Chitons and Gastropods (Haliotidae Through Adeorbidae) From the Western Pacific Islands

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By HARRY S. LADD

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Description and preliminary paleoecologic interpretations of fossil mollusks from seven island groups

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By HARRY S. LADD

ABSTRACT

Cenozoic mollusks from seven island groups in the western Pacific are treated systematically. The islands form a broad belt spreading 4,000 miles across tropical latitudes from the Mariana Islands and Palau on the northwest through the Marshall, Ellice and New Hebrides groups to Fiji and Tonga on the southeast. Each of the island groups has a section of Quaternary limestones and all except the Ellice group are known to have a Tertiary sequence as well. The known Tertiary in all island groups, except that in the New Hebrides, extends back as far as the Eocene. No Paleocene rocks have been recognized.

Two hundred and eight species and subspecies are described. These include representatives of 3 families of chitons and 16 families of gastropods (Haliotidae through Adeorbidae). Three new subgenera of gastropods are described: *Vitiastraea* (subgenus of *Astraea*), *Subditotectarius* (subgenus of *Tectarius*), and *Ailinzebina* (subgenus of *Zebina*). Sixty-seven new species and five new subspecies are described. The species discussed in the present report comprise approximately one-sixth of available collections.

About three-fourths of the new forms were recovered from the drill holes in the Marshall Islands; the remainder, from outcrop samples, are divided almost equally between Palau and Fiji. A few of the new forms from the Marshall Islands also occur in Palau and Fiji.

The richest and most widespread assemblages are Miocene (Tertiary *f* and *g*). Most of the mollusks are reef associated. Many, notably those of the limestones in the deep drill holes of the Marshalls, occur in beds that were deposited in lagoons; some species occur in beds that were accumulated on tidal flats; a few species lived in fresh or brackish waters.

The assemblages of fossil mollusks, like those living in the area today, are Indo-Pacific in general aspect. The strongest discernible ties are with living and fossil faunas of tropical Indonesia, rather than with faunas from more southerly areas (southern Australia and New Zealand) or more northerly areas (the Ryukyu Islands and Japan). Thirty-three of the described species that still live in the island area have been there at least since late Tertiary time. Of this group, the shells of 25 were recovered from Marshall Island drill holes, those of 10 from outcrops in Fiji. A few species that lived in the island area during the Tertiary are now living only in other parts of the Indo-Pacific region.

Numerous living Indo-Pacific species had close relatives, some perhaps ancestral, in the island area during the upper Tertiary. In the Miocene of Bikini is a species of *Pisulina*, a genus known previously only from a few species living near India and Ceylon. The nearest relatives of a lower Miocene *Cyniscа* of Eniwetok live off the Cape of Good Hope, South Africa. *Schizochiton*, the reef chiton that lives today in the Philippines and northern Australia, had representatives in the Marshall Islands and Palau during the Miocene. Ties between the island area and the Americas are suggested, but they are less impressive than relationships with the Indo-Pacific.

INTRODUCTION

AREA AND LOCALITIES

The islands of the western Pacific considered here form a broad and somewhat irregular belt spreading 4,000 miles across the tropical latitudes of the western Pacific, from the Mariana Islands and Palau on the northwest to Fiji and Tonga on the southeast (fig. 1). The belt measures approximately 1,000 miles in width and includes seven island groups—Marshall, Ellice, Mariana, Palau, New Hebrides, Fiji, and Tonga. Of these, only the Marshall and Ellice Islands lie in the Pacific Basin proper, within the circum-Pacific andesite line. As thus outlined, the belt includes all of Micronesia and easternmost Melanesia and separates Indonesia from most of the Pacific Basin proper.

PURPOSE AND SCOPE

This primarily paleontologic report deals mainly with large collections of fossil mollusks obtained by the U.S. Geological Survey and other governmental agencies during field investigations in Micronesia in the years immediately following World War II. These investigations were of two types: (1) Deep drilling at Bikini Atoll in connection with Operation Crossroads in 1947 and at Eniwetok Atoll for the Atomic Energy Commission in 1951–52; all deep drilling was under the supervision of U.S. Geological Survey personnel. (2) Detailed mapping projects carried on by the U.S. Geological Survey under the sponsorship of the U.S. Army, Corps of Engineers, in Palau, 1947–48, Saipan, 1948–49, Tinian, 1949–51, and Guam, 1951–54. The Survey's collections from Guam supplement even larger collections made earlier by the Pacific Island Engineers under contract with the U.S. Navy.

