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**Age and Stratigraphic Significance for Lyellian Correlation
of the Fauna of the Vigo Formation, Luzon, Philippines**

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DEDICATION

This paper is dedicated to the memory of Frank E. Merchant, paleontologist from 1939 to 1941 for the Philippine Bureau of Mines and the Philippine National Development Company, in association with the present authors. With our advice and encouragement, he planned to undertake the study and description of the rich and beautifully preserved, but little known Philippine later Tertiary faunas. In furtherance of this work, he had been awarded a scholarship at the California Institute of Technology and was on the point of returning to America to begin his studies when World War II broke out. He immediately joined the American Army in Cebu, was captured and interned in a military prison, and died a few weeks afterward of dysentery, pneumonia, and brutal treatment.

With his death, the science of paleontology lost a most promising neophyte, his country a scholar and patriot, and his associates a fine and valued friend.

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ABSTRACT

Popenoe, W. P., and R. M. Kleinpell. Age and stratigraphic significance for Lyellian correlation of the fauna of the Vigo Formation, Luzon, Philippines. *Occasional Papers of the California Academy of Sciences*, no. 129, 73 pages, 4 text-figs., 18 plates, 1 table, 1978. —Roy E. Dickerson, in two papers published in 1921, theorized that tropical Tertiary molluscan faunas evolved much slower than did faunas of temperate regions and that, hence, the percentage of Recent species in later Tertiary tropical faunas is higher than in contemporaneous faunas from temperate regions. This theory, derived from analysis of a tropical Philippine fauna of inferred Miocene age, has been frequently cited but never critically evaluated.

Studies of Philippine and Indonesian Tertiary molluscan and foraminiferal faunas collected since Dickerson's time and accurately placed stratigraphically indicate that the Philippine molluscan faunas that Dickerson believed to be of Miocene age are more probably later Pliocene or possibly Pleistocene in age, with a percentage of extinct species differing not very greatly from the percentages established by Lyell and Deshayes for contemporary faunas of Europe. The theory that tropical molluscan faunas evolve at a markedly different rate from those of temperate regions is therefore without foundation and is probably erroneous.

INTRODUCTION

In 1921 the late Roy E. Dickerson wrote two papers that have had a marked influence upon subsequent writing in the field of Cenozoic correlation by fossils and the field of organic evolution as a whole. These papers were devoted to the fauna of the Neogene Vigo Group, Philippines, and its bearing on the evolution of marine molluscan faunas (Dickerson 1921a, 1921b).

Dickerson was at that time Honorary Curator in the Department of Paleontology at the California Academy of Sciences in San Francisco, California. It was a period of active and widespread geological exploration for petroleum. In the Philippines, because of known surface seepages and suitable structural and stratigraphic conditions (see Pratt and Smith 1913), the Bondoc Peninsula of southeastern Luzon had been receiving more than ordinary exploratory attention, especially by the Richmond Petroleum Company, a subsidiary of the Standard Oil Company of California (see Moody 1922). By 1921, Dickerson had been able to collect, study, and publish upon a considerable fauna of fossil mollusks collected from the Canguinsa Formation and Vigo Group from the south part of this Bondoc Peninsula. His record of these data and their significance first appeared in January 1921 in the *Philippine Journal of Science* (Dickerson 1921a) and, again, with very slight modification, the paper appeared in July of the same year in the *Proceedings of the California Academy of Sciences* (Dickerson 1921b).

In the first of these two papers, Dickerson (1921a) questioned "the time rate of evolution of Tertiary molluscan faunas" and followed with a brief description of the geologic history of his collection area. He then listed the faunas from six localities within the upper part of the Vigo Group. Of the 128 forms which he tabulated in a "partial list of species from the Vigo Group," Dickerson noted that "there are 98 forms that are specifically determined and of these 74 or 75.5 per cent are living species, an astonishing number when the geologic history of the region yielding these forms is considered. In addition, the extinct forms are practically all common to the upper Miocene of Java, according to K. Martin." (Ibid.: 10-12)

In pursuit of the age of the Vigo Group, Dickerson (1921a: 12-16) gave evidence from earlier collections of fossil mollusks from elsewhere in the Philippines and from Java. He further added

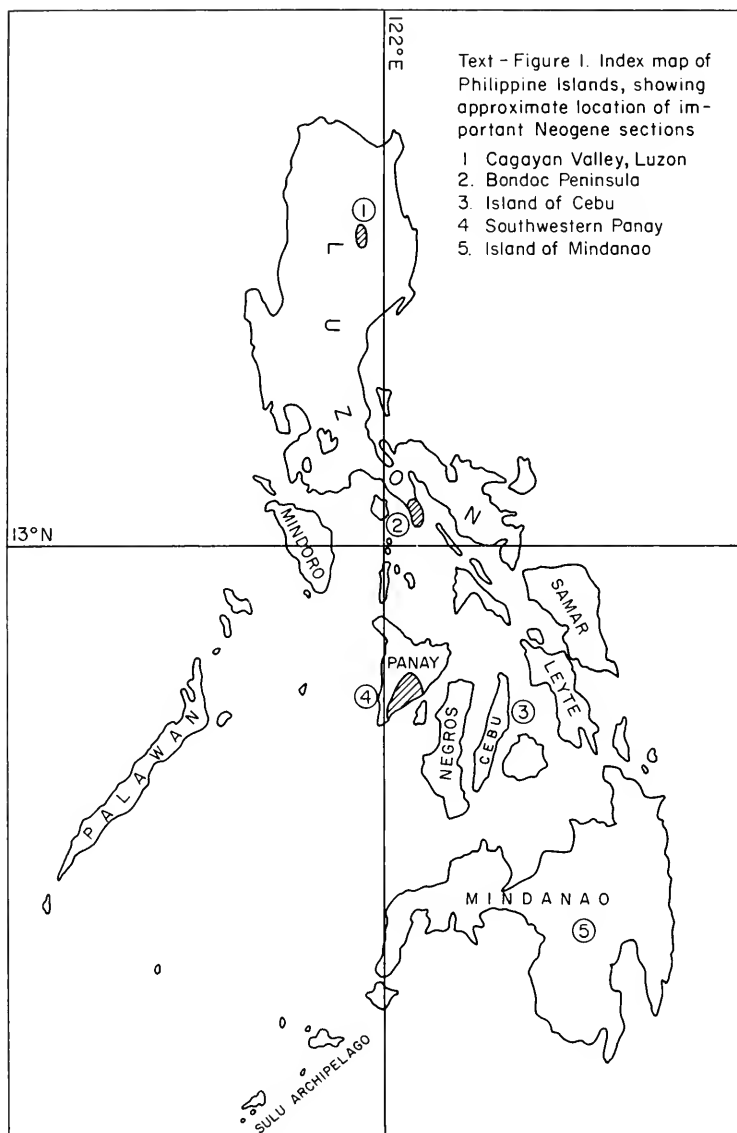
stratigraphic evidence from earlier recordings of larger foraminifers, principally cycloclypeids and lepidocyclinids, and of the algal reef-limestone-builder, *Lithothamnion ramosissimum* Reuss. These data led him to the first of his two most significant conclusions (ibid.: 16): "From all the evidence Canguinsa and Upper Vigo beds may be assigned to some stage of the Miocene, and the evidence of *Lepidocyclina* indicates a still greater age, the Oligocene."

With the age of the mollusk-bearing strata thus determined, Dickerson then discussed the "importance of guide fossils," "factors promoting evolution of pelecypods and gastropods," "comparison of life conditions during Vigo-Miocene time with those of Recent time," and "crowding of species and the Recent fauna of the Philippines" (ibid.: 16-20). A summary paragraph in which is embodied the second of his major conclusions followed:

The tentative conclusion of the writer is that in the study of Tertiary faunas of the Tropics a different percentage scale must be used. For the later Tertiary, Miocene, Pliocene, and Pleistocene the percentages which apply in the temperate regions to the Pliocene are roughly adaptable to the Miocene; similarly, the percentages which apply in the temperate regions to the Pleistocene are apparently those of the Pliocene of the Tropics. This apparent lack of faunal differentiation during the Tertiary in the Tropics is due to uniformity of temperature, salinity, food, and other life essentials. From another viewpoint the rate of evolution of gastropods and pelecypods in the Tropics during the Tertiary was far less than during this same time in the more rigorous environs in the temperate zones. The tropical or subtropical faunas [of the Eocene] of the Pacific Coast of North America exhibit but slight differences compared to the faunas of Miocene and Pliocene age of this same region, and the writer ascribes this to the uniformity of life conditions which prevailed during Eocene time. The amount of faunal change must not be used as a measure of time in the whole of the Tertiary, but in measuring the tropic and subtropic faunas differently marked scales are necessary for the Eocene and the Oligocene than for the Miocene, the Pliocene, and the Pleistocene. It is particularly noteworthy that the Japanese paleontologists are now searching for comparisons with the Pacific Coast of North America and Australia rather than with Europe. In other words, many problems of the tropical Orient will be solved only when conditions on both sides of the Pacific become better known [Dickerson 1921a: 20-21]

Subsequently, Dickerson (*in* Smith 1924: 315) summed up his conclusion more succinctly with respect to the significance of the Vigo fauna:

As noted above, the percentage of Recent species is remarkably high and, from a detailed study of the subject, I conclude that the evolution of marine molluscan faunas in the Tropics is far slower than in Temperate Zones . . .



On this account the same 'yardstick' in the Tertiary geologic time scale cannot be applied in both tropical and temperate regions.

Since Dickerson's time, several papers devoted to various aspects of the Philippine Tertiary have appeared (see References Cited). In many of these, conclusions as to the age and correlation of the Canguinsa Formation and Vigo Group have not agreed with Dickerson's Miocene age assignment (e.g., Corby et al. 1951; Irving 1952; Cloud 1956), yet, few have focused

on the basis for Dickerson's age assignment of the Vigo fauna or considered alternative correlations. Of greater interest and significance, however, is the wide extent to which the second and more far reaching of Dickerson's conclusions has been circulated and tacitly assumed to have been demonstrated; this concerns a differential in so-called "rates of evolution" in Tropic and Temperate zones and the consequent supposed irrelevancy of Lyellian principle to interregional Tertiary correlation. As an example,

the reader need go no further afield than a passage from what in all probability is as sound and as comprehensive a textbook in stratigraphic geology as any of the few that are currently available. In summarizing the origin of the terms currently employed to designate the series subdivisions of the Cenozoic, Dunbar and Rodgers (1958: 282) note that "Lyell's subdivision of the Cenozoic into Eocene, Miocene and Pliocene Series was based primarily on the percentage of still living species in the several faunas [although] from the first, he used guide fossils as well as the percentage of recent species in recognizing these main subdivisions of the Cenozoic."

In a second paragraph they added:

As study of the faunas of these and other areas progressed, and the gaps between the Eocene, Miocene, and Pliocene Series were in part filled by adding the Pleistocene, Oligocene, and Paleocene Series to the sequence, the characteristic proportions of living species cited by Lyell were modified from time to time and gradually this basis of classification and correlation lost its significance, yet the names have stuck. One of the most searching criticisms of the method is that of Dickerson (1921) who found that faunal changes and extinction during the Cenozoic Era have been more rapid in the Temperate Zone than in the Tropics, so that percentages worked out in western Europe are not usable in lower latitudes. [Dunbar and Rodgers, 1958: 282]

Finally, since this paper was submitted for publication, Shuto (1975: 296) has written: "*Bondoc Peninsula*: The Canguinsa formation seems to range, at least, from Preangerian to Miocene/Pliocene transition as suggested by the molluscan assemblages from Loc. 2, 3, 4, and 5 of DICKERSON (1921)."

During the years 1939–1941, we had occasion to study Tertiary fossils, including foraminifera and mollusks, from the Bondoc Peninsula, Luzon. The senior author also collected smaller foraminifers and mollusks from localities that were reported by Dickerson. In comparing these fossils from Dickerson's original localities with those from other areas then being collected by the Philippine Petroleum Survey, it became apparent that Dickerson's conclusions as to the age of the Canguinsa and upper Vigo mollusks were too theoretical to accommodate the evidence available. Evidence from mollusks and larger foraminifers, and evidence from the superpositional relationships of all three kinds of fossils in the Bondoc Peninsula and elsewhere did not support his conclusions. A further comparison with the faunas of the Malay Archipel-

ago only served to emphasize these discrepancies in correlation. If Dickerson's Miocene age assignment of the Vigo-Group mollusks was erroneous, his major conclusion concerning rates of evolution was automatically affected, and especially so his conclusion concerning a supposed invalidity of the principle of Lyellian correlation.

It is our aim to here focus upon those facets of the paleontological data that bear upon Dickerson's major conclusions and to critically evaluate the basis for those conclusions, especially in light of the additional evidence available. Hopefully, through such a synthesis, clarification of the significance of these data may be made, not only for the geology, stratigraphy, and paleontology of the Bondoc Peninsula Tertiary, but also for the principles of Lyellian Tertiary correlation by fossils and for those of organic evolution as a whole.

We begin with the data and criteria which led Dickerson to conclude that his 98 specifically identified fossil mollusks from the Canguinsa Formation and Vigo Group were of Miocene age.

STRATIGRAPHY AND PALEONTOLOGY:
AN HISTORICAL REVIEW

EVIDENCE AND CRITERIA FOR THE PREVIOUS
RECOGNITION OF MIOCENE ON THE BONDOK
PENINSULA, SOUTHERN LUZON

The Stratigraphic Geology.—The marine sedimentary strata exposed in the southern half of the Bondoc Peninsula consist of the lower sequence, the Vigo Group, and an upper, the Malumbang Formation, together with some still higher marine terraces. In general, Dickerson followed Pratt and Smith (1913) who described the stratigraphic sequence in detail.

On the peninsula proper the base of the Vigo is not exposed, its lowermost outcropping beds are those seen about mid-peninsula in the core of a close, principally southward plunging, anticlinorium (see Corby et al. 1951: 282, and pl. 26; Irving 1952: 466; Irving 1953: Section II). In Dickerson's summary (1921a: 3):

The oldest rocks here recognized consist of shales and sandstones from 3,000 to 4,000 feet in thickness, the Vigo group and its uppermost member, the Canguinsa formation. The strata exposed in the vicinity of Vigo River are steeply dipping, black, organic shales, subordinate sandstones, and minor lignitic strata which are unconformably overlain by the Malumbang formation.

The Malumbang formation consisting of coralline lime-

stone and associated marls varies in thickness from small residuals to 1,000 feet. In a few places . . . marine terraces truncate the Malumbang strata. These terraces are in places thickly mantled with coralline limestone of Pleistocene age. Some . . . may represent high Pleistocene terraces. . . . These horizons exhibit the same essential conditions in northwestern Leyte and are beautifully exemplified in the vicinity of Toledo, Cebu, as well.

After briefly comparing some strata in Mindanao with those of the Vigo, Dickerson (1921a: 3) added: "We are not dealing with local conditions but with general ones which existed over the site of these islands. . . . Conditions of deposition during Malumbang and Pleistocene time resembled those existing today in the vicinity of the Bondoc Peninsula, and essentially the same mollusca occur in the coral reef facies of all three. The deposition during Vigo time was in marked contrast with these later times, in that the contributing land masses consisted largely of diorites, schists, and serpentines or peridotites from which they were probably derived." He concludes (*ibid.*: 4) that "the sediments were deposited in the moderately deep waters of an inland sea with high mountainous islands to the east. The total time represented since the beginning of the Vigo is evidently long, and on these grounds as well as faunal, the Vigo group appears to be as old as the Miocene, and the Malumbang probably represents at least a portion of the Pliocene."

Dickerson based his paper on collections from strata that Pratt and Smith referred to the Canguinsa Formation and Vigo Group. He believed that the six fossil mollusk collections were "from strata which are . . . unconformably below the Malumbang formation," and that "there are but few places in these islands where good collections are obtained from localities with satisfactory stratigraphy" (*ibid.*: 4). Dickerson (1921a: 4-9) described the six localities and listed the species associated with each, emphasizing the stratigraphic position in every case insofar as was possible.

Locality 2x [was] on the northeast bank of Bahay River in a 50-foot cliff of yellow sandstone and bluish clayey sandstone disturbed by minor faulting. . . . The Malumbang limestone is found in the hill 100 yards to the northeast and from the the general relations in the field it is clearly unconformable upon the underlying Canguinsa formation.

Locality 3x [was also from the Bahay River but 200 meters upstream from locality 2x and in strata that are] nearly vertical . . . on the southwest bank of stream in a stiff dark gray shale.

Locality 4x, [again from the Bahay River, but] 320 me-

ters east of the mouth of Apad Creek in road cut 60 feet above the river in yellow sandstone, about 50 feet stratigraphically above the . . . lignitic strata of locality 5.

Locality 5 [was also from the Bahay River but] 300 meters east of the mouth of Apad Creek in lignitic gray sandstone which was deposited in brackish water.

Locality 9x [was] on Dumalog Creek . . . in uppermost Vigo just conformably below Canguinsa sandstone in black shale.

Locality 11x [was] on west bank of Sapa Tubiginukot 400 yards upstream from Sapa Yaknes; in soft, yellow sandstone of Canguinsa age. . . . The strata at this point dip west about 20° while the overlying Malumbang, a few hundred feet west, has a gentle dip of 2° to 3°. At other places in this vicinity a notable unconformity separates these two formations.

The Mollusks.—Dickerson (1921a: 10-12) listed the species of mollusks collected at his six localities and noted the percentage of living species represented in the fauna. Fourteen of these were also recorded by Martin (1879-1880) from the upper Miocene of Java—most were considered characteristic of that horizon. Only one other species from Java, *Vicarya callosa* Jenkins, recorded by Martin, was missing from Dickerson's Bondoc Peninsula localities. But Martin (1896), in a subsequent paper, recorded it from apparently the same horizon in the Cagayan Valley of northern Luzon. Two of Martin's collections were from "Minanga," one from "4 miles above Minanga," two presumably from nearby, and the other four from localities even more difficult to relate geographically, as well as stratigraphically, to the others. Dickerson (1921a: 13-14) listed the species from nine of Martin's Cagayan Valley localities (these appear to have been the collecting localities of Semper). Two of these nine localities yielded *Vicarya callosa*; one (locality 8) yielded only this species, the other (locality 2 from "Minanga; right bank of Ilaroen") yielded this species in association with seven others, none of which, however, appear in Dickerson's list from the Bondoc Peninsula. Among the seven, however, four (*Terebra jenkinsi* Martin, *Terebra bandonensis*, *Murex grooti* Jenkins, and *Rostellaria javana* Martin) in addition to *Vicarya callosa* are noted as having their "occurrence . . . in the Tertiary of other parts of the Indian Archipelago" as Miocene (*ibid.*: 14). A passage from Martin's discussion of these mollusks from the Cagayan Valley was included by Dickerson (1921a: 13):

Now, in reviewing Semper's collection, I was at once struck with *Vicarya callosa* Jenkins, which is known from

Java and is described in detail below; and this induced me to make a closer comparison between the fossils of the Philippines and those of the Indian Archipelago, whereby it at once became apparent that a whole series of species, especially of the Javanese Tertiary is common to both regions. Thus far, indeed, I have been unable to make a complete study of Semper's collection, and for the time being it has little further interest, because statements as to stratigraphical position are entirely lacking and the equivalent deposits of neighboring regions are still very insufficiently known. After completion of my monograph on the fossils of Java, however, I hope to undertake a more thorough study of the Philippine fossils, and to supplement this preliminary communication.

From these data, the reader may gather that *Vicarya callosa* may be widespread and of more than ordinary significance in the East Indian Archipelago as a whole, including the Philippines, and that other species, too, appear to be common to these two regions. In short, Dickerson suggests that at least some strata of Miocene age were probably present at some unspecified stratigraphic horizon in the Cagayan Valley (which is more than 200 miles (322 km) north of the Bondoc Peninsula), that the stratigraphic ranges of species, at least in Java, might be stated with more assurance following completion of Martin's monograph on the Javanese fossils, that Java and the Bondoc Peninsula shared several molluscan species in common, that Java and the Cagayan Valley shared several other species in common, and that of these several species, two (viz., *Natica mamilla* Lamarck and *Conus laroisii* Kiener) occurred both in the upper Vigo-Canguinsa sequence of the Bondoc Peninsula and at some stratigraphically unspecified horizon in the Cagayan Valley, none of which, however, carried *Vicarya callosa*.

Dickerson (1921a: 14) concluded his evaluation of the molluscan faunas stating:

The fossils in Martin's list come from nine different localities and the largest number of species from any one locality is ten. According to Martin, the strata in the vicinity of Minanga belong essentially to the same horizon, and he says:

Judging from these facts, the strata of Minanga are to be classed with the upper Miocene bed which exists in Java in the locality denoted by Junghuhn by O and at Selatajan on the Tjilongan.

As was indicated above, many of the fossils from the Bondoc Peninsula are common to this locality O in Java, and the equivalence of the Upper Vigo beds with these Javan beds is evident. Upon the basis of Martin's work, the age of the Vigo beds is upper Miocene.

In a subsequent section, "Importance of guide

fossils," Dickerson added another paragraph having direct bearing on the age of his mollusks.

As will be seen from a study of the fauna cited above, most of the forms which are extinct were originally described from a correlative horizon in Java. Of these, the writer is inclined to think that *Cerithium jenkinsi*, *C. herklotsi*, *C. bandongensis*, *Mitra javana*, *M. jenkinsi*, *M. junghuhnii*, *M. bucciniformis*, *Turris coronifer*, *Terebra bicincta*, *Terebra javana*, *Vicarya callosa*, and *Vermetus javanus* will probably prove reliable guides among the mollusca. [ibid.: 16]

The two cones and the columbellid previously listed from Martin's Javanese localities were omitted here; otherwise the lists are the same. Concerning these twelve species, Dickerson (1921a: 16) notes that "All of these species are representatives of highly organized genera and their extinction during the post-Miocene time was probably due to their inability to obtain life conditions suited to their highly specialized needs."

Before leaving this review of the direct molluscan evidence for the Miocene age of the upper Vigo and Canguinsa molluscan fauna, it seems appropriate to refer again to Dickerson's (in Smith 1924) subsequent discussion of the same Vigo and Canguinsa formations and their mollusks. In Table 24 of that work, Dickerson listed 118 species that he previously (1921) listed from the Bondoc Peninsula Vigo Group, and 119 forms in total. He again stated that "about 75 per cent of the specifically determined forms are living species, an astonishing percentage when the geologic history of the region yielding these forms is considered" (ibid.: 315). Conspicuous, however, in this 1924 list, is the presence of *Vicarya callosa*, previously absent from the Vigo list in his 1921 paper. No Bondoc Peninsula locality for this species was given, though, as in the earlier work, he listed it from other areas in the Philippines (Batan Island, Mindanao, Cebu and "from sandstones, lignites and shaley limestones which dip at an angle of 35° beneath the coralline limestone of Mount Mirador . . . six kilometers west of Baguio northern Luzon" (ibid.: 326-327)). In discussing the age of the Batan Island coal deposits, Dickerson noted that "in the gray shale overlying the East Batan coal seam in the Perseverancia claim, very excellent specimens of *Vicarya callosa* Jenkins and numerous species of *Corbula* were obtained by F. A. Dalburg (Bureau of Science locality No. 7)" (ibid.: 319). On the following page he stated:

... it is my opinion that this Batan coal is essentially of the same age as is the coal of Cebu and of tunnel I4 of Sibuguey Peninsula, Mindanao. At the latter place, Dalburg collected splendid specimens of *Vicarya callosa* Jenkins from the coal seams and shales (Plate 9, fig. 1). *Vicarya callosa* is associated with the coal seams of Cebu and seems to be a form which flourished in brackish water. Whether or not this form is very limited in geologic range is probably open to question, as those forms which have a great geographic distribution frequently have a considerable stratigraphic range as well. It is probably limited to the Vigo group at least; that is, to about 1,000 meters of sedimentary beds, as it never has been reported from the Malumbang formation.

Douvillé places locality 272 in his 11, 2, the *Lepidocyclus* limestone. The Bureau of Science possesses an excellent collection of gastropods and pelecypods from this place collected by Smith, among which the following forms have been identified. [Dickerson in Smith 1924: 320]

and he then lists the following from "Locality F272 (Cebu)": *Bullaria ampulla* (Linnaeus), *Comus* sp., *Cerithium* (Campanile) sp., *Cerithium* sp., *Cerithium jenkinsi* K. Martin, *Cerithium herklotsi* K. Martin, *Cypraea* sp., *Fusinus* sp., *Natica* sp., *Turbinella junghuhnii* K. Martin, *Trochus* sp., *Turbo* sp. a. *Seraphis* sp., *Vicarya callosa* Jenkins, *Voluta innexa* Reeve, *Chione lacerata* Hanley, *Lucina* sp., *Pecten* cf. *lenticinosus* Reeve, *Pecten leopardus* Reeve, *Plicatula imbricata* Menke. Concerning this assemblage he adds, "A brief comparison of these forms with collections from the Vigo group of the Bondoc Peninsula clearly demonstrates essential faunal unity" (ibid.). Of the nine forms specifically identified in this assemblage of twenty forms, three are in common with the earlier (1921) list from the upper Vigo and Canguinsa of the Bondoc Peninsula; four are in common with those listed in the preceding table as from the Vigo Group, the extra species in the latter instance being *Vicarya callosa*.

Further discussion of the age and correlative significance of the upper Vigo and Canguinsa mollusk fauna from the Bondoc Peninsula is left for a later page, when the problem is reviewed in the light of additional data.

The Foraminifers.—The balance of Dickerson's direct paleontological evidence for the Miocene age of the Vigo-Canguinsa fauna of the Bondoc Peninsula consists of foraminifera. For the sake of clarity, the pertinent passages from Dickerson (1921a: 14–15) are quoted in full.

Martin lists the distinctive foraminifera, *Cycloclypeus communis* Martin from his (and Junghuhn's) localities K, L, O, and P.; *Orbitoides gigantea* Martin is from locality

O; and *O. radiata* Martin is from locality K. The localities all represent about the same horizon in Java and it is important to note these forms here, as they are regarded as excellent horizon determiners.

Dr. W. D. Smith [footnote reference here to Pratt and Smith 1913: 330], on the strength of the occurrence of *Cycloclypeus communis* K. Martin and *Lepidocyclus richthofeni* Smith, refers the Canguinsa sandstone to the middle or lower Miocene. His exact statement is as follows:

... The limestone from Mount Morabi ... contains *Cycloclypeus communis* K. Martin, which represents the middle Miocene, and large lepidocycluses some of which are 45 millimeters in diameter and 5 millimeters broad in the thickened central portion. *Lepidocyclus richthofeni* Smith was identified among these. This species has been referred by Douvillé to the lower Miocene.

No definite age determination can be made from the fossils in the Canguinsa sandstone proper. The fossils in the included limestone, however, are well known and have been used in correlation by various authorities. From their presence it is concluded that the Canguinsa sandstone should be placed in the middle Miocene, extending perhaps into the lower Miocene.

In a recent publication, Prof. H. Yabe [footnote reference here to Yabe 1919: 40] gives a full discussion of correlation of these equivalent beds in Cebu, and Smith's and Douvillé's correlation tables are quoted. It is noteworthy that the beds under discussion are classified by Douvillé as Aquitanian. All who have studied the large foraminifers from the Philippine Islands agree that one of the characteristic genera is *Lepidocyclus*. Cushman [footnote reference here to Cushman 1918: 115] in a recent paper makes the following significant statement:

Because, in general, *Orbitoides* with some modification to be noted in a future paper, is Cretaceous, *Ortho-phragmina* Eocene and *Lepidocyclus* Oligocene, much importance is attached to these organisms in the investigation of problems of geologic correlation.

For the purpose of placing Dickerson's criteria for age and correlation in their relevant context here, it needs to be noted that *Cycloclypeus communis*, *sensu lato*, ranges geologically from Oligocene to Recent (see Corby et al. 1951: pl. 31; and Cole in Ladd and Hoffmeister 1945: 280, for a distinction between the "*C. communis*" of Douvillé and that of Martin; and see also Cole, op. cit.: 273, 279), and that the "limestone from Mount Morabi" referred to by Smith is at the very least stratigraphically 1,000 ft (305 m) (and probably more than 2,000 ft (610 m)) below the base of the Canguinsa Formation as used by Pratt and Smith (1913) and by Dickerson (1921a).

