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GEOLOGY

OF THE TERTIARY AND QUATERNARY PERIODS IN THE NORTH-WEST PART OF PERU

BY

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D.Sc., M.A., F.G.S., F.R.G.S., M.I.P.T.

WITH AN ACCOUNT OF THE

PALÆONTOLOGY

BY

HENRY WOODS, M.A., F.R.S.
T. WAYLAND VAUGHAN, PH.D.
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AND OTHERS

WITH MAPS AND NUMEROUS ILLUSTRATIONS

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1922

accompanied the author on his various expeditions in Peru and Ecuador throughout the period of years in which these surveys were being made—Nicholas Rodriguez, Gregorio Medina, Manuel Correa, Aurelio Abad, Floro Mogollon, Dimetrio Peralta, and several others.

The colleagues who assisted during the earliest stages of the surveys, especially Mr. H. G. Busk, also are recalled to mind with much appreciation.

With great pleasure the kindness of many friends in the oilfields is remembered—the Managers, Drillers, Office-men, Workmen, past and present; and also the Directors and Officials of the Oil Companies, particularly those of the International Petroleum Company of Toronto, Mr. H. G. Smith and Mr. A. M. McQueen, the President and Vice-President. So many are there that mention of them here would be impracticable.

Also remembered with gratitude are a number of good friends outside the oilfields, among the Peruvian landowners and citizens, in the towns and villages along the Rio Tumbes and the Rio Chira, and in Payta and elsewhere.

Thanks are due also to several gentlemen who have very kindly lent photographs for reproduction—Mr. J. Rennie, Secretary of the Lobitos Oilfields Ltd.; Mr. Beeby Thompson; Messrs. A. Beeby Thompson and Partners; Mr. A. H. Low; Mr. R. G. Sammons; Mr. O. D. Boggs.

Finally, the author is much indebted to the Publishers, Messrs. Macmillan & Company, for the care and trouble which they have taken, and for the consideration which they have shown.

T. O. BOSWORTH.

March 1922.

CONTENTS

PART I

STRUCTURE AND STRATIGRAPHY OF THE TERTIARY DEPOSITS

By T. O. Bosworth, D.Sc., M.A., F.G.S., F.R.G.S.

PART II

PALÆONTOLOGY OF THE TERTIARY DEPOSITS

Section A

MOLLUSCA FROM THE EOCENE AND MIOCENE DEPOSITS OF PERU

By Henry Woods, M.A., F.R.S.

the beds of clay-shale, fossils are rare or absent, and within the sandstones they are not often present.)

The fossils are of such kinds as would be expected on a beach. Many of the shells are broken and eroded, and seldom are two valves found together. There are also many bits of coral, and pieces of driftwood, worm-eaten and riddled by boring shellfish. On weathering, these fossil logs crumble to pieces and leave the ground strewn with the shells which were in them.

The fossils are well preserved in hard calcite; those in the Turritella Series generally are brown and ferruginous, whilst those in the Clavilithes Series often are white or only slightly coloured. Being harder than the shales and sandstone, these fossil seams weather out in relief, forming the bare dip-slopes of the ridges, and presenting to the observer plane surfaces covered with almost clean shells. (See Fig. 1 and Fig. 87.)

The stratigraphy of the Negritos Formation is best displayed a mile or two north-east of Parinas Point. By selecting the largest and least fractured fault-blocks, it is possible to walk across the outcrops of the whole of the exposed 5500 feet of strata, in a distance of $2\frac{1}{2}$ miles. (See Folder No. III., B.)

