that our species has a modern ally, *Oligopodia epigonus*, in the southern hemisphere, in the New Zealand waters.

LOCALITY.—Baixa do Leite, southeast of Macau, Rio Grande do Norte.

HORIZON.—Associated Mollusca of the genus *Nerinea*, prove this formation Cretaceous. Tentatively referred to the Turonian stage.

Genus **TOXASTER** Agassiz

Toxaster, sp. indet.

Embedded in the same whitish matrix with chalcedony replacements in which the *Lovenia* and *Spatangus* occur, is an internal mold comprising the upper portion of a single interambulacral area bordered on either side by ambulacral pores. The rather high, trigonal form of this fragmentary mold is suggestive of a *Toxaster* related to *Toxaster altiusculus* White³ but the specimen is too imperfect for definite comparison. The

¹Gregory, J. W. 1892. Bulletin Geological Society of America, III, p. 104.

²Clark W. B., and Twitchell, M. W. 1915. The Mesozoic and Cenozoic Echinodermata of the United States. Monographs of the United States Geological Survey, LIV, p. 148, Pl. LXVIII, figs. 1a-f.

³White, C. A. 1887. Archivos do Museu Nacional do Rio de Janeiro, VII, p. 262, Pl. xxviii, figs. 9-13.

height of the fragment is 19 mm., and its greatest width 17 mm. It resembles the upper part of the central ambulacral area shown in Dr. White's figure 13. Our Cretaceous mold probably represents a form allied to the Lower Eocene *Toxaster altiusculus* but ancestral and a precursor.

LOCALITY.—Baixa do Leite, southeast of Macau, Rio Grande do Norte.

HORIZON.—Proved by associated *Nerineas* to be Cretaceous. Tentatively referred to the Turonian stage.

Genus **HEMIASTER** Desor

Hemiaster catandubensis, sp. nov.

Plate XVI; Figures 2, 3

Our most complete specimen may be an adolescent individual. The test is small, cordiform, with the upper surface convex and high, the lower surface only slightly convex, almost flattened, sides roundly inflated. The ambulacra are deeply sunken, moderately broad, petaloid. Apical system nearly central. Peristome very excentric in position, subcircular. Length of test 25 mm., greatest width 21 mm., height 15 mm.

Associated with this specimen are fourteen fragmentary *Hemiasters*, of which the largest is about 40 mm. in length. This may be an adult of the same species as the more complete specimen described. The other fragments are too incomplete for comparison.

This *Hemiaster* is not identical with any already described from Brazil.

In general form the test is somewhat like *Hemiaster whitei* Clark,¹ especially figure 2a, Pl. XLIII, and 1a, Pl. XLIV, but the resemblance of our species to the form from the Fredericksburg group of Texas is really slight.

The genus *Hemiaster* was abundant in the Cretaceous and Tertiary, and eight or more species are living in the modern seas.

LOCALITY.—Olho d'Água da Catanduba, in the Cretaceous dolomitic limestone belt, Rio Grande do Norte.

HORIZON.—Tentatively referred to the Turonian stage of the Cretaceous.

Hemiaster, sp. indet.

A very perfect imprint of a single spatangid petal, that may be a *Hemiaster*, is stamped upon the hard rock matrix. No other trace of the test is preserved.

LOCALITY.—Camurupim, near Mossoró, Rio Grande do Norte. In a weathered and oxidized boulder which contains many traces of fossils.

HORIZON.—The molluscan species are long-ranging and not decisive stratigraphically. Tentatively referred to the Cretaceous, although this boulder horizon may be slightly younger than the main mass of Turonian limestone.

¹Clark, W. B., and Twitchell, M. W. 1915. Monographs United States Geological Survey, LIV, p. 89, Pl. XLIII, figs. 2a-c; Pl. XLIV, 1a-h; Pl. XLV, figs. 1a-d, 2a-f.

Genus **LOVENIA** Agassiz**Lovenia baixadoleitensis**, sp. nov.

Plate XV; Figure 1

Associated with the echinid described as *Spatangus baixadoleitensis* and embedded in the same whitish matrix with traces of molluscan fossils replaced by chalcedony, is a very remarkable fragment. Dr. Clark thinks it is probably a Cassidulid, judging from the peristome. The specimen is a cast of the interior surface of the test and shows clearly the phyllodes, or bulb-like expansions of the ambulacra as they approach the margin of the peristome. But the cast also shows an extraordinary coating of cushions covering the inner surface of the plates of the test, and presumably associated with large primary spines as in the genera *Lovenia* and *Homalampus*, a condition, Dr. Clark says, which is unknown in any other echini. These tiny cushions are each about three-quarters of a millimeter in diameter, and the center of each is hollowed out so they resemble minute air-cushions of ring-like form. They appear to have been an intricate pneumatic device connected with the movement of the external spines.

The fragmentary mold is only 25 mm. in its greatest dimension and shows only the character of the interior of the test in the region of the peristome. But because of the very rare characteristic of internal cushions, it is provisionally placed in the genus *Lovenia* of Agassiz, of which representatives are known in Miocene and Recent faunas. Apparently only living species have been recorded of the genus *Homalampus* of Alexander Agassiz, which also has internal cushions. Our species seems to be the oldest form known with the internal cushions. It inhabited the Cretaceous sea of Brazil.

In *Lovenia* the test is thin-shelled, elongate-cordate, low, and truncate posteriorly. The upper surface is covered with very large scattered tubercles.

Future collections may include more complete specimens of this exceedingly interesting and rare species.

LOCALITY.—Baixa do Leite, southeast of Macau, Rio Grande do Norte. In a whitish, siliceous, partly chalcedonized matrix which has undergone mineral replacement from aqueous solutions.

HORIZON.—The associated *Nerineas* prove with certainty a Cretaceous age. Tentatively referred to the Turonian stage.

Genus **SPATANGUS** Klein**Spatangus baixadoleitensis**, sp. nov.

Plate XVI; Figure 1

In the collection is an echinid which at first glance looks well preserved but the more one studies it the more apparent its deficiencies become. The upper third and the lower half of the test are concealed in a hard matrix. And the exposed surface of the test has been worn smooth and then largely coated over with chalcedony which obscures and oblit-

erates the structure. Only the general characters of the test can be observed. Provisionally the test is referred to the genus *Spatangus*.

The test is large, inflated, broadly heart-shaped, with a wide and conspicuous sulcation occupied by the unpaired ambulacrum. The paired ambulacra are nearly flush with the surface, and are rather broad, with their lines of pores a little sunken. Apical system very excentric in position. Estimated length of entire test 46 mm., greatest width 43 mm., height 28 mm.

This echinid is very unlike any yet found in the Brazilian fossil faunas, and is easily differentiated and recognizable, for it is a striking and conspicuous member of the Rio Grande do Norte Cretaceous echinid fauna.

LOCALITY.—Baixa do Leite, southeast of Macau, Rio Grande do Norte. In whitish partly chalcidized material.

HORIZON.—Proven by the presence of the molluscan genus *Nerinea* to be Cretaceous. Provisionally referred to the Turonian stage.

II. THE PLIOCENE TO RECENT FOSSILS OF THE STONE REEF, AREIA PRETA, NATAL, RIO GRANDE DO NORTE

Genus **ANOMALOCARDIA** Schumacher

Anomalocardia brasiliiana (Gmelin)

Plate XVIII; Figure 6

Venus brasiliiana GMELIN, 1792, *Systema Naturae*, p. 3289.

Anomalocardia brasiliiana DALL, 1903, *Proceedings United States National Museum*, XXVI, p. 375.

Anomalocardia brasiliiana JENKINS, 1913, *Proceedings American Philosophical Society*, LII, No. 211, p. 27.

Anomalocardia brasiliiana MAURY, 1920, *Bulletins American Paleontology*, No. 34, part 1, p. 75; 1925, No. 42, p. 165, Pl. XXIX, figs. 10, 11.

This species assumes two forms, one short and high, like our illustrated specimen, the other long and proportionately lower.

In some specimens the basal margin may be somewhat arcuate in front of the umbonal slope. The surface anteriorly is prettily sculptured with concentric ripples which may also be present posteriorly, and there are faint and delicate radials. Living shells are white or creamy, and are frequently delicately painted with violet in zigzag and arabesque designs. A large Brazilian specimen, in the Newcomb Collection, illustrating the elongated form of this species, is 41 mm. in length, 28 in height, and 11 mm. in semidiameter, while a short, high shell measures $30 \times 29 \times 10$ mm.

Anomalocardia brasiliiana ranges from Rio de Janeiro northward to Cape Hatteras, and is also a member of the fauna of the Gulf of Mexico. Its geological range is long, for it is present in the Upper Miocene (*Arca patricia* horizon) of Trinidad, West Indies; and in the Pliocene and Pleistocene of Florida.

This species was collected by Mr. Jenkins, and identified by Dr. Dall, in 1912, from an excavation in the bed of Rio Ceará-Mirim, ten kilometers northwest of Extremoz, Rio Grande do Norte, in an estuarine deposit of late Quaternary age.

Anomalocardia flexuosa (Linnaeus) is a valid species and was identified by Dr. Dall from Mangosoules, near Cabedello, in mangrove swamps near the mouth of Rio Parahyba, State of Parahyba do Norte. *Anomalocardia flexuosa* of Born is a synonym of *A. brasiliiana*.

The specimen of *Anomalocardia brasiliiana* herein figured is a small, young shell measuring 19×16 mm. Although it is in an extremely hard conglomerate, it is remarkably fresh in appearance.

LOCALITY.—Areia Preta, Natal, Rio Grande do Norte. At a glance, this material is seen to show the characteristic aspect of the conglomerate from the stone reefs of Brazil. It is very hard, with a glaze like quartzite, and the pebbles are often broken squarely across. The fossils contained are always very fresh and usually retain the colors of the living shell.

HORIZON.—The Areia Preta stone reef, Natal, forms a natural breakwater for the port. It extends parallel to the shore, and lies within, and to the landward, of the coral reef. The age of the stone reef is Recent, extending back continuously into the Pliocene period. The stone reefs and the coral reefs of Brazil are coexistent in geologic time.

III. THE RECENT TO PLIOCENE FOSSILS OF THE CORAL REEF, AREIA PRETA, NATAL, RIO GRANDE DO NORTE

Genus **PETALOCONCCHUS** Lea

Petalococonchus irregularis (d'Orbigny)

Plate XVII; Figure 4

Vermetus irregularis D'ORBIGNY, 1853, In, De la Sagra, Histoire Physique, Politique et Naturelle de l'Ile de Cuba, Mollusques, I, p. 235, Paris. Atlas, Pl. xvii, fig. 16.

Petalococonchus irregularis MAURY, 1922, Bulletins American Paleontology, No. 38, p. 103.

This molluscan species was separated by d'Orbigny from the recent Mediterranean *Serpula glomerata* Linnaeus, with which it had been confused.