Dickerson (in Smith 1924: 309–322) made further reference to the foraminiferal evidence for a Miocene age for this fauna under the subheading "*Lepidocyclus* limestone facies of the Vigo group." He discussed, under this subheading,

Douvillé's classification of foraminiferal samples collected by W. D. Smith from Batan Island (Caracaran, locality 2, and the soft sandy yellowish limestone of Gaba Bay, locality 8) and from the islands of Cebu (Sibul Gulch, old Alpaco Mine, locality 273; limestone of Guila-Guila, locality 278; limestones of the Barrio of Mesaba, locality 272; limestones of the valley of Cumajumayan, locality 28; the Compostella Mine, locality 289; along the road from Toledo to Cebu, on the edge of the Minanga River, locality 277, near camp 1; and the "very soft white limestone which runs along the cordillera central of Cebu Island, Valley of Cotabato," locality 279). Douvillé had concluded that these large foraminifers ranged in age from Oligocene Stampian to Miocene Burdigalian. Following a discussion of the stratigraphic relationships of these larger foraminifers to the associated mollusks, Dickerson (op. cit.: 321) returned to the large Foraminifera which "Smith reported . . . from Bondoc Peninsula from beds of Canguinsa age." Here Dickerson quoted part of an earlier (1921) passage referring to "the limestone from Mount Morabi," but without W. D. Smith's earlier qualification as to the age of "the fossils in the Canguinsa sandstone proper." Concerning these, Smith had clearly stated, "No definite age determinations can be made from them." Dickerson then added, in this (1924) paper,

This *Lepidocyclina* fauna occurs in the upper portion of the Vigo group, the Canguinsa formation [sic]. This formation in the same region has yielded a large part of the mollusks reported above, and it is clear that the vertical range of the large representatives of the genus *Lepidocyclina* is much greater than Douvillé suspected.

H. Yabe [footnote reference here to Yabe 1918: 2], in a recent publication, recognizes this possibility and he reviews the case as follows:

L. Rutten studied foraminiferal rocks from southern and eastern parts of Borneo and found it necessary to modify somewhat H. Douvillé's correlation of the Tertiary rocks, because *Lepidocyclina* appeared to have a more extended vertical range than was believed by Douvillé. Thus, the oldest Miocene and Oligocene deposits, according to Rutten, are characterized by *Lepidocyclina*s of larger and smaller sizes, while the smaller ones alone are found together with *Miogyopsina* in all parts of Miocene deposits except the lowest division.

Rutten [footnote reference here to Rutten 1911-1914: 287] presents a table in his paper which is copied by Yabe. Yabe [footnote reference here to "659," apparently Yabe 1919: 37-51] in another and later paper upon the *Lepidocyclina* limestone from Cebu, recognized *Lepidocyclina* (*Nephrolepidina*) *angulosa* Provale associated with *Lepidocyclina monstrosa* Yabe, *Lepidocyclina formosa* Schlumberger, and several other Foraminifera. It

is evident from this assemblage that the section *Nephrolepidina* is not restricted to the uppermost horizon, as Douvillé thought.

Briefly, in conclusion, then, the *Lepidocyclina* limestone is equivalent to the shales and sandstone of the Vigo group and the molluscan faunas of the latter beds are equivalent to the large-sized *Lepidocyclina* fauna of Cebu. In other words, the limestones, shale, sandstones, and coal are different depositional facies within the same group, the Vigo of probable middle and upper Miocene age.

Again, the systematics here involved could be clarified to advantage. Clearly, the bearing of these *Lepidocyclina*-carrying limestone beds upon the age of the upper Vigo and Canguinsa mollusk fauna of the Bondoc Peninsula is one of superpositional relationships. Needless to say, the islands of Batan, Cebu and Mindanao are many miles removed from each other as well as from the Bondoc Peninsula and, similarly, the Cagayan Valley and the Baguio area of northern Luzon are distantly removed. Even Mount Morabi is about five miles (8 km) from the Canguinsa mollusk-bearing outcrops. Pratt and Smith recognized an unconformity at the base of the Canguinsa which intervenes stratigraphically between the orbitoidal limestones in reference and most of the mollusk-bearing Canguinsa strata. However, Dickerson clearly disagrees with Pratt and Smith regarding the presence of this unconformity. In his 1921 paper the particulars are vague: "The writer's view concerning the stratigraphy of the region under discussion differs in this regard from that of Pratt and Smith, but a full exposition of this important point cannot be given here" (Dickerson 1921a: 3, footnote). But in his subsequent paper (1924), Dickerson's views are made clear.

I am not in agreement with Pratt and Smith concerning the stratigraphic relations of the Malumbang, Canguinsa, and Vigo in their type localities, Bondoc Peninsula. I believe that a great unconformity exists between the Malumbang and the underlying Vigo group. I failed to recognize an unconformity between the Canguinsa formation and the Vigo shale, although the areas cited by Pratt and Smith were critically examined. The relations that appear at these places are best explained by faulting. On this account the term "Vigo" is widened to include the Canguinsa formation as its upper sandstone facies, thus raising the term Vigo to a group rank. [Dickerson in Smith 1924: 313, footnote]

Subsequent field studies by the present authors and the field parties of the Philippine Petroleum Survey and the Philippine Oil Development Company have indicated the

controversial unconformity to be local, with elsewhere a local sandstone and fine sandy conglomerate occurring gradationally between the underlying dark claystone of the Vigo and the lowermost beds of the Canguinsa, *sensu stricto*. At one locality a single small outcrop of volcanic agglomerate occurs at the horizon of Pratt and Smith's "unconformity" at the base of the Canguinsa, *sensu stricto*. Yet, whether a mere diastem is reflected, or a hiatus of greater magnitude indicated, is not clear from the physical evidence. In any event, the notable geographic distance between the respective fossil localities and the intervening stratigraphic interval of at least 305 m, and probably more, both remain.

Thus, the residue of evidence for the contemporaneity of the mollusks and larger foraminifers stressed by Dickerson is of two kinds: one, indirect evidence involving species from widely separated islands that are interpreted to be correlative, although many of the forms involved turn out to be long-ranging species and the diagnostic species were absent in the critical localities; the other is direct evidence involving occurrences within a single formation, the Vigo, raised to group rank by Dickerson and supposedly "from 3,000 to 4,000 feet in thickness" (Dickerson 1921a: 3), though not at all clearly at the same stratigraphic horizons within that group or formation.

The Algae.—The remaining paleontologic evidence for the Miocene age of the upper Vigo and the Canguinsa mollusk fauna of the Bondoc Peninsula is clearly indirect, though again superpositional since it involves the presence of *Lithothamnion ramosissimum* Reuss in the lower limestone of the overlying Malumbang Formation. But from Dickerson's discussion, it is apparent that even he came to regard the stratigraphic significance of this fossil as equivocal. Concerning this, Dickerson (1921a: 15–16) first quoted Pratt and Smith (1913: 327), then Yabe (1918: 14), in the following passages:

Pratt and Smith state the case as follows:

The most conclusive evidence as to the age of the Malumbang series is found in the Lower limestone, which, on the basis of the fossil *Lithothamnion ramosissimum* Reuss . . . may be assigned to the Miocene. The upper beds in the series are apparently as young as the upper Miocene or Pliocene. The formation is similar to the "étage marneux" which Verbeek assigns to the middle stage of the upper Tertiary for Java.

Concerning the range of this species, Prof. H. Yabe . . . notes the following:

This reef building organism is very often cited from the limestone of the Oligocene and Miocene ages of the Indo-Pacific region, its occurrence being known from Japan, the Philippines, Borneo, Timor, Amboina, New Guinea and adjacent islands, New Hebrides, Victoria, the Christmas Is. etc.

In Japan it is found not only in *Lepidocyclina* and *Miogyopsina*-limestone and similar and equivalent beds of Formosa, Botel-tobakee, the Riukiu Islands and the Ogasawara-Jima, but also in the *Lepidocyclina* and *Miogyopsina*-limestones of the provinces of Sagami and Kae, 2, the *Lithothamnion*-limestones of Oyami-Yama and Megami-yami near Sagau, Province of Lotomi; and 3, the *Lithothamnion*-limestone intercalated in an oil-bearing Tertiary complex of Echigo, 4, the *Lithothamnion*-limestone of Shiroiwa, Makatsuka-mura, Otsu-gou, Province of Natigo.

It is evident from these references that this form has considerable range in the Miocene and probably the Pliocene.

In his subsequent paper, Dickerson (*in* Smith 1924: 327) quotes Smith in reference to Smith's work on the Sagada Limestone of Mountain Province, as recognizing therein "the well-known Mio-Pliocene marine alga, *Lithothamnion ramosissimum* Reuss," and Dickerson (*op. cit.*: 322, 331, and Table 3) consistently refers to the Malumbang "Pliocene."

RELEVANT LATER STUDIES IN THE CENOZOIC OF THE EAST INDIAN ARCHIPELAGO

General.—In the two decades that followed Dickerson's evaluation of the fauna from the Vigo Group, much additional information has come to light concerning the Cenozoic invertebrates of the East Indies (including the Philippines) and their stratigraphic distribution throughout the archipelago. More than one synthesis of these data have appeared during this interim. Some have emphasized the geologic history of the region, some its stratigraphic paleontology, and others the economic significance of the geology and stratigraphy of the area.

With these extensive regional studies, more detailed comparisons are possible between the Cenozoic of the Philippines and that of the Malay Archipelago as a whole. The molluscan studies of Martin and others have been concluded. The sequence of Tertiary larger foraminifers has come to form the bases for a biochronologic classification of the East Indian Tertiary—the so-called "letter classification" first proposed by Van der Vlerk and Umbgrove (1927) and later expanded by Leupold and Van der Vlerk (1931).

A record of the smaller foraminifers and their stratigraphic distribution has been added to some extent. In addition to the Leupold and Van der Vlerk (1931) summary, a geologic history of the East Indies (Umbgrove 1938) has paid notable attention to the Cenozoic stratigraphic geology and stratigraphic paleontology. In the Philippines economic and geologic reports by Corby et al. (1951) and by Irving (1952, 1953) have summarized, in reconnaissance fashion, the distribution of the Cenozoic in much of that archipelago. Cloud (1956) has placed these East Indian faunal and formational sequences into relationship with those of the Cenozoic of the Pacific basin as a whole. Within the context of these syntheses, the Neogene faunas of the southern Bondoc Peninsula have come into sharper focus than was possible in Dickerson's time. These syntheses have particular significance in that conclusions drawn as to the age of the Neogene faunas of the southern Bondoc Peninsula and as to the so-called rates of evolution of these faunas differ considerably from those of Dickerson which, nevertheless, have tended to persist.

We review first these regional syntheses; then, in the light of these data, we re-examine the Neogene sequence in the Vigo Group of the Bondoc Peninsula.

The Mollusks.—Karl Martin's studies of the East Indian Tertiary mollusks occupied more than fifty years of his lifetime. Dickerson, in his comparisons with Martin's upper Miocene mollusks from Java, apparently made all of his determinations from two of Martin's first publications, "Tertiarschichten auf Java" (1879–1880) and "Tiefbohrungen auf Java" (1883–1887). The tremendous amount of work that Martin did subsequently on the faunas may have been unknown to Dickerson. Dickerson seems to have been unaware of Martin's 1919 work ("Unsere Palaeozoologische Kenntnis von Java") in which Martin explains his own extinction-percentage scheme for the East Indies Tertiary. Martin considered his Tjilangang beds, together with Junghuhn's locality "O" to have 34% Recent species, these constituting the horizon with which Dickerson correlated his Bondoc Peninsula faunas with 75% Recent species. In 1921, Martin listed the percentages of Recent molluscan species in the Tertiary of Java as follows (Martin 1921; see also Davies 1934: 57; and Popenoe in Corby et al. 1951: 253–254):

Pleistocene	86 to 90%
Pliocene	51 to 64%
Odeng beds	43%
Tjilangang beds	34%
Njalindung beds	21.6%
Rembang beds	16.9%
West Progo Miocene	6.8%
Upper Eocene & (?)Oligocene	0%

As Davies (1934: 57) noted, "Here the steady increase in the percentage is obvious."

Pointing out that the terms "Eocene," "Miocene," "Pliocene," etc., used in his classification could not be held to represent exactly the same periods of time as the European Tertiary epochs so named, Martin classified these Javan molluscan faunas thus:

- "Pleistocene"—80% or more Recent species
- "Pliocene"—50–80% Recent species
- "Upper Miocene"—20–50% Recent species
- "Lower Miocene"—8–20% Recent species
- "Eocene"—no Recent species present

So the "West-Progogebirge beds," Rembang Beds, and Njalindung Beds served as guide for the "Upper Miocene," and the fauna from the Sonde Beds, with 150 molluscan species (53% Recent), furnished guide fauna for the "Pliocene" (see Popenoe in Corby et al. 1951: 253–254). The Fufa Beds of Seran and Obi, with a fauna of 158 species of which only 46.8 per cent were Recent, were also considered "Pliocene" by Fischer (1927; see also Popenoe in Corby et al. 1951: 260).

Martin (1919) included lists of important though less comprehensive publications dealing with the Tertiary paleontology of the Indo-Pacific region. A list of Martin's major papers on the subject, along with those of Tesch (1920; on Timor), Fischer (1927) and Van der Vlerk (1931) is given by Popenoe (in Corby et al. 1951: 263). Van der Vlerk (1931) gives a complete list of all Cenozoic mollusks reported or described from the Dutch East Indies up to 1931, with geologic range, references, a complete bibliography, and critical notes.

By 1927 Van der Vlerk and Umbgrove had further subdivided the East Indian Tertiary on the basis of the stratigraphic ranges of foraminifers. Leupold and Van der Vlerk (1931: 611–648) summarized the Tertiary history of the East Indies, employing 8 stages and 16 zones "based upon vertical distribution of larger foraminifera." They grouped these stages and zones into

a "Tentative general subdivision of the Tertiary of the Dutch East Indies based on the main stratigraphic features (transgressions, unconformities). . . ." with corresponding "percentages of still living species of Mollusca" as follows:

Upper Tertiary		
Upper: Stage h, Zone 2	60%	
Zone 1	50%	
Stage g	45%	
	35%	
Stage f, Zone 3	30%	
Middle: Stage f, Zone 2	20%	
Zone 1	18%	
	8%	
Stage e, Zone 5		
Zone 4		
Lower: Stage e, Zone 3		
Zone 2		
Zone 1		
Stage d		
Lower Tertiary		
Upper: Stage c		
Middle: Stage b		
Stage a, Zone 2		
Lower: Stage a, Zone 1		

A more recent percentage distribution summarized by Umbgrove (1933) has not notably altered these percentages.

Meanwhile, in the Philippines, the major additional contribution to the molluscan paleontology was probably that of Faustino (1926; 1928). He reviewed the disputed Oligocene or Miocene age of the typical Vigo Shale (*ibid.*: see also Corby et al. 1951: 238, 248–249) and focused attention on the conflicting evidence presented by the mollusks and the larger foraminifers as correlated by Douvillé (1909). Again the controversy centered around the Oligocene or Miocene age of the lowest of these beds and around the identification and biochronological significance of a gastropod, *Ampullinopsis*, and of certain aberrantly small "*Nummulites*" (*N. subniasis*) that are associated with *Lepidocyclus* in the lowest of the Batan Island beds from which the suite of larger foraminifers studied by Douvillé were collected (see Douvillé as quoted by Dickerson *in* Smith 1924: 317).

During 1939–1941, field parties of the Philippine Petroleum Survey assembled an extensive collection of fossil mollusks, principally from

the island of Panay, but also from Cebu and elsewhere, and on Luzon from the Bondoc Peninsula, the Batan Island area and the Cagayan Valley. Oldest were Jurassic ammonites from relatively undisturbed strata on Mindoro (Corby et al. 1951: 68), but most were of Neogene age. A partial list of the mollusks from these collections was presented by Popenoe (*in* Corby et al. 1951: pls. 36, 37, 44–46) together with their known geologic ranges in the East Indies and in the Philippines. The 152 Philippine localities from which these mollusks were collected were assigned a geologic age by Popenoe and Merchant in the same publication (*ibid.*: pl. 38), as were also the mollusks and the 60 mollusk-bearing Philippine Tertiary localities on record in the literature prior to 1939 (*ibid.*: 32–33). Popenoe (*op. cit.*: 252–264, and also pl. 47) presented a preliminary discussion of the molluscan faunas, their geologic age, and their relationships with the Tertiary molluscan faunas of the East Indies. In view of the direct bearing of these Philippine mollusk collections upon the age and significance of the molluscan fauna of the Vigo Group of the Bondoc Peninsula, Luzon, they are discussed in detail in the concluding section of this paper.¹

The Foraminifers.—Since Dickerson's (1921a, 1921b) works, the most important clarification of the age and stratigraphic distribution of Tertiary foraminifers in the East Indies resulted from the so-called "letter classification" of Van der Vlerk and Umbgrove (1927). Leupold and Van der Vlerk (1931) used this letter classification to provide the time coordinate for their summary of the East Indies Tertiary.

A jubilee book in honour of Professor Martin is the right place for an essay on the Tertiary of the Dutch East Indies, as it was he who laid the foundations of stratigraphy in that district.

The basis upon which he founded the subdivisions of the Tertiary deposits has proved the firmer the more it has been tested.

He laid down two fundamental principles upon which further investigations have been built.

In the first place he showed that during the Tertiary an autochthonous fauna developed in the East Indies and in the second place he insisted that a subdivision of the Tertiary systems can only be obtained by comparing their fossil contents with the fauna that still exists in these regions and not with the European Tertiary fossils. It might appear to be a simple matter to compare fossils with living species, but when entered upon it is found to be difficult in the extreme. Thousands of mollusks have passed through the

¹ See Note 1 in Appendix A.

hands of this untiring investigator and only those who have themselves experienced the endless difficulties that attach to the determination of fossil material are able to form an idea of the energy it must have cost to bring this comparative study to a satisfactory conclusion.

As the fauna that flourished in the East Indies was entirely different, it is not possible to apply the names current for European series with typical faunas to the East Indian Tertiary epoch.

The investigations of Vredenburg and DeCotter, in British India have rendered it possible to make a rough comparison between Java and Europe via Burma and North-western India (vide: MARTIN, Leidsche Geol. Meded., Deel IV, Afl. I), but a detailed correlation is not possible.

The authors have therefore decided to use the subdivisions by letters as proposed by VAN DER VLERK-UMBROGROVE (Wet. Meded. No. 6).

The basis for the subdivision in stages and horizons is formed by the foraminifera of the strata.

As tabulated on a previous page, the "letter classification" serves to subdivide the Tertiary of the East Indies into 8 stages and 16 zones. The ranges of the 52 diagnostic large foraminifer genera and species upon which this classification is based are tabulated by Leupold and Van der Vlerk (1931).

Stages a, b, and c, which do not directly concern us, are based primarily upon the ranges of certain species of *Camerina*, of "*Fasciolites*," and of the genera *Assilina*, *Pellatispira*, *Heterostegina*, and *Discocyclina*; the sequence a-1 through c was considered to range from lower Ypresian through lower Oligocene by Gerth (1929). Stage c of southeastern Borneo was equated with the Sannoisian by Douvillé. Stage d, also not directly involved in the problems of the Bondoc Peninsula Vigo Group fauna, carries the highest *Camerina* (three species, notably including *C. fichteli-intermedia*, which is shared with Stage c only), the restricted *Isolepidina* and *Eulepidina papuaensis*, together with the lowest *Cycloclypeus* and *Lepidocyclina* (the latter in isolepidine and eulepidine forms); Stage d is considered Stampian in age by Douvillé and "Upper Oligocene" by Gerth (1929).

Stage 3, the oldest involved in possible correlations with the Vigo Group of the Bondoc Peninsula is considered of Aquitanian age by both Douvillé and Gerth, of "Lower-Upper Aquitanian" by Tobler (1918) following Douvillé, and as (upper?) "Mio-Oligocene" by Rutten (1911); it carries the highest *Eulepidina*, *sensu stricto*, and "*Clausulus pygmaeus*" (= Alv. sp. 3 Verb.), the lowest *Nephrolepidina* and *Trilina howchini*, and is further zoned on the basis

of species of *Lepidocyclina*, *sensu lato*, and *Spiroclypeus*, with "*Trybliolepidina*," *Miogypsina*, and *Alveolina* appearing in its upper two zones.

With Tertiary Stage f, the "letter classification" enters unequivocal Miocene. Zonation within the stage leans heavily upon species of *Lepidocyclina* and *Miogypsina* of which all remaining species make their last stand in Zone f3 which in turn is characterized by the restricted occurrence of "*Trybliolepidina*" *rutteni*. Diagnostically also, "*Alveolina boscii*" appears in Zone f1 to range upward through the "Pliocene," whereas "*A. bontangensis*" becomes extinct at the top of Zone f3.

Finally, it is significant that Stages g and h (including the two zones, h1 and h2) reveal merely negative evidence in terms of the larger foraminifers; shown as present throughout, but all ranging upward from lower beds, are *Heterostegina*, *Cycloclypeus*, and *Alveolina*. Diagnostic distinctions clearly are based upon different percentages of living mollusk species (35% and 45%, presumably in higher beds, for Stage g, 50% in Zone h1, 60% in Zone h2). The smaller foraminifers are still another element in the East Indian Tertiary faunas that aid in subdividing the stratal sequences on a biochronological basis (see Koch 1923, 1925, 1926; Boomgaart and Vroman 1936; Boomgaart 1949; Caudri 1934; Tobler 1918; LeRoy 1938a, 1938b, 1939, 1941, 1944, 1948). With the disappearance, at the top of the "Miocene" (i.e., top of Tertiary f3), of the previously dominant lepidocyclines and miogypsines, the inshore shallow-water facies of East Indies Neogene witnesses an increase and diversification of mollusks in an expanded coarsely clastic lithofacies and a flowering and diversification of benthonic small foraminifers in the marls and more finely clastic inshore facies of the "Pliocene" generally. This is perhaps most conspicuous in the genus *Ammonia*, or "*Rotalia*," of which stock "*Rotalia*" *papillosa* Brady (see LeRoy 1941) is an especially conspicuous and widely flourishing newcomer. Stratigraphically it is not known from the "orbitoid"-bearing horizons of Stage f (though the less ornate ancestral species of the stock do occur), and even its occurrence in beds of the intervening Stage g is rare and sporadic, doubtful at best. The distinction between the "orbitoid"-bearing "Miocene" beds of Stage f, below, and the "*Rotalia*" *papillosa*-bearing beds of Stage h, above, had been so consistently noted that

the term "Rotalia Zone" had, by the late 1930's, come into wide usage for the "Pliocene" in reconnaissance petroleum exploration from Borneo and Java eastward to New Guinea (see Corby et al. 1951: 288; Kleinpell 1954b: 22; 1958: 4-5).

As work has progressed throughout the Indo-Pacific region as a whole, some of the zonal distinctions embodied in the Tertiary "letter classification" have become blurred. Thus, it has ceased being possible to distinguish on the basis of the larger foraminifers alone all the five zones of Stage 3 over a broad area, and similarly Zone f2 has tended to blend either upward or downward with the other two zones of Stage f (see for example Glaessner 1943, 1953, 1959). Thus Stage 3 today is usually subdivided into a lower (e1-e2-e3) and an upper substage or zone (e4-e5), although Zone e5 is, in some areas at least, subdivisible into two zones, as was suggested in the original Leupold and Van der Vlerk (1931) chart showing the ranges of *Spiroclineus*, *S. tidoenganensis*, *S. leupoldi*, *S. margaritatus*, *Miogypsina dehaarti*, and "Alveolina" *bontangensis*. Zone f2, in terms of large-foraminifer ranges, hinges upon nothing more distinctive than a somewhat higher range of *Nephrolepidina sumatrensis*, *N. s.* var. *douvillei*, and the miogypsines that lack lateral chambers, in relation to the not-so-high highest occurrences of *Pliolepidina*, *Nephrolepidina borneensis*, *N. verbeeki*, and certain species of microspheric lepidocyclines that are less than 15 mm in diameter. Nevertheless, locally at least, as in the Philippines (see Corby et al. 1951), small-foraminifer species apparently serve to distinguish a "middle f" Zone from lower and higher f1 and f3 equivalents, respectively. However this may be, the more commonly accepted "letter classification" in modified form is succinctly shown in the correlation chart for the Cenozoic of the western and central Pacific by Cloud (1956: pl. 1) in which he essentially follows the modifications of Van der Vlerk (1950; see also Cloud 1956: 557-563 for a general discussion of the problem).

In the Philippines both the larger and the smaller foraminifers have received considerable attention since the earliest geological studies. Oldest known to date are mid-Cretaceous *Orbitolina* from metamorphics in Cebu (Corby et al. 1951: 68; see also Arnold and Kleinpell 1951). Large foraminifers were the first Cenozoic fos-

sils recognized in the Philippines (Richtofen 1862); originally thought to have been nummulites of Eocene age, these large foraminifers from the Binangonan Peninsula, Laguna de Bay, Luzon, were subsequently shown by W. D. Smith (1906) to be orbitoids of the genus *Lepidocyclina* and of post-Eocene age. Abella y Casariego (1886) recorded "nummulites" from Cebu which, too, subsequently proved to be *Lepidocyclina*; and the record of orbitoids and cycloclipeids by Martin (1896; see also Becker 1901 for the English translation) has already been mentioned in connection with his recognition of Cenozoic mollusks in the Cagayan Valley and La Union Province, Luzon, and the Agusan Valley of Mindanao. Subsequently, Martin (1901) again recorded orbitoids from southern Luzon, and W. D. Smith's (1906) description of the orbitoids of Binangonan and of the Lobo Mountains followed. H. Douville (1909, 1911) described and correlated orbitoid samples collected by W. D. Smith on Cebu and on Batan Island, and a decade later Yabe (1919) published the first of a series of papers by Japanese investigators on the Philippine species of *Lepidocyclina* and their stratigraphic significance. Smaller foraminifers from the Philippines were first recorded by von Drasche (1878) in the report of his reconnaissance of Luzon which included a report by Felix Karrer (republished in 1880, in Spanish) on some Tertiary small foraminifers collected from the west coast of Zambales Province, Luzon; these Karrer related to the younger Tertiary smaller foraminifers described by Schwager (1866) from Kar Nicobar.

Attention to both the larger and smaller foraminifers of the Philippines has been more extensive since Dickerson's time, though not as comprehensive as in the Dutch East Indies. Two of the most significant additions to the knowledge of Philippine larger foraminifers appeared in papers by Yabe and Hanzawa (1925, 1929); in the first, faunas collected by Dickerson from Cebu and by Nomland from Leyte were described; in the later work, much additional material, mostly orbitoidal, was described from samples collected by W. D. Smith. R. E. Dickerson, W. E. Pratt, F. A. Dalburg, Graham Moody, H. M. Ickis, H. D. McCaskey, A. Kryshstofovich, F. Kearney, H. G. Schenck, Father Sanchez, M. Goodman, and R. D. Rowley, from localities on the islands of Cebu, Batan, Rapu Rapu, Luzon, Masbate, Mindanao,

Mindoro, Marinduque, Palawan, and Samar. In Rowley's sample from Palawan, Yabe and Hanzawa found the first Eocene large foraminifers to be recorded from the Philippines: *Discocyclina* and *Camerina*.

From 1939 to 1941 the Philippine Petroleum Survey added much data on Cenozoic foraminifers, both large and small. These data were recorded and discussed in the light of the previous literature by Corby et al. (1951: 227–297). The Philippine large foraminifers previously recorded in the literature were listed, their ranges in both Philippines and Dutch East Indies were tabulated and their ages and correlations shown on plate 31 of that report. A check list of published Cenozoic and Recent small foraminifers from the Philippines, prepared by Benjamin Daleon with assistance from Mariano Herrera, was presented as plate 32. The references to the systematics involved were tabulated in a bibliography prepared by Juan S. Teves of the Philippine Bureau of Mines, and this tabulation was included in the final report of the Survey, but due to the magnitude of the material covered, his contribution was omitted from the part of the report eventually published in the Corby et al. (1951) report. A copy of this tabulation is now on deposit at the California Academy of Sciences.

Certain foraminiferal collections of the Survey were also tabulated in the Corby et al. (1951) report. To the extent that preliminary identification of local type-specimens was possible within the time limitations imposed by the immediate aims and facilities of the Survey (ibid.: 229–231), their distribution in biostratigraphic sequences selected as types for a local biochronologic classification was shown on plates 34, 35, 39, 40, 41, 42 and 43. With the types subsequently destroyed, most of the value of plates 35, 39, 40, 41, and 43 have been lost, though the distribution of some genera—camerinids and orbitoids and “*Rotalia*,” for example—has retained certain significance, although the local biochronologic terminology was never intended for publication.² In the wake of the Philippine Petroleum Survey, considerable additional information has been published. A chart of the relative stratigraphic ranges of certain Neogene smaller foraminifers in the Philippines has been presented by Daleon (1958; see also Cook 1963,

fig. 4). Hashimoto (1939: table 1) had previously proposed a stratigraphic classification for the Philippines, listing both large and small foraminifers from the series and formation of his classification, the former from 24 localities, the most interesting of which are in the Cordillera Central of northern Luzon, which had not previously been realized to be productive of forms such as *Spiroclypeus margaritatus*, *S. vermicularis*, and *Biplanispira mirabilis*. Minute forms of foraminifers are also listed from eight other localities (ibid.: tables 3, 5; see also Kleinpell 1958: 9, footnote 5).