The formation in this district consists of the following members:—

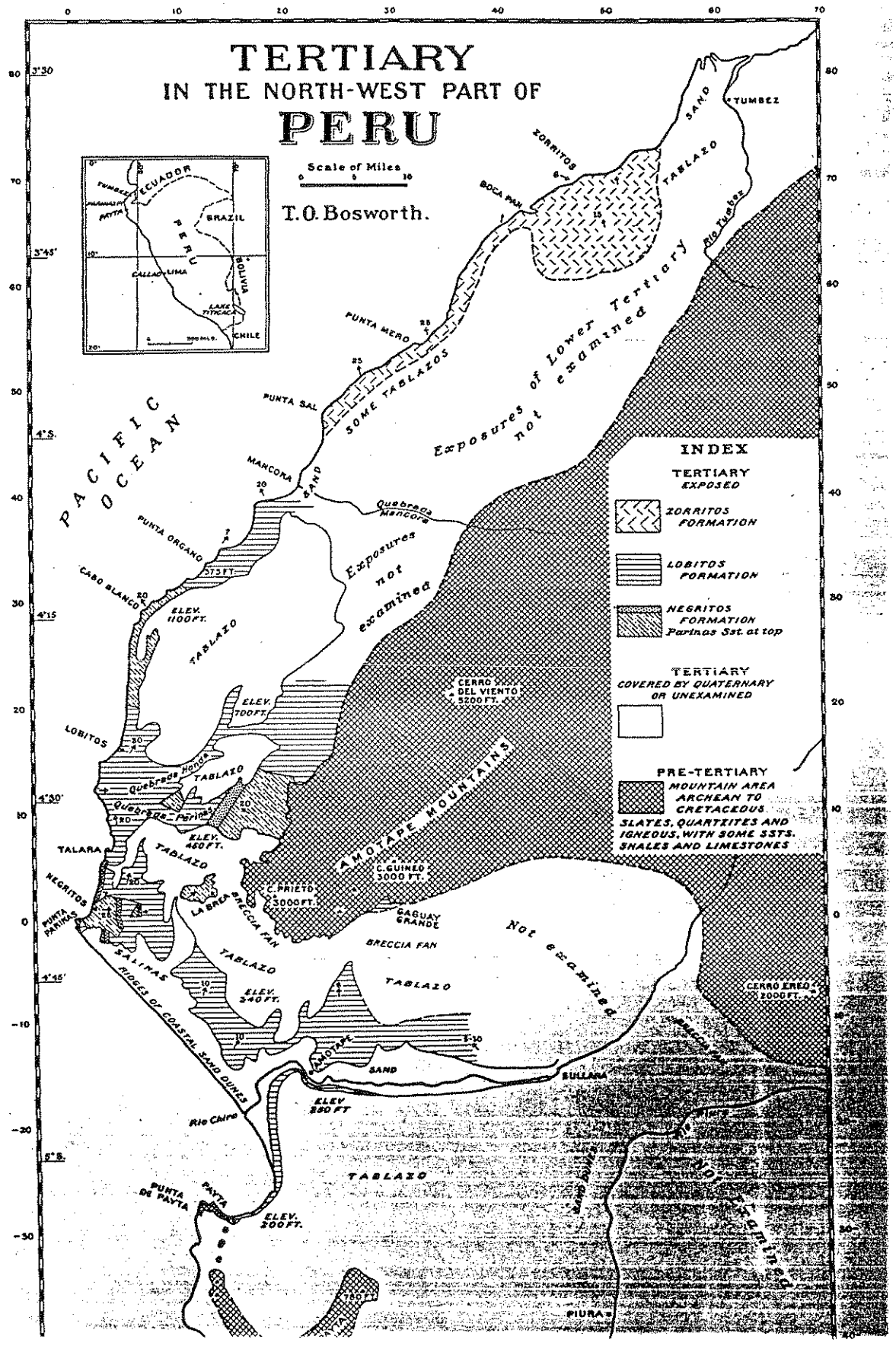
[TABLE

THE NEGRITOS FORMATION AT NEGRITOS

CLAVILITHES SERIES, 4000 *feet*
e. PARINAS SANDSTONE (1000 feet). Massive brown sandstone, and beds of sandstone and conglomerate, with some beds of clay-shale. Characteristic fossils: *Clavilithes pacificus*, sp. nov., *Pseudoglauconia Lissoni*, *Morgania magna*, sp. nov., *Turritella annectens*, sp. nov.
d. PALE SHALES (2000 feet). Clay-shales with thin, red, ferruginous seams; some thin beds of sand-shale; few sandstones, few pebble-seams. Fossils generally scarce—*Turritella*, forms connecting *T. anceps* and *T. annectens*. Passage-beds near top, with irregular sandstones, and occasionally many fossils, which include some new species characteristic of Parinas Sandstone.
c. SHALES WITH PEBBLE SEAMS (1000 feet). Blue-grey clay-shales with bands of sandstone, and many seams of beach pebbles, crowded with fossils. Fossils very abundant—*Turritella anceps*, sp. nov., *Melanatria acanthica*, sp. nov., *Surcula occidentalis*, sp. nov., *S. Thompsoni*, sp. nov., *Clavilithes peruvianus*, sp. nov., *Volutospina peruvianus*, sp. nov.

TURRITELLA SERIES, 3000 *feet* +
b. SHALES WITH PEBBLE SEAMS (1500 feet). Blue and grey clay-shales, with sandstone bands and many seams of beach pebbles, crowded with fossils. Fossils very abundant, especially *Turritella* of several species.
a. SHALES UNEXPOSED (1500 feet +). Probably similar to those above, but known only in bore-holes. Base not found.

FOLDER No. 1.


TERTIARY
IN THE NORTH-WEST PART OF
PERU
Scale of Miles
0 5 10
T.O. Bosworth.
ECUADOR
BRAZIL
PERU
BOLIVIA
CHILE
LAKE TITICACA
TUMBEZ
PAITA
CALLAO
LIMA
PACIFIC OCEAN
ZORRITOS
BOCA PAN
SAND
TABLAZO
Río Tumbez
PUNTA MERO
PUNTA SAL
SOME TABLAZOS
Exposures of Lower Tertiary not examined
MANCORA SAND
Quebrada Mancora
PUNTA ORGANO
CABO BLANCO
ELEV. 1100 FT.
Exposures not examined
LOBITOS
Quebrada Honda
Quebrada Parinas
ELEV. 700 FT.
ELEV. 450 FT.
TALARA
NEGRITOS
PUNTA PARINAS
LA BREA
BRECCIA FAN
C. PRIETO 3000 FT.
AMOTAPE MOUNTAINS
C. GUINEO 3000 FT.
CERRO DEL VIENTO 3200 FT.
GAGUAY GRANDE
BRECCIA FAN
Not examined
SALINAS
RIDGES OF COASTAL SAND DUNES
ELEV. 540 FT.
AMOTAPE
SAND
BULLANA
ELEV. 250 FT
Río Chira
PUNTA DE PAYTA
PAYTA
ELEV. 200 FT.
CERRO EREO 2000 FT.
PIURA
INDEX
TERTIARY EXPOSED
ZORRITOS FORMATION
LOBITOS FORMATION
NEGRITOS FORMATION Parinas Sst. at top
TERTIARY COVERED BY QUATERNARY OR UNEXAMINED
PRE-TERTIARY
MOUNTAIN AREA ARCHEAN TO CRETACEOUS.
SLATES, QUARTZITES AND IGNEOUS, WITH SOME SSTS. SHALES AND LIMESTONES

SECTION A

MOLLUSCA FROM THE EOCENE AND MIOCENE DEPOSITS OF PERU

By Henry Woods, M.A., F.R.S.