The Vermetidae, which include the genera *Vermetus*, *Petalococonchus*, and *Serpulorbis*, are true Mollusca, but their shells resemble those of the Serpulae which are tube-secreting worms. The shells of the Vermetidae, however, in early stages are spiral and show their affinity to the Turritellidae. This initial spiral coiling is beautifully shown in the drawing of our specimens.

D'Orbigny's types of *Petalococonchus irregularis* were from Cuba and Martinique, West Indies. In living shells the color is blackish-brown or

reddish. The form is very irregular in later stages of growth and results in a colony of shells in confused, twisted, and entangled masses. Each individual shell is tubular with rugose transverse plications and often with irregular longitudinal folds.

This species is present in the Pliocene and Pleistocene of Florida. It is in the living fauna of the Antilles and the shores of the Gulf of Mexico. Apparently its range is extended south to the Brazilian coast, for Dr. Woodring has kindly compared our specimen with those in the National Museum of this species and finds them specifically the same.

Petalconchus varians (d'Orbigny)¹ is a related species which ranges from Rio de Janeiro northward to southwestern Florida. It is also in the Pliocene of Florida.

LOCALITY.—Areia Preta, Natal, Rio Grande do Norte. In soft material of coral reef origin, with cavities made by boring bivalve molluscs. The coral reef lies to the seaward of the stone reef of Natal.

HORIZON.—The range of this species is Pliocene to Recent, and the coral reefs of Brazil extend from Recent into Pliocene time. This particular specimen looks very recent and was probably living lately on the reef.

IV. THE RECENT TO PLEISTOCENE FOSSILS OF THE SOFT SANDSTONE AND COQUINA AT THIBAU, NORTHWEST OF MOSSORÓ, RIO GRANDE DO NORTE Genus **DIODORA** Gray

Members of this genus are often placed under the genera *Fissurella* Bruguière and *Fissuridea* Swainson, and are also referred to *Glyphis* Carpenter, 1856. But Iredale,² in a discussion of the subject in 1915, adopts Gray's *Diodora*,³ 1821. Popularly these odd and attractive shells are called the keyhole limpets because of the form of the aperture.

Diodora listeri (d'Orbigny)

Plate XIX; Figure 1

Fissurella listeri D'ORBIGNY, 1855, De la Sagra, Histoire Physique, Politique et Naturelle de l'Île de Cuba, Mollusques, II, p. 197, Paris. Atlas, Pl. xxiv, figs. 37-39.

D'Orbigny separated this recent west Atlantic species from *Fissurella graeca* of the living Mediterranean fauna with which it had been confused.

The types of *Fissurella listeri* were from Florida, Cuba, St. Lucia, and Martinique. The specimen figured by d'Orbigny measured 27 mm. in diameter.

¹d'Orbigny, A. 1843. Voyage dans l'Amérique Méridionale, p. 456, Pl. LIV, figs. 7-10.

²Iredale, T. 1915. Proceedings Malacological Society, London, XI, p. 331.

³Gray, J. E. 1821. Monthly Journal and Review London Medical Repository, XV, p. 233.

This species was identified by Dr. Dall,¹ in 1901, from sand beaches and reefs at Maceio, State of Alagôas, 9° 40' South Latitude; and we now have a specimen from the northeastern coast of Brazil. Also living on the Brazilian coast are *Diodora alternata* (Say) and *D. patagonica* (d'Orbigny). The former has been reported from the shores of the Island of Fernando Noronha; and was cited by Dr. Dall from sand beaches and reefs at Maceio, Alagôas; and off the mouth of Rio Goyanna, 6° 33' South Latitude, where it was collected by Dr. Branner from a stone reef. *Diodora alternata* ranges northward to Cape Hatteras and the West Indies. Stratigraphically it extends back into the Pliocene of Matura, Trinidad; of Port Limon, Costa Rica; and of North and South Carolina.

Diodora patagonica (d'Orbigny) extends from Rio de Janeiro south to Patagonia. This is rather exceptional, as the distribution is usually from the region of Cape St. Roque northward into the Antillean province, but a number of species extend down to Rio de la Plata.

Diodora listeri (d'Orbigny), as far as known, is a younger species than *D. alternata*, for it is recorded only from the recent fauna.

LOCALITY.—Thibau, on the coast northwest of Mossoró, Rio Grande do Norte, at the boundary line between that state and the State of Ceará. In a loosely consolidated coquina from the reef.

HORIZON.—Recent, or possibly as old as Pleistocene.

Genus **ARCA** Linnaeus

Subgenus **SCAPHARCA** Gray

Section **ARGINA** Gray

Arca (Argina) campechensis Gmelin

Plate XVIII; Figure 5

Arca campechensis GMELIN, 1792, Systema Naturae, VI, p. 3312.

Arca campechensis DILLWYN, 1817, Descriptive Catalogue Recent Shells, I, p. 238.

Scapharca (Argina) campechensis DALL, 1898, Transactions Wagner Free Institute Science, III, p. 650.

Arca (Scapharca) pexata var. *holmesi* JENKINS, 1913, Proceedings American Philosophical Society, LII, No. 211, p. 27.

Arca (Argina) campechensis SHELDON, 1916, Palaeontographica Americana, I, No. 1, p. 61, Pl. xv, figs. 6-13.

Arca (Argina) campechensis MAURY, 1920, Bulletins American Paleontology, No. 34, p. 19; 1925, No. 42, p. 74, Pl. VII, fig. 8.

The earliest description of this species was non-binomial, by Lister,² in 1770, as *Pectunculus dense et profunde striatus, ovali figura*, from the

¹Dall, W. H. 1901. Mollusks from the Vicinity of Pernambuco. Proceedings Washington Academy of Sciences, III, pp. 139-148.

²Lister, M. 1770. Historia Conchologia, Pl. ccxxxvii, fig. 71.

Bay of Campeche, Mexico. Gmelin's description was inadequate but clarified by his reference to Lister's work, and Dillwyn further elucidated the characters of this species.

The typical form assumed by the shell is the southern, small, rounded shape, which is true *Arca campechensis*; while the larger, coarse, hirsute, northern form is variety *pexata* Say;¹ and the elongated South Carolina variety is *americana* Gray.²

Hundreds of typical shells have been studied by the writer from the recent fauna of Trinidad, W. I., and from many localities along the Gulf of Mexico; and also many Pleistocene specimens from the deep experimental oil wells of Louisiana, even to the great depth of 2450 feet in Terrebonne Parish. This species, including varieties, is also in the Pleistocene of Georgia and certain other Atlantic coast states of North America. But it has never been identified with certainty from horizons older than Pleistocene.

Argina campechensis is the only *Argina* living along the Atlantic coast of the Americas. Its range, including variety *pexata*, is from Brazil northward to Cape Cod, Massachusetts.

The *Arca* (*Scapharca*) *pexata* Say, variety *holmesi* Stimpson, listed by Mr. Jenkins, in 1912, from an excavation in the bed of Rio Ceará-Mirim, ten kilometers northwest of Extremoz, Rio Grande do Norte, is identical specifically with ours. For, as Dr. Sheldon showed, in 1916, Stimpson's³ *Arca holmesi* is the typical, rounded, southern *Arca campechensis*. The deposit in the bed of Rio Ceará-Mirim is an estuarine, marine and brackish water formation of late Quaternary age.

LOCALITY.—Thibau, on the coast northwest of Mossoró, Rio Grande do Norte, at the boundary line between that state and the State of Ceará. In a loosely consolidated coquina from the reef.

HORIZON.—Recent probably, or if older, the lowest limit is Pleistocene, set by the presence of this species, and the associated *Cardium muricatum*, which also does not antedate the Pleistocene.

Genus **DIVARICELLA** von Martens

Divaricella quadrisulcata (d'Orbigny)

Plate XIX; Figure 4

Lucina quadrisulcata D'ORBIGNY, 1846, *Voyage dans l'Amérique Méridionale*, Mollusques, p. 584; 1855, De la Sagra, *Histoire Physique, Politique et Naturelle de l'Île de Cuba*, II, p. 29. Atlas, Pl. xxvii, figs. 34-36.

Divaricella quadrisulcata DALL, 1889, *Bulletin United States National Museum*, No. 37, p. 50; 1901, *Proceedings Washington Academy of Sciences*, III, p. 140; 1903, *Transactions Wagner Free Institute of Science*, III, p. 1389, Pl. LI, fig. 1.

¹Say, T. 1822. *Journal Academy Natural Sciences Philadelphia*, II, p. 268.

²Wood, W. 1828. *Index Testacea*, Supplement, Pl. II, *Arca*, fig. 1.

³Stimpson, W. 1860. *Smithsonian Institution Checklist*, p. 2.

Divaricella quadrisulcata JENKINS, 1913, Proceedings American Philosophical Society, LII, No. 211, p. 27.

Divaricella quadrisulcata MAURY, 1920, Bulletins American Paleontology, No. 34, p. 58.

The type of this genus is *Divaricella angulifera* von Martens,¹ living in the Indo-Pacific seas.

D'Orbigny differentiated *Divaricella quadrisulcata* from the recent Mediterranean species, *D. divaricata* Linnaeus, with which it had been confused. *D. dentata* Wood is a larger American form.

Divaricella quadrisulcata is living in 10 to 50 fathoms, from Rio de Janeiro northward to Nantucket Island, Massachusetts. It is in the Pleistocene of Saratoga, Texas, in a well at 940 feet depth; and it has also been cited from the Miocene of Maryland and Virginia.

This species was identified by Dr. Dall, in 1901, from Tacuara, near Maceio, Alagoas; and from Recife, Pernambuco, from sand beaches and reefs. In 1912, specimens found by Mr. Jenkins were identified by Dr. Dall from an excavation in the bed of Rio Ceará-Mirim, ten kilometers northwest of Extremoz, Rio Grande do Norte, in a marine and brackish water deposit of late Quaternary age.

LOCALITY.—Thibau, on the coast, northwest of Mossoró, Rio Grande do Norte, at the boundary between that state and the State of Ceará. In both the soft sandstone of the reef and in the loosely consolidated coquina on the reef. The illustrated specimen is resting in the matrix of soft sandstone with the *Tivela* and the *Donax*.

HORIZON.—Recent to Pleistocene.

Genus **CARDIUM** Linnaeus

Cardium (Trachycardium) muricatum Linnaeus

Plate XVIII; Figure 4

Cardium muricatum LINNAEUS, 1758, Systema Naturae, 10th Edition, p. 680.

Cardium muricatum REEVE, 1844, Conchologia Iconica, II, *Cardium*, Pl. VI, fig. 33.

Cardium (Trachycardium) muricatum DALL, 1900, Transactions Wagner Free Institute Science, III, p. 1089.

Cardium muricatum JENKINS, 1913, Proceedings American Philosophical Society, LII, No. 211, p. 27.

Cardium (Trachycardium) muricatum MAURY, 1920, Bulletins American Paleontology, No. 34, p. 62; 1925, No. 42, p. 127, Pl. XXII, fig. 9.