Grey (1954, 1956) described and discussed the occurrences of Eocene large foraminifers in the Philippines, including previously unrecorded localities in Cebu, Mindoro, the Caramoan Peninsula, and in Albay, Luzon. Additional occurrences of Tertiary small foraminifers have been recorded by Daleon (1951), Daleon and Samaniego (1954), Cook (1963), and Amato (1964).

Planktonic small foraminifers, together with a few benthonic species, have been recorded by Bandy (1963) and made the basis for a Neogene zonation (ibid.: 1735, fig. 2, 3) based on sections in southern Iloilo, Panay, and in the central valley of Luzon, where the two thickest and structurally most unbroken sections and also the two most continuously foraminifera-bearing sequences in the Philippines have long been known. Oldest beds in Bandy's foraminiferal sequences are those from a subsurface occurrence (Tigbauan well No. 1) in the southern Iloilo basin of Panay which he correlates with *Globigerina concinna ciparoensis* Zone of the Caribbean and with the Chattian Oligocene of Europe. The bulk of Bandy's planktonic foraminifer faunas are of Miocene, Pliocene, and Pleistocene age (ibid.: figures 5, 7).

Philippine Stratigraphy and Correlations.—Geologic and stratigraphic studies in the Philippines in recent years have added to the records of Cenozoic fossils, mainly foraminifers. Irving (1952, 1953) followed the letter symbols employed by Corby et al. (1951) who, in 1954, pointed to the probable Indonesian correlates (i.e., the “letter classification” equivalents) of the local Philippine letter symbols. Vergara et al. (1959) presented an areal geology map of the Cagayan Valley north of Tuguegarao, together with three graphic columnar sections from the Cagayan Valley region, in a paper in which the “letter classification” of Indonesia (the former

² See Note 2 in Appendix A.

Dutch East Indies) is brought directly into the stratigraphy of northeastern Luzon. In view of the bearing of Martin's study of Cagayan Valley fossils upon Dickerson's evaluation of the Vigo Group of the Bondoc Peninsula, the Neogene column in the Cagayan Valley is worth further discussion.

In 1954, the junior author, while engaged in petroleum exploration for private industry, undertook a study of the stratigraphy, paleontology and structure of northern Luzon and especially of the Cagayan Valley, the geology of which had, at that time, been left in essentially the broad reconnaissance state of coverage of the Philippine Petroleum Survey. Corby et al. (1951: pl. 139) summarized the formation sequence as consisting, in ascending order, of the Ibulao Limestone (Tertiary Upper and Lower X), Callao Limestone (Tertiary Lower X), Tuguegarao Sandstone (Tertiary Middle X), Ilagan Sandstone (Tertiary Lower Z), and Magapit Limestone (Tertiary Z). They suggested that an upper member of the Ibulao in a southerly area ("south of Jones") was in possible lenticular relationship with the generally overlying Lubuagan (ibid.: 210), and they recognized a local unconformity between Tuguegarao and underlying Lubuagan (ibid.: 211). In subsequent studies of Kleinpell (1954),³ some revisions of the local stratigraphy were found necessary. For example, the Lubuagan, though locally rich in carbonaceous material and even leaf impressions, seemed more appropriately designated as a formation than as "coal measures"; it appeared divisible into three clastic members with the Ibulao as a fourth and basal member of lenticular limestone (ibid.: 5, and correlation chart between pp. 15 and 16). Kleinpell found the Callao Limestone to grade laterally into sands previously mapped as Tuguegarao, and both were in turn lateral equivalents of the middle and upper Lubuagan Formation (ibid.: 8). The Tuguegarao Sandstone of previous mapping also, in part, graded laterally into a portion of the Ilagan Formation; at best it constitutes a cartographic unit areally much more restricted than the formation of that name as previously mapped. The mapping of the Tuguegarao as a formation was more than seriously open to question⁴ (ibid.: 10-11) and perhaps was due to an attempt to depict

areally clastic sediments of presumably about the same age as deduced from scattered fossil content. Kleinpell encountered no unconformity between the Tuguegarao and Ilagan Formation, the implied hiatus being not depositional but due instead to the lack, or at least the scarcity of, fossils definitely of upper Miocene, Mio-Pliocene, or lower Pliocene age in the interval between fossiliferous middle Miocene below and the "Upper Pliocene" of previous correlations above (ibid.: 11-12). The Ilagan, coarsely clastic throughout in areas where it overlapped onto crystalline basement complex (as for example in the San Mariano region southeast of the community of Ilagan), included a local and lenticular fine-grained clastic lower member (as, for example, around Penablanca, west of Calao, where the Pinacanauan de Tuguegarao flows for some distance essentially due south through low terrain between the more resistant Callao Limestone on the east and Ilagan Sandstone on the west) (ibid.: 12-14). The fossils which had been the basis for considering the Magapit Limestone as of "Tertiary Z" age were mostly shells of essentially Recent type from a shellbank immediately above the limestone (ibid.: 14, footnote 38). Thus Kleinpell (1954: 5) presented a revised stratigraphic column for the Neogene of the Cagayan Valley:

Lagoonal and Terrestrial Deposits	Pleistocene
Ilagan Formation	Pliocene
Transitional Beds	Miocene to Pliocene
Lubuagan Formation	Miocene

Kleinpell considered the former Ibulao Limestone a member, basal and lenticular, of the Lubuagan Formation, and included under the designation Transitional Beds, the Callao Limestone, the upper member and parts of the middle member of the Lubuagan Formation (together with local coarse clastics left as local residue, as it were, of the unmappable Tuguegarao Sandstone), and a lenticular "lower Ilagan mudstone" member.

The Miocene age determinations stemmed principally from orbitoids found at the localities shown in the Corby et al. report (1951: pl. 10); these were of f1 and f2 age (lower and middle Miocene) but also included a number that were of older Tertiary e4-e5 age, with *Eulepidina* (*sensu stricto*), which might better be considered upper Oligocene or at least Oligo-Miocene in age

³ See Note 3 in Appendix A.
⁴ See Note 4 in Appendix A.

(Kleinpell et al., 1954: 8–11). Pliocene determinations were based on small-foraminifer assemblages (ibid.: 14) rich in *Ammonia* ["*Rotalia*"] *papillosa* and close relatives, in keeping with their consistent supraorbitoid stratigraphic occurrences in the "*Rotalia* Zone" of the East Indies (ibid.: 22). Panay,⁵ Cebu,⁶ and Leyte.⁷ Pleistocene determinations stem from fossil mammalian data (ibid.: 15; see also Beyer 1956, and Koenigswald 1954, 1956). The oft-referred-to guide fossil, *Vicarya callosa*, was not encountered in the Cagayan Valley above foraminifer-bearing strata of Miocene age.

By 1957, in view of the revised stratigraphy, it was possible⁸ to relate this Cagayan Valley Neogene sequence, both as to age and geologic history, to the Tertiary sequence of the East Indies by the "letter classification" much more closely and in greater detail than before; it was also possible to include the results of comparative studies, made with private funds in Bandoeng and Balikpapan late in 1940, between the Philippine and East Indies foraminifer sequences (see Kleinpell 1958: 1–3). In 1940, it had been possible only to write:

Were comparison with type material possible at present . . . it is conceivable that the stratigraphic terminology of the Netherlands East Indies could be employed in the present report, and the currently employed local terminology eliminated; thus geologic comparisons between the two areas would be much more satisfactory as to detail. [Corby et al. 1951: 294; see also pp. 295–296]

Subsequently, 18 years later, it was possible to add that

Upon examination of these faunal sequences in Balikpapan it was immediately apparent that the Philippine Neogene assemblages were in faunal facies nearest to those from New Guinea and to some extent those from Java in marked contrast to those from eastern Borneo, although in nearby northern Borneo strong similarities of this sort again were very much more apparent. It was also soon clear, as had been previously suggested by comparative studies in Bandoeng, that tentative correlations between the Philippines and the southern Indies based on the larger-foraminifers could on the whole be readily corroborated. A few minor discrepancies between the ranges as previously published and certain stratigraphic occurrences observed in the Philippines remained. This was much as already noted by Mrs. Harriet Williams Morrison in Manila (Corby et al., 1941: 1951; pp. 266–277); yet the latest data on the stratigraphic ranges of nummulite and orbitoid subgenera and species in the Indies seemingly called for no major modification of the "letter classification" . . . Again, in Balikpapan

Papan, . . . classification of Miocene and Pliocene molluscan correlations . . . was greatly aided through comparisons of the associated small-foraminifer faunas . . .

For example, small-foraminifers definitely of Tertiary h1 and h2 age in the Netherlands Indies were essentially those of the typical Tertiary "Y" and "Lower Z" intervals in the provisional Philippine time-scale. In both regions, the faunal sequences in question occupy a stratigraphic interval characterized by a marked evolutionary diversification, and a quantitative efflorescence as well, within the genus *Rotalia* [= *Ammonia*]. In the Philippines such newly appearing rotalid species are exemplified by "*Rotalia* 2" through "*Rotalia* 4" in the typical "Y" and "Lower Z" sequences of west-central Panay [footnote 3: Corby et al. (1951: pl. 35 and also pl. 34 and p. 288)]. The basal horizon of the interval in question corresponds to the base of the so-called "*Rotalia* Zone," which has been widely employed as a key horizon in reconnaissance exploration throughout the East Indies and the Indo-Pacific province as a whole. This horizon generally is taken as the base of the local Pliocene (see Kleinpell, 1954, p. 22). In the more southerly Indies it coincides with the base of h1—even somewhat below the base of Tertiary g (Corby et al. 1941; 1951, p. 262). Many factors were involved in these discrepancies in Pliocene correlation. One of these had been . . . perforce . . . partial analysis of incomplete data. Another . . . in Borneo and in the southern Indies generally the typical Tertiary g interval is distinguished from immediately older and younger sequences principally on the basis of negative faunal features alone. Too, examination in Balikpapan of the characteristic Tertiary f3-Tertiary g-Tertiary h1 small-foraminifer sequence soon revealed that the microfauna of Tertiary g was represented in the Philippines by those faunules found characteristically in the uppermost 'Upper X' marl, i.e., the small-foraminifer faunules within the local ['Upper X' but above the highest local orbitoids yet still below the local] 'Tertiary Y' beds (Corby et al. 1951, pl. 35). . . . finally, it was also apparent that the Philippine 'Upper Z' assemblages were all post-Tertiary in terms of the 'letter classification.' Though some local and related problems of faunal facies still remain unresolved, probably this provisional 'Upper Z' interval in the Philippines represents not the Upper Pliocene Tertiary h2 equivalent but instead the lowermost Quaternary, i.e., the Lower Pleistocene. This would, in turn, correspond to the so-called 'folded Pleistocene,' which is also the east Asiatic 'Villefranchian' of some authors (see Movius 1944). [Kleinpell 1958: 2–6]

The mammal bones, artifacts, and tektites found in the Pleistocene of the Cagayan Valley between Laya and Tabuk strongly suggest that the Philippine horizon of their occurrence may be roughly correlated with the horizon of *Pithecanthropus erectus* in the so-called upper Trinil beds of Java, though no bones of Java Man have been found associated with them in the Philippines (see Beyer 1956; Koenigswald 1954, 1956; Kleinpell 1958: 13; Durkee and Pederson 1961: 160).

Passing over additional discussion of Eocene, Oligocene, and Tertiary f2 faunas and correla-

⁵ See Note 5 in Appendix A.

⁶ See Note 6 in Appendix A.

⁷ See Note 7 in Appendix A.

⁸ See Note 8 in Appendix A.

EUROPEAN STANDARDS	NETHERLANDS INDIES		PHILIPPINE ISLANDS			EUROPEAN STANDARDS	
Series	Leupold and van der Vlerk (1931), after van der Vlerk and Umbgrove		Provisional Local Terminology Employed for Purposes of Petroleum Survey Report			Series	
	Stage	Zone	Zone		Stage		
Holocene						Holocene	
Pleistocene		Lower Pleistocene	Upper			Pleistocene	
Pliocene	h	2	Lower		Z	Pliocene	
		1					
	g						
Miocene	f	3	Upper Non-orbitoidal		X	Miocene	
		2	Orbitoidal				
		1					
	e	5	Typical Upper, Middle, and Lower, undifferentiated		W		
4		"Pre-Upper W"; barren of small foraminifers, but often orbitoid-bearing					
3							
2							
		1					
Oligocene	d		Sample L-DB 260 from the Coal Harbor limestone (see pl. 43, facing p. 250); "Lower W" Sample Mr-JH No. 15 from Mindoro (see pp. 265-266 and 267-270)			Oligocene	
	c					V	
Eocene			Sample Bo-JH No. 7 from Bohol	(See pp. 268-269)	(Typical and other undifferentiated occurrences)	Eocene	
			Sample Ct-Ha No. 5 from Catanduanes				
Paleocene(?)	a	2				Paleocene(?)	
		1	Sample M-GC No. 8 from Mindanao				

TEXT-FIGURE 2. Correlation of provisional Philippine time-rock and Dutch East Indies letter classification.

tions between the Philippines and the more southerly Indies (Kleinpell 1958: 6), and adding data pertinent to Tertiary c of the Indies and "V" of the Philippines, the summary chart of correlation between the "letter classification" and the tentative classification of the Philippine Cenozoic (Kleinpell 1958: 8) is reproduced here as Text-figure 2.

These revised correlations, especially at the late Miocene, Pliocene, and Pleistocene horizons, affect the graphic summaries of the comparative geologic histories of the two regions (Corby et al. 1951: pls. 12, 50; Irving 1952: fig. 3). Perhaps of at least equal interest and significance in this connection, however, is the relationships of the Cagayan Valley Neogene history to the rest of the Philippine Neogene as indicated by the 1954-1958 revision of Cagayan Valley stratigraphy. Post-1945 drilling in the Visayan region had already shed additional light on the same matter in the central Philippines (see Daleon 1951) and by 1957 it was possible to write that:

In northwestern Cebu, and on the Bondoc Peninsula of southern Luzon, deposition appears to have been more nearly continuous throughout Miocene time than in most other nearby areas in the central and eastern Visayas.

Thus, the Neogene history both of northwestern Cebu and of the Bondoc Peninsula appears to be almost as closely related to that of Central Panay and of the adjacent northernmost Negros coast as to that of the balance of central and southern Cebu, northwestern Leyte, and southeasternmost Luzon.

In northern Luzon conspicuously the Neogene depositional record is again more like that of central Panay. Both surface and subsurface stratigraphic studies, carried on since 1954 by Paul H. Dudley, Benjamin Daleon and the writer, assisted by Mario Nieto, Jose Kanapi and others, have demonstrated that throughout much of the Cagayan Valley of northeastern Luzon deposition was essentially continuous through Miocene and Pliocene time instead of having been widely interrupted there during Upper Miocene and Lower Pliocene times, due, as previously supposed, to the local effects of the mid-Miocene (t2, or 'Middle X') orogeny in that area.

Thus, major tectonic lines and tectonic province-boundaries probably are, in detail, more sinuous in the Philippines than as originally shown in the petroleum survey report, with stronger east-west components. This now appears to be more as in the Banda Arc, though on a smaller scale. It is also in keeping with the postulate that the modern Sulu-Mindanao and Palawan-Mindoro-Luzon topographic alignments both reflect very ancient and long prevalent structural and topographic features of a similar position and orientation. In summary, it may therefore be stated that a large part of the Visayan Sea and the Sibuyan Sea lies within that historical-geologic belt termed 'tectonic province II,' instead of in 'tectonic province III' as previously shown (Corby et al. 1941; 1951: pls. 12, 50). In keep-

ing with the additional data from northeastern Luzon the same may be said of the Cagayan Valley. [Kleinpell 1958: 9-10]

Thus in "tectonic province II" north of North Borneo, as early as Paleogene times, no continuous depositional record is to be found from Tertiary b to Tertiary c, though both stages are present in separate areas there. Kleinpell (1958: 10-13) also noted that the major Cenozoic geosyncline more or less coinciding with "tectonic province II," also reflected a paleogeographic seaway which, waxing and waning in breadth but ever present throughout Cenozoic time, was at the root of the celebrated Oriental-Australian life-zone boundary between Molengraaf's Sundaland and Papualand and known to zoogeography as Wallace's Line. Miocene orogenies probably played a role in the establishment of the peculiarly transitional life-area of unstable geologic history termed Wallacea, between Wallace's Line and Weber's Line and including the larger part of the Philippines, Celebes, and most of the more westerly Lesser Sundas (see Dickerson 1928: 281-303, figs. 4, 16-28, 50, 56, 57, 60-64, pl. 40; see also W. D. Smith 1924; Umbgrove 1938, 1949; Wisser 1940; Mayr 1944; de Beaufort 1948; Beyer 1948, 1955; von Koenigswald 1956). From a purely physical standpoint it had been previously

... possible to extend the northward recognition of the axis of this ancient Tertiary marine trough from the northern end of Makassar Strait to south-central Panay. There its traces seemed to emerge from the depths of the modern Sulu Sea; and thence, to all appearances, it extended north via Verde Island Passage, between Mindoro and Luzon, and, by way of the Manila Plain and Lingayen Gulf, on north into the South China Sea. Post-war studies in northern Luzon, however, have suggested that north of the Vigan region, the marine Neogene Lingayen basin passes inland rather than seaward, that many of its sedimentary deposits grade laterally there into pyroclastics and volcanics, and that its axis then rises northward above the older crystalline rocks of northern Abra Province. Rather, it is now indicated that the modern Cagayan Valley reflects the northward continuation of the belt of most continuous Neogene deposition.

Paleogeographically, the old Cagayan depositional basin apparently connected with the former Tertiary trough of the Manila Plain by way of the western Ifugao foothills and the region of Balete Pass. This connecting area is one which subsequently has been strongly folded, uplifted, and then covered with Quaternary pyroclastics. Outcrops of the older marine limestones and clastics of the Tertiary, all strongly deformed, are limited to sporadic "windows" in the younger volcanics, as in the vicinity of Kiangsan, of Balete Pass, and of the Carranglan Valley in Nueva Ecija. [Kleinpell 1958: 12-13; and see Corby et al. 1951: pls. 9, 10]

Durkee and Pederson (1961) greatly extended the previous stratigraphic studies of the Cagayan Valley and of the area west of the Cordillera Central of northern Luzon. Following a precedent established by Abadilla (1931) in northern Panay and employed in the Baguio district of Luzon by Leith (1938) and later by the Philippine Petroleum Survey (the procedure originally had been employed by W. D. Smith (1906), Ferguson (1909, 1911) in Masbate, and Pratt and Smith (1913), but had subsequently fallen into disuse), Durkee and Pederson gave a number of local mappable stratigraphic units in the Cagayan Valley new names as well as selecting and designating type sections. Except for the Callao Limestone, such typology had been omitted in previous reconnaissance mapping of the area. They measured and described these type sections in great detail.⁹

Future work may make it advisable to consolidate some of these local formations but, for the present, they serve admirably to clarify the distinction between fact and interpretation. For example, in discussing the southward disappearance of the Sicalao Limestone along the east side in the vicinity of Salegseg, Durkee and Pederson (1961) considered this as possibly due to Post-Sicalao and pre-Macaba River Group faulting and stripping, whereas lenticularity is as ready a possibility, since fossiliferous limestone stringers of this same age are interbedded with clastics of the Lubuagan Formation at several localities in the middle Chico River-Lubuagan region.¹⁰ Stratigraphically higher clastics with even younger orbitoids¹¹ were found in subsurface sequences (the Tumauini wells) farther south to have lensed southward into very fine-grained siltstones and silty mudstones carrying not the inshore orbitoids but their offshore-facies, small-foraminifer age equivalents. Much of what the authors accurately referred to as serving to "further muddle the concepts of the stratigraphy along the western margin of the Cagayan Valley" (Durkee and Pederson 1961: 150) stems from failure to distinguish differences within biofacies in the course of correlation. Meanwhile, even lithofacies change has been picked up only very slowly in this same area, though Durkee and Pederson were meticulous in this matter. One may question the worth of

⁹ See Note 9 in Appendix A.

¹⁰ See Note 10 in Appendix A.

¹¹ See Note 11 in Appendix A.

replacing with the term Macaba River Group, the old term "Lubuagan Formation"—certainly it was anything but a "coal measure," and certainly it had no specified type section, nor would it be likely to have a very good one, except as a "group" or as a formation with its members more clearly defined elsewhere. Whether or not, in an area of overturning and isoclinal folds such as that around Naneng, it actually does attain a thickness of 8200 m (ibid.: 151), in our view, it is these authors' handling of the highly lenticular stratigraphy of the Cagayan Valley with a discreet and carefully disciplined terminology that will serve in the end to clarify the biofacies as well as the lithofacies problems involved there.

Occurrences of large foraminifers, such as *Camerina* (presumably in "derived" form, from the basement complex on Capilyan Creek about five kilometers south of the Tumauina River along the east side of the Cagayan Valley), *Eulepidina* and a few others, at least by implication, are noted by Durkee and Pederson. The formations described and discussed are correlated directly with the East Indies "letter classification" as well as with the local letter terminology of the Corby et al. report, as they are also in a correlation chart of nine Cagayan Valley columnar sections with, in addition, one from the west side of the Cordillera Central in which most of the extant terminology (Kennon Limestone, Tertiary e4–e5 to f1; Twin Peaks Formation, Tertiary f1–f2; overlying Klondyke Conglomerate, tentatively Tertiary f2, on the basis of superpositional relationships with fossiliferous underlying and overlying formations; and Rosario Formation, Tertiary f3 to probably h2) is retained.

Beyond the wealth of detail, one other observation by Durkee and Pederson is of great significance for the stratigraphy, paleontology, and Cenozoic history of the Cagayan Valley in particular and the Philippines in general: the likelihood that the crystalline basement complex in and around the Cagayan Valley is of Tertiary rather than of pre-Tertiary age (ibid.: 148, 154). Their postulate is in keeping with the demonstration by Wisser (1940) that the Tertiary Vigo Group in the nearby Baguio district of northern Luzon, has been intruded by quartz-diorite. The youngest strata invaded by diorites at various points are of Tertiary f1 age (see Corby et al. 1951: 102–103); similar implications of extensive Tertiary f2 diorite intrusion are indicated by or-

bitoid-bearing intruded metamorphics in the Paracale mining district of Camarines.

It will be recalled that criteria for the original recognition by Dickerson of the Miocene age of the Vigo Group molluscan fauna from the Bondoc Peninsula consisted of the relevant geologic history, stratigraphy, larger foraminifers, and relationships of the mollusks themselves to fossil mollusks elsewhere, especially those of Java. With the Neogene of Panay, northern Cebu, northwestern Leyte, the Singayen region, and Cagayan Valley subsequently brought into much closer relationship to each other, to that of the Bondoc Peninsula, and to that of the East Indies generally, and with even details of both biofacies and lithofacies coming to be clarified over a wide terrain, it is appropriate at this point to view the Vigo Group molluscan fauna within the context of this subsequently gathered data.

AGE AND CORRELATION OF THE VIGO GROUP, BONDOC PENINSULA, LUZON

A. ON THE BASIS OF FORAMINIFERA AND BIOSTRATIGRAPHIC SUPERPOSITION

Stratigraphy.—Summary descriptions or depictions of the Neogene stratigraphic sequence in the southern Bondoc Peninsula have appeared at least four times in the literature. The earliest description was that of Pratt and Smith (1913) whose detailed descriptions of the Vigo Shale and the Canguinsa Sandstone were modified by those of W. D. Smith (1924: 80–83). Pratt and Smith's (1913) description of the sequence may be summed up about as follows:

Malumbang Formation. More or less coralline limestones, calcareous sandstones and marls, concordant and locally conformable on the highest underlying formation in synclinal areas, and widely transgressive.

- a. Upper Limestone Member 30 m
- b. Cudiapi Sandstone Member 40–135 m
- c. Lower Limestone Member 20 m

Canguinsa Sandstone. Close-grained, gray or blue sandstone, more massive than the Cudiapi Member of the Malumbang and characteristically with a considerable proportion of clay. Upper portion usually a soft, clayey sandstone, calcareous, occasionally close jointed and concretionary. Lower portion either a deep blue typical sandstone that

weathers gray or brown, or an indurated massive or jointed blue clay that weathers gray.

"In the section on lower Bahay River, the Canguinsa sandstone includes a few meters of limestone and conglomerate. On Mount Maglihi and Mount Morabi limestone which contains coarse sand and small pebbles of diorite, quartz, and andesite is present in the Canguinsa sandstone, but no conglomerate was observed. [Ibid.: 329]

"No definite age determinations can be made from the fossils in the Canguinsa sandstone proper. The fossils in the included limestone, however, are well known and have been used in correlation by various authorities. From their presence it is concluded that the Canguinsa sandstone should be placed in the middle Miocene, extending, perhaps, into the lower Miocene." [Ibid.: 330]

----- 50-160 m

Vigo Shale. Fine-grained gray, blue, or black shale and sandy clay shale interstratified in thin regular beds from 5-10 cm thick, with occasional beds of gray or brown sandstone varying from 10 cm to 1 m in thickness; petrolierous, especially in upper 50-75 m which have fewer sandstone beds, are more massive and conchoidally fracturing—the so-called "Bacau stage."

"There is an apparent transition from east to west in the character of the Vigo shale. In the eastern limb of the Central anticline, exposed in the valley of Vigo River, the formation is predominantly shale throughout, sandstone occurring only at intervals. In the western limb shale predominates in the exposure near the axis only, that is, the lower part of the series. Farther to the west the sandstone beds increase in number, until in the upper horizons they become more prominent than the shale. The grain-size likewise increases in the upper beds, and small pebbles occur, forming layers of sandy conglomerate. [Ibid.: 331]

"... In the eastern half of the field, the Canguinsa sandstone overlies the Bacau stage in a majority of exposures. Occasionally ... sandstone and fine conglomerate, which are evidently a part of the Vigo series, occur above the Bacau stage. In the western part of the peninsula sandy conglomerate is found near the top of the Vigo formation. These

overlying beds may be always present above the Bacau stage, but concealed generally by an overlap of the unconformable Canguinsa sandstone.

"... The thickness of the Vigo is unknown. An apparent thickness of about 1,400 meters is revealed in the Matataha River section, the section on Malipa Creek in the southern limb of the Malipa anticline shows 800 meters of Vigo shale, and the section on Guinhalinan River indicates 600 meters. None of these sections exposes the base of the formation. The apparent thickness of the sections as measured along the outcrop may be in excess of the actual thickness as a result of superficial expansion of the beds or of the repetition of beds from faulting or close folding." [Ibid.: 332-333]

----- 1400+ m

Dickerson (1921a: 2-3) described the Malumbang as up to 1000 feet (305 m) thick and, referring his readers to the "strata referred by Pratt and Smith to the Canguinsa formation and Vigo group, ... " sums up:

The oldest rocks here recognized consist of shales and sandstones from 3000 to 4000 feet in thickness, the Vigo group and its uppermost member, the Canguinsa formation. The strata as exposed in the vicinity of the Vigo River are steeply dipping, black, organic shales, subordinate sandstones, and minor lignitic strata which are unconformably overlain by the Malumbang formation. ...

Dickerson added in a footnote that his "view concerning the stratigraphy of the region under discussion differs in this regard from that of Pratt and Smith, but a full exposition of this important point cannot be given here." Subsequently, he (Dickerson *in* Smith 1924: 313) explains:

I am not in agreement with Pratt and Smith concerning the stratigraphic relations of the Malumbang, Canguinsa, and Vigo in their type localities, Bondoc Peninsula. I believe that a great unconformity exists between the Malumbang and the underlying Vigo group. I failed to recognize an unconformity between the Canguinsa formation and the Vigo shale, although the areas cited by Pratt and Smith were critically examined. The relations that appear at these places are best explained by faulting. On this account, the term "Vigo" is widened to include the Canguinsa formation as its upper sandstone facies, thus raising the term Vigo to a group rank.

With the exceptions noted, Dickerson essentially follows the stratigraphy of Pratt and Smith.