In an attempt to make the study of island fossil mollusks as complete as possible, collections from other island groups—Fiji, Tonga, New Hebrides, and Ellice Islands—have been reviewed. Some material from these islands, already described in print, has been reexamined.

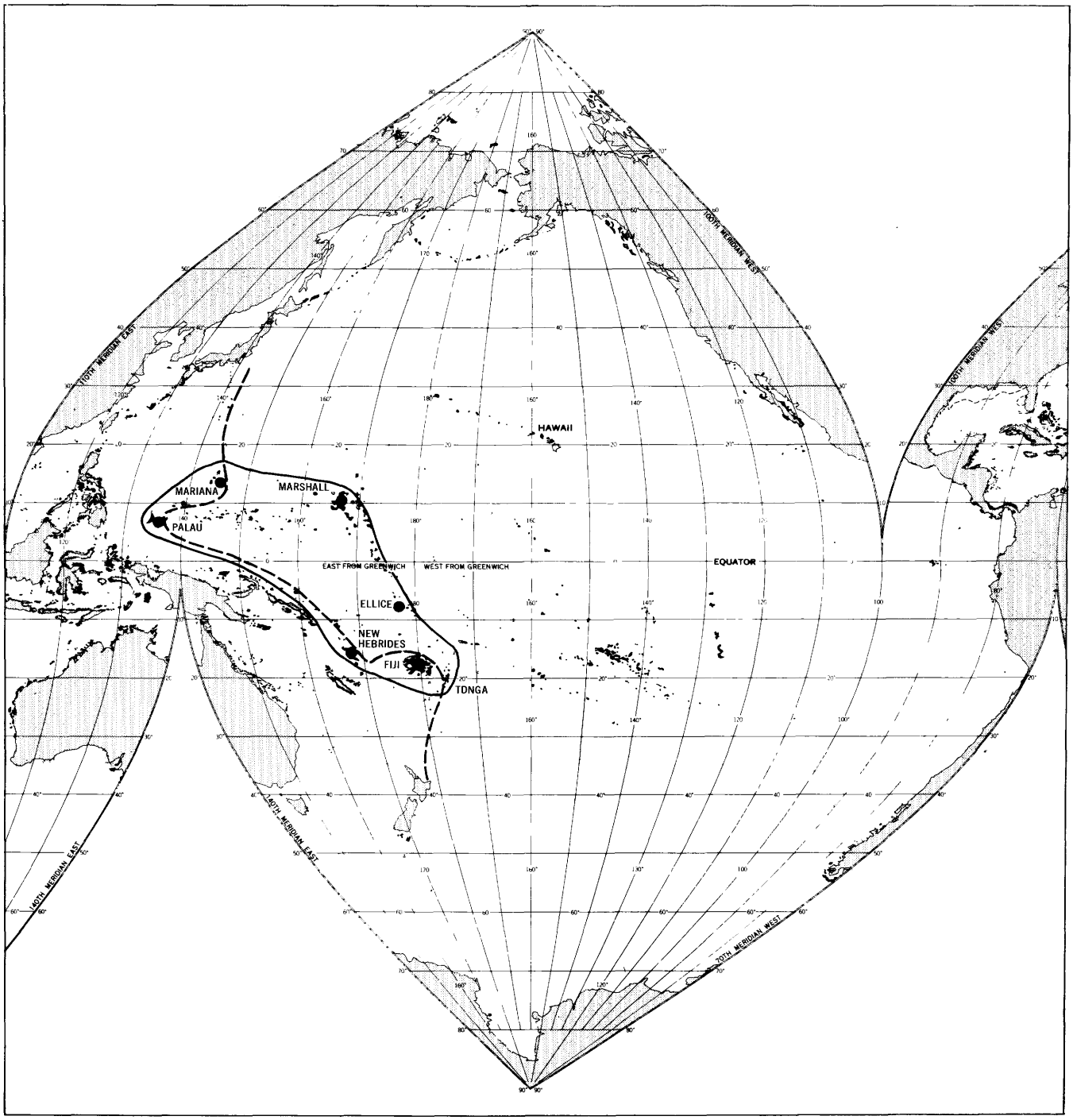


FIGURE 1.—Location of island groups from which fossil mollusks have been obtained. Dashed line marks structural boundary of Pacific Basin (andesite line).