CHAPTER I

GENERAL ACCOUNT OF THE FAUNAS AND THEIR RELATIONSHIP

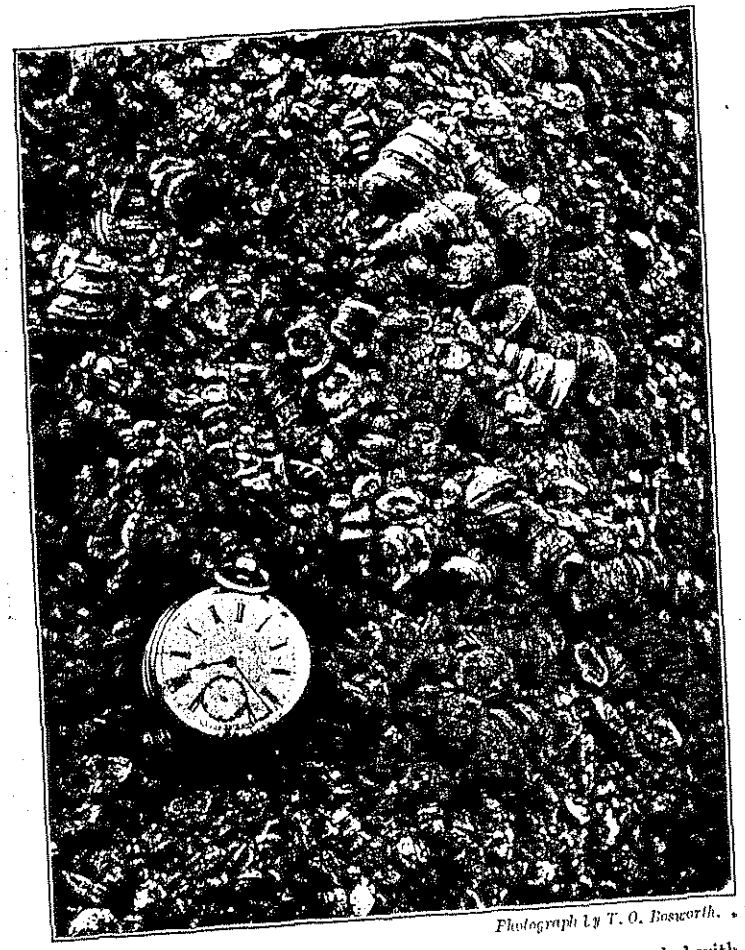
With the exception of a small number of species of Mollusca, mainly of Miocene and Quaternary age, described by W. M. Gabb,[1] E. T. Nelson,[2] and J. Grzybowski,[3] nothing seems to have been written on the Palæontology of the Tertiary deposits of Peru.[4] The discovery of a rich Eocene fauna in this region is of considerable interest on account of the limited development of Eocene formations in the Southern Hemisphere.

[1] "Descriptions of New Species of South American Fossils.—No. 1, Tertiary," *American Journ. Conch.* v. (1870), p. 25; figures published in *Journ. Acad. Nat. Sci. Philadelphia* (8), II. (1877), p. 264, Pl. xxxv.

[2] "On the Molluscan Fauna of the Later Tertiary of Peru," *Trans. Connecticut Acad. Arts and Sci.* II. Pt. 1 (1870), p. 186, Pls. vi., vii.

[3] "Die Tertiärablagerungen des nördlichen Peru und ihre Molluskenfauna," *Neues Jahrb. für Min.* etc., Beil.-Bd. XII. (1899), p. 610.

[4] A brief account of the Eocene of Peru has recently been published by Prof. H. Douvillé, *Compte Rendu Acad. Sci.* clxxi. (1920), p. 1345, and *Compte Rendu somm. Soc. géol. France*, No. 14 (1921), p. 198.



Photograph by T. O. Bosworth.

FIG. 2.—Surface of a fossil-seam in the Turritella Series, crowded with *T. negritosensis*, sp. nov. (Viewed from above.) One mile E.N.E. from Punta Parinas.

ZORRITOS FORMATION, 5000 *feet* +

Exposed extensively in the north part of the region (but little studied); absent or denuded from the south part.

Clay-shales and sandstones.

Fossils—all different from those in formations below.

LOBITOS FORMATION, 5000 *feet* +

Exposed mainly in the middle and south parts of the region.

Clay-shales, with thick and thin beds of calcareous sandstone containing *Nummulites*, etc. Southward this passes into a mass of clay-shales with or without some thin seams of sandstone and pebbles.

Fossils—chiefly discoidal foraminifera, but in places some gasteropods and pelecypods.

NEGRITOS FORMATION, 7000 *feet* +

Exposed in the middle part of the region.

Clay-shales, sandstones, and seams of beach pebbles, with many fossils.

Consists of two members:

Clavilithes Series, 4000 feet.

Turritella Series, 3000 feet +.

Fossils—chiefly gasteropods and pelecypods. *Aturia* present.

These three formations of the Tertiary, and their occurrence, will be briefly described in the following three chapters, in order commencing with the oldest.

Thompsoni, sp. n., and *Callista* (*Macrocallista*) *Dickersoni*, sp. n. Of these species *Turritella anceps* is particularly abundant. Forms confined to the Parinas Sandstone are *Corbula parinasensis* and *Sycum americanum*.

There appear to be no marine deposits of similar age yet described in South America,[1] but comparison of the fauna of the Negritos Formation can be made with the Eocene faunas of (1) the Pacific coastal region of the United States, and (2) the Eastern and Gulf States.

The stages reached in the evolution of the *Venericardia planicosta* group indicate that the Negritos Formation is represented by the Tejon Group and part of the Meganos Group[2] of California. But although many of the other genera of Mollusca are common to the two regions, the resemblances between the species are few and not striking.

The relation to the faunas of the Eastern and Gulf States of America is more marked, and the stages of development reached by the *Venericardia planicosta* group indicate that the Negritos Formation is represented by the Wilcox and Lower Claiborne Groups. The Claiborne Group is probably of Lutetian and Auversian age, and represented by the Bracklesham Beds of England; the Wilcox Group may be in part of Ypresian age. Although scarcely any of the other species of Mollusca are common to the two regions this correlation receives support from the resemblances between some of the species found in

[1] Dr. Bosworth states that Eocene deposits occupy a considerable area in Ecuador, and probably also in Colombia and Venezuela.