Large shells of this species under favorable conditions may attain a length of 54 mm., and height of 60 mm. Shells from the northern part of the range and fossil forms have fewer ribs than those from more southern waters. The color is usually white, maculated with brown and

¹Martens, E. C. von. 1880. Beiträge zur Meeresfauna der Insel Mauritius und der Seychellen, p. 321.

orange, but some from Trinidad Island, W. I., are straw-colored, banded with salmon pink; and others white with rose-purple.

The type locality is the Bay of Campeche, Mexico. This species ranges from Brazil northward to Cape Hatteras, usually living in very shallow water.

Cardium muricatum was collected by the Branner-Agassiz Expedition to Brazil at Pernambuco and identified by Dr. Dall, in 1901. Members of the Stanford University Expedition to Brazil in 1912, obtained this species from an excavation in the bed of Rio Ceará-Mirim, ten kilometers northwest of Extremoz, Rio Grande do Norte, in an estuarine deposit of late Quaternary age.

Pleistocene specimens were identified by the writer from the New Orleans pumping station, Louisiana. But this shell has never been found in earlier horizons.

Both *Arca campechensis* and *Cardium muricatum* set the Pleistocene as the extreme basal limit of the coquina in which these species are present.

LOCALITY.—Thibau, on the coast northwest of Mossoró, Rio Grande do Norte, at the boundary line between that state and the State of Ceará. In a loosely consolidated coquina.

HORIZON.—Recent, or possibly extending back into the Pleistocene.

Genus **TIVELA** Link

Tivela mactroides (Born)

Plate XIX; Figure 3

Venus mactroides BORN, 1780. Testacea Musei Caesarei Vindobonensis.

Cytherea mactroides REEVE, 1863, Conchologia Iconica, *Cytherea*, Pl. v, figs. 18 a-c.

Tivela mactroides DALL, 1902, Proceedings United States National Museum, XXVI, p. 367.

Tivela mactroides MAURY, 1925, Bulletins American Paleontology, No. 42, p. 143, Pl. XXVI, fig. 8; Pl. XXVII, fig. 3.

This species is the type of the section *Tivela*, *sensu stricto*. It is living on the coast of the State of Santa Catharina, southern Brazil, and ranges northward through the Antilles and Bahamas.

The form of the shell is trigonal with high, full beaks, and the color of living specimens is whitish, stained with pink, purple, or chestnut.

Tivela mactroides was identified by Dr. Dall, in 1901, from northeastern Brazil at Mamanguape, 6° 58' South Latitude, from a stone reef of Recent to Pliocene age.

LOCALITY.—Thibau, on the coast northwest of Mossoró, Rio Grande do Norte, at the boundary line between that state and the State of Ceará. In both the soft sandstone of the reef and in the loosely consolidated coquina.

HORIZON.—Recent to Pleistocene. The coquina looks very recent geologically, but the sandstone may be as old as Pleistocene. It is soft.

Genus **PITARIA** Roemer

Pitaria (Lamelliconcha) circinata (Born)

Plate XIX; Figure 2

Venus circinata BORN, 1780, Testacea Musei Caesarei Vindobonensis, p. 61, Pl. iv, fig. 8.

Pitaria (Lamelliconcha) circinata DALL, 1903, Transactions Wagner Free Institute Science, III, p. 1269.

Pitaria (Lamelliconcha) circinata MAURY, 1912, Journal Academy Natural Sciences, Philadelphia, 2nd Series, XV, p. 56, Pl. ix, figs. 12, 13; 1925, Bulletins American Paleontology, No. 42, p. 149, Pl. xxvii, figs. 12, 13

This species is sculptured with very beautiful, sharp, concentric lamellae. A closely related, Antillean Miocene, form is *Pitaria juncea* Guppy. The analogous Pacific species, living on the west coast of Central America, is *Pitaria alternata* described by Broderip in 1835, and differentiated by its larger and more convex shell.

Pitaria circinata ranges from the coast of Santa Catharina, southern Brazil, northward along the coasts of Venezuela and Central America, and through the Antilles. It is present in Pliocene and Recent faunas of Trinidad Island, W. I.

LOCALITY.—Thibau, on the coast northwest of Mossoró, Rio Grande do Norte, at the boundary line between that state and the State of Ceará. In a loosely consolidated coquina.

HORIZON.—Recent, or perhaps extending back into Pleistocene.

Genus **ANOMALOCARDIA** Schumacher

Anomalocardia brasiliiana (Gmelin)

This species is discussed in detail under the fauna of the stone reef, Areia Preta, Natal, in this bulletin.

LOCALITY.—Thibau, on the coast northwest of Mossoró, Rio Grande do Norte, at the boundary line between that state and the State of Ceará. In a loosely consolidated coquina.

HORIZON.—Recent, or perhaps extending back into Pleistocene.

Genus **STRIGILLA** Turton

Strigilla pisiformis (Linnaeus)

Plate XVIII; Figure 2

Tellina pisiformis LINNAEUS, 1758, Systema Naturae, 10th Edition, p. 677.

Strigilla pisiformis DALL, 1900, Transactions Wagner Free Institute Science, III, p. 1039; 1903, p. 1587.

Strigilla pisiformis MAURY, 1917, Bulletins American Paleontology, No. 29, p. 225, Pl. xxxix, fig. 6; 1925, No. 42, p. 120, Pl. xx, fig. 13, March.

Strigilla pisiformis WOODRING, 1925, Carnegie Institution of Washington, Publication No. 366, p. 175, Pl. xxiv, figs. 17, 18, May.

In the loosely consolidated shell débris from the reef at Thibau, is a single valve of a *Strigilla*, provisionally referred to *S. pisiformis*. The color is not preserved, but the shell is the size of that species, and of similar form and sculpture, and although *Strigilla pisiformis* has not been recorded from so far south, our valve is probably that species.

Strigilla pisiformis is in the Lower Miocene of Cercado de Mao, Dominican Republic; the Middle Miocene of Costa Rica; and of Bowden, Jamaica; and in the modern fauna is distributed all through the Antilles and as far north as Cape Hatteras. When living the shells are maculated with a brilliant rose pink on the center of the valves and this vivid coloring combined with the exquisitely fine sculpture, seen only under a lens, makes this a lovely little shell.

The type of *Strigilla*, *sensu stricto*, is the much larger species, *Strigilla carnaria* Linnaeus, which is living on the coast of Brazil and extends northward to Cape Hatteras; and has been recorded from the Pleistocene at Ft. Morgan, Alabama, in a well at a depth of 175 feet.

LOCALITY.—Thibau, on the coast northwest of Mossoró, Rio Grande do Norte, at the boundary line of that state and the State of Ceará. In a loosely consolidated coquina.

HORIZON.—Recent, or perhaps extending back into the Pleistocene.

Genus **DONAX** Linnaeus

Donax striata Linnaeus

Plate XIX; Figure 5

Donax striata LINNAEUS, 1767, Systema Naturae, 12th Edition, p. 1127.

Donax striata GUPPY, 1867, Proceedings Scientific Association Trinidad, part 3, p. 162.

Donax striata DALL, 1900, Transactions Wagner Free Institute Science, III, p. 968.

This species is living from the coast of Brazil northward through the Antilles, and was identified by Dr. Guppy from the Pliocene of Matura, Trinidad Island, West Indies.

The genotype, *Donax rugosa* Lamarck, is living on the coast of Rio Grande do Sul, southern Brazil, and also extends northward through the Antilles.

Donax (Chion) reticulata is distributed in the Recent fauna from Rio de Janeiro north to the West Indies. It was identified by the writer¹ in sandstone at Bahia de Tury-Assú, State of Maranhão, the formation being probably Pliocene but possibly as young as Pleistocene.

¹Maury, C. J. 1924-1925. Fosséis Terciários do Brasil com Descrição de Novas Formas Cretáceas. Monographias do Serviço Geológico e Mineralógico do Brasil, IV, pp. 443, 454-457, Rio de Janeiro.

Donax (Iphigenia) brasiliiana Lamarck has a similar distribution, from Rio de Janeiro north to the Antilles. This form may be stratigraphically illuminating because the section *Iphigenia* is strictly Recent.

In the present collection are fine specimens that Dr. Woodring kindly compared with *Donax striata* in the National Museum, Washington, and found them specifically identical.

LOCALITY.—Thibau, on the coast northwest of Mossoró, Rio Grande do Norte. In both the soft sandstone of the reef and in the loosely consolidated coquina.

HORIZONS.—The coquina is Recent, with an extreme limit of Pleistocene, set by the presence of *Arca campechensis* and *Cardium muricatum*, neither of which antedates that period.

The soft sandstone of the reef may be somewhat older, for it contains *Divaricella quadrisulcata*, Recent to Miocene; *Tivela mactroides*, Recent to Pliocene; and *Donax striata*, Recent to Pliocene. Thus the sandstone of the reef at Thibau may be as old as Pliocene, but its aspect is very recent geologically.

Genus **MULINIA** Gray

Mulinia branneri Dall

Plate XVIII; Figure 1

Mulinia branneri DALL, 1901, Proceedings Washington Academy Sciences, III, p. 140. Not figured.

This species was described but not illustrated by Dr. Dall, in 1901. The type specimens were collected by Mr. A. W. Greeley of the Branner-Agassiz Expedition to Brazil, on the Mamanguape stone reef, Latitude 6° 58' South.

Our shell has been compared by Dr. Woodring with specimens at the National Museum, Washington, and found specifically identical.

LOCALITY.—Thibau, on the coast, northwest of Mossoró, Rio Grande do Norte, at the boundary between that state and the State of Ceará. In a loosely consolidated coquina.

HORIZONS.—Recent, or with an extreme lower limit of Pleistocene for the coquina at Thibau.

The type locality which was the Mamanguape stone reef is Recent, extending back into the Pliocene.

Genus **CORBULA** Bruguière

Corbula cf. **uruguayensis** Marshall

Plate XVIII; Figure 3

Corbula uruguayensis MARSHALL, 1928, Proceedings United States National Museum, LXXIV, Art. 17, p. 5, Pl. IV, figs. 7-9.

In the collection is a single right valve of a *Corbula*, measuring about 12×7 mm., with very fine, rather regular, concentric growth ridges, a

gently angulate umbonal slope, and a somewhat compressed, produced posterior end. Left valve not known.

This right valve bears some resemblance to a *Corbula* from Cape Santa Maria, Department of Rocha, on the coast of Uruguay, described by Dr. Marshall as *Corbula uruguayensis*, which is similar in size and general form to our valve.

C. B. Adams,¹ in 1852, described but never figured *Corbula swiftiana* from Jamaica, and in 1889, Dr. Dall illustrated this species,² the figured example measuring 10 mm. in length, and being very much the same type of *Corbula* as our valve. But the specimens of *Corbula swiftiana* in the American Museum of Natural History are all very much smaller than Dr. Dall's drawn specimen.

Corbula swiftiana is known to be along the Venezuelan coast and ranges north through the Antilles to Cape Hatteras. It might readily be also on the Brazilian coast.