In the Corby et al. report of 1951, a graphic

cross section (ibid.: pl. 8) along Bacal Creek across a faulted anticline shows the following sequence:

Malumbang Formation Unconformity

Upper Canguinsa	About 600 ft (200 m)
Bacau "stage"	About 750 ft (225 m)
Lower Canguinsa	About 250 ft (76 m)
Maglihi Lime and Sandstone	About 1250 ft (380 m)
Molave Gravels	About 250 ft (75 m)
Vigo Shales ("Upper Vigo")	Undetermined thickness

The thickness of the Maglihi Lime and associated sandstone, and of the Molave Gravels are considerably greater than those of comparable units of the Vigo in Pratt and Smiths' work and are probably more accurate. More detailed mapping in the area permitted recognition of more members, both of the Canguinsa and of the Vigo formations. Allowing for a maximum of 1400 m of exposed Vigo (Pratt and Smith 1913), or from 914–1219 m (3000–4000 ft) of exposed Vigo Group (the combined Canguinsa and Vigo of Dickerson 1921, 1924), a thickness of about 760 m (2500 ft) of Vigo Shales below the Molave Gravels appears to be a maximum thickness of these shales in outcrop. In view of the twice-modified rock-stratigraphic terminology in use by 1951, it should be noted that the Bacau Member ("stage" of Pratt and Smith, "local facies, and its position not uppermost" of Dickerson *fide* Smith 1924:81) is the "middle Canguinsa" of the Corby et al. (1951) report, with some 76 m (250 ft) of sandstones mapped as Canguinsa, though not included within that formation by Pratt and Smith. It seems also significant to add volcanic agglomerate, a single small outcrop of which occurs at the base of the Bacau and again at Pratt and Smiths' "unconformity" at the base of their Canguinsa. To repeat, the base of the Vigo Shales is not exposed on the southern Bondoc Peninsula; the stratigraphically lowest beds are those exposed in the core of a closed, but generally southward plunging, anticlinorium (see Corby et al. 1951: pl. 26; Irving 1953: map section 11). To the north, on the Tayabas isthmus, the lowest or "Tayabas coal measures" formation (with limestones, brown car-

bonaceous sandstones, and gritty calcareous sandstones) is a more-or-less comparable stratigraphic sequence (Tayabas-Aloneros Conglomerate—Hondagus Silt—Sumulong Diatomite—Vinas Formation—Malumbang Formation). It is intensely folded and appears to lie with depositional contact upon schist and gneiss along the north coast of the isthmus opposite Alabat Island (Corby et al. 1951: 192–195).

Cloud (1956: pl. 1) presented the following sequence for the Neogene of southeastern Luzon:

Malumbang ls. (after Dickerson)	100–200 ft
Canguinsa fm.	
marl, ls., sh., sdy marl	500–1200 ft
Maglihi s.	
calc. s.	1000–2000 ft
Molave cg.	100–400 ft
Vigo fm.	
mainly sh. and ss.	1450 ft plus

Biostratigraphy of the Foraminifers.—"The oldest fauna yet recorded from the Vigo area is the orbitoid assemblage from a piece of float on Bahay River reported by Yabe and Hanzawa as Pratt's locality No. 3" (Corby et al. 1951: 282, pl. 31, locality no. 177). The orbitoid is *Lepidocyclina (Eulepidina) formosa* Schlumberger, a species not known from strata younger than Tertiary e5. This eulepidine, *sensu stricto*, is probably conspecific with *Lepidocyclina richthofeni* Smith, and is perhaps the form in the limestone from Mount Morabi referred to the latter species by W. D. Smith and cited by Dickerson (1921a: 14–15), although the species was not found in place in any of the strata on Mount Morabi by the Philippine Petroleum Survey (see Corby et al. 1951: 286). The eulepidine would permit a correlation with at least a part of the Cebu Limestone which carries *L. (E.) formosa*, as discussed by Yabe (1919) and cited by Dickerson (1921a: 15). Its actual stratigraphic occurrence in the Vigo area is not known, however, and concerning this sample of fossiliferous float, it is only possible to repeat, "This material was probably derived from the Vigo formation, though not assuredly so, and it is apparently of Upper W age" (Corby et al. 1951: 282), i.e., Tertiary e4–e5, and thus Oligocene (see Dickerson 1921a: 16), or at least Oligo-Miocene strata are present at some unknown horizon within the Vigo Group of this area.

Small foraminifers in the Vigo Shale from below the Molave ("Morabi") Gravels point to a

similar conclusion; none appear to indicate an age younger than Tertiary f1–f2, and they permit correlation with the Malumbang Formation–Mt. Uling Limestone–Toledo Formation sequence of Cebu stratigraphically above the Cebu Limestone, the Singit Formation–Lower Tarao Formation sequence of Panay (see Corby et al. 1951: pls. 34, 35; and Bandy 1963), and with the Tagnacot Shales of Leyte, which are stratigraphically below the limestone with *Lepidocyclus* ("Trybliolepidina") *rutteni* of Tertiary f3 age.

Moreover, the orbitoidal limestone included locally within the Canguinsa by Pratt and Smith . . . and by Dickerson . . . does not outcrop at the type locality of the Canguinsa formation, and in fact stratigraphically underlies any beds there exposed. Pratt and Smith note its absence in the more northerly section of Vigo and Canguinsa on Bondoc. In the present report, it is given the name Maglihi limestone because of its well-defined occurrence on Mount Maglihi. "*Lepidocyclus* richthofeni," reported by Smith . . . from this limestone, and upon which rests the Miocene age determination of Dickerson's Vigo mollusks . . . has not been found, nor have additional specimens of this species been found, in this in the field. However, numerous specimens of large Foraminifera of similar generous dimensions have been found locally. Microscopic examination has revealed that the bulk are specimens of *Cycloclypeus*; others appear to represent a large species of *Lepidocyclus* (*Trybliolepidina*) an orbitoid which, like *Cycloclypeus*, is known elsewhere from Upper X limestone. Finally, it should be emphasized that his orbitoid horizon not only does not represent the Upper W horizon of the Cebu orbitoid limestone of Cebu, but also that it conformably underlies the base of the Canguinsa, a formation here over 600 meters thick, in the very uppermost beds of which occur the "Vigo" mollusks reported by Dickerson. . . . [Corby et al. 1951: 286–287]

The orbitoids from the Maglihi Limestone are stratigraphically the highest found to date from the typical Vigo-Canguinsa sequence, and they indicate a Tertiary f3 (orbitoidal "Upper X") age. Small-foraminifer faunas from the overlying lower Canguinsa (of Corby et al., not of Pratt and Smith) and Bacau are meager, and some of them indicative of brackish-water deposition; evidence as to their age is more negative than otherwise, suggesting though not indicating a situation characteristic of Tertiary g (postorbitoidal "Upper X") throughout the archipelago. Thus, the Vigo-Canguinsa sequence as high as the orbitoidal horizons of the Maglihi Limestone Member (Tertiary f3) is clearly of Miocene age. Above this point evidence as to age is negative.

On the Bondoc Peninsula, the Upper X faunas of the lower Canguinsa and Bacau . . . are succeeded upwards by

the Y faunas of the upper members of the Canguinsa. Above the Y faunas is a thin limestone bed used as a key horizon in mapping structure in the area, and above this, still in the upper Canguinsa, are the fine-grained and richly fossiliferous beds from which Dickerson's 'Vigo' mollusks were collected. Both the mollusks and the small foraminifera from this uppermost Canguinsa are typical of the Lower Z of Panay. [Corby et al. 1951: 290]

Translating the local letter symbols into the stages and zones of the East Indian "letter classification," "Upper X" reads Tertiary f3 and g, "Y" Tertiary h1, and "Lower Z" Tertiary h2.

A recent systematic study (Cook 1963) of the small-foraminifer assemblages at these upper Canguinsa localities has served to corroborate and emphasize the Tertiary h age of the strata at these localities. Seven samples from upper Canguinsa localities are rich in the species of "Rotalia" characteristic of the "Rotalia Zone" Tertiary h, including Dickerson's locality 2x which, with his 3x, occupy the stratigraphic position of those molluscan faunas upon which his percentages of extinction are derived. They are horizons high in the Canguinsa and most probably well above the top of the highest Bacau beds.¹²

Thus, independent evidence from the foraminifers, both direct and indirect, indicates a Pliocene age for the strata of the Canguinsa Formation of Pratt and Smith (the upper Canguinsa of Corby et al.) including the horizons yielding the mollusks of Dickerson's Vigo-Group fauna. It remains to review, in the full light of Martin's comprehensive studies of the mollusks of Java, the direct evidence from the Vigo-Group mollusks themselves.

B. ON THE BASIS OF THE MOLLUSKS

The Fauna.—Dickerson's theory concerning the relatively slow rate of evolution of marine tropical faunas was derived from study of collections that he made from Tertiary beds exposed in the Bondoc Peninsula, Luzon. These collections were later brought to America and deposited in the paleontological museums of the California Academy of Sciences, San Francisco, and the University of California at Berkeley and have been made available to us. In addition to Dickerson's original material, we have studied collections from three Bondoc Peninsula localities made in 1937 by W. P. Popenoe while work-

¹² See Note 12 in Appendix A.

ing for the Far East Oil Development Company of Manila. Two of the three localities, CIT 1388 and 1389, are the same as Dickerson's localities 2x and 5x, respectively. Dickerson's localities 3x, 4x and 11x were not duplicated in Popenoe's collections, and CIT 1390 is new. Dickerson's locality 9x, being far removed from the others and of dubious relationship to them, was not used.

One hundred forty-nine species of gastropods and bivalves are listed in the accompanying checklist with approximate abundance of individuals of each species, reported geologic occurrence from areas outside of the Bondoc Peninsula, and notes and references from the literature and from museum collections giving authority for the identifications. With two or three exceptions, all of the species listed are also figured with full locality and dimension data. Most figures of specimens are magnified two or three times.

Identification of the molluscan species has been made with aid of the references listed, and by direct comparison of the Bondoc Peninsula fossils with Recent specimens in the collections of the Department of Mollusks, U.S. National Museum, and of the Department of Geology, University of California, Los Angeles. Nomenclatorially, genera have been used in a broad sense, subgenera and subspecies have not been recognized, strictly nomenclatorial problems have been avoided, and the synonymy presented makes no claim to completeness, but lists only those references recently published and readily available that were used for identifications. Broadly, the classification of Wenz has been employed for the gastropods, and the Bivalvia are classified according to the plan in Part N, *Treatise on Invertebrate Paleontology*.

Any criticism of the Dickerson theory on the evolutionary rate of molluscan faunas in the tropics must consider two questions: first, Are the mollusk-bearing beds of the Bondoc Peninsula Miocene in age?; second, Are the contained fossil faunas made up of species of which approximately 75% are still living? We believe that Dickerson was incorrect in concluding that the beds are of Miocene age—they are much younger. Most of the reasons for this opinion have been expressed earlier in this paper, though some discussion dealing specifically with the supposedly extinct species will follow. Dickerson's conclusion that the faunas are made up of

approximately 75% Recent species, we believe is approximately correct. This will be pointed out in the analysis of the information assembled in the faunal checklist.

In his first paper concerning the Bondoc Peninsula faunas, Dickerson (1921a: 12) wrote: "In the above list there are 98 forms that are specifically determined, and of these 74 or 75.5% are living species, an astonishing number when the geologic history of the region yielding these forms is considered. In addition, the extinct forms are practically all common to the upper Miocene of Java, according to K. Martin [1880: 44–51]." Dickerson (1921a: 10–12) listed the following supposedly extinct species:

Actaeon reticulatus Martin
Buccinium simplex Martin #*
Cerithium jenkinsi Martin
Cerithium herklotsi Martin
Cerithium bandongensis Martin
Cerithium jonkeri Martin #*
Cerithidea near dohrni? #*
Conus ornatissimus Martin
Conus hardi Martin
Conus striatellus Jenkins #
Columbella bandongensis Martin
Mitra javana Martin
Mitra cf. jenkinsi Martin #
Mitra junghuhnii Martin
Mitra bucciniformis Martin
Strombus (?) fusus? Martin
Turris coronifer Martin #
Terebra bicincta Martin
Terebra javana Martin
Trivia smithi Martin #*
Voluta cf. innexa Reeve #
Corbula socialis Martin
Psammobia cf. lessoni Blainville #*
Vermetus javanus? Martin #*

It was not explicitly stated that the presence of these species in the Bondoc fauna was evidence of Miocene age, but the inference is difficult to avoid.

Specimens representing these species, with the exception of those starred, were later figured by Dickerson (1922: pls. 2–7) and the hypotypes were deposited in the collections of the California Academy of Sciences. Through the courtesy of the late Dr. Leo G. Hertlein, Curator Emeritus of Invertebrate Paleontology at the Academy, we have been able to borrow these hypotypes for study and refiguring (see pls. 17 and

TABLE 1. FOURTEEN SPECIES FROM THE VIGO GROUP. Dickerson's (1921a) identifications in the first column, our identifications in second column. Figure numbers refer to illustrations of conspecific specimens on plates 1-16. Geological age ranges compiled from the "Feestbundel" and from works of Oostingh, Regteren Altena, MacNeil, and Shuto.

Dickerson's Identifications	Identification Used in This Paper	Figure	Known Age Range
1. <i>Actaeon reticulatus</i> Martin	<i>Pupa sulcata</i> (Gmelin)	150	Recent
2. <i>Cerithium jenkinsi</i> Martin	<i>Cerithidea jenkinsi</i> (Martin)	18	U. Mio-Rec.
3. <i>Cerithium herklotsi</i> Martin	<i>Cerithium jonkeri</i> Martin	26, 27	Plio.
4. <i>Cerithium bandongensis</i> Martin	Not found		
5. <i>Conus ornatissimus</i> Martin	<i>Conus socialis</i> Martin	134, 138	U. Mio-Rec.
6. <i>Conus hardi</i> Martin	<i>Conus loroisii</i> Kiener	142	L. Mio-Rec.
7. <i>Columbella bandongensis</i> Martin	<i>Parametaria philippinarum</i> (Reeve)	71, 72	U. Mio-Rec.
8. <i>Mitra javana</i> Martin	<i>Vexillum vulpecula</i> (Linnaeus)	114	Plio-Rec.
9. <i>Mitra junghuhnii</i> Martin	<i>Mitra interlirata</i> Reeve	105	U. Mio-Rec.
10. <i>Mitra bucciniformis</i> Martin	<i>Vexillum cruentatum</i> (Gmelin)	109	U. Mio?-Rec.
11. <i>Strombus</i> (?) <i>fusus</i> ? Martin	Not found		
12. <i>Terebra bicincta</i> Martin	Not found		
13. <i>Terebra javana</i> Martin	Not found		
14. <i>Corbula socialis</i> Martin	Not found		

18), with the exception of those indicated by the #-symbol, which could not be found. Comparison of Martin's illustrations of the species (reproduced on some plates) with illustrations of the inferred identical species from the Philippines raises doubts as to the correctness of Dickerson's identifications and the validity of his stratigraphic correlations.

Listed in Table 1 are the fourteen hypotypes figured on Plates 17 and 18. In the first column are Dickerson's identifications of the forms; in the second, our identifications are listed, followed by the figure number of conspecific specimens illustrated on Plates 1 to 16; and in the final column the inferred geologic ranges of these species are compiled from the "Feestbundel" and from the subsequent works of Oostingh, Regteren Altena, MacNeil and Shuto.

Nine species for which geologic ranges are inferred are included in Table 1. All except one have been recognized from the Recent faunas. Six are reported from beds of Miocene age, though none is restricted to that epoch. Only one—*Cerithium jonkeri*—appears to be extinct. Thus, the assemblage as a whole implies only a Neogene and not Miocene age, and correlation with the fauna from Junghuhn's locality "O."

In summary, it is held that none of the evidence put forward by Dickerson to demonstrate the Miocene age of the Bondoc Peninsula molluscan faunas has been sustained by later work, and the inferred correlations and substructure for the theory that molluscan evolution in the

tropical Pacific is slower than in temperate regions are without foundation.

The question may next be asked: Does any evidence exist as to the age of the Bondoc Peninsula faunas relative to those found elsewhere in the western Pacific, and to the standard Cenozoic time scale based upon type faunas from western Europe? At least a partial and tentative answer to this question will be attempted below.

Two systems for correlation are in common use in western Pacific Tertiary biostratigraphy. The first, based commonly upon analysis of the molluscan faunas, expresses the ages of fossiliferous beds in terms of the standard epoch terminology of western Europe—Eocene, Oligocene, Miocene, etc. The actual stratigraphic succession of the most prolific faunas is hard to determine in most cases, and the faunal succession has therefore been inferred upon determination of the percentage of Recent species present in the faunas according to methods originated by Lyell and modified for use in Indonesia by Karl Martin. This method of age determination has been used generally by other molluscan paleontologists working with Indonesian mollusk faunas, e.g., Tesch, Oostingh, Regteren Altena, MacNeil and Shuto. All have recognized that the Cenozoic epochs used in Indonesia are not necessarily exactly equivalent with those of the type sections in western Europe.

The second system of biostratigraphic classification is the letter system of Leupold and van

der Vlerk (1927) and is based principally upon the succession of larger foraminifera, with more recent utilization of smaller foraminifera as well. The two types of classification have not been completely satisfactorily integrated nor has either as yet been satisfactorily coordinated with European and American Cenozoic divisions. In the discussion that follows, Cenozoic epoch terms will be employed in the sense that they have been used by Karl Martin and later paleontologists working with western Pacific molluscan faunas.

The faunal chart (Text-fig. 3) accompanying this report lists 149 species of gastropods and bivalves, comprising all forms believed to be specifically determinable. We identified 127 species; the remaining 22 were either considered as conferred, or as undetermined, but not indeterminate species. There are 105 species, including those questionably identified, that are believed to be still living. A few unidentified species are listed as still living because of their presence in collections of Recent shells in the U.S. National Museum.

Dickerson calculated the percentage of Recent species as the proportion of identified forms in the fauna; on this basis, the fauna in our check list is 83% Recent, calculated to the nearest whole percent. This figure is slightly more than the 75% calculated by Dickerson. Neither figure includes the fairly large proportion of undetermined species, and there is no compelling reason to think that the percentage of Recent forms in the undetermined fraction of the fauna is necessarily the same as in the determined fraction. It might be argued that the percentage of *extinct* forms in the 22 undetermined species in the checklist would probably be greater than in the determined species because the fossil molluscan fauna of the Philippine area is poorly known, whereas the Recent faunas of this region have been much better described and figured, and because the collections of Philippine Recent mollusks in the U.S. National Museum, consulted in the course of this study, are among the best in the world. For this reason, percentages of Recent species in the following calculations are based upon the total number of species in the fauna, assuming in the first figure that all unidentified species are extinct, and in the second that they are all living. The two figures thus given indicate essentially the minimum and maximum percentages of Recent species in the fau-

nas. For the composite fauna, these figures are 70–85%.

For the discussion below of the Bondoc Peninsula faunas, the assemblages from the three most prolific localities are analyzed and tabulated separately as to specific abundance, proportion of Recent species, and the known time ranges of the various species. The data for these analyses are taken principally from the "Feestbundel," and are supplemented by information from subsequent publications by Oostingh, Regteren Altena, MacNeil, Shuto, Cossmann, Abbott and Powell. Data for the three most prolific localities, 2x–1388, 3x and 11x are furthermore expressed graphically on Text-fig. 4.

These data and graphs show that: (1) All localities have a considerable number of species whose ranges begin in lower Miocene or in upper Miocene time. Such species make up from 27% (loc. 1390), to 55% (loc. 1389) of the total species in each locality. Only two species of the total fauna, however, are not found in beds later than Miocene elsewhere in the western Pacific Tertiary faunas. These two are *Potamides sucradjanus* Martin, known elsewhere by a single specimen from the upper Miocene of Java, and *Crassispira* cf. *C. hataii* MacNeil, which is found in a single locality in the Yonabaru Clay Member of Okinawa. (2) All of the Bondoc Peninsula localities yield species whose ranges begin in the Pliocene and are either elsewhere known only from beds of that series or range higher. The percentage of such varies from 54% (11x) to 72% (3x & 1389). All of these localities have a small number of species, from 1 to 6, that are elsewhere found only in Pliocene beds. (3) Several, but not all, of the Bondoc Peninsula localities include species whose ranges begin in beds of Pleistocene age. The greatest number of such species is three, from locality 11x. (4) All of the Bondoc Peninsula collections contain identified species that have not hitherto been found as fossils. The percentage of such to the total fauna ranges from 16% (9 species) in locality 3x to 31% (8 species) in locality 1390. Recognition of these species for the first time in the fossil record obviously contributes nothing to determination of the age of the containing beds. (5) All localities yield a large proportion of species known as fossil but still found living in Recent seas. It has been pointed out earlier that it is not possible to obtain precise figures for the percentage of Recent species in each locality so

UPPER CANGUINSA LATE TERTIARY MOLLUSKS, BONDOL PENINSULA, LUZON, PHILIPPINES

SPECIES:	LOCALITIES							RANGE	ILLUSTRATIONS	SYNONYMY AND IDENTIFICATION REFERENCES		TEXT - FIGURE 3, SHEET 1
	24	34	44	14	1389	1390	1391	U10	Pls	Pls	Pls	
CLASS GASTROPODA												
SUPERFAMILY TROCHACEA												
1. <i>Umbonium vestiarum</i> (Linnaeus)	Δ				○				+	+	+	1 I-3
SUPERFAMILY NERITACEA												
2. <i>Neritina</i> cf. <i>N. danovana</i> Recluz					Δ					+		4, 6
SUPERFAMILY RISSOACEA												
3. <i>Rissoana</i> sp.					x							5
SUPERFAMILY CERITHIACEA												
4. <i>Architectonica perspectiva</i> (Linnaeus)	x	x	x	x	x				+	+	+	7-9
5. <i>Architectonica maxima</i> (Philippi)					x				+	+	+	10-12
6. <i>Tescheum tescheum</i> ? (Linn)		x							+	+	+	2 13, 14
7. <i>Palatides sucadjanus</i> Martin					○				+			15
8. <i>Palatides</i> sp. β					x							16
9. <i>Cerithidea</i> ? sp.					x							17
10. <i>Cerithidea jenkinsi</i> (Martin)	x	x			○				+	+	+	18
11. <i>Rhinoclausis pfefferi</i> (Dunker)	x	Δ			○				+	+	+	19
12. <i>Rhinoclausis</i> ? sp. β					○							20
13. <i>Clypeomorus marus</i> (Lamarck)	x				Δ				+			21
14. <i>Cerithium alternatum</i> Sowerby		x							+	+		22
15. <i>Cerithium rubus</i> Martyn		x							+	+		23, 24
16. <i>Cerithium</i> sp. E												3 25
17. <i>Cerithium jankeri</i> Martin		○							+			26, 27
18. <i>Cerithium</i> sp. C		x										28
19. <i>Cerithium</i> sp. F		x										29
20. <i>Cerithium</i> sp. a	x				x							30
SUPERFAMILY EPITONACEA												
21. <i>Epitonium scalare</i> (Linn)					x				+	+		31
SUPERFAMILY STROMBACEA												
22. <i>Dicathochilus crispatus</i> (Sowerby)		Δ	x		○				+	+	+	32, 33
23. <i>Triton</i> (Linn)			x	x					+	+	+	37
24. <i>Strombus maduensis</i> Martin			Δ						+	+	+	34
25. <i>Strombus plicatus pulchellus</i> Reeve					○				+	+	+	35
26. <i>Strombus canarium</i> Linn		○			○				+	+	+	36
27. <i>Strombus gendangensis</i> Martin		x	○	x					+	?		39-42
28. <i>Strombus fennanai</i> ? Martin				x								4
SUPERFAMILY CYPRAEACEA												
29. <i>Cypraea miliaris</i> Gmelin											+	43, 44
30. <i>Cypraea parana</i> ? Linn					x						+	45
SUPERFAMILY NATICACEA												
31. <i>Natica mamata</i> (Röding)	x		x	x					+	+		46, 47
32. <i>Natica peruvianiana</i> (Recluz)					x				+	+		48, 49
33. <i>Natica papilla</i> (Gmelin)	x								+	?	+	50, 51
34. <i>Natica</i> sp. α					x	x			+	+	+	52, 53
35. <i>Natica solida</i> (Blainville)	Δ	Δ		Δ	Δ	x			+	+	+	54, 56
36. <i>Natica duranensis</i> (Röding)	Δ	x		Δ	Δ				+	+	+	55
37. <i>Natica marchensis</i> (Gmelin)	Δ	Δ		Δ	○	x			+	+	+	5
38. <i>Natica</i> cf. <i>N. columnaris</i> Recluz	x											59, 62
SUPERFAMILY TONNACEA												
39. <i>Tonna glauca</i> (Linn)				x							+	65
40. <i>Tonna canaliculata</i> (Linn)				x							+	UNFIGURED
41. <i>Tonna bayeri</i> Altena	x								+			61
42. <i>Tonna gracile</i> ? (Reeve)				x	x				+	+		60, 63
43. <i>Tonna reticulata</i> (Röding)		x	x						+	+	+	64, 63
44. <i>Tonna bituberculata</i> (Lamarck)		x	Δ			x			+	+	+	66
45. <i>Tonna parana</i> ? (Linn)		x	x	x					+	+	+	68
SUPERFAMILY MURICACEA												
46. <i>Murex sobrinus</i> (A. Adams)				Δ					?	?	+	67
SUPERFAMILY BUCCINACEA												
47. <i>Fucimeria philippinarum</i> (Reeve)	x	Δ			○	x			+	+	+	7 71, 72
48. <i>Fucimeria acuminata</i> (Reeve)				Δ					+	+	+	73
49. <i>Megastoma gigas</i> (Martin)					x				+	?	+	6 69, 70
50. <i>Megastoma galeodes</i> (Lamarck)	x	x	x	○	Δ				+		+	7 73
51. <i>Hebra subspinosus</i> (Lamarck)	x	x							+	+		76
52. <i>Hebra jankeri</i> (Martin)	Δ	x			x				?	+		77
53. <i>Natica</i> sp. cf. <i>N. gemmulata</i> (Lamarck)					x						+	78

EXPLANATION OF SPECIES-SYMBOLS	
x	RARE 1-3 SPECIMENS
Δ	COMMON 4-10 SPECIMENS
○	ABUNDANT 11 OR MORE SPECIMENS
+	PRESENT IN EPOCH

SHUTO p 53, PI 1, fig 1-3, 5-7

= USNM 419513, Guimaras, Philippines

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SHUTO, p 96, PI 1, fig 4, 8, 15, MACNEIL, p 38, PI 1, fig 18, 22, 26, UCLA 24677, 41436

MACNEIL, p 38, PI 1, fig 17, 21, 25, = USNM 229223, Linapacan Strait, Philippines, = UCLA 24678

TESCH 1920, p 56, PI 14, fig 191, MARTIN 1891, p 220, PI XXXIII, fig 509, = UCLA 18198, 43026

MARTIN 1891, p 211, PI XXXII, fig 480, a, b

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MARTIN 1879, p 65, PI XI, fig 6, MARTIN 1891, p 216, PI XXXIII, fig 499, 500, 502, [P. djadjarjensis], USNM 232879, Catanduanes, Philippines

HABE 1964, p 41, PI 12, fig 19, = USNM 275855, = UCLA 31442

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REEVE, C I, Cerithium, PI VII, species 42, = USNM 243952, = UCLA 23687

= "Cerithium alternatum Sowerby", USNM 18652, Singapore, = USNM 634325, Yap, Caroline Is.