[2] B. L. Clark, *Bull. Geol. Soc. America*, xxix. (1918), p. 281.

the two areas. The principal forms in the Negritos Formation which are comparable with species found in the Wilcox and Lower Claiborne Groups are *Solarium Nelsoni*, sp. n., *Turritella negritosensis*, sp. n., *Dientomochilus* (*Ectinochilus*) sp. cf. *laqueata* (Conr.), *Pseudoliva parinasensis*, sp. n., *Clavilithes Harrisi*, sp. n., *C. peruvianus*, sp. n., *Volutospina peruviana*, sp. n., and *Ostrea Inca*, sp. n. The differences between the faunas of the two regions are, however, very striking; in addition to almost complete differences in species, a number of genera which are abundant in the Wilcox and Claiborne Groups are unknown in the Negritos Formation of Peru; as, for example, *Olivula*, *Bullinella* (*Cyclichna*), *Caricella*, *Lacinia*, *Buccinanops*, *Crassatellites*, *Pectunculus*, and *Grateloupia*; on the other hand the genera *Morgania*, *Melanatria*, *Bezanconia*, *Sycum*, and *Xanthopsis* appear to be unknown in the Wilcox and Claiborne Groups. The resemblances between the faunas are sufficient to indicate the existence of a sea connection between the Pacific and the Atlantic; the dissimilarities in the faunas point to a difference in climate, and probably also to the want of any direct shallow-water connection between the two regions. Evidence for inter-oceanic communication across Central America in Upper, and probably Middle Eocene, and later times has been furnished by the study of the Tertiary faunas of the West Indies and the Panama region,[1] as well as from the distribution of Tertiary Mammals.

[1] T. W. Vaughan, *U.S. National Mus. Bull.* 103 (1919), pp. 198, 207, 211, 221, 607, and table, p. 611; and *Bull. Geol. Soc. America*, xxix. (1918), p. 615. R. E. Dickerson, "Ancient Panama Canals," *Proc. California Acad. Sci.* (4), vii. (1917), p. 197.

For help in comparing some of the Mollusca with recent and fossil specimens in the British Museum (Nat. Hist.) I am indebted to Mr. G. C. Robson and Mr. R. Bullen Newton. The late Mr. G. C. Crick kindly examined the specimens of *Aturia*. I must also thank Mr. C. P. Chatwin for giving me his opinion on the affinities of some of the Gasteropods. Mr. T. H. Withers has been good enough to report on the two Cirripedes found in the Zorritos Formation.

The deposits under consideration are divided into three main groups termed (1) the Negritos Formation, (2) the Lobitos Formation, (3) the Zorritos Formation.

1. The Negritos Formation

The fauna of the Negritos Formation is of shallow-water character, and consists mainly of Gasteropods and Lamellibranchs, with a small number of Fish teeth, Decapod Crustacea, and Corals. Cephalopods are represented by a species of *Aturia*. No remains of Brachiopods, or Cirripedia have yet been found. The Mollusca are, in general, well preserved, but unfortunately the apertures of the Gasteropods are often imperfect, and owing to weathering in an arid region, the ornamentation of the early part of the spire is often indistinct or obliterated; so that exact generic determination is not infrequently difficult.

Some of the species of Mollusca, which range through the greater part of the Negritos Formation, are of interest in that they show a gradual change of characters, when traced through successive horizons, the change consisting mainly in the increase of senile features. Thus the group of *Venericardia planicosta* starts with forms in which the ribs are well developed throughout life, and is succeeded in later beds by others in which they become obsolete near the ventral margin, and eventually are wanting over a large part of the shell.

In *Volutospina peruviana*, sp. n., the callus shows progressive development in passing from early to later beds, until ultimately it covers the entire shell. Similarly *Pseudoliva mutabilis*, sp. n., and *Strepsidura pacifica*, sp. n., exhibit an increase in the development of senile features.

A considerable proportion of the species occur in both divisions of the Negritos Formation; but the earlier division, the Turritella Series, in addition to the zonal forms of *Venericardia planicosta*, *Volutospina peruviana*, sp. n., and of *Pseudoliva mutabilis*, sp. n., is characterised by *Turritella negritosensis*, sp. n., *T. Lissoni*, sp. n., *T. Douvillei*, sp. n., *Melanatria dimorphica*, sp. n., *M. propinqua*, sp. n., *Bezanconia pupoidea*, sp. n., *Cerithium Chatwini*, sp. n., *Volutospina crassiuscula*, sp. n., *Ostrea Buski*, sp. n. Of these, *Turritella negritosensis* is especially abundant and shows much variation.

The newer division, the Clavilithes Series, with the Parinas Sandstone at the top, in addition to the zonal forms of *Venericardia planicosta*, *Volutospina peruviana*, and *Pseudoliva mutabilis*, is distinguished especially by the presence of *Clavilithes*, represented by four species, and by *Turritella anceps*, sp. n., *Morgania magna*, sp. n., *Melanatria acanthica*, sp. n., *M. venusta*, sp. n., *Cerithium negritosense*, sp. n., *Diastoma americanum*, sp. n., *Sycum americanum*, sp. n., *Surcula*

this horizon are *Telescopium peruvianum*, sp. n., *Faunus? lagunitensis*, sp. n., *Tympanotonus lagunitensis*, sp. n., *Olivancillaria (Agaronia) peruviana*, sp. n. These differences in the fauna at Lagunitas are due, in part, at any rate, to a difference in the conditions of deposition.

3. The Zorritos Formation

The fossils of the Zorritos Formation include, amongst others, *Solarium sexlineare*, Nels., *Turritella infracarinata*, Grzyb., *T. robusta*, Grzyb., *T. gothica*, Grzyb., *T.* sp. cf. *altilira*, Conrad, *Conus* sp., *Scapharca zorritosensis*, sp. n., *Crassatellites charanensis*, sp. n., *Clementia* sp. cf. *dariena*, Conr., *Balanus* sp. cf. *concavus*, Bronn. The Zorritos Formation has been regarded by Grzybowski and other writers as of Miocene Age, and this view is supported by the presence of *Turritella* sp. cf. *altilira*, *Clementia* sp. cf. *dariena*, and *Crassatellites charanensis*, sp. n. *Balanus* is represented by two specimens; these have been examined by Mr. T. H. Withers, who states that they may be provisionally identified with *B. concavus*, Bronn, and that they are probably of Miocene Age, and certainly not Eocene.[1]

[1] An account of the Miocene Plants of Peru is given by E. W. Berry, *Proc. U.S. Nat. Mus.* lv. (1919), p. 279. See also *Bull. Geol. Soc. America*, xxix. (1918), p. 637.