Both *Corbula swiftiana* C. B. Adams and *Corbula uruguayensis* Marshall are ovate in form with the left valve slightly smaller than the right and fitting within the right valve. With our incomplete specimen no exact comparison is possible, but its affinities seem to be with these two species.

LOCALITY.—Thibau, northwest of Mossoró, Rio Grande do Norte, at the boundary line between that state and the State of Ceará. In a loosely consolidated coquina.

HORIZON.—Recent, or perhaps as old as Pleistocene.

V. THE TERRESTRIAL PLEISTOCENE MOLLUSCAN FOSSILS OF THE SUBAERIAL CALCAREOUS BRECCIA OF ALMINO AFFONSO IN THE INTERIOR OF RIO GRANDE DO NORTE

Family **HELICIDAE** Keferstein

Genus **DRYMAEUS** Albers

The genus *Drymaeus* was founded by Albers, in 1850, the genotype being *Drymaeus hygrohylaenus* d'Orbigny.

These land snails³ are distributed through tropical and subtropical areas of the Americas. A great many species are living in South America. Representatives are also common in Mexico, the Antilles, and Florida.

Drymaeus, sp. indet.

We are indebted to Dr. Pilsbry of the Philadelphia Academy for very kindly examining our material containing Helicidae.

¹Adams, C. B. 1852. Contributions to Conchology, No. 12, p. 236.

²Dall, W. H. 1889. Bulletin United States National Museum, No. 37, p. 70, Pl. II, figs. 5a, b, c.

³See Tryon, G. W., and Pilsbry, H. A. 1897-1898. Manual of Conchology, Second Series, XI, pp. 182-317, and plates.

Small shell surfaces exposed in the rock matrix suggested to Dr. Pilsbry a species of the genus *Drymaeus* because of their curvature. The matrix is so much harder than the shells that it is not possible to work them out further than their exposures on the surface. The specimens are too incomplete for description, but it is interesting to know that a fossil species of *Drymaeus* is present in the collection.

LOCALITY.—Almino Affonso, southwest of Patú, in the southwestern interior of Rio Grande do Norte. In a brownish-gray, calcareous breccia, that appears to be of subaërial origin.

HORIZON.—Both the matrix and the fossils, which appear very fresh, suggest a Pleistocene age. The extreme lower limit for this fauna is Miocene. But the formation is probably Pleistocene.

Genus **HELICINA** Lamarck

Ampullina of Blainville is synonymous with Lamarck's *Helicina*. The shell is globose, depressed or keeled, callous beneath. The aperture is squarish or semilunar, and the operculum is shelly, or membranous.

These terrestrial molluscs are very abundant in the recent fauna of tropical America, the Antilles, the Pacific Islands, and the Australian Islands.

Helicina, sp. indet.

A small species, measuring about 8 mm. in diameter, was identified by Dr. Pilsbry in the breccia. He remarked that the remains are too fragmentary for specific description, but are generically characteristic. Moreover, one fragment shows this fossil species was spirally striate like the living form, *Helicina braziliensis* (Gray).

Our fossil would thus seem to have been of the group of *Helicina braziliensis*, and perhaps ancestral to that recent shell.

LOCALITY.—Almino Affonso, southwest of Patú, in the southwestern interior of Rio Grande do Norte. In a brownish-gray, calcareous breccia, that appears to be of subaërial origin.

HORIZON.—Pleistocene.

Genus **ARTEMON** Beck

The generic name *Artemon* was proposed by Beck, in 1837, and Ancey,¹ in 1884, named *Streptaxis candidus* as the genotype of *Artemon*.²

Streptaxis Gray, genotype *Streptaxis contusus*, is regarded by some authors as entirely synonymous with *Artemon*, but Dr. Pilsbry, the great authority on terrestrial molluscs, states that they are not exactly equivalent.

¹Ancey, C. F. 1884. Le Naturaliste, II, p. 508.

²Pilsbry, H. A. 1930. Proceedings Academy Natural Sciences, Philadelphia, LXXXII, p. 362 (A recent discussion of the genus by Dr. Pilsbry.)

In these land molluscs the shell is oval, *helix*-like, but often oblique, the aperture lunar, with or without teeth. A striking characteristic is the frequent oblique spiral of the whorls, causing a torsion of the axis of revolution, which suggested to Gray the name *Streptaxis* for the distorted forms.

There are many living species of *Artemon*, in South America, Africa, and the East Indies. A number of Brazilian species have been described by Dr. Pilsbry and we are indebted to him for the following notes on our fossil species and for a synthetograph, upon which our drawing is based, reconstructing the complete form of the shell. Brazilian *Artemons* are a prolific group of rather closely similar forms. Dr. Pilsbry states that our fossil species is not one that he has seen in the recent fauna, but adds that all the recent *Artemons* of this region of Brazil are probably not known.

***Artemon alminoaffonsicum*, sp. nov.**

Plate XVII; Figures 1, 2, 3

Shell with about six whorls, the upper depressed, with the summit quite obtuse. Last whorl descending rather more rapidly than the penultimate volution. Umbilicus narrow, about 2.5 mm. wide in the last whorl. Sculpture, where preserved, of distinct striae, wider than their interspaces. Diameter of shell 24 mm.

The synthetograph, which is a composite of several fragmentary specimens, shows that our fossil *Artemon* is much like *Artemon helios* Pilsbry¹ of the living Brazilian fauna, but Dr. Pilsbry states that the fossil shell is more depressed with a decidedly smaller umbilicus. *Artemon helios* belongs to a small group of smooth species including also *A. spixianus* Pfeiffer, a recent Brazilian species, and *A. politus* Fulton, smooth except for puckerings below the suture.

Our fossil appears to have been an ancestral member of the group of *Artemon helios*.

In the breccia are also remains of a different, smaller, species of *Artemon*, too incomplete for description.

The presence of two species, and the number of fragmentary shells, indicate that *Artemon* was the leading genus of the land molluscan fauna preserved in the breccia.

LOCALITY.—Almino Affonso, southwest of Patú, in the southwestern interior of Rio Grande do Norte. In a brownish-gray, calcareous breccia, that appears to be of subaërial origin.

HORIZON.—Pleistocene.

¹Pilsbry, H. A. 1930. Proceedings Academy Natural Sciences, Philadelphia, LXXXII, p. 362, Pl. XXXII, figs. 1a-b. Reproduced for comparison on Plate XVII, this bulletin.

Genus **BULIMULUS** Leach

Leach created the genus *Bulimulus* in 1815, the genotype being *B. guadalupensis* Bruguière.

These land snails are widely distributed in the recent fauna of the Americas.¹ Representatives are found from Patagonia northward into the southern portion of the United States.

Bulimulus, sp. indet.

In the breccia are fragmentary specimens which Dr. Pilsbry thinks indicate a rather short-whorled, compact species, not unlike the living *Bulimulus pubescens* (Moricand).

LOCALITY.—Almino Affonso, southwest of Patú, in the southwestern interior of Rio Grande do Norte. In a brownish-gray, calcareous breccia, that appears to be of subaërial origin.

HORIZON.—Pleistocene.

VI. THE FRESHWATER TRIASSIC FAUNA OF THE RIO DO PEIXE SHALES
IN THE WESTERN INTERIOR OF PARAHYBA DO NORTE

Far in the western interior of the State of Parahyba do Norte, cradled in all surrounding crystalline rocks, is a sedimentary area of sandstones and shales grouped as the Rio do Peixe series.

Since this sedimentary basin is centered around the city of Souza, it is often called the Souza basin, or, as it is traversed by the Rio do Peixe, it is also called the Rio do Peixe basin.

This area of sandstones and shales is of irregular shape, long and narrow, with a northward lobe. The area commences some distance west of Pombal and passes through Acauan, Souza, Passagem da Pedra, São João do Rio do Peixe, Araras, Pilões, and from Pilões north to Belém, and from Pilões west across the state boundary line of Parahyba do Norte to Umary, in the State of Ceará. An excellent map showing the areal distribution of the Rio do Peixe series and its exact geographical position, and detailed descriptions of the sandstones and shales, are given by Dr. Luciano Jacques de Moraes,² of the Geological Survey of Brazil, and geological sections are also shown by Dr. Moraes. The section given in his Figure 20 runs from Cajazeiras northeast through São João do Rio do Peixe, Passagem da Pedra, and Souza to Acauan, through the sandstones and shales. In general the bedding of the Rio do Peixe series is

¹See Tryon G. W., and Pilsbry, H. A. 1897-1898. Manual of Conchology, Second Series, XI, pp. 1-162, and plates.

²Moraes, L. J. de. 1924. Serras e Montanhas do Nordeste. Ministerio da Viação e Obras Publicas, Inspectoria Federal de Obras contra as Secas, Publicação No. 58, Serie I.D. Mappa No. 3, Figuras Nos. 20, 21, Rio de Janeiro.

horizontal, but to the westward, from Kilometer 14.6 to 16, in a section from Cajazeiras to São João do Rio do Peixe, the series as shown in Dr. Moraes' Figure 21 is markedly folded. At Souza the sandstones and shales were drilled to a depth of 184.2 meters without striking crystalline rocks.

This sedimentary area lying in the midst of ancient crystalline rocks has for years excited the interest of Brazilian geologists. But search for traces of fossils was wholly in vain, until the area was explored by Dr. Moraes who was so fortunate as to discover two sets of Dinosaur tracks, and minute bivalve shells. These are the only vestiges of life ever found in the Rio do Peixe sandstones and shales, except indeterminate Ostracods and a fish scale.

The Dinosaur tracks were very interestingly described, and figured, by Dr. Moraes,¹ in 1924. At Passagem da Pedra, four kilometers west of Souza, Dr. Moraes discovered the paths of two dissimilar Dinosaurs which crossed each other and are preserved in the hardened mud, indurated into shale, a quarter of a meter thick, cracked, and ripple-marked. Beneath is red calcareous shale which rests on sandstone that breaks readily into angular fragments. The strike of these rocks is N. 70° W., and the dip 5° SW.² The tracks were referred by Dr. Moraes to a plantigrade and a digitigrade Dinosaur respectively, with a discussion as to their possible relationships, and calculations of their strides and relative size.

Mr. Barnum Brown, Curator of Fossil Reptiles at the American Museum of Natural History, who has studied Dinosaur tracks the world over, after examining the photographs taken by Dr. Moraes of the Passagem da Pedra footprints, states that he thinks two groups of Dinosaurs are represented: the three-fingered Theropod, which was made by some Carnivorous Dinosaur, and the larger tracks made by an Orthopodous Dinosaur similar to *Iguanodon*. He adds that the Tridactylid, or Carnivorous Dinosaur, is probably of Middle or Upper Triassic age, but he has never found any of the Orthopodous tracks so low—never lower than Middle Cretaceous, although this type of reptile lived in the Jurassic period, and some members, without doubt, were developed during Triassic times.

Both sets of tracks are of bipedal animals having the fore legs much reduced and using the hind legs for locomotion. Animals as large as those indicated by the tracks have existed since the Permian.