TESCH 1920, p 55, PI LXXX, fig 176-177

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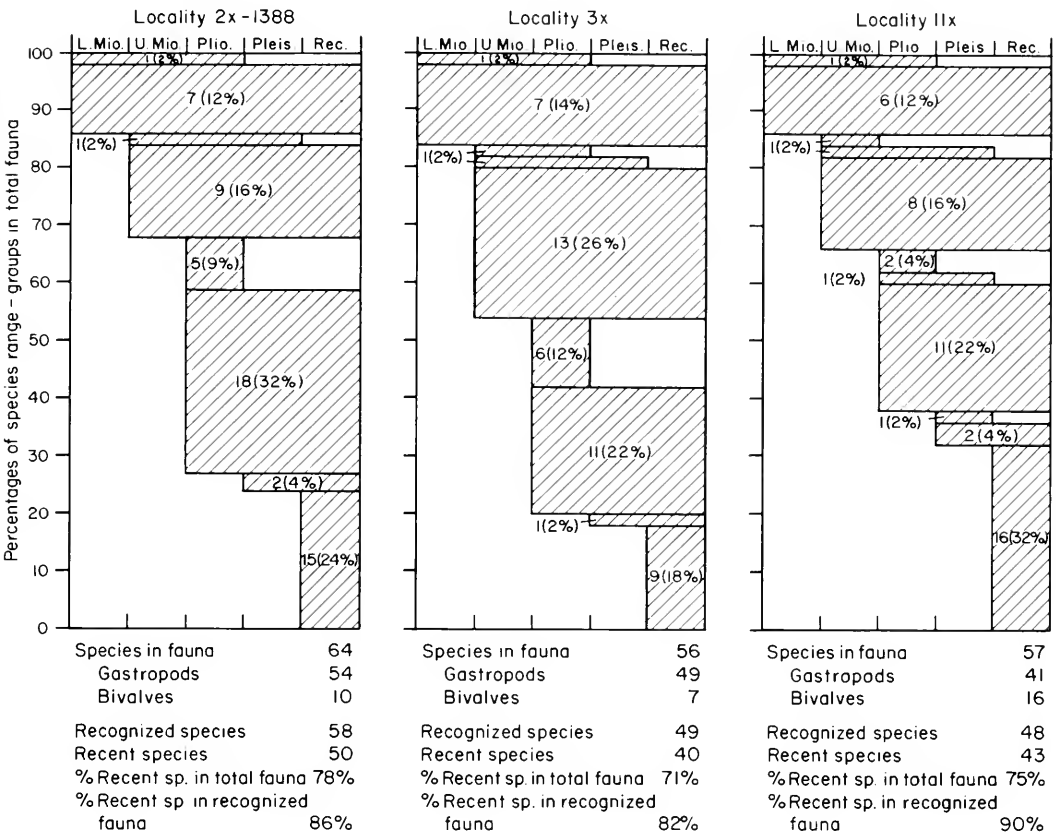
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UPPER CANGUINSA LATE TERTIARY MOLLUSKS, BONDOC PENINSULA, LUZON, PHILIPPINES

SPECIES	LOCALITIES										RANGE			ILLUSTRATIONS		SYNONYMY AND IDENTIFICATION REFERENCES		TEXT-FIGURE 3, SHEET 3		
	PX	XX	X	H	I	S	B	R	O	S	L	M	G	P	R	C	RE	PLATE	FIGS	
CLASS GASTROPODA																				
SUPERFAMILY CONACEA (cont)																				
113 <i>Terebra duplicata</i> ? Linnaeus							X							+	+	+	11	147	SHUTO, p.231, Pl.23, fig.4, <i>Diplomeriza</i> , REEVE, C.I., <i>Terebra</i> , Pl. I, species 3	
114 <i>Terebra myriformis</i> ? Fischer																		148	FISCHER, p.89, Pl.3, fig.67a, b, aff. USNM 343418, " <i>T. pretiosa</i> Reeve, Kii, Japan"	
SUPERFAMILY PYRAMIDELLACEA																				
115 <i>Pyramidella</i> sp.							X												149	
SUPERFAMILY ACTEONACEA																				
116 <i>Pupa sulcata</i> (Gmelin)	X	X															+	150	HABE in KURODA, 1949-53, p.41, Text-fig. 1; REEVE, C.I., <i>Tornatella</i> , Pl. I, species 4; DICKERSON 1922, Pl.2, fig.2, [<i>Actaeon reticulatus</i> K. Martin]	
CLASS BIVALVA																				
SUPERFAMILY NUCULANACEA																				
117 <i>Yoldia</i> sp. α		X															+	UNFIGURED	+ USNM 204406, common in Japan seas, Yesso, Hondo, Kagoshima Gulf	
118 <i>Yoldia</i> sp. β						X		Δ										12	ISI-153	
SUPERFAMILY ARCAEA																				
119 <i>Anadara panglossensis</i> (Martin)			X													+		154	MARTIN 1891, p.372, Pl. L III, fig. 117a, b, c	
120 <i>Anadara antiquata</i> (Linnaeus)		X				X								+	+	+		155	MARTIN 1891, p.371, Pl. L II, fig. 96, [<i>Arca lennana</i>] ; VANDERVLERK, p.289, note 19, +USNM 631801, Cebu, Philippines	
121 <i>Anadara bifurcata</i> (Martin)		X				X								+	+	+		156	MARTIN 1891, p.377, Pl. L III, fig. 113, 114, TESCH 1920, p.94, Pl. 20, fig. 253, 254, FISCHER, p.118	
122 <i>Anadara corneo</i> (Reeve)		O	Δ			O								+	+	+		160, 161	MARTIN 1891, p.379, Pl. L IX, fig. 118-120, TESCH 1920, p.96, Pl. 20, fig. 256, REEVE, C.I., <i>Arca</i> , Pl. 3, species 16	
123 <i>Anadara granosa</i> (Linn.)			Δ											+	+	+		157-159	TESCH 1920, p.92, Pl. 19, fig. 248, 249, MARTIN 1881, p.242, ? DICKERSON 1922, Pl. 6, fig. 4	
124 <i>Anadara</i> sp. α			X															13	162	
125 <i>Tridacna semitorata</i> (Lamarck)						X										+		163	KIRA, p.123, Pl. 44, fig. 3, REEVE, C.I., <i>Arca</i> , Pl. XIII, species 89	
126 <i>Sitarca olivacea</i> (Reeve)						X										+		164, 165	REEVE, C.I., <i>Arca</i> , Pl. XXV, species 113	
127 <i>"Sitarca sinensis"</i> Habe & Kosuge, non Thiele						X										+		166	HABE & KOSUGE 1966, p.126, Pl. 47, fig. 1, ? non THIELE 1931, p.174, Pl. I, fig. 7	
SUPERFAMILY LIMOPSACEA																				
128 <i>Limopsis</i> sp. β						Δ											+	167, 168	+USNM 294954, off Marinduque, Philippines	
129 <i>Glycymeris</i> sp. α						X											?	169	cf. UCLA 50070, <i>Glycymeris modesta</i> (Angas), New Zealand	
130 <i>Glycymeris</i> sp. A						Δ												171		
131 <i>Glycymeris</i> sp. B						X												170		
SUPERFAMILY PECTINACEA																				
132 <i>Amusium pleurocetes</i> ? (Linnaeus)								X								+	+	14	172	
133 <i>Chlamys crassicaulus</i> ? (Sowerby)						X												173	? REEVE, C.I., <i>Pecten</i> , Pl. XIII, species 48, ? +USNM 258262	
SUPERFAMILY LUCINACEA																				
134 <i>Cyclindroma oblonga</i> (Sowerby)						X		O						+	+	+		174-176	MARTIN 1881, p.252, Pl. XIII, fig. 49, 49b, [<i>Cytherea everwijnii</i> , n. sp.] ; HABE, p.181, Pl. 56, fig. 9; USNM 127018 & 562505, brackish water, Philippines	
SUPERFAMILY CARDITACEA																				
135 <i>Cardita canaliculata</i> Reeve						O										?	+	177, 180	REEVE, C.I., <i>Cardita</i> , Pl. XVII, species 40, DICKERSON 1922, Pl. 6, fig. 10, [<i>C. antiquata</i> Linn.] ? FISCHER, p.121, Pl. 5, fig. 109, " <i>C. javana</i> Martin"	
SUPERFAMILY CARDIACEA																				
136 <i>Laevicardium cf. L. multipunctatum</i> (Sowerby)						X												178	cf. UCLA 50778, " <i>Laevicardium multipunctum</i> [Sowerby]", DICKERSON 1922, Pl. 6, fig. 7, [<i>Cardium elongatum</i> (Bruguiere)]	
137 <i>Laevicardium unicolor</i> ? (Sowerby)						X											+	179	REEVE, C.I., <i>Cardium</i> , Pl. XVIII, species 88, DICKERSON 1922, Pl. 6, fig. 8a, 8b, " <i>Cardium unicolor</i> [Sowerby]"	
SUPERFAMILY TELLINACEA																				
138 <i>Hemimex donaciformis</i> (Spengler)								X									+	181, 182	HABE & KOSUGE, p.162, Pl. 63, fig. 16; DICKERSON 1922, Pl. 6, fig. 9a, 9b, <i>Cardium donaciformis</i> Cumming, USNM 248123, Bohol, Philippines	
SUPERFAMILY GLOSSACEA																				
139 <i>Meloidia aff. M. vulgaris</i> (Reeve)						X												15	183	
SUPERFAMILY VENERACEA																				
140 <i>Costastergocina</i> (Linnaeus)						X											?	184	? HABE & KOSUGE, p.164, Pl. 64, fig. 8, <i>Costacallista erycina</i> (Linnaeus), +UCLA 24100 & 26270	
141 <i>Glycymeris sinensis</i> ? (Gmelin)								X									+	185	KIRA, p.159, Pl. 57, fig. 5	
142 <i>Clavoscapophanes</i> Gray								X	X								+	186	HABE, p.193, Pl. 59, fig. 19, +USNM 297653, Borneo, off Sandakan Island	
143 <i>Polydora glypta</i> ? (Philippi)											Δ						+	187	KIRA, p.161, Pl. 57, fig. 25	
144 <i>Polydora</i> sp. α								X										188		
145 <i>Polydora isabellina</i> (Philippi)								X	Δ								+	189	HABE & KOSUGE, p.160, Pl. 63, fig. 4, cf. TESCH 1920, p.104, Pl. 21, fig. 275a, b, [<i>Venus chloratica</i> Philippi], UCLA 50818	
SUPERFAMILY MYACEA																				
146 <i>Corbula insculcata</i> Smith		O	O			O	O										+	16	190-192	
147 <i>Corbula melletia</i> Fischer	X	X		X	X	X	X									+		193-195	SMITH 1878, p.819, Pl. L, fig. 23, 23a, 23b, HABE, p.204, Pl. 63, fig. 6, DICKERSON 1922, Pl. 6, fig. 13a, 13b, [<i>Corbula scaphoides</i> Hinds]	
148 <i>Corbula scaphoides</i> Tesch, non Hinds						X		Δ								+		196-198	FISCHER, p.131, Pl. 6, fig. 124-126, aff. <i>Anisocardia scaphoides</i> Hinds, in HABE & KURODA, p.3, Pl. 1, fig. 13, 14	
149 <i>Corbula</i> sp.						X												199	TESCH, p.106, Pl. 22, fig. 281-283, non <i>C. scaphoides</i> Hinds, REEVE, C.I., <i>Corbula</i> , Pl. 3, species 24	

Text—Figure 4. Species - Range Diagram, Upper Canguinsa Molluscan Fauna, Philippines



long as geologic ranges of the unidentified forms are unknown. Therefore, the proportion of Recent species is represented by a double percentage figure as explained above. The true percentage then lies somewhere between the two given, and for reasons given above, probably is nearer the minimum than the maximum. Percentages for all localities on this calculation are given below:

2X-1388	78%-89%
3X	73%-86%
4X	81%-85%
11X	75%-91%
1389	78%-89%
1390	77%-85%

Martin, Tesch, Fischer, Shuto, Oostingh and a few others have rather consistently placed in the Pliocene fairly large faunas having from 50% to 64% Recent species. In a few instances (Oostingh 1935: 222; Fischer 1927), faunas with

slightly under 50% Recent species have been considered Pliocene. Records of Quaternary faunas are few. Martin (1883-87: 348) lists only two for which percentage figures are given, "Umgegend von Grisee," with 30 mollusca, 90% Recent species, and "Untergrund von Batavia, bis 6 m. Tiefe," with 22 species of which 86% are Recent. Thus, percentagewise, there is a considerable interval, 65% to 86%, that is represented by no sizable fauna. It is in this interval that the Bondoc Peninsula faunas appear to belong. On this basis they may be dated as very late Pliocene or very early Quaternary.

Other data suggesting that the Bondoc Peninsula faunas are of Pliocene age have been mentioned above where it is shown that from 54% to 72% of the species from the several localities are known elsewhere from Pliocene, but not from earlier beds. This strongly Pliocene aspect of the faunas is tremendously increased if we disregard the species for which no other occur-

rence is known, and those which are elsewhere known only in the Holocene. For example, locality 11X, which has 57 recognized species, has only 32 identified species with occurrence in the fossil record; 30 of these occur in the Pliocene, but only 17 are found in Miocene strata, and only 1 species, doubtfully determined, is confined to the Miocene.

In summary, the Canguinsa molluscan faunas are probably late Pliocene or possibly early Pleistocene in age, in the sense that these terms are used by western Pacific molluscan paleontologists. The conclusion of Dickerson that Miocene faunas of this region contain 75% Recent species is therefore without basis.

The much more difficult problem as to the different rate of evolution of molluscan faunas in the tropics as compared to temperate seas cannot be confidently solved at this time, but some facets of the problem are considered next.

Rates of Evolution.—The term “rates of evolution” as used by Dickerson evidently applies to what might be termed differences in percentage of Recent (or extinct) species between contemporary tropical and temperate faunas. The arguments put forward to explain these differences are based upon inferences and conclusions that do not appear valid at this time. Dickerson’s conclusions depended upon his dating of the Canguinsa molluscan fauna as Miocene, whereas work subsequent to publication of his conclusions suggests that the Canguinsa fauna is much younger.

The concept that tropical later Tertiary faunas contain a higher percentage of Recent species than do contemporary temperate or arctic faunas apparently was first put forward by Martin (1879–1880: 22–30), and it is here that Dickerson may have found the germ of his conclusions regarding the Canguinsa fauna. Martin (op. cit.: 29) states that the true percentage of Recent species in the Javanese faunas described was probably near 50%, approximately the percentage of the lower Pliocene of Europe. Martin’s Javanese faunas closely resembled those described a little earlier by Medlicott and Blanford (1879) from the Gaj Series of Sindh and referred by them to the Miocene. As the Javanese faunas showed little or no resemblances to Eocene faunas and little or none to (known ?) Pliocene faunas, Martin concluded that they, too, are probably of Miocene age. Martin (op. cit.: 22–24) discussed at length the difficulties attendant upon corre-

lating tropical Indo-Pacific faunas with contemporary assemblages in Europe, summarizing these difficulties as follows (free translation by us): “However, neither the species which are related to or are identical with European ones, nor even the percentages of Recent species found in [European] Tertiary beds supply a ways-and-means for the age determination of tropical Tertiary beds.”

Martin explained this situation in paragraphs a little too long to quote, but which he summarized forty years later (Martin 1921: 763; translation by T. Wayland Vaughn):

That I designate as Miocene, sediments which contain 45% of living mollusks, may raise doubt, especially when this estimated percentage, for reasons already stated, is appreciably below the real percentage. In reply to this, it is to be emphasized that in *similar Neogene sediments of Europe and the Indies the deposits in the latter region must contain a higher percentage of living species than the former* [Martin’s italics]. This is because there was during the Tertiary time important climatic changes in the extratropical regions while no such changes took place in the tropics. In the tropics, accordingly, there were fewer factors which would modify the species and, therefore, the transformation of the fauna in the tropics did not take place so rapidly as in our [European] region and, consequently, more species have persisted until present time. The younger the strata are, the larger must be the differences in percentage for equivalent strata in Europe and the Indies; precise values for these cannot be given.

The two concluding sentences in the paragraph quoted above are of particular interest. The statements seem untenable, and it is hard to avoid the feeling that they imply interpretations that the author did not intend to put forward. If accepted at face value, the implication is that in Miocene times tropical faunas will have a higher percentage of still-living species than do contemporary Temperate-Zone faunas; in Pliocene time the disparity in percentage between the faunas of the two regions increases and, by inference, would necessarily be progressively yet greater in the Pleistocene and Holocene epochs. Stating the situation somewhat differently, the Recent faunas of the Indo-Pacific region contain a higher percentage of living species than do the Recent faunas of the European coasts. If it be argued that Martin’s statement applies only to later Tertiary faunas, the same absurdity holds, for every time-horizon in the later Tertiary—lower Miocene, upper Miocene, Pliocene—had its then-living or “Recent” faunas which, it is implied, differed in percentage of “Recent” species in Indonesia and in Europe.

The hypothesis presented above is that of a very able worker with profound acquaintance with Indonesian later Tertiary faunas, but it remains only an hypothesis and has not been supported by later work. Indeed, a small amount of evidence brought out in the last half century tends to throw doubt on some of the basics of this hypothesis.

It is clear that Martin's ideas regarding the fundamental differences in percentage of Recent species in late Tertiary tropical faunas, on the one hand, and those of temperate and cold seas, on the other, cannot be tested until it is possible to correlate with considerable refinement across these latitudinal barriers and, in this case, particularly between tropical Indo-Pacific and temperate west European faunas. Unless we know with a considerable degree of precision that two faunas are of the same age, we have no basis for evaluating any differences they may show in percentage of Recent species. Quotations from two active current workers in this field suffice to show that the problem of interprovincial correlation still escapes solution. Cloud (1956: 560) wrote: "Establishment of age equivalents in the standard European succession is perhaps the most difficult task of Indo-Pacific Cenozoic correlation. Indeed it is sometimes considered impossible, and efforts to do so are periodically abandoned." H. S. Ladd (1966: 9) stated: "Age determinations and correlations involving major stratigraphic units in the several island groups are based on the letter classification established for Indonesia. No attempt is made to tie these Indonesian units to the stages of the standard European sequences. Efforts of this sort have been made, but most such efforts have been regarded as tentative, even by their proposers."

The factors inferred by Martin to be responsible for the differing rates of faunal change are those of the physical environment. He believed that temperature changes were minimal in the tropics throughout later Tertiary time, whereas, in the later Tertiary European seas, a steady decline in marine temperatures obtained, culminating in the glacial climates of the Pleistocene. He believed that factors other than that of marine temperature were operative with about equal intensity over both time and space. The nearly persistent warm seas of the tropics exerted little influence productive of faunal changes, hence a greater percentage of the faunas in any time-horizon persisted into later times

and ultimately into the Holocene. In line with the above inferences, Martin used a percentage scale for the Indonesian Tertiary differing considerably from that used by western European and western Atlantic paleontologists. Comparison of these scales is given below:

EPOCH	EUROPEAN AND EASTERN AMERICAN (%)		INDO- NESIAN (%)
Pleistocene	+ 50-100		70-100
Pliocene	30-50+		50-70
Young Miocene	} 3-30		20-50
Old Miocene			8-20

Since Martin's (1919) summary, a number of comprehensive studies of Indonesian later Tertiary faunas have appeared. In these, there is a tendency to consider as Pliocene, faunas with percentages of Recent species somewhat lower than those given above as the lower limit for this epoch. Thus, Fischer (1927: 11) placed the faunas of the Fufa Beds of Seran and Obi in the Pliocene with 46.8% Recent species. Tesch (1920: 110 et seq.) included in the Pliocene of Timor assemblages containing as low as 43% Recent species. Oostingh (1935: 222 et seq.), using Martin's methods, considered his Pliocene Kali Bieok Beds to be older Pliocene; on the basis of superposition, he considered them older than Martin's reference fauna for the Pliocene—the Sonde Beds, with about 53% Recent species.

If, as has been implied, uniformity of the tropical climates has resulted in slow faunal alteration, whereas the changing climates of higher latitudes have accelerated faunal change, the tropical later Tertiary faunas of the New World should show relatively high percentages of Recent species, as has been claimed for the Indonesian faunas. In the last half century, a number of extended studies on tropical American Neogene faunas have appeared, including works by Woodring (1925, 1928), Weisbord (1929, 1962, 1964), Olsson (1922), Pilsbry and Olsson (1941), Jung (1965, 1969), Marks (1951), Maury (1934), and others. The faunas considered in these studies have commonly been dated according to the percentage of Recent species recognized or by comparison with earlier described faunas which have themselves been dated by the percentage method. The scale used is approximately that

used by European and American workers (as given above), and which also approximates the percentages used by Lyell (see Davies 1934: 56–57), Woodring (1928: 107), and Vaughan (1923: 526). Roughly, large faunas with Recent-species percentages between 3% and 30% would be placed in an appropriate part of the Miocene; those with Recent-species percentages of 30% to 50% would be considered Pliocene. These percentages, at least for middle Miocene and younger, are 10–20% below those given for “Miocene” and “Pliocene” faunas of Indonesia by Martin. The faunas considered above are all tropical; therefore, these differences in percentages can scarcely be due to differences in marine climate. They suggest, for example, that the “Pliocene” of Indonesia may well represent a time interval different from, and quite possibly somewhat younger than, that of the “Pliocene” of tropical America, or that influences not yet recognized are responsible for the discordance in percentages.

A recent work on the Caloosahatchee fauna of southwestern Florida (Du Bar 1958) adds to the anomalous situation discussed above. This Caloosahatchee fauna is very large and has uniformly been considered tropical (Dall 1903: 1605; Du Bar 1958: 88). The calculated percentage of Recent species in the assemblage varies considerably with the individuals who have analyzed it, emphasizing, perhaps, the importance of the personal factor in specific determinations. Dall (1903: 1604) determined 639 molluscan species of which 48% are Recent; Olsson and Harbison (1953: 10) recognized 505 species of which 33.8% are Recent; while Du Bar identified from the type-locality 341 species of which 39.5% are Recent. Diverse as these figures are, they would all date the Caloosahatchee Beds as later Miocene if the yardstick used by Martin were applied, and as Pliocene according to the scale used by most students of the American later Tertiary. However, Du Bar (1958: 138–139) collected in place in the Caloosahatchee Beds a small mammalian fauna, including horse teeth identified as *Equus* sp. cf. *E. (E.) leidyi* from two different levels. This genus of horse is commonly thought to be restricted to Pleistocene and Holocene time. Thus, the Caloosahatchee fauna would, by some, be placed in the Pleistocene, despite having between 33.8% and 48% Recent species of Mollusca.

In summary, the Canguinsa molluscan faunas

are probably late Pliocene or possibly early Pleistocene in age, in the sense that these terms are used by western Pacific molluscan paleontologists. The conclusion of Dickerson that Miocene faunas of this region contain 75% Recent species is therefore without basis.

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The study described in this paper would have been well-nigh impossible without the generous aid of a number of colleagues and museums who have put their facilities and knowledge at our disposal. Loan of Dickerson's original collections was made by the California Academy of Sciences through the authority of its curators in the Department of Geology, the late Drs. G. Dallas Hanna and Leo G. Hertlein, and its present curator of Geology, Dr. Peter Rodda. Similarly, Dr. J. Wyatt Durham and Mr. Joseph Peck, of the Museum of Paleontology, Berkeley, have loaned us Dickerson's large original collection from locality 11x. We have been given full access to the fine reference collections of Recent shells at the above institutions, at the United States National Museum of Natural History, and at the University of California at Los Angeles. Dr. A. Myra Keen of Stanford University has aided in the identification of a number of rare South Pacific gastropod species; Mrs. Jean Cate and Dr. Walter Cernohorsky have kindly identified the miters. The superb photographs of the fossil specimens illustrated were taken by Mr. Takeo Susuki of U.C.L.A. The exacting preparation of the faunal range and distribution charts is the work of Miss Julie Guenther. Finally, all phases of the work upon the molluscan faunas have been greatly improved by the cheerful, informed and patient aid of Louella R. Saul.

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APPENDIX A—NOTES

1. See Kleinpell (1958: 4–5, footnote 3, and p. 7, footnote 4) for the nature and the fate of the fossils upon which these discussions were originally based. It had been the hope and plan of the writers in 1941 that the late Frank Merchant, who had assisted them in these studies, both in field and laboratory, and with particular emphasis upon the mollusk collections, would, with the fellowship that had been granted him at the California Institute of Technology, be able to pursue these studies to their logical conclusion. But at that point the second World War intervened. Mr. Merchant's promising career was violently terminated in a war-time prison camp. At the Bureau of Science in Manila, 18 large cabinets containing thousands of specimens of some seventeen hundred mollusk species, along with the microscopic slides of foraminifer types, assemblages, and polished limestone sections also stored there, were totally destroyed in the shelling during the American recapture of Manila. Subsequently, cloth-sacked foraminifer samples stored in a company riverside bodega, surviving the hostilities, disintegrated into incoherent mud and rot for lack of post-war curatorial funds. By 1951, nevertheless, four volumes of the nine comprising the Philippine Petroleum Survey's preliminary report, preserved in the States, had been published, salvaging much of the data and preliminary conclusions. Unhappily for the paleontologic checklists, however, the aims of the preliminary typology and distributional data (see Corby et al. 1951: 231, 292–297) which they record were totally defeated; even descriptions of the fossil localities to which they are geared were not included in the partially published report, though these may be found in copies of the original report on deposit in the Manila Bureau of Mines, and some of them do appear, graphically located by numbers, in some of the areal geology maps included in the publication. Too, a handful of duplicate specimens and slides, although scattered, had been preserved outside the war-devastated area through the foresight of the late Dr. Quirico Abadilla, Director at the time of the Philippine Bureau of Mines, who also lost his life in the final phases of the hostilities. Through the assistance of the post-war Philippine Bureau of Mines, Mr. Earl Irving and associates of the U.S. Geological Survey, and the management and staff of the Philippine Oil Development Company, considerable recollecting of fossils has been made possible (although, unlike neontological specimens, fossils do not reproduce their kind). Thus, it has been possible to reassemble at least some of the more critical material, either in original or duplicate form, over the years. In addition, the senior author has been able to study the original Dickerson molluscan material on deposit at the California Academy of Sciences and in the Museum of Paleontology at the University of California in Berkeley.
2. See Kleinpell (1958: 1–3). Comparison with material in Bandoeng, Java, and Balikpapan, Borneo, had been projected and, in fact, subsequently accomplished, after preparation of the Petroleum Survey's preliminary report. The biostratigraphic sequences selected to typify the tentative local age classification have retained descriptive value as presented in plates 34, 40, and 42 of the Corby et al. (1951) report. Especially valuable in this connection are plates 31 and 43 and the accompanying discussion of Philippine larger foraminifers (pp. 247–250, 264–288) by Morrison et al.
3. This PODCO report on the reconnaissance geology and oil possibilities of northern Luzon was at that time made available, along with the paleontological data from the localities published by Corby et al. (1951: pl. 10), to the geological staffs of American Overseas Petroleum Limited (see Durkee and Pederson 1961: pl. 137) and STANVAC, who were subsequently engaged with PODCO in joint geological exploration of the Cagayan Valley. Further studies, with the same context, were pursued in conjunction with Paul H. Dudley, Benjamin Daleon, and Mario Nieto, and references to scientific aspects of these private data were released for publication as of January 1957 (see Kleinpell 1958: 1, footnote 2).
4. This Tuguegarao Sandstone, essentially non-existent as a formational unit, was nicknamed by the field party at that time the "Kamlon Formation" after Datu Kamlon of Jolo who, up until that time, had successfully eluded every attempt by the Philippine army to find and capture him.

5. See Corby et al. (1951: pls. 34 & 35). Here the highest orbitoids occur in sample P-JH 32 within the "Type Upper X" portion of the sequence along the "Tarao" (a cartographer's misspelling of the original Jarao) River, the lowest "Rotalias" of the species in reference ("*Rotalia*" sp. 1, sp. 2, and sp. 3) in sample P-JH 15 of the "Type Y" part of the same sequence, and extending upward in greater abundance stratigraphically higher in the "Type Y" and through the "Type Lower Z" sequence.
6. See Corby et al. (1951: pl. 40). Here the highest orbitoids ("*Trybliolepidena*" sp. 35 and sp. 36, including "*T.*" *rutteni*, and *Miogypsina*) occur in the sampled sequence C-JH 38-0, 39-0, and 40-0 near Sibonga, and C-JH-37B-0 on the Aloguinsan-Barili road near kilometer 78, all in the Lower Limestone Member of the Barili Formation; and in the overlying marls and limestones the "Rotalias" in reference are far rarer than in the more clastic facies of the Philippine Neogene.
7. See Corby et al. (1951: pl. 31). Here the highest orbitoids are again of f3 age, from localities 155 and 156, as reported by Yabe and Hanzawa, the "Rotalias" are rare and restricted to the higher Hubay Formation and associated with its molluscan faunas.
8. Through permission from Colonel A. Soriano and the Philippine Oil Development Company to include references to private data in notes for publication. See Kleinpell (1958: 1).
9. Thus, the former Lubuagan "coal measures" or Lubuagan Formation on the west side of the valley became, in effect, the Mabaca River Group with three formations (a lower Asiga, a middle Balbalan Sandstone, and an upper Baluan). On the east side it became the Gatangan Creek Formation; the former Callao Limestone along the northwestern edge of the valley became the Sicalao Limestone, a name extended to also include the former Ibulao Limestone of the Kiangnan syncline in Ifugao and that of the south end of the valley (southwest of Mones, Isabela), while the name Callao was restricted to the original typical area along the eastern side. The former lower mudstone member of the Ilagan Formation along the east side became the Baliway Formation, following the designation of Vergara et al. (1959: 47, 52); the term Ilagan Formation was restricted to the upper more preponderantly coarse-clastic member of that formation in previous usage; and the designation Lallo Formation, without a type section due to poor exposures, was applied to the more or less tuffaceous clastics of variable texture previously mapped for the most part as Ilagan in the Aparri basin of the extreme north. Certain distinctively thin-bedded limestones in a relatively small and isolated area in the north became the Abaan Limestone, and the term Awidon Mesa Formation was given to certain welded tuffs and pyroclastics of Lubuagan.
10. See Corby et al. 1951, plate 10, localities LHB-301, 303, 306, 494, 726, 365, 461, 462, 469, 470, 471, 472, 473, 475, with *Eulepidina*, *Miogypsina*, and associated small foraminifers, all of Tertiary e age, and localities LHB-496, 497, 701, 796, 463, 464, 465, 480, 481, 487 and, especially, 474, 482, 483, 484, 488 and 489, all with Tertiary f1 orbitoids, as at LHB-315 near the top of the Sicalao, or former Callao Limestone, extension farther north in the area southwest of Luna.
11. See Corby et al. 1951, plate 10, localities LHB-727, 558, 560 and 562.
12. Localities D-1581 (LWP-35), D-1583 (LWP-33), D-1586 (LWP-29), D-1587 (LWP-28), D-1589 (LWP-24), D-1594 (LWP-19) and D-1597 (LWP-1 = Dickerson's locality 2x). The last-mentioned locality is especially rich in "*Rotalia*" *beccarii koeboeensis* LeRoy; "*Rotalia*" *indopacifica* Thalmann, "*Rotalia*" *japonica* Hada, and "*Rotalia*" *ketienziensis* (Ishizaki) are well represented; and "*Rotalia*" *papillosa* Brady is especially abundant in samples LWP-19, 24, 28 and 33.