Table showing Range of Mollusca and Crustacea in the Negritos and Lobitos Formations

	Negritos Formation.			Lobitos Formation (between Talara and Payta).		
	Turritella Series.	Clavilithes Series.				
	Shales with Pebble Seams.	Shales with Pebble Seams.	Parinas Sandstone.	Lowest 1000 feet around Negritos.	Horizons exposed at Payta and W.N.W. of Sullana.	Horizon exposed near Lagunitas, and higher beds.
Lamellibranchia						
Leda ingens, sp. n.	q	p				
Barbatia, sp.	o					
Scapharca (Argina) sullanensis, sp. n.					p	
Mytilus euglyphus, sp. n.	p (?)	p	p (?)			
Ostrea Inca, sp. n.	q	p				
„ *Buski*, sp. n.	q	q				
Perna arbolensis, sp. n.			o		(?)	
Venericardia planicosta, Lam. (group)	p	p	p	p	o	
Lucina paytensis, sp. n.					p	
Callista (Macrocallista) Dickersoni, sp. n.		o				
Meretrix Bosworthi, sp. n.	p	q				
„ *negritosensis*, sp. n.	o	q				
Cardium, sp.	o					
Corbula peruviana, sp. n.	p	o				
„ *Waringi*, sp. n.	p	o				
„ *Arnoldi*, sp. n.	o					
„ *parinasensis*, sp. n.			p			
Teredina, sp.	p	p	p	o		
Gasteropoda						
Solarium Nelsoni, sp. n.	p	p	p			
Natica (Naticina), sp.				o		
Ampullina Gabbi, sp. n.		o				
„ *paytensis*, sp. n.					p	
Turritella negritosensis, sp. n.	q					
„ *Dickersoni*, sp. n.	p	p	p (?)			
„ *Bosworthi*, sp. n.		p	p			
„ *Douvillei*, sp. n.	q					
„ *Lissoni*, sp. n.	q					
„ *anceps*, sp. n.		q				
„ *annectens*, sp. n.		q	q	p		
Morgania magna, sp. n.		(?)	p	(?)		
„ *costata*, sp. n.	q	q	q			
Melanatria dimorphica, sp. n.	p					
„ *acanthica*, sp. n.		q	p			
„ *propinqua*, sp. n.	p					
„ *venusta*, sp. n.		o				
Pseudoglauconia Lissoni, Douv.	p	q	q	o (?)		
Faunus? lagunitensis, sp. n.						p
Cerithium paytense, sp. n.					p	p
„ *negritosense*, sp. n.		p				
„ *Chatwini*, sp. n.	q					
Bezanconia pupoidea, sp. n.	p					
Potamides occidentalis, sp. n.	o (?)	p				
Tympanotonus lagunitensis, sp. n.						p
Telescopium peruvianum, sp. n.				p	(?)	p
Diastoma americanum, sp. n.		o				

Explanation

o denotes fossil was found occasionally.
p „ „ „ „ plentifully.
q „ „ „ „ in quantities.

Eocene deposits with *Venericardia planicosta* have been found near Tonosi, Panama, but unfortunately no other fossils have been recorded. In the West Indian Islands deposits of this age appear to be known only at Soldrodo Rock, Trinidad, where *V. planicosta* has been found.

There are some forms found in the Negritos Formation which resemble species present in the Lutetian and Auversian of France and England, such as species of *Clavilithes*, *Strepsidura*, *Sycum*, *Venericardia*, and *Xanthopsis*. Other species show some resemblance to forms found in the Alpine Middle Eocene, especially to those from Vicenza and Verona (N. Italy); these forms are *Volutospina crassiuscula*, sp. n., *Melanatria dimorphica*, sp. n., *M. venusta*, sp. n., *Bezanconia pupoidea*, sp. n., *Cerithium negritosense*, sp. n., and *Diastoma americanum*, sp. n. Also *Pseudoliva mutabilis*, sp. n., is similar to a species in the Eocene of Algiers. Taken collectively, these resemblances seem to be of significance in connection with the relationship noticed, by various writers,[1] between the Tertiary faunas of the West Indies and the Mediterranean region. The two elements in the Negritos fauna—(1) resembling the Eocene of the Eastern and Gulf States of America and Western Europe, and (2) resembling the Eocene of Southern Europe—would be explicable on the assumption of a Transatlantic Ocean with a northern and southern shore-line.[2]

[1] See, for example, P. M. Duncan, *Quart. Journ. Geol. Soc.* xxiv. (1868), pp. 26-33; J. W. Gregory, *ibid.* li. (1895), pp. 306-309. Revised names of the corals are given by T. W. Vaughan, *U.S. Nat. Mus. Bull.* 103 (1919), pp. 228-237 and in the systematic descriptions following.

[2] E. Haug, *Traité de Géologie*, ii. (1908–11), pp. 1525, 1560, and Map Fig. 431.

2. The Lobitos Formation

The fossils in the Lobitos Formation are less abundant and not so well preserved as those in the Negritos Formation, and it has not been possible to determine the species in all cases. The greater part of the fossils examined were collected from the lowest 1000 feet of the formation, east of Negritos. These, and the specimens from the Payta and Sullana districts, show a close connection with the Clavilithes Series of the Negritos Formation. Nearly all these species are either the same as or only slightly different from those found in the Clavilithes Series, and indicate correlation with a part of the Claiborne Group. *Venericardia planicosta* although uncommon is still represented. *Volutospina peruviana*, sp. n., of the type which occurs in the Parinas Sandstone, is present. Other species which connect the Lobitos Formation with the Negritos Formation are *Turritella annectens*, sp. n., *Strepsidura pacifica*, sp. n., *Clavilithes pacificus*, sp. n., *C. Harrisi?*, *C. incertus?*, *Volutospina meridionalis*, sp. n., *Morgania magna?*, *Pseudoliva parinasensis*, sp. n., *Callianassa americana*, sp. n. Part of an unstalked Crinoid has been found in the Lobitos Formation.