The mollusks living in the western Pacific island area today are closely related to those of Indonesia, and a study of fossil forms should have some bearing on questions involving origin and migration. Preliminary statements of age, correlation, and paleoecologic interpretation are given in this paper, but a full discussion of these matters and detailed interpretations of regional relations of the faunas are reserved for a later paper.

EARLIER REFERENCES TO FOSSIL MOLLUSKS

Published papers that contain identifications or descriptions of fossil mollusks from the island under consideration are briefly annotated and arranged chronologically under island groups below.

PALAU

1951. Hatai, Kotora, Fossil Mollusca from Angaur Island: Inst. Geology and Paleontology, Tohoku Univ., Short paper 3, p. 127.

Collections made by R. Tayama contain a dozen forms. Five are identified with Recent species, and it is concluded that the beds are probably post-Miocene in age.

MARIANA ISLANDS

1956. Gardner, Julia, *in* Cloud, P. E., Jr., Schmidt, R. G., and Burke, H. W., Geology of Saipan, Mariana Islands: U.S. Geol. Survey, Prof. Paper 260-A, p. 47, 60, 66–67, 80–81, 86–87.

Preliminary reports on collections of fossil mollusks from Tertiary and younger rocks of Saipan. From the Eocene (Hagman Formation and Matanzas Limestone) a few generic references; from the Miocene (Tagpochau Limestone) 29 mollusks named, 13 being specifically identified or compared with named species; from the Pleistocene (Mariana and Tanapag Limestones) 30 mollusks, of which 19 are identified specifically or compared with described species. Molluscan fauna of Mariana Limestone probably represents older Pleistocene.

MARSHALL ISLANDS

1954. Ladd, H. S., *in* Emery, K. O., Tracey, J. I., Jr., and Ladd, H. S., Geology of Bikini and nearby atolls, Marshall Islands: U.S. Geol. Survey Prof. Paper 260-A, p. 80–84, 90.

Fossil mollusks from seven intervals in upper 300 feet in deep drill holes identified with species living in existing lagoons of Bikini and Eniwetok. Mollusks from 925 to 935 feet recognized as appreciably older shallow-water fauna.

1957. Ladd, H. S., and Tracey, J. I., Jr., Fossil land shells from deep drill holes on western Pacific atolls: Deep-Sea Research, v. 4, no. 3, p. 218–219.

Records occurrence of four species of minute land snails in Miocene and younger rocks of atolls, including Bikini and Eniwetok. Because the shells belong to a genus (*Ptychodon*) that normally lives on forested islands well above sea level, their occurrence suggests that the present-day atolls periodically stood above sea level, functioning as stepping stones in the distribution of life.

1958. Ladd, H. S., Fossil land shells from western Pacific atolls: Jour. Paleontology, v. 32, no. 1, p. 183–198.

Descriptions of fossil endodont land snails (*Ptychodon*) including three species obtained from Bikini and Eniwetok from lagoonal deposits now 170–1800 feet below sea level. Ages ranges from Miocene (Tertiary *e*) to Pleistocene or Recent.

1960. Ladd, H. S., Origin of the Pacific Island molluscan fauna: Am. Jour. Sci., Bradley volume, 258-A, p. 137–150.

Summarizes data supporting a suggestion that many elements of the Indo-Pacific fauna may have originated in the islands in Cretaceous and Tertiary times and later migrated with aid of prevailing winds and currents to west and southwest.

1960. Ladd, H. S., and Schlanger, S. O., Drilling operations on Eniwetok Atoll, U.S. Geol. Survey Prof. Paper 260-Y, p. 863–903.