APPENDIX B—REGISTER OF CIT FOSSIL LOCALITIES,
BONDOC PENINSULA, LUZON, PHILIPPINES

- 1388 CIT Blue-gray sandy marls cropping out on right bank of Bahay River, 1219 m (4000 ft) S 25°E of the mouth of Apad Creek, and about 366 m (1200 ft) upstream from abandoned oil well on left bank of river (Dickerson's Bureau of Lands bench mark no. 1), Bondoc Peninsula, Tayabas Province. Same as locality 2x/RED, 27 Nov. 1937. Collectors: W. P. Popenoe, Peregrino Pomania and Cosme Albis.
- 1389 CIT Gritty sandstones in bed of Bahay River, 152 m (500 ft) N 40°E of the mouth of Apad Creek, Bondoc Peninsula, Tayabas Province. Same as locality 5x RED, 27 Nov. 1937. Collectors: Popenoe, Pomania and Albis.
- 1390 CIT Soft blue sandy marls cropping out in bed of Bahay River, about 488 m (1600 ft) upstream from abandoned oil well (Dickerson's Bureau of Lands bench mark no. 1), Bondoc Peninsula, Tayabas Province, 27 Nov. 1937. Collectors: Popenoe, Pomania and Albis.

Descriptions of RED localities 2x, 3x, 4x, 5x and 11x are recorded on p. 4 of this paper.

PLATES
ILLUSTRATIONS OF CANGUINSA FOSSIL MOLLUSKS

We have described no new species in this paper. Species names followed by nov. spec. (=n. sp. = new species) refer to new species described by Martin in references 1879–1880, 1881–1884, and 1883–1887. The illustrations of these species on our plates 17 and 18 are photo copies of Martin's original figures. Quotation marks enclosing specific identifications by Dickerson on plates 17 and 18 indicate dubious or wrong identification, generally the latter.

Explanation of specimen catalogue number symbols

- UCB —University of California, Berkeley, Invertebrate Paleontology catalogue
CAS — California Academy of Science, Invertebrate Paleontology catalogue
UCLA —University of California, Los Angeles, Invertebrate Paleontology catalogue

PLATE I

- Figs. 1–3. *Umbonium vestiarium* (Linnaeus). UCLA cat. no. 48534; Locality no. 1388 CIT; (1) apertural view; (2) umbilical view; (3) apical view; all $\times 2$; height 6.8 mm; diameter 19.4 mm.
- Figs. 4, 6. *Neritina* cf. *N. donovana* Recluz. UCLA cat. no. 48355; Loc. no. 1388 CIT; (4) apertural view; (6) abapertural view; all $\times 2$; height 13.0 mm; diameter 12.9 mm.
- Fig. 5. *Rissoina* sp. UCLA cat. no. 48356; Loc. no. 1388 CIT; apertural view; $\times 3$; height 8.6 mm; diameter 3.3 mm.
- Figs. 7–9. *Architectonica perspectiva* (Linnaeus). UCLA cat. no. 48357; Loc. no. 1388 CIT; (7) apical view; (8) umbilical view; (9) apertural view; all $\times 2$; height 10.0 mm; diameter 20.6 mm.
- Figs. 10–12. *Architectonica maxima* (Philippi). UCLA cat. no. 48358; Loc. no. 1390 CIT; (10) apical view; (11) umbilical view; (12) apertural view, all $\times 2$; height 12.4 mm; diameter 27.3 mm.

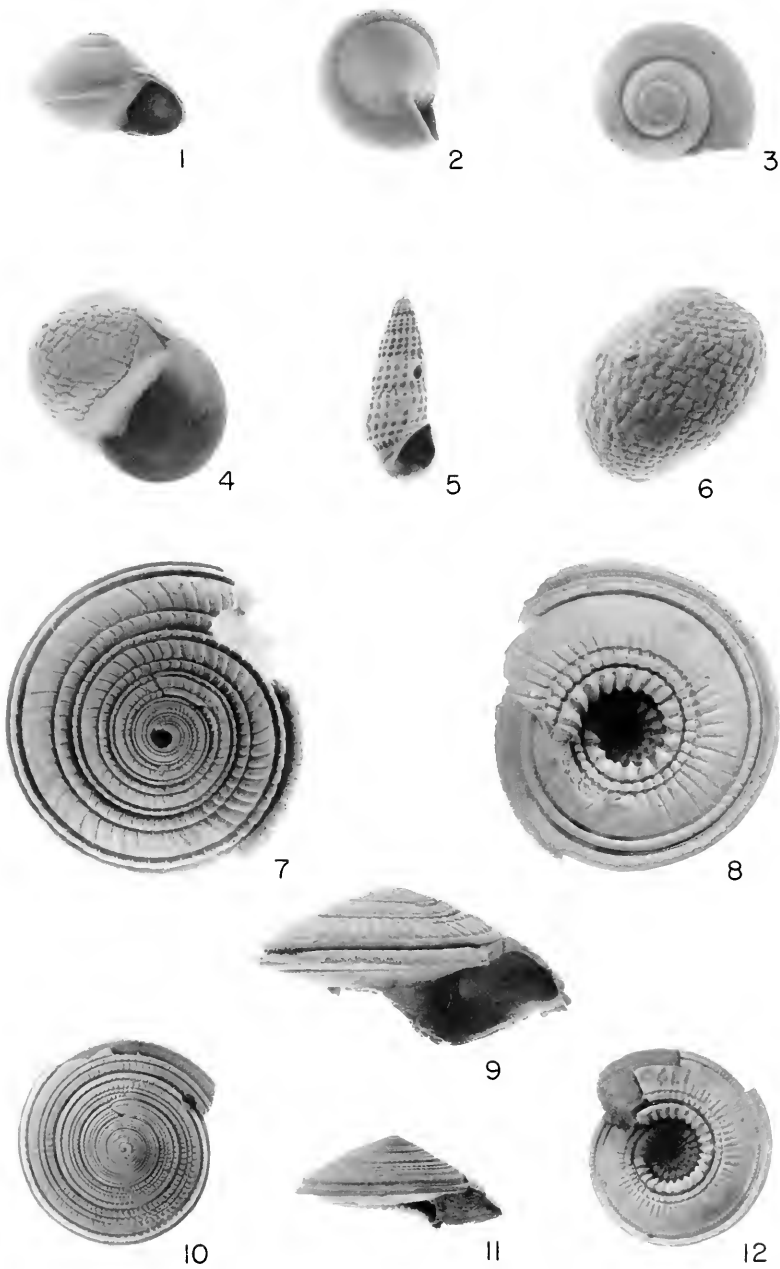


PLATE 2

- Fig. 13. *Telescopium telescopium* ? (Linnaeus). UCLA cat. no. 48359; loc. no. 1389 CIT; apertural view, $\times 2$; height 22.0 mm; diameter 14.2 mm.
- Fig. 14. *Telescopium telescopium* ? (Linnaeus). CAS cat. no. 53504; loc. no. 3x RED; apertural view, $\times 2$; height 21.0 mm; diameter 19.2 mm.
- Fig. 15. *Potamides sucaradjanus* Martin. UCLA cat. no. 48360; loc. no. 1389 CIT; apertural view, $\times 2$; height 24.8 mm; diameter 7.4 mm.
- Fig. 16. "*Potamides*" sp. β . UCLA cat. no. 48361; loc. no. 1389 CIT; apertural view, $\times 2$; height 52.9 mm; diameter 19.4.
- Fig. 17. *Cerithidea* ? sp. UCB cat. no. 10871; loc. no. 11x RED; abapertural view, $\times 2$; height 24.0 mm; diameter 9.0 mm.
- Fig. 18. *Cerithidea jenkinsi* Martin. UCLA cat. no. 48362; loc. no. 1388 CIT; apertural view, $\times 2$; height 26.1 mm; diameter 9.5 mm.
- Fig. 19. *Rhinoclavis pfefferi* Dunker. UCLA cat. no. 48363; loc. no. 1388 CIT; apertural view, $\times 2$; height 16.5 mm; diameter 5.5 mm.
- Fig. 20. *Rhinoclavis* ? sp. B. CAS cat. no. 53505; loc. no. 3x RED; apertural view, $\times 2$; height 23.9 mm; diameter 13.7 mm.
- Fig. 21. *Clypeomorus morus* (Lamarck). UCLA cat. no. 48364; loc. no. 1388 CIT; apertural view, $\times 2$; height 16.7 mm; diameter 9.1 mm.
- Fig. 22. "*Cerithium alternatum* Sowerby." CAS cat. no. 53506; loc. no. 3x RED; apertural view, $\times 2$; height 12.0 mm; diameter 7.3 mm.
- Fig. 23. *Cerithium rubus* Martyn. CAS cat. no. 53507; loc. no. 3x RED; apertural view, $\times 2$; height 20.0 mm; diameter 11.5 mm.
- Fig. 24. *Cerithium rubus* Martyn. UCLA cat. no. 48365; loc. no. 1388 CIT; apertural view, $\times 2$; height 27.0 mm; diameter 10.3 mm.

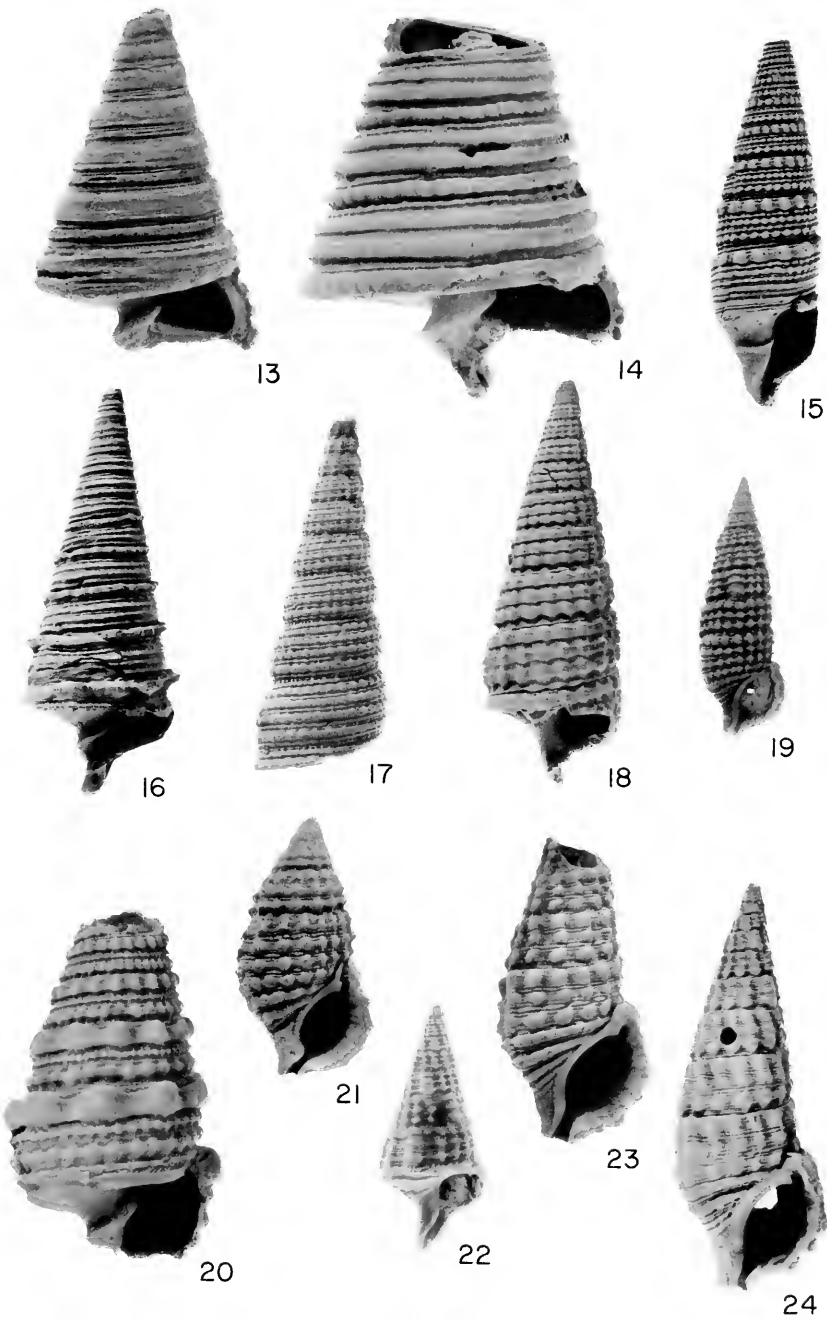


PLATE 3

- Fig. 25. *Cerithium* sp. E. CAS cat. no. 53508; loc. no. 3x RED; apertural view, $\times 2$; height 19.9 mm; diameter 8.6 mm.
- Figs. 26, 27. *Cerithium jonkeri* Martin. CAS no. 53509; loc. no. 3x RED; (26) apertural view; (27) abapertural view; both $\times 2$; height 40.7 mm; diameter 15.0 mm.
- Fig. 28. *Cerithium* sp. C. CAS cat. no. 53510; loc. no. 3x RED; apertural view, $\times 2$; height 17.5 mm; diameter 6.8 mm.
- Fig. 29. *Cerithium* sp. F. CAS cat. no. 53511; loc. no. 3x RED; apertural view, $\times 2$; height 14.5 mm; diameter 9.6 mm.
- Fig. 30. *Cerithium* sp. α . CAS cat. no. 53529; loc. no. 2x RED; apertural view, $\times 2$; height 19.9 mm; diameter 8.8 mm.
- Fig. 31. *Epitonium scalare* (Linnaeus). UCLA cat. no. 48366; loc. no. 1390 CIT; apertural view $\times 1$; height 22.0 mm; diameter 16.0 mm.
- Figs. 32, 33. *Dientomochilus crispatus* (Sowerby). UCLA cat. no. 48367; loc. no. 1388 CIT; (32) apertural view; (33) abapertural view, both $\times 2$; height 19.9 mm; diameter 10.2 mm.
- Fig. 34. *Strombus madiunensis* Martin. CAS cat. no. 53540; loc. no. 4x, RED; abapertural view, $\times 1$; height 37.3 mm; diameter 17.5 mm.
- Fig. 35. *Strombus plicatus pulchellus* Reeve. UCB cat. no. 10872; loc. no. 11x RED; abapertural view, $\times 1$; height 37.3 mm; diameter 23.8 mm.
- Fig. 36. *Strombus gendinganensis* Martin. CAS cat. no. 53512; loc. no. 3x RED; apertural view, $\times 2$; height 27.3 mm; diameter 11.9 mm.
- Fig. 37. *Tibia fusus* (Linnaeus). UCB cat. no. 10873; loc. no. 11x RED; apertural view, $\times 1$; height 110.9 mm; diameter 30.8 mm.
- Fig. 38. *Strombus canarium* Linnaeus. UCLA cat. no. 48368; loc. no. 1388 CIT; apertural view, $\times 1$; height 48.8 mm; diameter 31.4 mm.

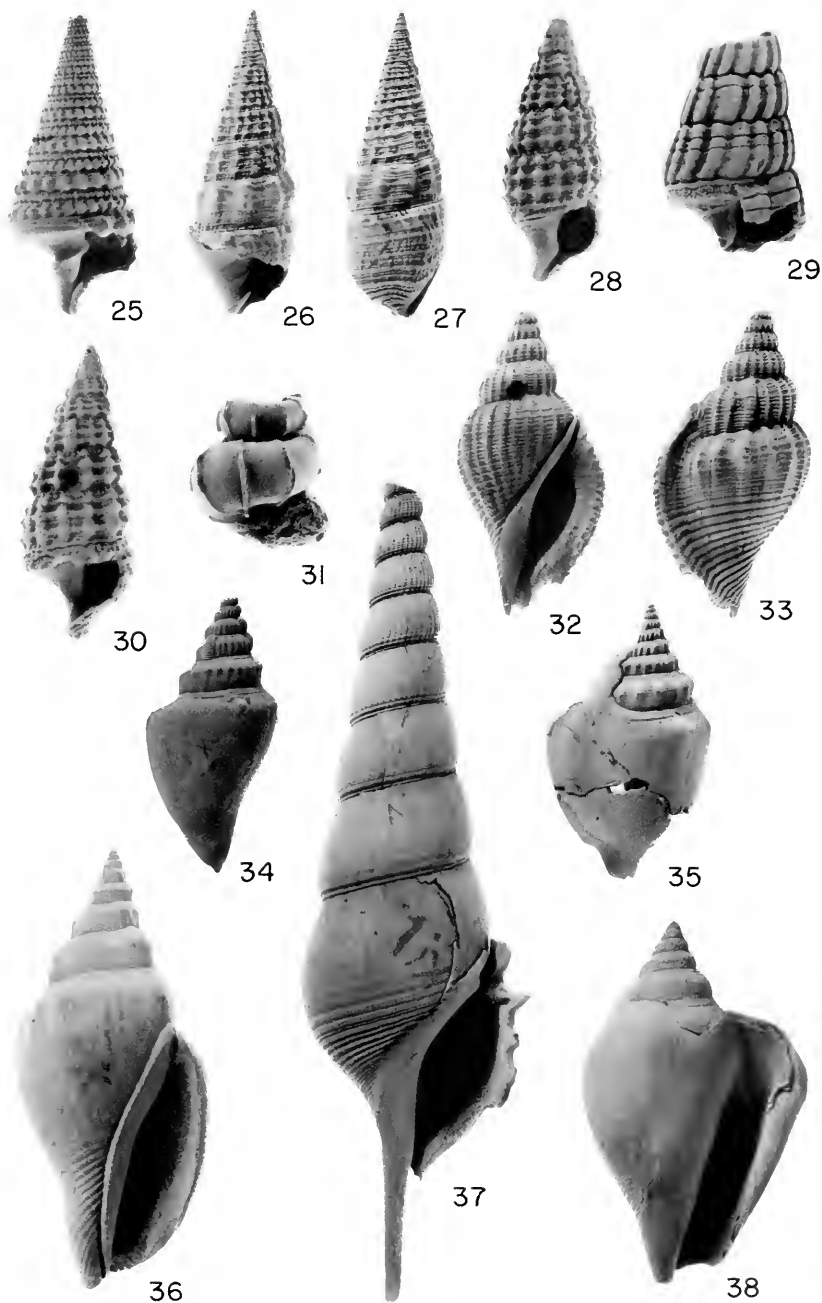


PLATE 4

- Figs. 39–42. *Strombus fennamai* ? Martin. UCB cat. no. 10874, for figs. 39, 42; UCB cat. no. 10875 for fig. 40, 41; locality 11x RED; (39) and (41), abapertural view, (40) and (42), apertural view, all $\times 1$; no. 40, height, 41.6 mm; diameter 22.0 mm; no. 39, 42 height 32.0 mm; diameter 20.5 mm.
- Figs. 43, 44. *Cypraea miliaris* Gmelin. UCB cat. no. 10876; loc. no. 11x RED; (43) apertural view, (44) abapertural view; $\times 1$; height 29.8 mm; diameter 18.0 mm.
- Fig. 45. *Cypraea poraria* ? Linnaeus. UCLA cat. no. 48369; loc. no. 1390 CIT; apertural view, $\times 1$; height 20.4 mm; diameter 13.5 mm.
- Figs. 46, 47. *Mamilla mammata* (Röding). UCLA cat. no. 48370; loc. no. 1388 CIT; (46) apertural view, (47) abapertural view, $\times 2$; height 19.5 mm; diameter 17.2 mm.
- Figs. 48, 49. *Neverita petiveriana* (Recluz 1855). UCLA cat. no. 48371; loc. no. 1389 CIT; (48) abapertural view, (49) umbilical view, $\times 3$; height 15.9 mm; diameter 15.0 mm.
- Figs. 50, 51. *Eunaticina papilla* (Gmelin). CAS cat. no. 53530; loc. no. 2x RED; (50) apertural view, (51) abapertural view, $\times 2$; height 10.0 mm; diameter 9.7 mm.
- Figs. 52, 53. *Polinices* sp. α . UCLA cat. no. 48372; loc. no. 1388 CIT; (52) apertural view, (53) apical view, $\times 2$; height 14.9 mm; diameter 11.5 mm.
- Figs. 54, 56. *Polinices solida* Blainville. UCLA cat. no. 48373; loc. no. 1388 CIT; (54) apertural view, (56) apical view, $\times 2$; height 11.3 mm; diameter 10.8 mm.
- Fig. 55. *Polinices aurantius* Röding. UCLA cat. no. 48374; loc. no. 1388 CIT; apertural view, $\times 1$; height 27.9 mm; diameter 21.2 mm.

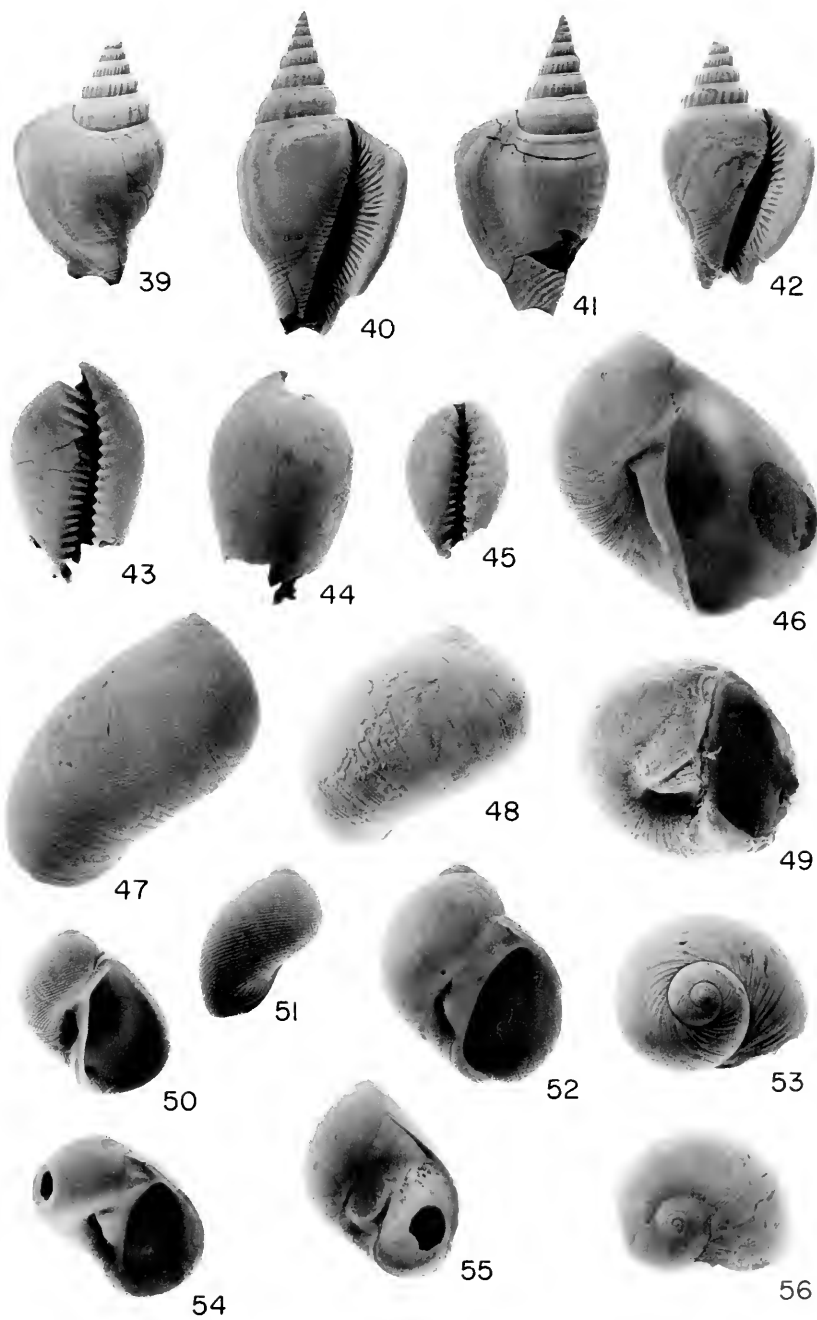
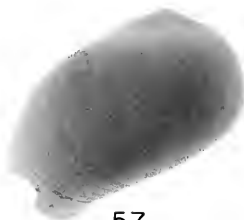
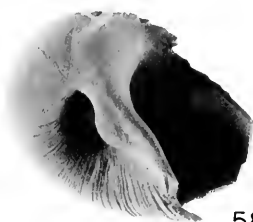


PLATE 5

- Figs. 57, 58. *Natica* cf. *N. columnaris* Recluz. CAS cat. no. 53531; loc. no. 2x RED; (57) abapertural view; (58) umbilical view, $\times 2$; height 14.4 mm; diameter 14.8 mm.
- Figs. 59, 62. *Natica marochiensis* Gmelin. UCLA cat. no. 48375; loc. no. 1388 CIT; (59) apertural view, (62) apical view, $\times 1$; height 16.9 mm; diameter 14.6 mm.
- Figs. 60, 63. *Cymatium gracile* ? (Reeve). UCLA cat. no. 48376; loc. no. 1388 CIT; (60) apertural view, (63) abapertural view, $\times 2$; height 19.4 mm; diameter 13.7 mm.
- Fig. 61. *Cymatium bayeri* Altena. CAS cat. no. 53513; loc. no. 3x RED; apertural view, $\times 2$; height 25.3 mm; diameter 13.5 mm.
- Fig. 64. *Distorsio reticulata* (Röding). UCB cat. no. 10877; loc. no. 11x RED; abapertural view, $\times 1$; height 32.5 mm; diameter 22.5 mm.
- Fig. 65. *Phalium glauca* (Linnaeus). UCB cat. no. 10878; loc. no. 11x RED; partial exterior of last whorl, $\times 1$.
- Fig. 66. *Apollon bitubercularis* (Lamarck). UCB cat. no. 10879; loc. no. 11x RED; apertural view, $\times 1$; height 33.5 mm; diameter 20.0 mm.
- Fig. 67. *Murex sobrinus* (A. Adams). UCB cat. no. 10880; loc. no. 11x RED; apertural view, $\times 1$; height 26.0 mm; diameter 20.5 mm.
- Fig. 68. *Bursa rana* ? (Linnaeus). UCLA cat. no. 48377; loc. no. 1388 CIT; apertural view, $\times 1$; height 32.0 mm; diameter 22.6 mm.



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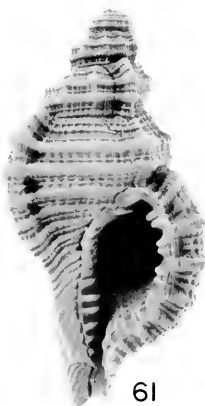
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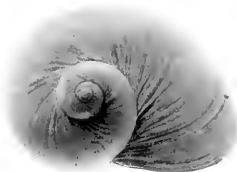
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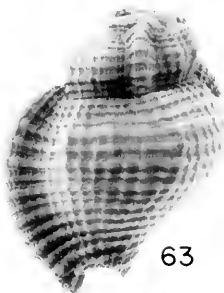
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PLATE 6

Figs. 69, 70. *Melongenella gigas* (Martin). CAS cat. no. 2387; loc. no. 5x RED; (69) apertural, and (70) apical views, $\times 1$; height 101 mm; diameter 86.4 mm.