At Lagunitas, the horizon of which is believed to be considerably higher, the species are mainly different from those of the Negritos Formation. *Nassa lagunitensis*, sp. n., is found here and probably also in the lower beds of the Lobitos Formation. *Strepsidura* is represented by small weathered specimens which may belong to *S. pacifica*. Species which are confined to

TABLE SHOWING RANGE OF MOLLUSCA AND CRUSTACEA IN THE NEGRITOS AND LOBITOS FORMATIONS—*continued*.

	Negritos Formation.			Lobitos Formation (between Talara and Payta)		
	Turritella Series.	Clavilithes Series.				
	Shales with Pebble Seams.	Shales with Pebble Seams.	Parinas Sandstone.	Lowest 1000 feet around Negritos.	Horizons exposed at Payta and W.N.W. of Sullana.	Horizon exposed near Lagunitas, and higher beds.
GASTEROPODA—*continued*						
Calyptrophorus (*Aulacodiscus*) *Lissoni*, Douvillé		o				
Dientomochilus (*Ectinochilus*) sp. cf. *laqueata* (Conr.)					p	
Pseudoliva parinasensis, sp. n.	o	o	p	p	p	
" *mutabilis*, sp. n.	p	p	p		(?)	p
Nassa lagunitensis, sp. n.						(?)
Strepsilura pacifica, sp. n.	p	q	p	p		(?)
Clavilithes Harrisi, sp. n.		o		(?)		
" *peruvianus*, sp. n.	?	q	p	o		
" *pacificus*, sp. n.		p	q	p		
" *incertus*, sp. n.		p	o	(?)		
Sycum americanum, sp. n.			p			
Volutospina peruviana, sp. n.	p	q	p	o	p	
" *crassiuscula*, sp. n.	p					
" *meridionalis*, sp. n.		o		p		
Olivancillaria eocenica, sp. n.	p	q	p			
" (*Agaronia*) *peruviana*, sp. n.					(?)	p
Surcula occidentalis, sp. n.	o	q	p			
" *Thompsoni*, sp. n.		p				
Conus (*Lithoconus*), sp.					p	
CEPHALOPODA						
Aturia, sp.	p	p				
CRUSTACEA						
Callianassa parinasensis, sp. n.				p		
" *americana*, sp. n.	q	q				
Xanthopsis errans, sp. n.		q				
Thaumastoplax eocenica, sp. n.		o				

EXPLANATION

o denotes fossil was found occasionally,
p " " " " plentifully,
q " " " " in quantities.

CHAPTER II

DESCRIPTION OF THE LAMELLIBRANCHIA FROM THE NEGRITOS AND LOBITOS FORMATIONS

FAMILY LEDIDÆ

Genus LEDA, Schumacher.

Leda ingens, sp. n.

Plate I., Figs. 1-3.

Description.—Shell inflated; length a little less than twice the height. Umbones nearly median, turned posteriorly. Behind the umbones is an elongate-ovate depressed area, without ornamentation. Anterior margin of valves rounded, passing gradually into the convex ventral margin which makes a small sinuosity where it joins the posterior (or rostral) prolongation; this prolongation is relatively short, compressed, and with the posterior margin vertically truncated.

The ornamentation consists of strong concentric ribs which make an obtuse angle with the nearly vertical ribs of the rostral prolongation; the ribs on that part are narrower, sharper, and less numerous than those on the flanks.

Remarks.—This species shows some resemblance to *Leda alæformis* (Gabb)[1] from the Martinez Group of California,[2] but the shell is relatively less elongate, the rostral part is less produced, the convexity of the ventral border (and the concentric ribs) is continued farther back so that the postero-

[1] *Geol. Surv. California Palæont.* vol. ii. (1869), p. 177, Pl. XXIX. Fig. 63. T. W. Stanton, "Faunal Rel. of Eoc. and U. Cret. Pacific Coast," *17th Ann. Rep. U.S. Geol. Surv.* (1896), p. 1040, Pl. LXIV. Figs. 6, 7. C. A. Waring, *Proc. California Acad. Sci.* (4), vii. (1917), p. 76, Pl. XII. Fig. 12.

[2] For distribution, see R. E. Dickerson, "Fauna of Martinez Eocene," *Univ. Calif. Publ. Bull. Geol.* viii. (1914), p. 107.

SECTION B

CRUSTACEA FROM THE EOCENE DEPOSITS OF PERU

By Henry Woods, M.A., F.R.S.

CHAPTER VI

DESCRIPTION OF THE DECAPOD CRUSTACEA FROM THE NEGRITOS AND LOBITOS FORMATIONS

Genus Callianassa, Leach.

Callianassa parinasensis, sp. n.

Plate XVII., Fig. 4.

Description. — Left cheliped: hand nearly oblong, upper and lower margins with sharp edges, the upper curved, the lower nearly straight; external surface of hand evenly convex and apparently smooth, but with a tooth-like projection at the distal end near the base of the movable finger. Fingers about half the length of the hand, both curved inwards; free finger with a tooth near the proximal end, fixed finger apparently without teeth. Carpus equal to the hand in length, upper margin nearly straight, the lower curving upwards at the proximal end; a row of minute and widely separated tubercles occurs near the lower and proximal margins. Merus a little shorter than the carpus, much narrower, especially at the distal end, lower margin very convex. Ischium long, slender, the outer surface with granulations.

Remarks.—This species is represented by four left chelipeds, of which two showing the external surface are fairly well

preserved. *C. Stimpsoni*, Gabb,[1] has been found in the Tejon Group (Eocene) of California[2]; the figures published show only an imperfect hand, but it appears to be quite distinct from the species here described.

Distribution.—Bottom of Lobitos Formation at Punta Parinas.

Callianassa americana, sp. n.

Plate XVII., Figs. 5, 6.

Description.—Hand quadrate and nearly rectangular in outline, its length equal to or rather greater than its breadth. Edge of the upper and especially of the lower margin sharp. Outer surface nearly uniformly convex; inner surface with the middle and upper part convex, the lower part concave, the middle part with numerous small tubercles. Fixed finger slender, sharp, only slightly curved, shorter than the hand. Movable finger stout, with the inner margin sharp and produced into three teeth.