¹Moraes, L. J. de. 1924. *Serras e Montanhas do Nordeste*, Ministerio da Viação e Obras Publicas, Inspectoria Federal de Obras contra as Secas, Publicação No. 58, Serie I.D., pp. 43-49, estampas 28, 30, 32, 33; plantas 1, 3. Rio de Janeiro.

²Communicated in a letter from Dr. Moraes.

In the Bahia estuarine group, a vertebral centrum was provisionally referred by Owen to *Megalosaurus*, while other centra resemble those of Iguanodons. The Bahia series was referred by Woodward to the Neocomian. Dinosaurs are also in the Baurú beds, São Paulo, referred by Pacheco to the Neocomian stage of the Lower Cretaceous.

Dr. Roderic Crandall,¹ in 1910, described the Rio do Peixe sandstones and shales and suggested that this area of sedimentaries, although now isolated, might originally have been connected with the basal sandstone under the Cretaceous limestone in the Araripe series of the State of Ceará, and that this connection might have been *via* Lavras.

Dr. Ralph Soper also described the Rio do Peixe sandstones and shales and provisionally referred them to the Cretaceous in his report of 1913,² and later article in 1916.³ He remarked that lithologically the Rio do Peixe limestone resembles the sandstone that underlies the limestone belt and thought it might once have been a continuation of that sandstone, or, as Crandall had thought, it might have once been continuous with the sandstone beneath the Sant' Anna limestone of the Araripe series, in Ceará. Indeed, he adds, it would be difficult otherwise to account for the presence of the Rio do Peixe sandstone.

This difficulty is, however, removed if we regard the Rio do Peixe series as of lacustrine origin. This idea of a non-marine origin of the sandstones and shales was suggested to Dr. Moraes⁴ by the abundance of arkose in the sandstone, the feldspar to a large degree being unaltered. This mineralogical evidence accords with the paleontological evidence, for the bivalve shells seem to be of freshwater habitat.

Dr. Branner⁵ mapped the Rio do Peixe basin surrounding the city of Souza as Eocene, for up to that time no traces of life had been discovered, but the Dinosaur tracks found later by Dr. Moraes, at once showed that the rocks of this basin could not be younger than Mesozoic.

The age of the Rio do Peixe series was thought by Dr. Moraes to be Lower Cretaceous, equivalent to the Comanchean of North America.

All those who have studied the series in the field have thought the age Cretaceous or Lower Cretaceous. In favor of this is the possible former connection with the lower sandstone of the Araripe series, or with

¹Crandall, R. 1910. Geographia, Geologia, Supprimento d'Agua, Transportes e Açudagem nos Estados orientaes do Norte do Brazil, Ceará, Rio Grande do Norte, Parahyba. Ministerio da Viacão e Obras Publicas. Inspectoria de Obras contra as Seccas. Publicação No. 4, Serie I, D, E, pp. 28-29, Rio de Janeiro.

²Soper, R. H. 1913. Geologia e Supprimento d'Agua Subterranea no Rio Grande do Norte e Parahyba. Inspectoria Federal de Obras contra as Seccas, Publicação No. 26, Serie I. D., p. 30, Rio de Janeiro.

³Soper, R. H. 1916. Proceedings American Philosophical Society, LV, p. 15, Philadelphia.

⁴Communicated by letter.

⁵Branner, J. C. 1919. Mappa Geologico do Brazil. Published by the Geological Society of America.

the sandstone beneath the limestone belt; and the fact that Dinosaurs were in the State of Bahia and in the State of São Paulo in Neocomian time.

In regard to a possible connection with the Araripe series, I hoped to obtain some evidence from specimens in this collection of Ostracods in a layer of black bituminous shale from Acauan. These recalled the bituminous shales swarming with Ostracods from the Araripe series, Ceará, discussed by the writer in 1929.¹ The Ceará specimens were from shales beneath the Sant' Anna limestone carrying Upper Cretaceous fossil fish, and the Ostracods were probably species of the genus *Cytheridea* as thought by Rupert Jones, Sherborn and Dr. Ulrich. *Cytheridea* ranges from Jurassic to Recent. But the specialists in Washington reported that the smooth Ostracods are hopeless, and they would not attempt to determine the Ostracods from Acauan. In the Acauan black Ostracod shale was also a fish scale. The Acauan Ostracods and fish scale remain enigmatical.

But in the present collection are also the exceptionally interesting minute bivalve shells from Passagem da Pedra where they were found by Dr. Moraes in the same locality as the Dinosaur tracks. By a striking contrast the only records of life are these minute shells and the tracks of the two bipedal Dinosaurs.

The small size of the bivalves, which measure only 5 or 6 millimeters, suggests the possibility of their being Phyllopods, but the specimens have very strongly marked radials, which converge towards the umbonal area. In contrast to this, the Phyllopod genus *Estheria* has strong concentric sculpture, but no radials, and the related genus *Estheriella* shows in the genotype, *Posidonomya wengensis* (Wissmann),² radials so fine as to be visible only under a lens, the concentric sculpture being much stronger and consisting of growth ridges. A number of *Estherias* and *Estheriellas* are described and figured in a comparatively recent Russian publication by Tchernychev,³ but none have the strong radial ribbing of our bivalve shells.

Thus it appears that our bivalve shells are Mollusca and represent small, young Pelecypods. Dr. John B. Reeside, Jr., most kindly examined them and reports that similar specimens are in the collection in the

¹Maury, C. J. 1929. Novas Collecções Paleontológicas do Serviço Geológico e Mineralógico do Brasil, Boletim No. 33, pp. 10-15. Rio de Janeiro.

²Wissman, H. L. 1841. Beiträge zur Geognosie und Petrefactenkunde des südöstlichen Tirols, Beiträge zur Petrefacten-Kunde, IV, p. 23, Pl. xvi, fig. 12a, b, Bayreuth, 1841. Described as *Posidonomya*. *Estheriella* was created by Weiss in Zeitschrift der deutschen geologischen Gesellschaft, XXVII, p. 711, 1875, and based on Giebel's citation of Wissmann's species, which was thus transferred from the Mollusca into the Phyllopoda, and became *Estheriella wengensis* (Wissmann).

³Tchernychev, B. 1927. Sur *Estheria* et *Estheriella* du bassin de Donetz. Annuaire de la Société Paléontologique de Russie, VI, pp. 67-82, Pl. vii, figs. 1-16.

National Museum, Washington, from the Triassic of North America. In his opinion they are small Naiads, perhaps belonging to the genus *Diplodon*, which has the beaks radially ribbed. Because of the resemblance of our Brazilian specimens to the Triassic forms in the National Museum, Dr. Reeside expects our Rio do Peixe material will turn out to be Triassic.

A Triassic age is suggested independently by both the Tridactylid Dinosaur tracks at Passagem da Pedra; and by the freshwater Naiad shells which are also from Passagem da Pedra, in the Rio do Peixe series.

Genus **DIPLODON** Spix

In the Rio do Peixe shale are hundreds of specimens of a very small, radially ribbed bivalve shell, provisionally referred to the genus *Diplodon*. Many members of this genus are now living in Brazil and elsewhere in South America, and also in Australia and New Zealand. Examples of Brazilian species are *Diplodon semigranosus* Simpson,¹ from Ponte Grande, São Paulo; and *Diplodon jacksoni* Marshall,² from Arcas, Minas Geraes, from a tributary of Rio São Francisco. The beak sculpture of the latter consists of about twenty radiating ridges, and the adult shell measures 49×28 mm. The genotype is *Diplodon ellipticum* Spix, which is of elliptical form, with rather low beaks radially sculptured and marked by weak concentric growth ridges. The mother-of-pearl inner layer of the shell is bluish to white, dull, often blotched; and the epidermis dull and rayless. Like all the Naiads, *Diplodon* is strictly freshwater in habitat.

The Naiads appeared in the Triassic, became important in the early Cretaceous, and very abundant in the Tertiary and Recent. In the modern fauna the two greatest centers of development of the Family are the rivers of North America and of southern China. More than a thousand living species are known.

Like all freshwater Mollusca, the Naiads are very static, with a remarkable persistence of generic and specific characters. Very little change differentiates the species that inhabited the great Triassic lake of the Staked Plains of Texas³ from related forms of today. The Unios from these Dockum beds of Texas are of normal size and aspect, and doubtless lived in an inland freshwater lake. This was of shallow water because it was also the home of shoal water vertebrates. In this Triassic

¹Simpson, C. T. 1914. A Descriptive Catalogue of the Naiades or Pearly Freshwater Mussels, p. 1252. No plates. Detroit, 1914.

²Marshall, W. B. 1928. Proceedings United States National Museum, LXXIV, article 17.

³Simpson, C. T. 1895. Proceedings United States National Museum, XVIII, p. 382.

lake of the Staked Plains of Texas, horizontal strata forming sandstones, conglomerates and clays were deposited. Conditions appear to have been not unlike those in the Rio do Peixe Lake, which seems to have been contemporaneous. In the Rio do Peixe Lake, deposits forming sandstones, conglomerates and clays were similarly accumulated. Ripple marks which are very characteristic and abundant in the Rio do Peixe beds indicate that our Lake was of shallow water. And the presence of arkose and unaltered feldspar in the Rio do Peixe series proves that the material was not much worked over nor transported any great distance.

The generally accepted theory regarding the origin of the Naiads is that they developed from the Anthracosidae¹ which inhabited the freshwater lakes and rivers of the Carboniferous and Permian periods. These two families agree in many essential characters of shell structure, which points reasonably to a line of descent from the Anthracosias to the Naiads. The theory of their origin from the marine Trigonias^{2, 3} is now abandoned.

***Diplodon lucianoi*, sp. nov.**

Plate XII; Figures 2, 4, 6

Three specimens have been selected as types, two of which are right valves and the third is a left valve. Like all the specimens, they are very young shells that attained growth only of the very early, umbonal, area of the shell. They seem to have been decimated by some unfavorable event, possibly desiccation, in this very delicate phase of early life.

One right valve shows about fifteen radial ribs, not all of equal strength, and tending to alternate with weaker interpolated riblets on the anterior part of the valve. Length of valve 6 mm., height 4 mm.

The other right valve selected for illustration has sixteen radial ribs, subequal. Length of valve 6.5 mm., height a trifle over 4 mm.

The left valve chosen for illustration has the ribbing very well preserved and shows nearly twenty radial ribs; of these, three or four are at the anterior end and are very narrow, almost linear. Length of valve a little more than 6.5 mm., height 4.5 mm.

Both the delicate, radial ribs and the interspaces are seen under a lens to be marked with fine concentric lines of growth. All three drawings are enlarged five times.

This exceedingly interesting species is named in honor of Dr. Luciano Jacques de Moraes of the Geological Survey of Brazil, who discovered these shells and the Dinosaur tracks which were in the same place.

¹Amalitzky, W. 1892. *Palaeontographica*, XXXIX, p. 198. Stuttgart

²Neumayr, M. 1889. Über die Herkunft der Unionidae. *Sitzungsbericht Wien Akademie*, Band 98.