69



70

PLATE 7

- Figs. 71, 72. *Parametaria philippinarum* (Reeve). UCLA cat. no. 48378; loc. no. 1388 CIT; (71) apertural, and (72) abapertural views, $\times 2$; height 20.5 mm; diameter 10.2 mm.
- Fig. 73. *Melongena galeodes* (Lamarek). CAS cat. no. 53532; loc. no. 2 \times RED; apertural view, $\times 1$; height 44.6 mm; diameter 34.6 mm.
- Fig. 74. *Hindsia acuminata* (Reeve). UCB cat. no. 10881; loc. no. 11 \times RED; apertural view, $\times 1$; height 30.7 mm; diameter 17.3 mm.
- Figs. 75, 79. *Arcularia* cf. *A. globosa* (Quoy and Gaimard). CAS cat. no. 53533; loc. no. 2 \times RED; (75) abapertural, and (79) apertural views, $\times 2$; height 11.7 mm; diameter 7.8 mm.
- Fig. 76. *Hebra subspinosa* (Lamarek). UCLA cat. no. 48379; loc. no. 1388 CIT; apertural view, $\times 2$; height 13.6 mm; diameter 8.7 mm.
- Fig. 77. *Hebra jonkeri* (Martin). UCLA cat. no. 48380; loc. no. 1388 CIT; apertural view, $\times 2$; height 12.8 mm; diameter 8.5 mm.
- Fig. 78. *Niotha* sp. cf. *N. gemmulata* (Lamarek). UCLA cat. no. 48381; loc. no. 1388 CIT; apertural view, $\times 2$; height 12.9 mm; diameter 8.4 mm.
- Figs. 80, 81. *Arcularia thersites* (Bruguiere). UCLA cat. no. 48382; loc. no. 1388 CIT; (80) apertural, and (81) abapertural views, $\times 2$; height 13.2 mm; diameter 9.3 mm.
- Figs. 82, 83. *Arcularia bimaculosa* (A. Adams). UCLA cat. no. 48383; loc. no. 1388 CIT; (82) apertural, and (83) abapertural views, $\times 3$; height 9.9 mm; diameter 7.2 mm.
- Fig. 84. *Arcularia* sp. β , =? *A. globosa* (Quoy and Gaimard). CAS cat. no. 53534; loc. no. 2 \times RED; abapertural view, $\times 3$; height 10.0 mm; diameter 7.9 mm.
- Fig. 85. *Arcularia* sp. α . CAS cat. no. 53514; loc. no. 3 \times RED; abapertural view, $\times 3$; height 10.2 mm; diameter 6.7 mm.
- Figs. 86, 87. *Chelunassa elegantissima* Shuto 1969, CAS cat. no. 53515; loc. no. 3 \times RED; (86) apertural, and (87) abapertural views, $\times 2$; height 16.5 mm; diameter 9.5 mm.

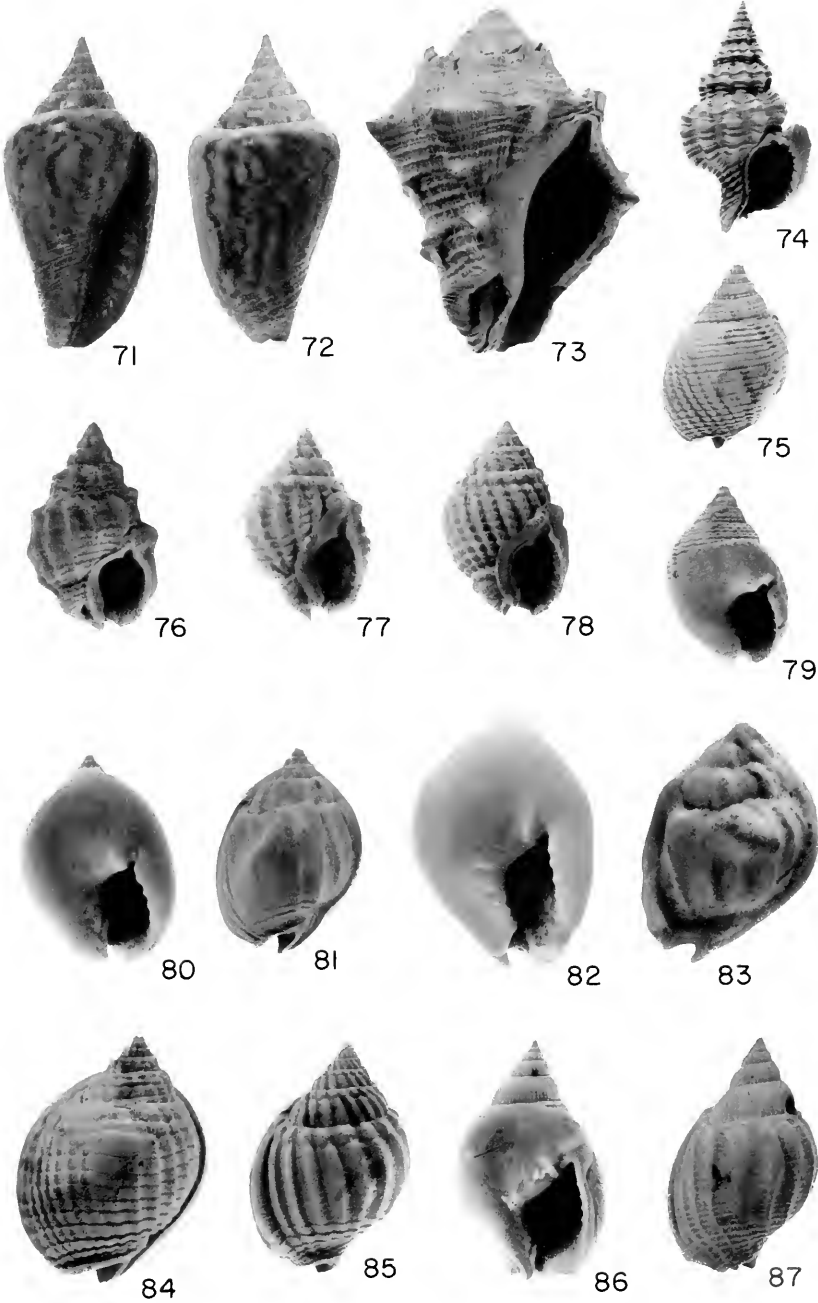


PLATE 8

- Fig. 88. *Alectrion* sp. cf. *A. coronatus* (Lamarck). UCLA cat. no. 48384; loc. no. 1388 CIT; apertural view, $\times 2$; height 21.0 mm; diameter 12.7 mm.
- Fig. 89. *Alectrion verbeeki* (Martin). CAS cat. no. 53542; loc. no. 4x RED; apertural view, $\times 2$; height 18.5 mm; diameter 9.1 mm.
- Fig. 90. *Alectrion dispar* (A. Adams). CAS cat. no. 53516; loc. no. 3x RED; apertural view, $\times 2$; height 17.1 mm; diameter 10.5 mm.
- Figs. 91, 95. *Alectrion sinusigera* ? (A. Adams). UCLA cat. no. 48385; loc. no. 1388 CIT; (91) apertural, and (95) abapertural view, $\times 3$; height 11.2 mm; diameter 6.4 mm.
- Fig. 92. *Alectrion* cf. *A. succinctus* (A. Adams). UCLA cat. no. 48386; loc. no. 1388 CIT; apertural view, $\times 3$; height 13.7 mm; diameter 7.6 mm.
- Figs. 93, 94. *Alectrion sordida* ? (A. Adams), =? *A. coronatus* (Lamarck). CAS cat. no. 53542; loc. no. 4x RED; (93) apertural, and (94) abapertural view, $\times 3$; height 10.4 mm; diameter 5.4 mm.
- Fig. 96. *Alectrion gaudiosus* (Hinds). UCLA cat. no. 48387; loc. no. 1390 CIT; apertural view, $\times 2$; height 18.8 mm; diameter 9.3 mm.
- Fig. 97. *Alectrion crenulatus* (Lamarck). UCLA cat. no. 48388; loc. no. 1388 CIT; apertural view, $\times 2$; height 20.6 mm; diameter 11.8 mm.
- Fig. 98. *Alectrion canaliculatus* (Lamarck). CAS cat. no. 53517; loc. no. 3x RED; apertural view, $\times 1$; height 27.3 mm; diameter 11.0 mm.
- Fig. 99. *Alectrion algidus* (Reeve). UCLA cat. no. 48389; loc. no. 1388 CIT; apertural view, $\times 2$; height 17.3 mm; diameter 10.0 mm.
- Fig. 100. *Alectrion euglyptus* (Sowerby). CAS cat. no. 53543; locality 4x RED; apertural view, $\times 2$; height 20.5 mm; diameter 11.3 mm.
- Fig. 101. *Oliva reticulata* (Röding). UCB cat. no. 10882; loc. no. 11x RED; abapertural view, $\times 1$; height 33.0 mm; diameter 13.7 mm.
- Fig. 102. *Oliva oliva* Linnaeus. CAS cat. no. 53518; loc. no. 3x RED; apertural view, $\times 3$; height 11.0 mm; diameter 6.4 mm.
- Fig. 103. *Oliva funebris* Lamarck. UCB cat. no. 10883; loc. no. 11x RED; apertural view, $\times 1$; height 38.9 mm; diameter 18.9 mm.

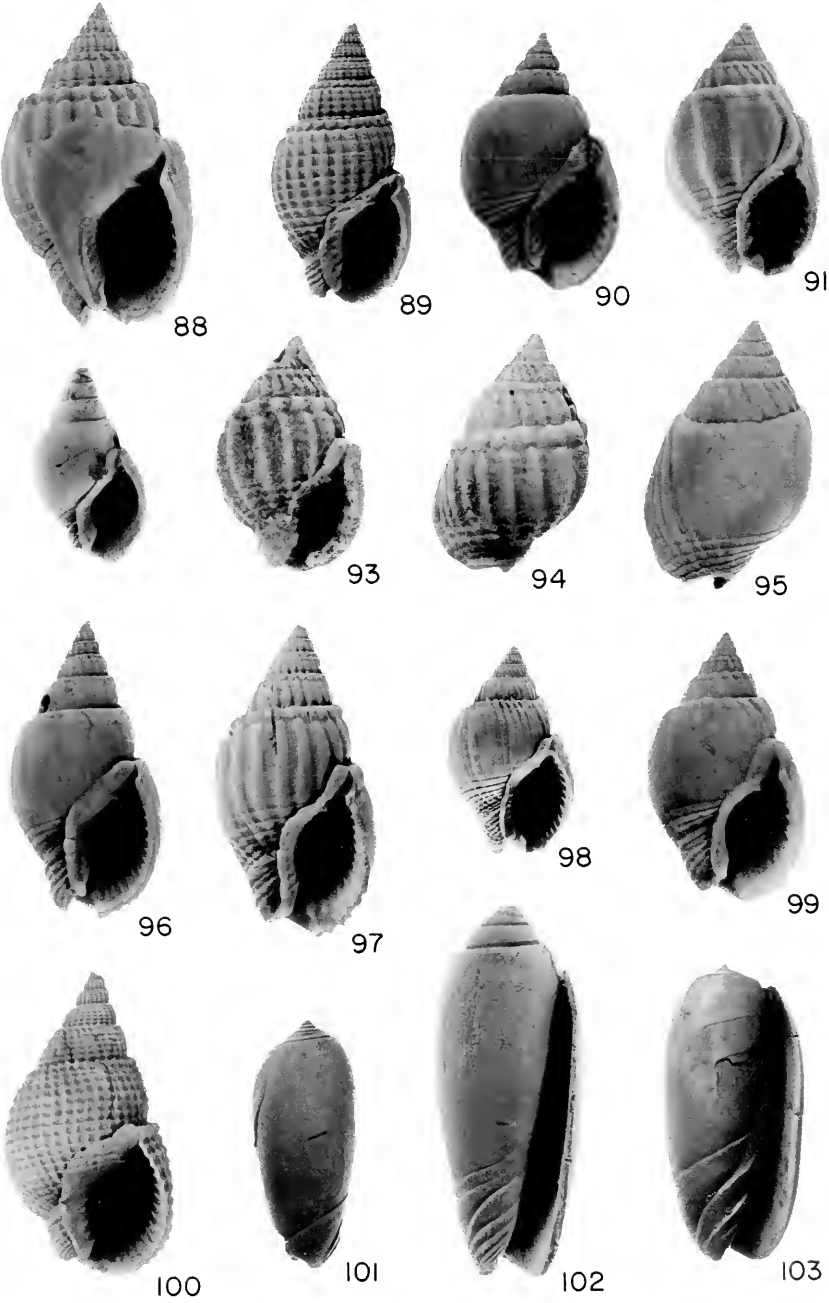


PLATE 9

- Fig. 104. *Mitra fulgetrum* Reeve. UCLA cat. no. 48390; loc. no. 1388 CIT; apertural view, $\times 2$; height 19.4 mm; diameter 7.2 mm.
- Fig. 105. *Mitra interlirata* Reeve. UCLA cat. no. 48391; loc. no. 1388 CIT; apertural view, $\times 3$; height 14.3 mm; diameter 5.3 mm.
- Fig. 106. *Vexillum subdivisum* (Gmelin). UCLA cat. no. 48392; loc. no. 1388 CIT; apertural view, $\times 1$; height 48.4 mm; diameter 16.5 mm.
- Fig. 107. *Vexillum amanda* (Reeve). CAS cat. no. 53519; loc. no. 3x RED; apertural view, $\times 2$; height 22.3 mm; diameter 7.6 mm.
- Fig. 108. *Vexillum obeliscus* (Reeve). UCB cat. no. 10884; loc. no. 11x RED; apertural view, $\times 1$; height 28.9 mm; diameter 10.0 mm.
- Fig. 109. *Vexillum cruentatum* (Gmelin). UCLA cat. no. 48393; loc. no. 1388 CIT; apertural view, $\times 3$; height 15.5 mm; diameter 5.9 mm.
- Fig. 110. *Vexillum formosense* (Sowerby). UCLA cat. no. 48394; loc. no. 1388 CIT; apertural view, $\times 2$; height 22.0 mm; diameter 9.6 mm.
- Fig. 111. *Vexillum gambacanum* ? (Martin). CAS cat. no. 53520; loc. no. 3x RED; apertural view, $\times 2$; height 22.8 mm; diameter 10.6 mm.
- Fig. 112. *Vexillum* sp. cf. *V. amanda* (Reeve). UCLA cat. no. 48395; loc. no. 1390 CIT; apertural view, $\times 2$; height 26.4 mm; diameter 10.2 mm.
- Fig. 113. *Vexillum costellaris* (Lamarck). UCLA cat. no. 48396; loc. no. 1388 CIT; apertural view, $\times 1$; height 34.3 mm; diameter 14.0 mm.
- Fig. 114. *Vexillum vulpecula* (Linnaeus). CAS cat. no. 53521; loc. no. 3x RED; apertural view, $\times 1$; height 39.2 mm; diameter 13.3 mm.
- Fig. 115. *Pterygia sinensis* (Reeve). UCB cat. no. 10885; loc. no. 11x RED; apertural view, $\times 2$; height 23.8 mm; diameter 9.5 mm.
- Fig. 116. *Trigonostoma crenifera* (Sowerby). UCLA cat. no. 48397; loc. no. 1388 CIT; apertural view, $\times 2$; height 12.0 mm; diameter 9.8 mm.
- Fig. 117. *Cancellaria verbeeki* Martin. UCLA cat. no. 48398; loc. no. 1388 CIT; apertural view, $\times 2$; height 22.8 mm; diameter 14.0 mm.
- Fig. 118. *Cancellaria asperella* (Lamarck). UCB cat. no. 10886; loc. no. 11x RED; abapertural view of last whorl, $\times 2$; height 17.5 mm; diameter 14.8 mm.
- Fig. 119. *Harpa conoidalis* Lamarck. UCB cat. no. 10887; loc. no. 11x RED; abapertural view, $\times 1$; height 45.6 mm; diameter 28.0 mm.

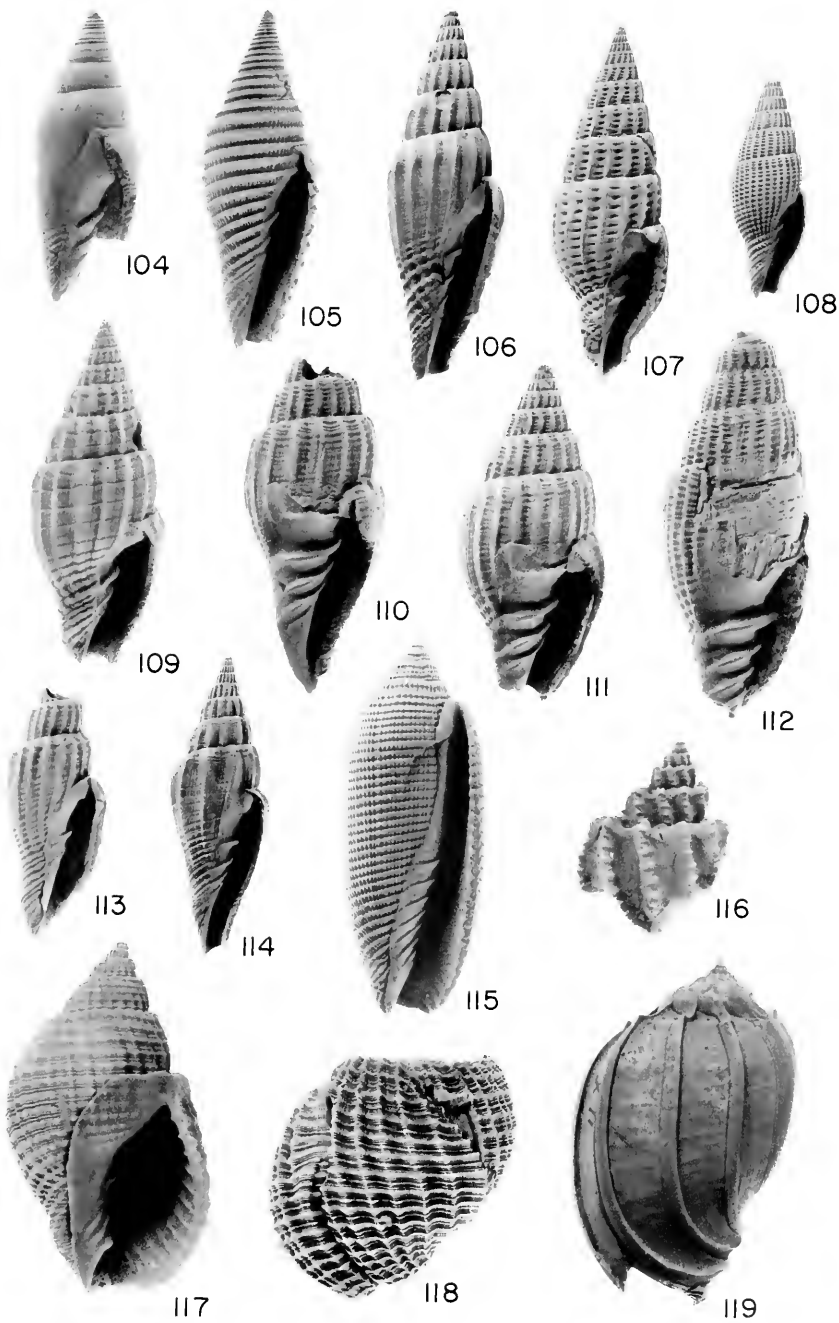


PLATE 10

- Fig. 120. *Marginella karikalensis* ? Cossmann. CAS cat. no. 53544; loc. no. 4x RED; apertural view, $\times 2$; height 16.0 mm; diameter 8.5 mm.
- Fig. 121. *Turris nodiliratus* Smith. CAS cat. no. 53522; loc. no. 3x RED; apertural view, $\times 2$; height 20.2 mm; diameter 12.2 mm.
- Fig. 122. *Turris crispa* Lamarck. CAS cat. no. 53535; loc. no. 2x RED; abapertural view, $\times 1$; height 30.5 mm; diameter 13.5 mm.
- Fig. 123. *Lophiotoma "marmorata"* (Lamarck). UCB cat. no. 10888; loc. no. 11x RED; apertural view, $\times 1$; height 42.2 mm; diameter 11.5 mm.
- Fig. 124. *Lophiotoma gendinganensis* (Martin). CAS cat. no. 53545; loc. no. 4x RED; apertural view, $\times 2$; height 27.0 mm; diameter 10.0 mm.
- Fig. 125. *Lophiotoma acuta* ? (Perry). CAS cat. no. 53523; loc. no. 3x RED; apertural view, $\times 2$; height 29.0 mm; diameter 10.5 mm.
- Fig. 126. *Turricula losariensis* ? (Martin). CAS cat. no. 53524; loc. no. 3x RED; apertural view, $\times 2$; height 21.9 mm; diameter 7.4 mm.
- Fig. 127. *Crassispira pseudoprincipalis* (Yokoyama). UCB cat. no. 10889; loc. no. 11x RED; apertural view, $\times 2$; height 20.7 mm; diameter 7.0 mm.
- Fig. 128. *Crassispira* sp. cf. *C. hataii* MacNeil. UCB cat. no. 10890; loc. no. 11x RED; apertural view, $\times 2$; height 26.7 mm; diameter 8.3 mm.
- Fig. 129. *Compsodrillia torvita* MacNeil. CAS cat. no. 53525; loc. no. 3x RED; apertural view, $\times 3$; height 22.4 mm; diameter 8.0 mm.
- Fig. 130. *Eucithara funiculata* (Reeve). UCLA cat. no. 48399; loc. no. 1388 CIT; apertural view, $\times 3$; height 16.4 mm; diameter 11.6 mm.
- Fig. 131. *Inquisitor neglectus* ? (Martin). CAS cat. no. 53536; loc. no. 2x RED; abapertural view, $\times 2$; height 26.9 mm; diameter 9.4 mm.
- Fig. 132. *Gemmula speciosa* (Reeve). CAS cat. no. 53526; loc. no. 3x RED; apertural view, $\times 1$; height 39.1 mm; diameter 16.4 mm.
- Fig. 133. *Gemmula monilifera* (Pease). CAS cat. no. 53549; loc. no. 3x RED; apertural view, $\times 3$; height 18.2 mm; diameter 11.2 mm.

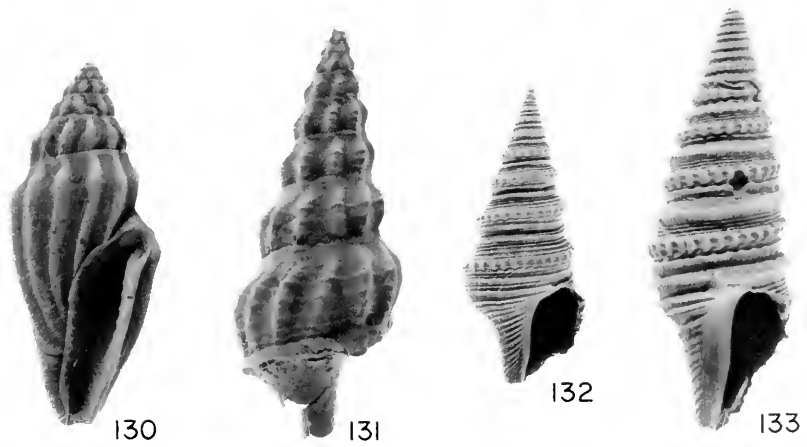
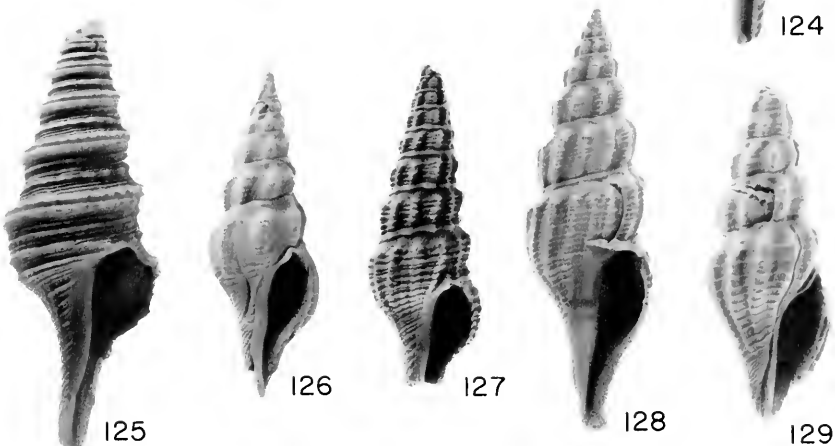
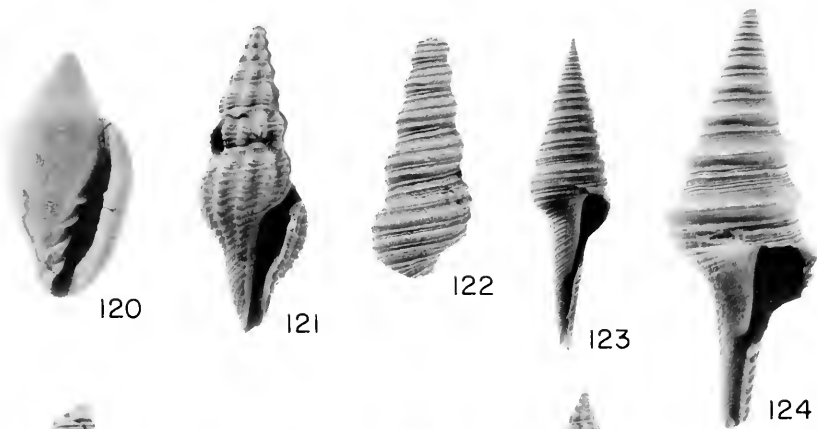


PLATE 11

- Figs. 134, 138. *Conus socialis* Martin. UCB cat. no. 10891; loc. no. 11x RED; (134) apertural, and (138) apical view, $\times 1$; height 39.6 mm; diameter 19.0 mm.
- Figs. 135, 139. *Conus kieneri* Reeve. UCB cat. no. 10892; loc. no. 11x RED; (135) apertural, and (139) apical view, $\times 1$; height 31.3 mm; diameter 15.1 mm.
- Figs. 136, 140. *Conus ngavianus* Martin. CAS cat. no. 53546; loc. no. 4x RED; (136) apertural, and (140) apical view, $\times 1$; height 35.7 mm; diameter 19.8 mm.
- Figs. 137, 141. *Conus tessulatus* Born. UCB cat. no. 10893; loc. no. 11x RED; (137) apertural, and (141) apical views, $\times 2$; height 20.2 mm; diameter 10.8 mm.
- Fig. 142. *Conus figulinus* Linnaeus = *C. lotoisii* Kiener. UCLA cat. no. 48400; loc. no. 1389 CIT; apertural view, $\times 1$; height 28.2 mm; diameter 21.3 mm.
- Fig. 143. *Conus longurionis* Kiener. UCB cat. no. 10894; loc. no. 11x RED; abapertural view, $\times 3$; height 17.1 mm; diameter 6.9 mm.
- Fig. 144. *Conus menengtenganus* Martin. CAS cat. no. 53537; loc. no. 2x RED; abapertural view, $\times 1$; height 67.6 mm; diameter 18.7 mm.
- Fig. 145. *Conus insculptus* Kiener. UCB cat. no. 10895; loc. no. 11x RED; abapertural view, $\times 2$; height 18.8 mm; diameter 8.3 mm.
- Fig. 146. *Terebra pamotanensis* Martin. CAS cat. no. 53547; loc. no. 4x RED; apertural view, $\times 2$; height 25.6 mm; diameter 8.4 mm.
- Fig. 147. *Terebra duplicata* ? Linnaeus. UCLA cat. no. 48401; loc. no. 1389 CIT; apertural view, $\times 1$; height 43.8 mm; diameter 10.9 mm.
- Fig. 148. *Terebra myuriformis* ? Fischer. UCB cat. no. 10896; loc. no. 11x RED; apertural view, $\times 1$; height 34.3 mm; diameter 10.6 mm.
- Fig. 149. *Pyramidella* sp. CAS cat. no. 53548; loc. no. 4x RED; apertural view, $\times 2$; height 10.9 mm; diameter 7.0 mm.
- Fig. 150. *Pupa sulcata* (Gmelin). CAS cat. no. 53538; loc. no. 2x RED; apertural view, $\times 1$; height 18.8 mm; diameter 11.4 mm.