Remarks.—This species appears to be distinct from the forms already known,[3] but is represented only by chelæ (which are numerous), and occasionally by a part of the carpus. It resembles in form *C. Scotti*, Brown and Pilsbry,[4] from the Gatun formation (Miocene) of Panama.

Distribution.—Turritella Series and Clavilithes Series, around Negritos; a portion of a chela (probably of this species) from the Lobitos Formation, one mile south of Talara.

Genus Xanthopsis, M'Coy.

Xanthopsis errans, sp. n.

Plate XVII., Figs. 7-10.

Description.—Carapace transversely oval, broader than long, considerably convex from front to back, moderately from side to side. Lobes not distinctly limited, but broad

[1] *Geol. Surv. California Palæont.* i. (1864), p. 57, Pl. ix. Fig. 1; ii. (1869), p. 127, Pl. xix. Fig. 3.

[2] Heilprin, *Contrib. Tert. Geol. and Pal. U.S.* (1884), p. 102. Stanton, "Faunal Relations Eoc. and Upper Cret. Pacific Coast," *17th Ann. Rep. U.S. Geol. Surv.* (1896), p. 1030.

[3] A list of fossil species of *Callianassa* is given by Böhm, *Zeitschr. Deutsch. Geol. Gesellsch.* lxiii. (1911), *Monatsber.* p. 42.

[4] *Proc. Acad. Nat. Sci. Philadelphia*, lxiv. (1912), p. 503, Pl. xxii. Figs. 1-3.

deep depressions bound laterally the cardiac and posterior gastric regions and broaden out posteriorly. The nodules on the protogastric region are only slightly raised; the one on the mesogastric region is a little more distinct; the urogastric nodule is more elevated and is near the mesogastric; on the cardiac region there are two prominent nodules, of which the anterior is about midway between the urogastric and the posterior cardiac nodule. Inner epibranchial nodule large, near the urogastric nodule; outer epibranchial nodule smaller, farther forward, about half-way between the inner nodule and the antero-lateral margin. Mesobranchial nodule small but prominent, almost in a direct posterior line with the outer epibranchial nodule. Metabranchial nodule large, prominent, near the posterior margin but not quite so far back as the posterior cardiac nodule.

Antero-lateral margins regularly convex, rather longer than the postero-lateral margins, with three lateral spines, of which the posterior is prominent and pointed, the middle one smaller, and the anterior one small and inconspicuous; sometimes in front of this is an indication of a fourth spine. Orbits rounded, with a spine-like projection externally. Front projecting forwards, with four prominent teeth, of which the two inner are nearer together and rather more prominent than the two outer. Surface of carapace finely punctate.

The upper margin of the hand of the right cheliped bears a row of about six small tubercles; external to this row is a shallow furrow limited by a slight ridge, which in places is tuberculate. Outer surface of hand convex, with four conspicuous tubercles; one on the distal part at the level of the division between the fixed and movable fingers, the other three on the posterior third forming an oblique row parallel to the posterior proximal border of the hand. Fingers with rounded teeth.

Affinities.—This species belongs to the group which includes *Xanthopsis Leachi* (Desm.), *X. nodosa*, M'Coy, *X. Dufouri*, M.-Edw., *X. unispinosa*, M'Coy, *X. tridentata* (Meyer), and *X. sonthofenensis* (Meyer). A. Milne-Edwards [1] was inclined to regard all of these as varieties of one species, *X. Leachi*. Of the forms mentioned the species now described approaches most nearly to *X. Dufouri*, Milne-Edwards,[2]

[1] *Hist. Crust. Podophthal. Fossiles*, i. (1861–65), p. 270. [2] *Ibid.* p. 255, Pl. XIV.

from the Lower Lutetien of Saint Sever (Landes); the chief points of difference are: the carapace is relatively broader, the urogastric nodule is a little more posterior in position, the outer epibranchial nodule is farther forward and farther from the antero-lateral margin, and the mesobranchial nodule is farther from the postero-lateral margin.

Miss Rathbun [1] states that specimens of an undescribed species of *Xanthopsis* have been found in the Eocene of Alabama, and she has recently described a new species from the Eocene of St. Bartholomew, West Indies.[2] With these exceptions, no example of this genus, which is so common in Europe, appears to have been hitherto recorded from the Eocene deposits of North or South America.

Distribution.—The "Crab Bed," in the Clavilithes Series, about 1000 feet above the base, one mile east of Negritos.

Genus THAUMASTOPLAX, Miers.

Thaumastoplax eocenica, sp. n.

Plate XVII., Fig. 11.

Description.—Carapace rather more than one and a third times as broad as long; very convex from front to back, slightly convex from side to side; sides with sharp edges; regions not defined. Orbits nearly as wide as the front. Antero-lateral margin forming a regular curve; postero-lateral margin slightly curved; posterior margin nearly straight. A curved lateral furrow is seen on each side of the middle of the carapace a little behind the centre; between the furrows in front are two elongate oblique tubercles, and behind are two small rounded tubercles. Chelipeds short and stout.

Remarks.—Only one specimen of this species has been found; most of the carapace has been lost, leaving an internal cast. The chelipeds are fairly preserved, and a portion of one of the walking legs on the left side.

This species is provisionally referred to the genus *Thaumastoplax* (Family Goneplacidæ) on account of the close resem-

[1] *Bull. Geol. Soc. America*, xiii. (1902), p. 44.
[2] "W. Indian Tert. Decapod Crustaceans," *Carnegie Inst. Publ.* 291 (1919), p. 176, Pl. VIII. Fig. 8.

blance in the form of the carapace to that of the type species; the specimen gives no indication of the number of the walking legs, but the shortness of the carapace suggests that only three were present. The type of *Thaumastoplax* (*T. anomalipes*, Miers [1]) is in the British Museum (Natural History), and through the kindness of Dr. W. T. Calman I have been able to compare it with the fossil form. A specimen from the Culebra Formation (Oligocene) of the Panama Canal zone has been referred by Miss M. J. Rathbun [2] to the *Thaumastoplax*, but it does not resemble the type species so closely as does the specimen here described.