³Wohrmann, S. F. von. 1893. Über die systematische Stellung der Trigoniden und die Abstammung der Nayaden. *Jahrbuch der Geologischen Reichsanstalt*, Band 43.

LOCALITY.—Passagem da Pedra, near the city of Souza, in the interior of the State of Parahyba do Norte. In gray shales of the Rio do Peixe series. The shales of this series are often stained red with iron oxide, and beautifully ripple-marked.

HORIZON.—Triassic. In a freshwater lake that occupied the Rio do Peixe basin during Middle or Upper Triassic time.

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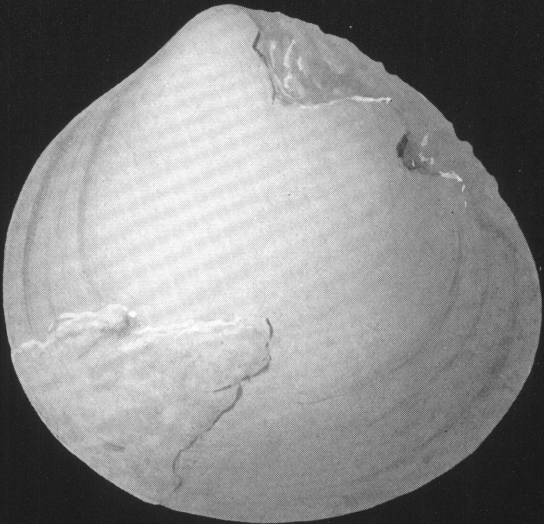
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PLATE IX

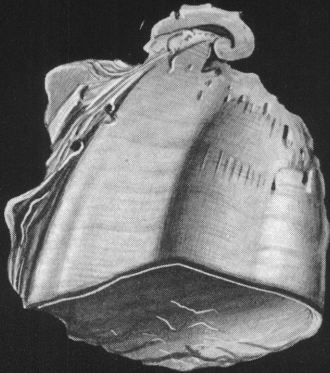
Fig. 1. *Cyprimeria riograndensis*, sp. nov. Natural size. Internal mold. Baixa do Leite, Rio Grande do Norte. Cretaceous. Turonian. A. M. No. 24131.

Fig. 2. *Ostrea lagoapiatensis*, sp. nov. $\times 1\frac{1}{2}$. Fragment showing adult hinge area and wide, heavy beak. Lagôa do Piató, Rio Grande do Norte. A. M. No. 24157.

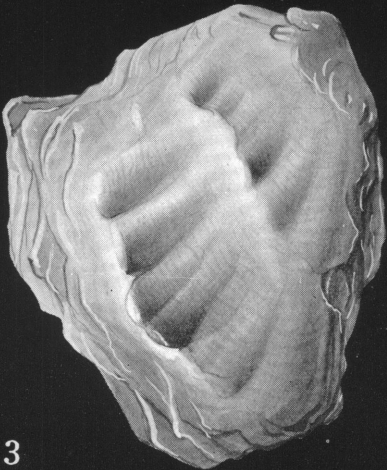
Fig. 3. *Ostrea lagoapiatensis*, sp. nov. $\times 1\frac{1}{2}$. Fragment of an adult valve showing sculpture. Lagôa do Piató, northwest of Assú, Rio Grande do Norte. A. M. No. 24158.



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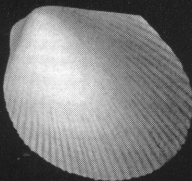
PLATE X

Fig. 1. *Pteria mossoroensis*, sp. nov. $\times 3$. Drawn from an artificial cast of an imprint in a siliceous boulder. Camurupim, near Mossoró, Rio Grande do Norte. A. M. No. 24155.

Fig. 2. *Pteria camurupimica*, sp. nov. $\times 2$. Natural, internal mold. Camurupim. In bowlders. A. M. No. 24143.

Fig. 3. *Pholadomya baixaleitensis*, sp. nov. $\times 1\frac{1}{2}$. Baixa do Leite, southeast of Macau, Rio Grande do Norte. Cretaceous. Turonian. A. M. No. 24161.

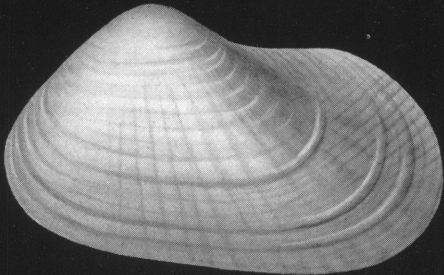
Fig. 4. *Cardium endymionis*, sp. nov. $\times 1\frac{1}{2}$. Near São Sebastião, Rio Grande do Norte. Cretaceous. Turonian. A. M. No. 24145.



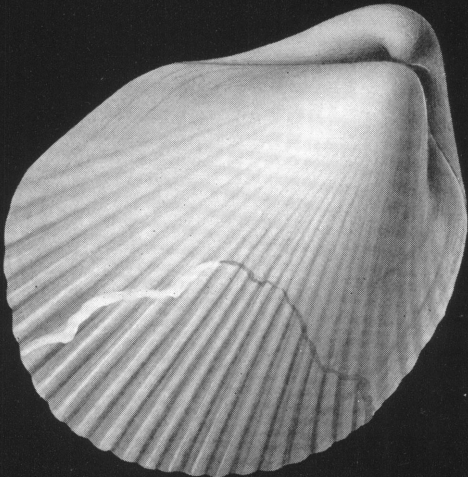
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PLATE XI

Fig. 1. *Arca (Barbatia) camurupimensis*, sp. nov. $\times 2$. Left valve. Camurupim, near Mossoró, Rio Grande do Norte. In siliceous bowlders. Species long-ranging, indecisive stratigraphically. A. M. No. 24124.

Fig. 2. *Arca (Barbatia) mossoroensis*, sp. nov. $\times 3$. Right valve. Camurupim. In bowlders. A. M. No. 24154.

Fig. 3. *Cardium galateae*, sp. nov. $\times 3$. Near São Sebastião, Rio Grande do Norte. Cretaceous. Turonian. A. M. No. 24129.

Fig. 4. *Modiola camurupimica*, sp. nov. $\times 3$. Camurupim. In a bowlder. A. M. No. 24125.

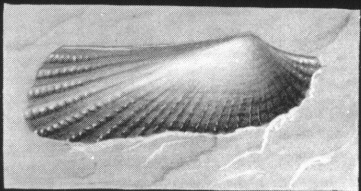
Fig. 5. *Modiola arvoredensis*, sp. nov. $\times 3$. Arvoredo, near Macahyba, Rio Grande do Norte. Cretaceous. Turonian. A. M. No. 24144.

Fig. 6. *Perna arvoredensis*, sp. nov. $\times 1\frac{1}{2}$. Arvoredo. Cretaceous. Turonian. A. M. No. 24139.

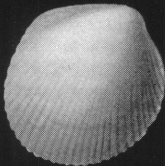
Fig. 7. *Cardium itapassarocanum*, sp. nov. Natural size. Itapassaroca, near Macahyba, westward of Natal, Rio Grande do Norte. In magnesian limestone. Cretaceous. Turonian. A. M. No. 24153.



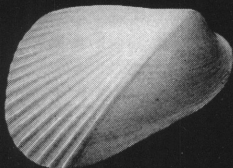
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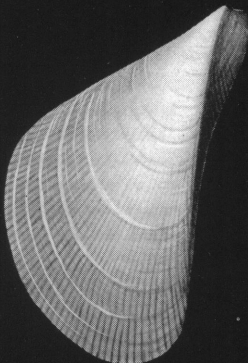
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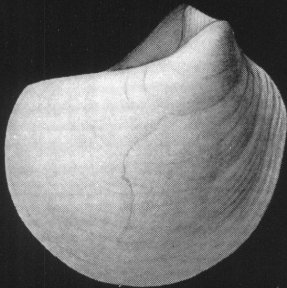
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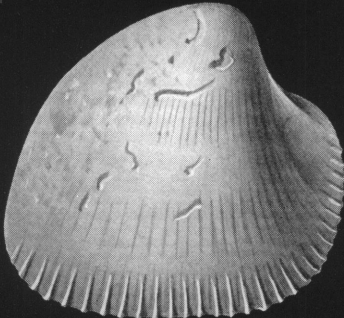
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PLATE XII

Fig. 1. *Cardium jenkinsi*, sp. nov. $\times 2$. Composite drawing, partial restoration. Itapassaroca, near Macahyba. In dolomitic limestone. Cretaceous. Turonian. A. M. No. 24127.

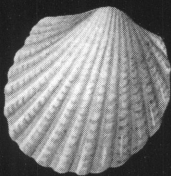
Fig. 2. *Diplodon lucianoï*, sp. nov. $\times 5$. Right valve. Very young shell, showing characteristic umbonal radial ribs, and weak concentric growth ridges. Passagem da Pedra, Parahyba do Norte. Middle or Upper Triassic. A. M. No. 24167.

Fig. 3. *Corbis maiae*, sp. nov. $\times 2$. Baixa do Leite, Rio Grande do Norte. Cretaceous. Turonian. A. M. No. 24138.

Fig. 4. *Diplodon lucianoï*, sp. nov. $\times 5$. Left valve. Passagem da Pedra, Parahyba do Norte. In gray, or often red, ripple-marked shales. Middle or Upper Triassic. A. M. No. 24168.

Fig. 5. *Venericardia mossoroensis*, sp. nov. $\times 3$. Camurupim, near Mossoró, Rio Grande do Norte. In a siliceous boulder. A. M. No. 24170.

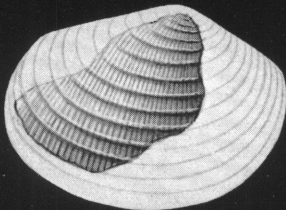
Fig. 6. *Diplodon lucianoï*, sp. nov. $\times 5$. Right valve. Passagem da Pedra, Parahyba do Norte. Middle or Upper Triassic. A. M. No. 24169.



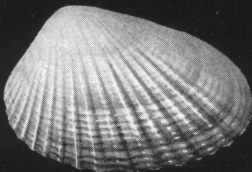
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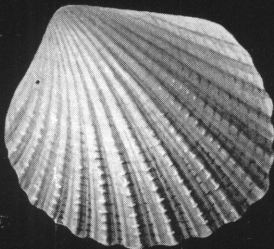
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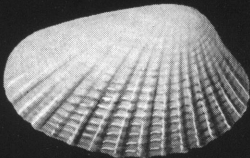
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PLATE XIII

Fig. 1. *Nerinea (Ptygmatis) baixadoleitensis*, sp. nov. $\times 3$. Baixa do Leite, Rio Grande do Norte. Cretaceous. Turonian. A. M. No. 24160.

Fig. 2. *Nerinea (Ptygmatis) riograndensis*, sp. nov. $\times 3$. Baixa do Leite, Rio Grande do Norte. Cretaceous. Turonian. A. M. No. 24137.