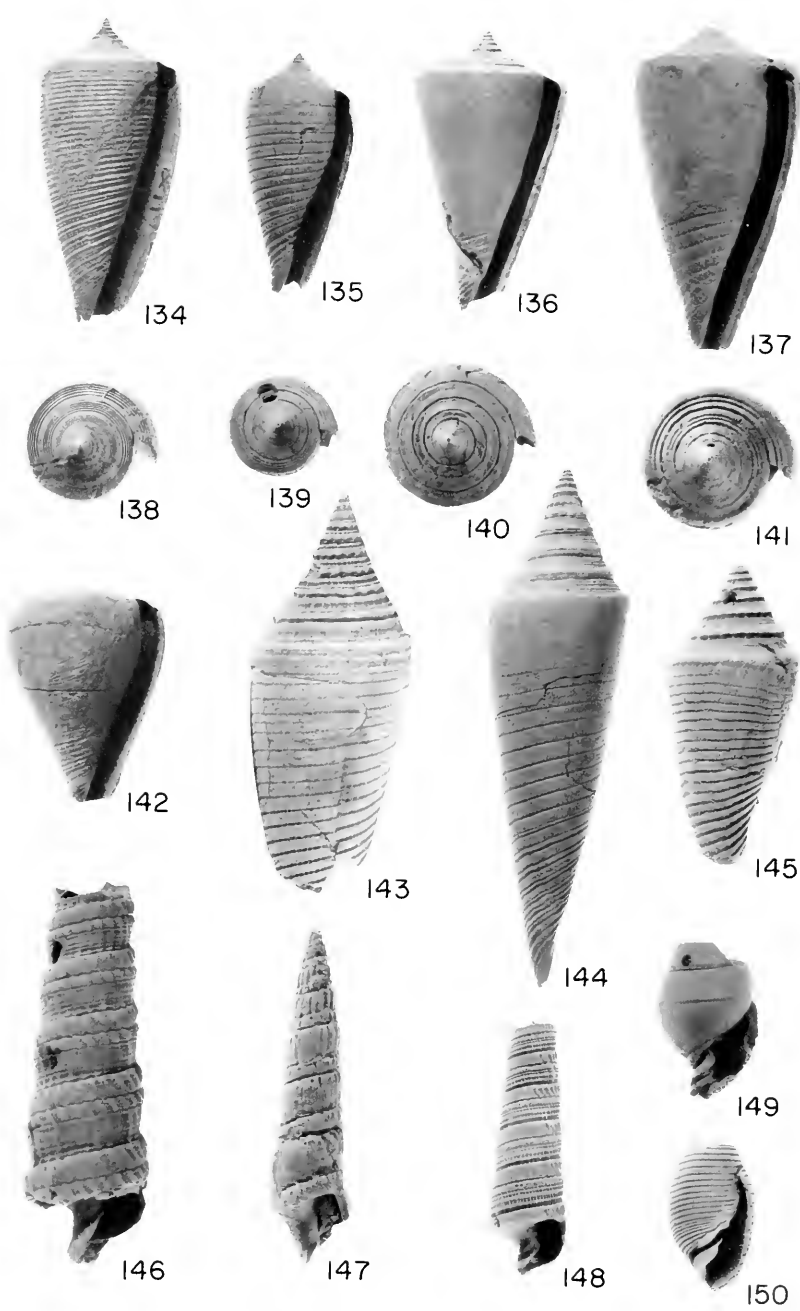


PLATE 12

- Figs. 151–153. *Yoldia* sp. β . UCLA cat. no. 48402; loc. no. 1388 CIT; (151) exterior left valve, (152) dorsal view of both valves, (153) exterior right valve, $\times 2$; height 9.4 mm; length 16.6 mm.
- Fig. 154. *Anadara pangkaensis* (Martin). CAS cat. no. 53527; loc. no. 3x RED; exterior left valve, $\times 1$; height 27.0 mm; length 37.4 mm.
- Fig. 155. *Anadara antiquata* (Linnaeus). UCLA cat. no. 48403; locality no. 1388 CIT; exterior left valve, $\times 1$; height 28.2 mm; length 39.0 mm.
- Fig. 156. *Anadara biformis* (Martin). UCLA cat. no. 48404; loc. no. 1390 CIT; exterior of right valve, $\times 1$; height 33.5 mm; length 47.5 mm.
- Fig. 157–159. *Anadara granosa* (Linnaeus). UCLA cat. no. 48405; loc. no. 1452 CIT, Santa Barbara, Panay; (157) exterior left valve; (158) interior left valve; (159) dorsal view both valves, $\times 1$; height 39.4 mm; length 53.5 mm; thickness of both valves 37.8 mm.
- Fig. 160–161. *Anadara cornea* (Reeve). UCLA cat. no. 48406; loc. no. 1388 CIT; (160) exterior right valve; (161) exterior left valve, both $\times 1$; height, right valve, 30.2 mm; length, right valve, 33.7 mm.



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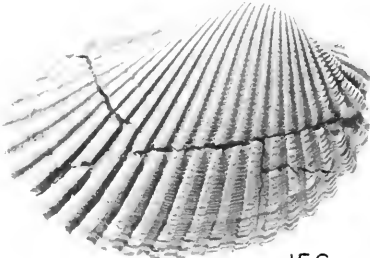
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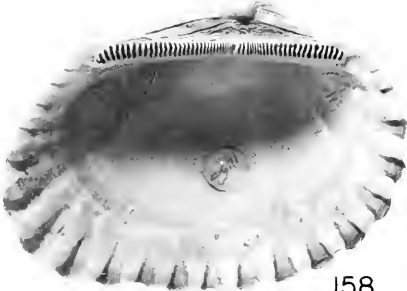
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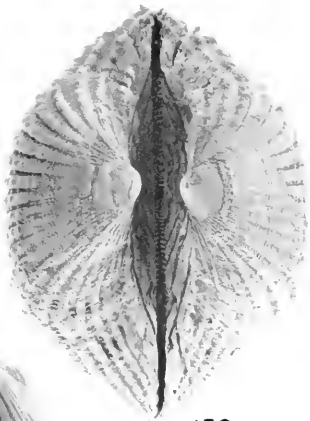
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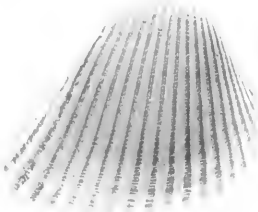
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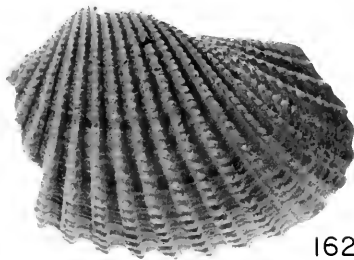
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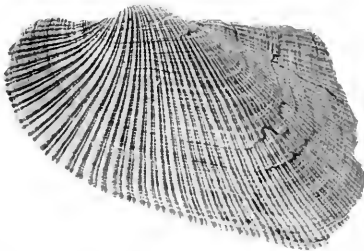
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PLATE 13

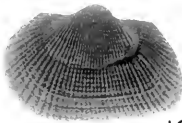
- Fig. 162. *Anadara* sp. α . CAS cat. no. 53528; loc. no. 3x RED; exterior left valve, $\times 2$; height 17.3 mm; length 23.0 mm.
- Fig. 163. *Trisidos semitorta* (Lamarck). UCLA cat. no. 48417; loc. no. 1454, Bagacay, Panay; exterior left valve, $\times 1$; height 33.0 mm; length 48.0 mm.
- Figs. 164, 165. *Striarca olivacea* (Reeve). UCLA cat. no. 48407; loc. no. 1388 CIT; (164) exterior, and (165) interior of left valve, $\times 2$; height 7.9 mm; length 11.7 mm.
- Fig. 166. *Striarca sinensis* Habe & Kosuge, *non* Thiele. UCLA cat. no. 48408; loc. no. 1390 CIT; exterior of right valve, $\times 2$; height 13.0 mm; length 18.2 mm.
- Figs. 167, 168. *Limopsis* sp. β . UCB cat. no. 10897; loc. no. 11x RED; (167) exterior, and (168) interior of left valve, $\times 3$; height 11.9 mm; length 11.6 mm.
- Fig. 169. *Glycymeris* sp. α . UCB cat. no. 10898; loc. no. 11x RED; exterior left (?) valve, $\times 3$; height 10.9 mm; length 11.0 mm.
- Fig. 170. *Glycymeris* sp. B. UCB cat. no. 10899; loc. no. 11x RED; exterior of right valve, $\times 1$; height 36.0 mm; length 38.6 mm.
- Fig. 171. *Glycymeris* sp. A. UCB cat. no. 10900; loc. no. 11x RED; exterior of right valve, $\times 1$; height 37.3 mm; length 38.2 mm.



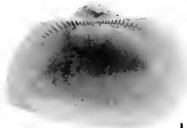
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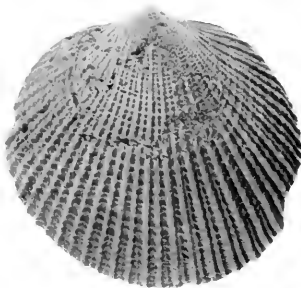
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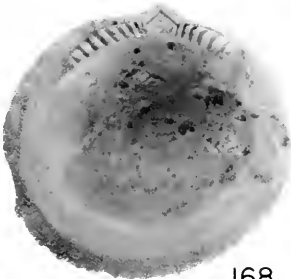
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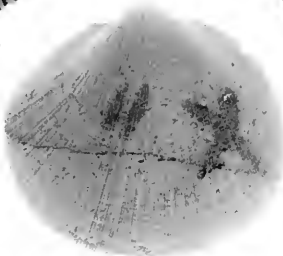
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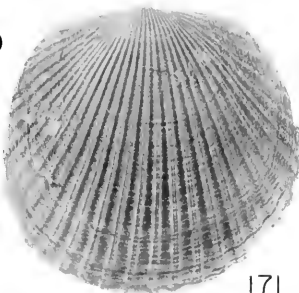
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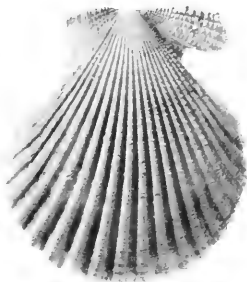
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PLATE 14

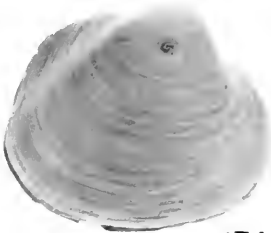
- Fig. 172. *Amussium pleuronectes* ? (Linnaeus). UCLA cat. no. 48409; loc. no. 1390 CIT; exterior of left valve, $\times 1$; height 30.5 mm; length 29.3 mm.
- Fig. 173. *Chlamys crassicosatus* ? (Sowerby). UCB cat. no. 10901; loc. no. 11x RED; exterior of right valve, $\times 2$; height 17.5 mm; length 15.4 mm.
- Figs. 174–176. *Cycladicama oblonga* (Sowerby). UCLA cat. no. 48410; loc. no. 1390 CIT; (174) exterior of right valve, (175) anterior view, both valves, (176) dorsal view both valves, $\times 1$; height 30.3 mm; length 34.5 mm; thickness of both valves 20.8 mm.
- Figs. 177, 180. *Cardita canaliculata* Reeve. UCB cat. no. 10902; loc. no. 11x RED; (177) exterior of right valve, (180) exterior of left valve, $\times 2$; height of right valve, 14.4 mm; length of right valve, 17.9 mm.
- Fig. 178. *Laevicardium* cf. *L. multipunctatum* (Sowerby). UCB cat. no. 10903; loc. no. 11x RED; exterior of right valve, $\times 1$; height 37.0 mm; length 29.5 mm.
- Fig. 179. *Laevicardium unicolor* ? (Sowerby). UCB cat. no. 10904; loc. no. 11x RED; exterior of left valve, $\times 2$; height 30.8 mm; length 21.1 mm.
- Figs. 181, 182. *Hemidonax donacaeiformis* (Spengler). UCLA cat. no. 48411; loc. no. 1388 CIT; (181) exterior, and (182) interior of left valve, $\times 2$; height 14.6 mm; length 18.8 mm.



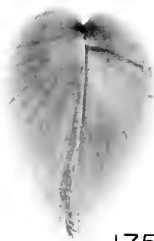
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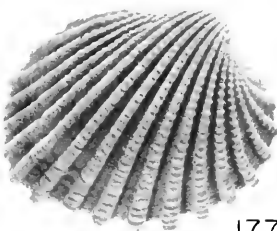
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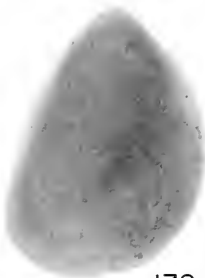
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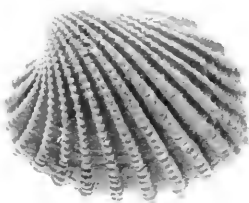
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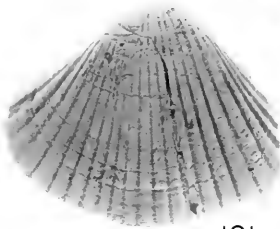
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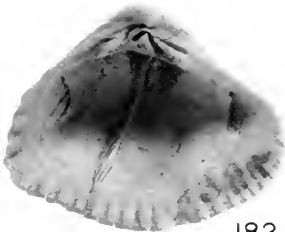
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PLATE 15

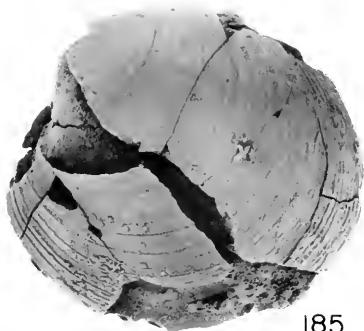
- Fig. 183. *Meiocardia* aff. *M. vulgaris* (Reeve). UCB cat. no. 10905; loc. no. 11x RED; exterior of left valve, $\times 1$; height 33.0 mm; length 47.3 mm.
- Fig. 184. *Callista erycina* (Linnaeus). UCB cat. no. 10906; loc. no. 11x RED; exterior of right valve, $\times 1$; height 33.2 mm; length 48.3 mm.
- Fig. 185. *Cyclina sinensis* ? (Gmelin). UCLA cat. no. 48412; loc. no. 1389 CIT; exterior of left valve, $\times 1$; height 44.0 mm; length 47.0 mm.
- Fig. 186. *Clementia papyracea* Gray. UCLA cat. no. 48413; loc. no. 1390 CIT; exterior of right valve, $\times 2$; height 19.4 mm; length 26.5 mm.
- Fig. 187. *Paphia euglypta* (Philippi). UCLA cat. no. 48414; loc. no. 1390 CIT; exterior of right valve, $\times 1$; height 20.5 mm; length 35.0 mm.
- Fig. 188. *Paphia* sp. α . UCB cat. no. 10907; loc. no. 11x RED; exterior of left valve, $\times 1$; height 22.6 mm; length 33.8 mm.
- Fig. 189. *Placamen isabellina* (Philippi). UCB cat. no. 10908; locality 11x RED; exterior of left valve, $\times 1$; height 31.8 mm; length 35.2 mm.



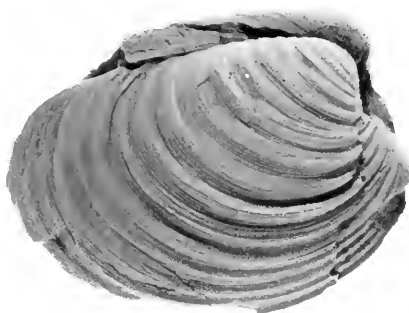
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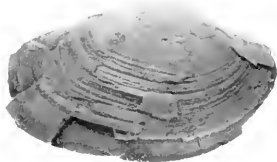
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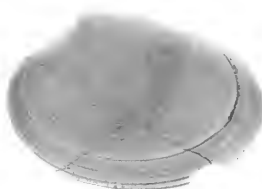
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PLATE 16

Figs. 190–192. *Corbula fortisulcata* Smith. UCLA cat. no. 48415; loc. no. 1388 CIT; (190) right exterior, (191) both valves, dorsal view, (192) left exterior, $\times 2$; height 12.4 mm; length 15.4 mm; thickness both valves 10.8 mm.

Figs. 193–195. *Corbula lamellata* Fischer. CAS cat. no. 53539; locality 2x RED; (193) right exterior, (194) dorsal view of both valves, (195) left exterior, $\times 2$; height 11.3 mm; length 16.6 mm; thickness both valves 8.8 mm.

Figs. 196–198. *Corbula* “*scaphoides*” Tesch, *non* Hinds. UCLA cat. no. 48416; loc. no. 1388 CIT; (196) left exterior, (197) right exterior, and (198) dorsal view of both valves, $\times 2$; height 14.1 mm; length 19.4 mm; thickness of both valves 11.6 mm.

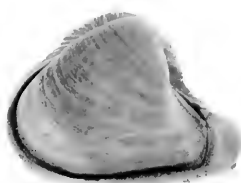
Fig. 199. *Corbula* sp. UCB cat. no. 10909; loc. no. 11x RED; exterior of right valve, $\times 2$; height 16.5 mm; length 21.6 mm.



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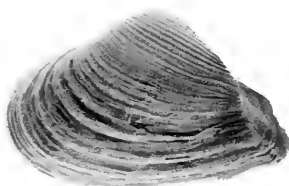
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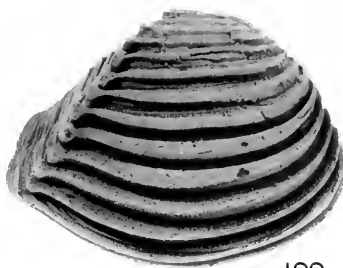
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PLATE 17

- Fig. 200. "*Actaeon reticulatus* K. Martin": DICKERSON 1922, pl. 2, fig. 2, = *Pupa sulcata* (Gmelin), fig. 150, this paper.
- Fig. 201. *Actaeon reticulatus* nov. spec.: MARTIN 1883–1887, pl. IV, fig. 42 (original figure).
- Fig. 202. *Conus ornatissimus* Martin: MARTIN 1891–1906, p. 12, pl. I, fig. 8.
- Fig. 203. "*Conus ornatissimus* K. Martin": DICKERSON 1922, pl. 2, fig. 11; = *Conus socialis* Martin, this paper.
- Fig. 204. "*Conus hardi* K. Martin": DICKERSON 1922, pl. 2, fig. 15, = *Conus loroisii* Kiener, fig. 142, this paper.
- Fig. 209. *Conus hardi* Martin: MARTIN 1891–1906, p. 18, pl. III, fig. 38.
- Fig. 205. *Terebra bicincta* nov. spec.: MARTIN 1879–80, p. 33, pl. VI, fig. 13b (original figure). Not found in present study.
- Fig. 206. "*Terebra bicincta* K. Martin": DICKERSON 1922, pl. 5, fig. 14.
- Fig. 207. "*Terebra javana* K. Martin.": DICKERSON 1922, pl. 5, fig. 15. Not found in present study.
- Fig. 208. *Terebra javana* nov. spec.: MARTIN 1879–80, p. 32, pl. VI, fig. 11 (original figure).
- Fig. 210. "*Mitra javana* K. Martin": DICKERSON 1922, pl. 3, fig. 3a, = *Vexillum vulpecula* (Linnaeus), fig. 114, this paper.
- Fig. 211. *Mitra javana* nov. spec.: MARTIN 1879–80, p. 27, pl. VI, fig. 2 (original figure).
- Fig. 212. "*Mitra bucciniformis* K. Martin": DICKERSON 1922, pl. 3, fig. 5, = *Vexillum cruentatum* (Gmelin), fig. 109, this paper.
- Fig. 213. *Mitra bucciniformis* nov. spec.: MARTIN 1879–1880, p. 28, pl. VI, fig. 4a (original figure).
- Fig. 214. "*Mitra junghuhni* (?) K. Martin": DICKERSON 1922, pl. 3, fig. 4, = *Mitra interlirata* Reeve, fig. 105, this paper.
- Fig. 215. *Mitra junghuhni* Martin: TESCH 1915, p. 44, pl. LXXIX(7), fig. 94b.

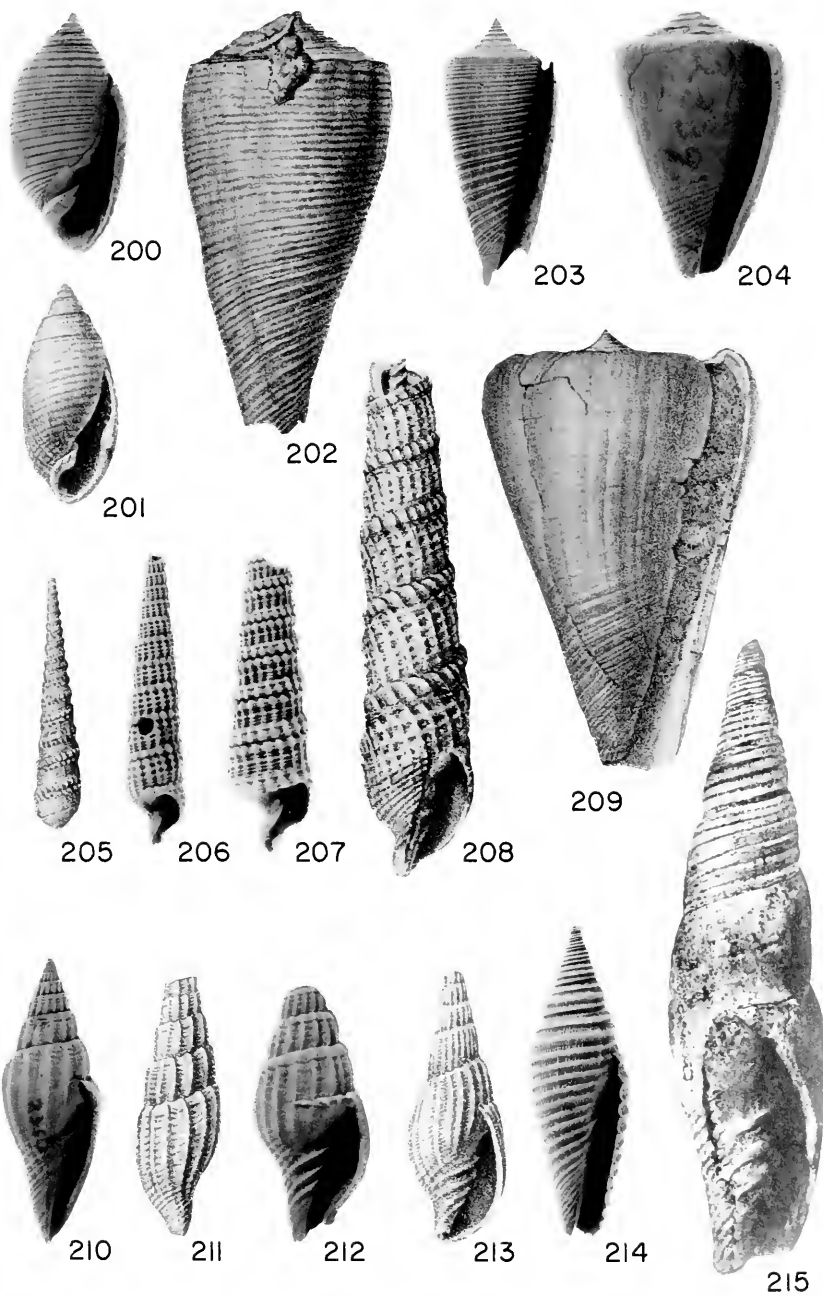
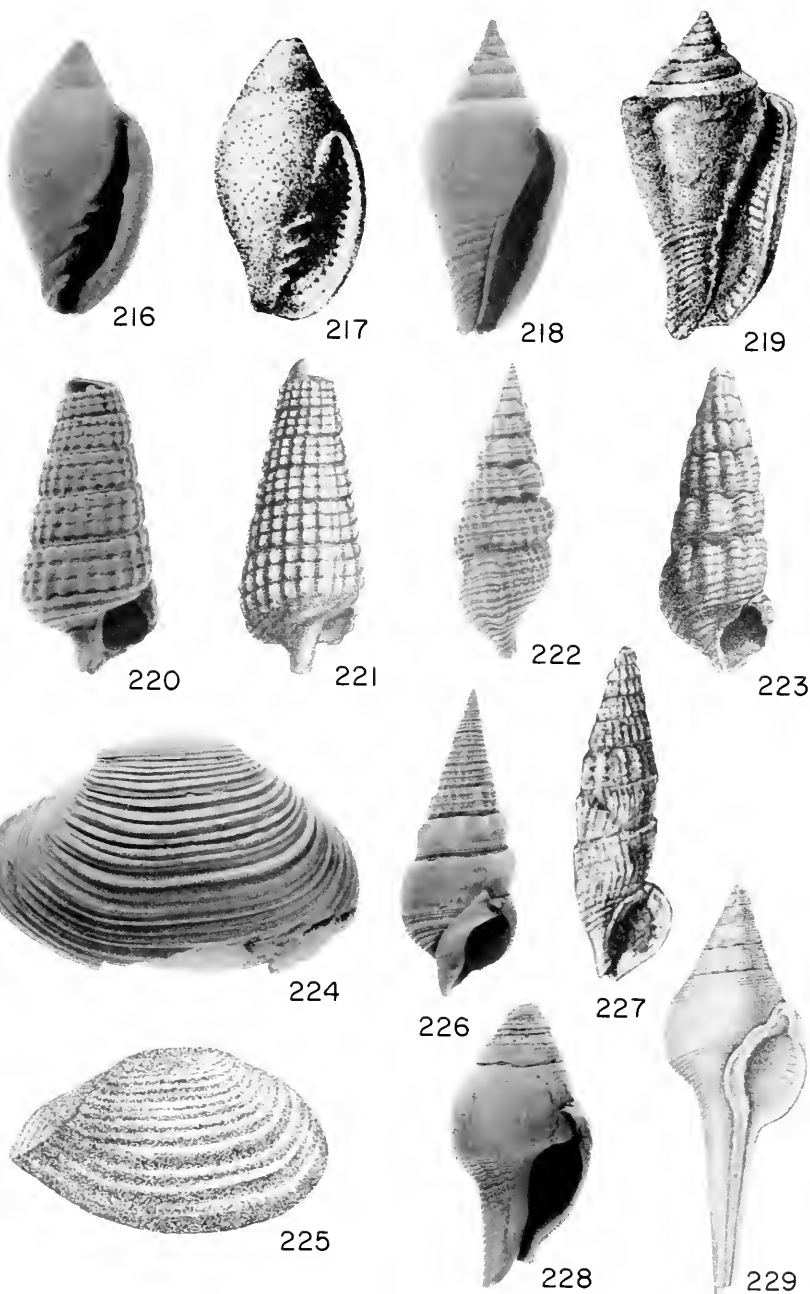


PLATE 18

- Fig. 216. "*Marginella simplicissima* K. Martin": DICKERSON 1922, pl. 3, fig. 11b. = *Marginella* sp., this paper.
- Fig. 217. *Marginella simplicissima* nov. spec.: MARTIN 1879-80, p. 24, pl. V, fig. 3 (original figure).
- Fig. 218. "*Columbella bandongensis* K. Martin": DICKERSON 1922, pl. 2, fig. 16. = *Parametaria philippinarum* (Reeve), fig. 71-72, this paper.
- Fig. 219. *Columbella bandongensis* Martin: MARTIN 1891-1906, p. 118, pl. XVIII, fig. 263.
- Fig. 220. "*Cerithium jenkinsi* K. Martin": DICKERSON 1922, pl. 2, fig. 7. = *Cerithidea jenkinsi* (Martin), fig. 18, this paper.
- Fig. 221. *Cerithium jenkinsi* nov. spec.: MARTIN 1879-80, p. 65 pl. XI, fig. 6 (original figure). = *C. cingulata* (Gmelin), VAN REGTEREN ALTENA 1942, vol. 12, p. 7.
- Fig. 222. "*Cerithium bandongensis* K. Martin": DICKERSON 1922, pl. 2, fig. 6. This species not found in present study.
- Fig. 223. *Cerithium bandongense* nov. spec.: MARTIN 1879-1880, p. 63, pl. XI, fig. 5a (original figure).
- Fig. 224. "*Corbula socialis* K. Martin": DICKERSON 1922, pl. 6, fig. 11. Not found in present study.
- Fig. 225. *Corbula socialis* nov. spec.: MARTIN 1879-80, p. 92, pl. XV, fig. 10a (original figure).
- Fig. 226. "*Cerithium herklotsi* K. Martin": DICKERSON 1922, pl. 2, fig. 9a. = *Cerithium jonkeri* Martin, this paper.
- Fig. 227. *Potamides herklotsi* (Martin): MARTIN 1921, p. 473, pl. (III) LX, fig. 76.
- Fig. 228. "*Strombus* cf. *fusus* K. Martin": DICKERSON 1922, pl. 5, fig. 8. Not found in present study.
- Fig. 229. *Fusus verbeeki* spec. nov.: MARTIN 1891-1906, p. 85, pl. XIII, fig. 195. = ? *Strombus* (?) *fusus* spec. nov., MARTIN 1879-80, p. 50, pl. IX, fig. 9 (original figure).



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