Distribution.—The " Crab Bed " in the Clavilithes Series about 1000 feet above the base, one mile east of Negritos.

[1] E. J. Miers, *Ann. Mag. Nat. Hist.* (5), viii. (1881), p. 261, Pl. XIV. Fig. 2.
[2] *Bull. U.S. Nat. Mus.*, 103 (1918), p. 176, Pl. LXVI., Figs. 15-18.

SECTION C

AN ECHINOID FROM THE EOCENE DEPOSITS OF PERU

By HERBERT L. HAWKINS, D.Sc.

CHAPTER VII

A NEW SPECIES OF ECHINOID FROM THE LOBITOS FORMATION

FIVE small Echinoids from the Lobitos Formation of Peru were sent me for examination. These were collected near Punta Parinas, from a seam just above a Crustacea Bed, near the base of the Lobitos Formation. They are quite free from matrix (except internally), but have lost almost all their surface detail through weathering. They seem all to belong to one species. One specimen (No. 2) has been dissected in an endeavour to determine its generic position, but crumbling of the test made the attempt unsuccessful. On most external evidence the forms belong to *Echinocyamus*, but it was impossible to recognise with certainty either the perignathic girdle or radiating partitions in the specimen broken. If the latter features are really absent, the form would be more of a *Fibularia*; but the flatness of the test makes

PLATE XVII.

Figs. 1, 2.—*Surcula Thompsoni*, sp. n. Clavilithes Series, near Negritos. (P. 107.)

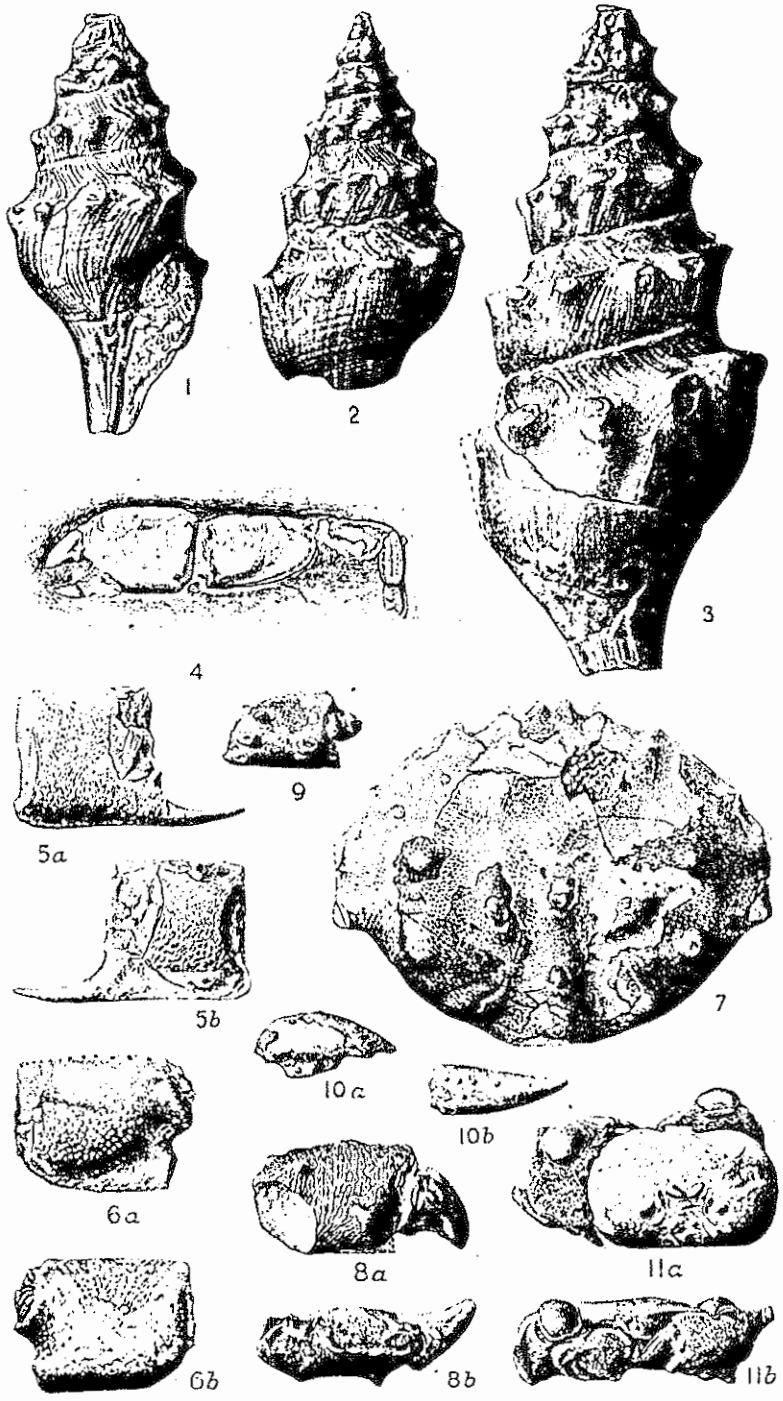
Fig. 3.—*Surcula Thompsoni*, var. Turritella Series, near Negritos. (P. 108.)

Fig. 4.—*Callianassa parinasensis*, sp. n. Bottom of Lobitos Formation, Punta Parinas. Left cheliped. (P. 114.)

Figs. 5, 6.—*Callianassa americana*, sp. n. Clavilithes Series, near Negritos. (P. 115.)

Figs. 7-10.—*Xanthopsis errans*, sp. n. Clavilithes Series, 1 mile E. of Negritos. Figs. 8, 9, Chelæ; Fig. 8*b*, upper margin of Fig. 8*a*. Fig. 10*a*, *b*, Dactylos. (P. 115.)

Fig. 11.—*Thaumastoplax eocenica*, sp. n. Clavilithes Series, 1 mile E. of Negritos. Fig. 11*b*, Anterior view of 11*a*. ×1½. (P. 117.)



T. A. Brock del.

EOCENE GASTEROPODA AND CRUSTACEA.