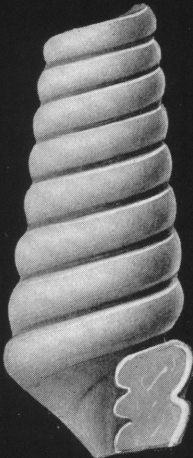
Fig. 3. *Nerinea*, sp. indet. After Jenkins, Jacoca quarries, near Ceará-Mirim, northwestward of Natal, Rio Grande do Norte. In magnesian limestone. Cretaceous. Turonian.

Fig. 4. *Nerinea (Plesiptygmatis) coutinhoi*, sp. nov. $\times 2$. Longitudinal section showing the internal plications. Near São Sebastião, Rio Grande do Norte. In dolomitic limestone. Cretaceous. Turonian. A. M. No. 24126.

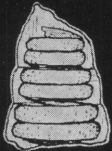
Fig. 5. *Nerinea (Plesiptygmatis) coutinhoi*, sp. nov. $\times 2$. Exterior of the same specimen shown in Figure 4. Deeply concave whorls. Near São Sebastião, Rio Grande do Norte. Cretaceous. Turonian. A. M. No. 24126.



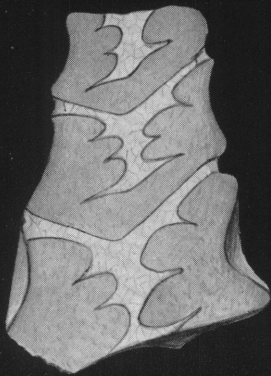
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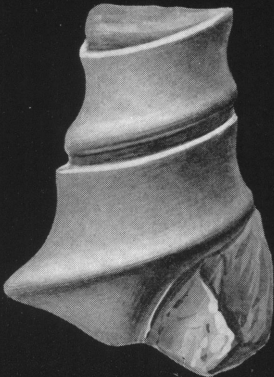
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PLATE XIV

Fig. 1. *Turritella euphrosynes*, sp. nov. $\times 3$. Baixa do Leite, southeast of Macau, Rio Grande do Norte. Cretaceous. Turonian. A. M. No. 24134.

Fig. 2. *Turritella thaliae*, sp. nov. $\times 4$. Baixa do Leite, Rio Grande do Norte. Cretaceous. Turonian. A. M. No. 24156.

Fig. 3. *Cerithium mirimense* Jenkins. $\times 3$. Composite, restoration based on various specimens. Itapassaroca, near Macahyba, westward of Natal. In magnesian limestone. Cretaceous. Turonian. A. M. No. 24136.

Fig. 4. *Cerithium* (?) *jacoquea* Jenkins. After Jenkins. Jacoca, near Macahyba, Rio Grande do Norte. Cretaceous. Turonian.

Fig. 5. *Clava* (*Ochetoclava*) *aglaiae*, sp. nov. $\times 3$. Drawn from an artificial cast of an imprint of the shell. Baixa do Leite, southeast of Macau, Rio Grande do Norte. Cretaceous. Turonian. A. M. No. 24128.

Fig. 6. *Melania catandubica*, sp. nov. $\times 1\frac{1}{2}$. Olho d'Agua da Catanduba, near Lages, Rio Grande do Norte. In a siliceous boulder. A. M. No. 24130.

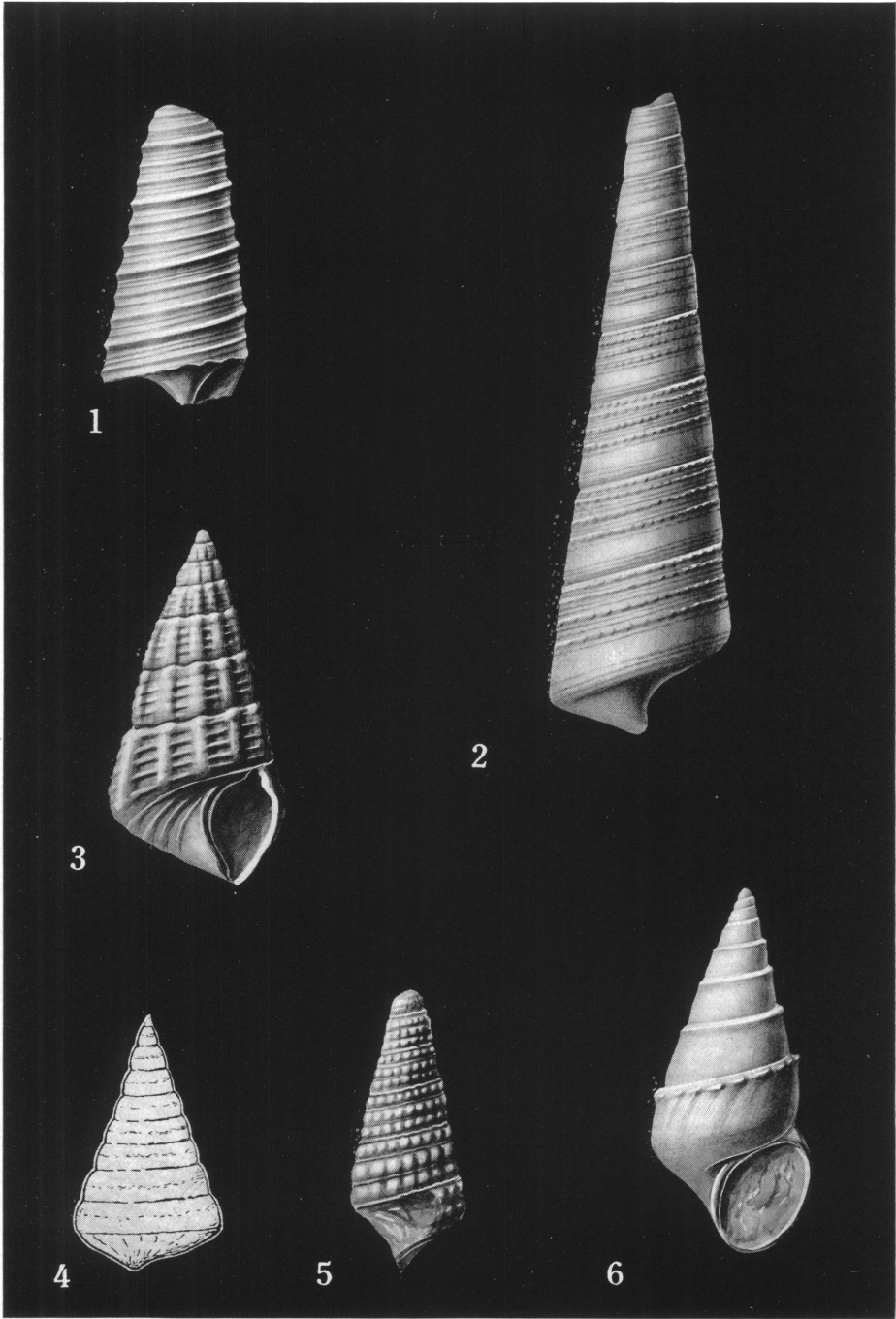
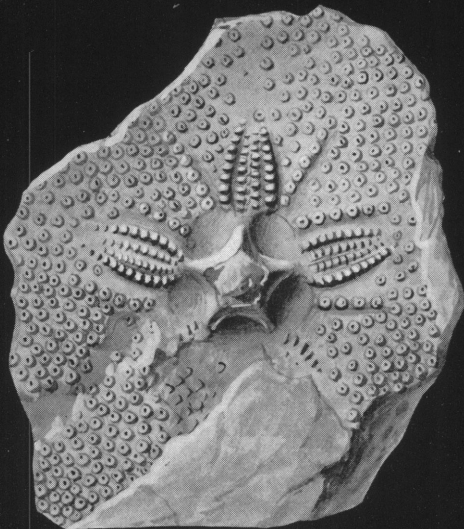


PLATE XV

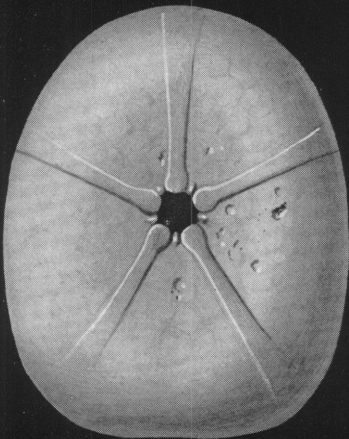
Fig. 1. *Lovenia baixadoleitensis*, sp. nov. $\times 3$. Showing the phyllodes and the remarkable coating of cushions in the interior of the test. Baixa do Leite, Rio Grande do Norte. Cretaceous. Turonian. A. M. No. 24166.

Fig. 2. *Breynella baixadoleitensis*, sp. nov. $\times 2$. Under surface showing peristome. Baixa do Leite, Rio Grande do Norte. Cretaceous. Turonian. A. M. No. 24141.

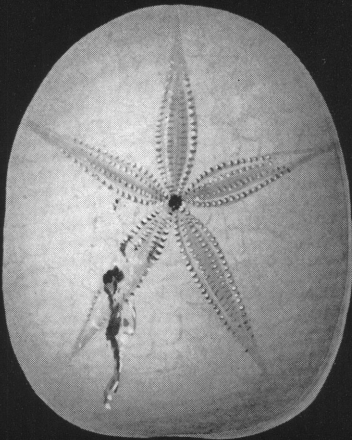
Fig. 3. *Breynella baixadoleitensis*, sp. nov. $\times 2$. Apical surface of the same specimen shown in Figure 2. Baixa do Leite. Cretaceous. Turonian. A. M. No. 24141.



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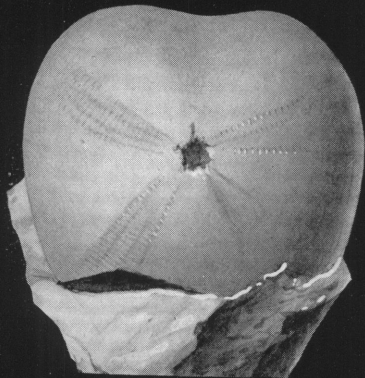
PLATE XVI

Fig. 1. *Spatangus baixadoleitensis*, sp. nov. Natural size. Baixa do Leite, Rio Grande do Norte. Cretaceous. Turonian. A. M. No. 24135.

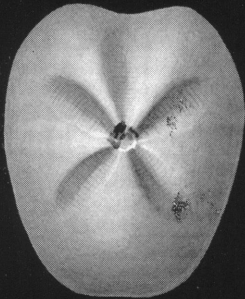
Fig. 2. *Hemiaster catandubensis*, sp. nov. $\times 1\frac{1}{2}$. Olho d'Agua da Catanduba, near Lages, Rio Grande do Norte. In siliceous bowlders strewn over the surface of the Turonian limestone. A. M. No. 24142.

Fig. 3. *Hemiaster* cf. *catandubensis*, sp. nov. $\times 1\frac{1}{2}$. Olho d'Agua da Catanduba. In bowlders. A. M. No. 24165.

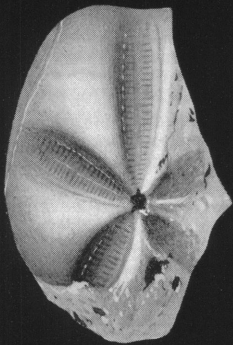
Fig. 4. *Aporrhais baixaleitensis*, sp. nov. Natural size. Baixa do Leite, Rio Grande do Norte. Cretaceous. Turonian. A. M. No. 24132.



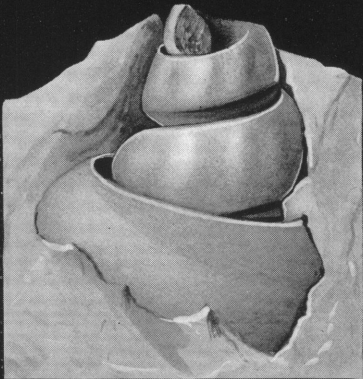
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PLATE XVII

Fig. 1. *Artemon alminoaffonsicum*, sp. nov. Natural size. Under surface. Shaded portion actual specimen, unshaded area restoration. Almino Affonso, southwest of Patú, Rio Grande do Norte. In subaërial, calcareous breccia. Pleistocene. Terrestrial. A. M. No. 24171.

Fig. 2. *Artemon alminoaffonsicum*, sp. nov. Lateral view. Pleistocene.

Fig. 3. *Artemon alminoaffonsicum*, sp. nov. Upper surface. Pleistocene.

Fig. 4. *Petalconchus irregularis* (d'Orbigny). $\times 3$. Areia Preta, Natal, Rio Grande do Norte. Coral reef. Specimen Recent. Reef Recent, continuing back into the Pliocene. A. M. No. 24133.

Fig. 5. *Artemon helios* Pilsbry. Natural size. After Pilsbry. Recent terrestrial mollusk from Brazil. For comparison with the related Pleistocene species from Almino Affonso, Figures 1-3.

Fig. 6. *Artemon helios* Pilsbry. After Pilsbry. Recent. Brazil.

Fig. 7. *Artemon helios* Pilsbry. After Pilsbry. Recent. Brazil.

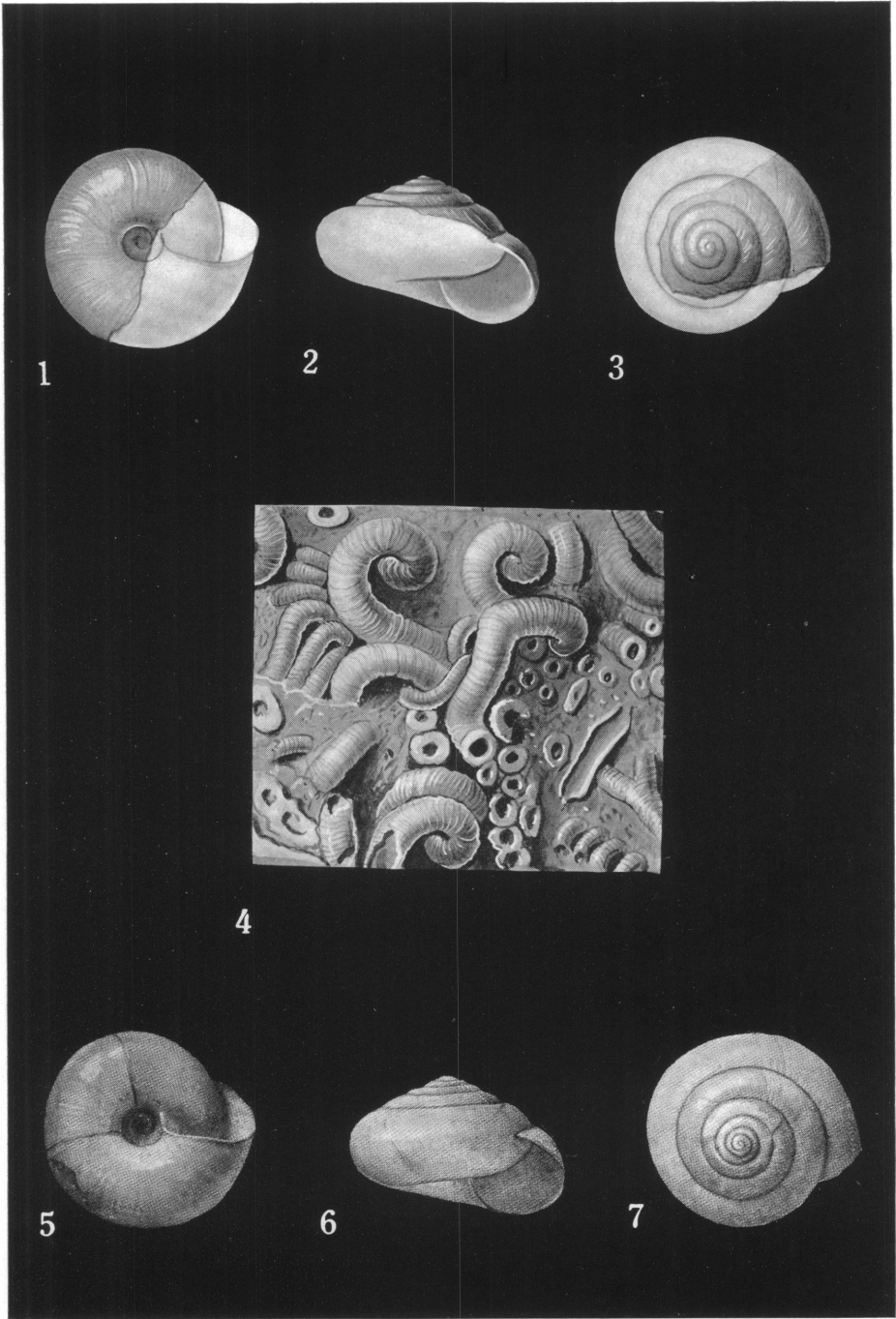


PLATE XVIII

Fig. 1. *Mulinia branneri* Dall. ×2. Thibau, on coast of Rio Grande do Norte at boundary line with Ceará. In coquina. Recent to Pleistocene. A. M. No. 24150.

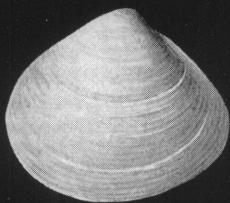
Fig. 2. *Strigilla pisiformis* (Linnaeus). ×4. Thibau. In coquina. Recent to Pleistocene. A. M. No. 24151.

Fig. 3. *Corbula* cf. *uruguayensis* Marshall. ×3. Thibau. In coquina. Recent to Pleistocene. A. M. No. 24149.

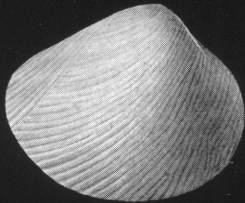
Fig. 4. *Cardium* (*Trachycardium*) *muricatum* Linnaeus. ×2. Very young shell. Thibau. In coquina. Recent to Pleistocene. A. M. No. 24148.

Fig. 5. *Arca* (*Argina*) *campechensis* Gmelin. ×2. Young shell. Thibau. In coquina. Recent to Pleistocene. A. M. No. 24146.

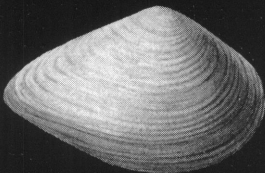
Fig. 6. *Anomalocardia brasiliiana* (Gmelin). ×2. Areia Preta, Natal, Rio Grande do Norte. In the conglomerate of the Stone Reef. The Reef is Recent, extending back continuously into the Pliocene. A. M. No. 24140.



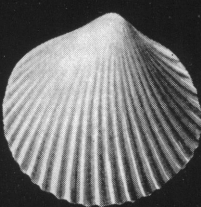
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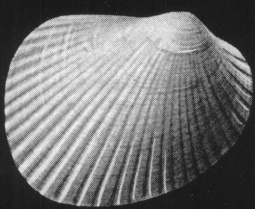
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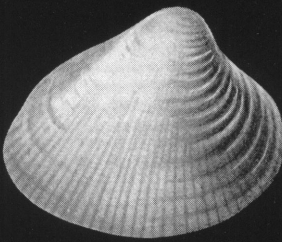
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PLATE XIX

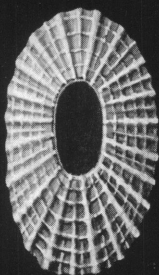
Fig. 1. *Diodora listeri* (d'Orbigny). $\times 3$. Thibau, on the coast of Rio Grande do Norte, at the Ceará boundary line. In coquina. Recent to Pleistocene. A. M. No. 24152.

Fig. 2. *Pitaria (Lamelliconcha) circinata* (Born). $\times 2$. Thibau. In coquina. Recent to Pleistocene. A. M. No. 24147.

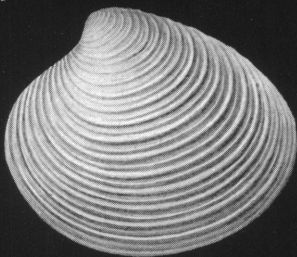
Fig. 3. *Tivela mactroides* (Born). $\times 2$. Thibau. In the soft sandstone of the reef which is Recent, extending back to Pliocene. A. M. No. 24163.

Fig. 4. *Divaricella quadrisulcata* (d'Orbigny). $\times 2$. Thibau. In the soft sandstone of the reef which is Recent, extending back into the Pliocene. A. M. No. 24164.

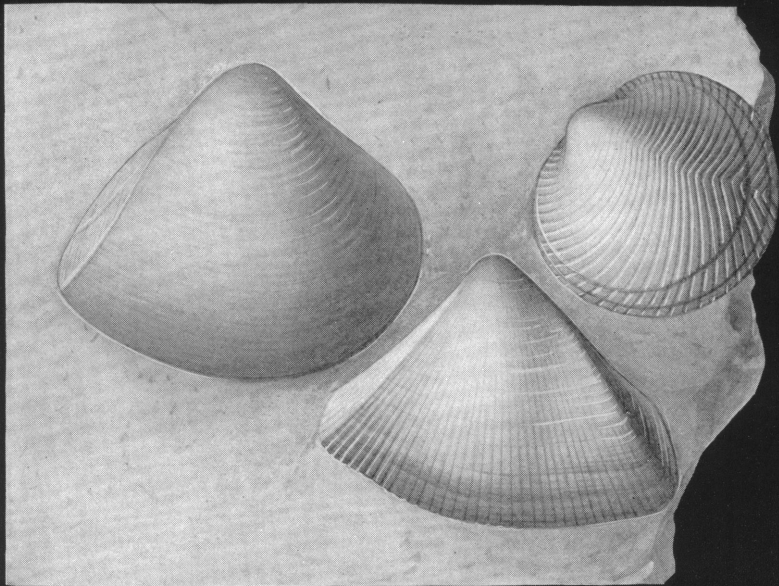
Fig. 5. *Donax striata* Linnaeus. $\times 2$. Thibau. In the reef sandstone which is Recent, extending back into the Pliocene. A. M. No. 24162.



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