Includes generic identifications of mollusks in series of drill holes, deepest of which reached upper Eocene (Tertiary *b*).

1960. Ladd, H. S., Distribution of molluscan faunas in the Pacific islands during the Cenozoic: U.S. Geol. Survey Prof. Paper 400-B, p. B374–B375.

Brief summary of known occurrences of fossil mollusks in six island groups in the western Pacific.

ELLICE ISLANDS

FUNAFUTI

1904. Hinde, G. J., Report on the materials from the borings at the Funafuti Atoll, *in* The Atoll of Funafuti: Royal Soc. London, p. 187–361.

A few of the sands obtained from the upper parts of the drill holes contain rare but well-preserved shells of micromollusks, and many of the cores from lower levels show molds of larger mollusks. A few generic determinations made by E. A. Smith and others are cited, but in most places molluscan occurrences are recorded merely as casts of gastropods or lamellibranchs.

1957. Ladd, H. S., and Tracey, J. I., Jr., Fossil land shells from deep drill holes on western Pacific atolls: Deep-Sea Research, v. 4, no. 3, p. 218–219.

Cites occurrence of species of *Ptychodon* in sample obtained from holes drilled in post-Miocene reefs.

1958. Ladd, H. S., Fossil land shells from western Pacific Islands: Jour. Paleontology, v. 32, no. 1, p. 183–198.

Ptychodon sp. A is described and figured from partially leached coralliferous limestone from a drill hole at a depth of 166–170 feet. Age, Pleistocene or Recent.

NEW HEBRIDES

1905. Mawson, Douglas, The geology of the New Hebrides: Linnean Soc. New South Wales Proc., v. 30, p. 400–485.

Includes reference (by number) to occurrences of fossil mollusks identified by Charles Hedley and listed in appendix.

1905. Hedley, Charles, Determinations of Mollusca, *in* Mawson, Douglas, The geology of the New Hebrides: Linnean Soc. New South Wales Proc., v. 30, p. 477–478.

Lists 82 generic and specific determinations of mollusks believed to range in age from Pliocene to Recent. Several are considered to be new but are not described. Some forms thought to have lived beyond intertidal levels, perhaps as deep as 15 fathoms.

1937. Abrard, René, and La Rüe, E. A. de, Sur l'existence du Néogène supérieur à *Cycloclypeus* aux îles Epi et Malekula (Nouvelles-Hébrides): Acad. sci. [Paris] Comptes rendus, v. 204, no. 25, p. 1951–1953.

Nine fossil mollusks are identified with Recent Indo-Pacific species, four with fossil forms described by Ladd from Viti Levu, Fiji, two with Miocene species from Java; 17 others appear to be undescribed.

1937. Abrard, René, and La Rüe, E. A. de, Sur la présence du Pliocene à l'île Malekula (Nouvelles Hébrides): Acad. sci. [Paris] Comptes rendus, v. 205, no. 4, p. 290–292.

A total of 31 mollusks are identified with Recent species or compared with such forms. Three others are recognized as new, and three are identified with species from the Pliocene of Java. The beds are assigned to the Pliocene.

1938. Abrard, René, and La Rüe, E. A. de, Note sur les dépots Quaternaires et les récifs soulevés du Nouvelles-Hébrides: Soc. géol. France Bull., v. 8, p. 63–66.

Twenty-five generic and specific identifications of mollusks are reported from elevated limestone on Efate; age probably Quaternary but possibly Pliocene. Nineteen mollusks are listed from similar limestones on Eromanga.

1946. Abrard, René, Fossiles Néogènes et Quaternaires des Nouvelles-Hébrides: Annales de paléontologie, v. 32, 112 p., 5 pls.

Detailed and well-illustrated report on large collections of mollusks (126 species) and other fossils made by E. A. de La Rüe from Miocene and later rocks at Malekula, Epi, Efate, and Eromanga. Close ties established to Miocene of Fiji.

FIJI

1880. Woods, J. E. T., On some fossils from Levuka, Viti: Linnean Soc. New South Wales Proc., v. 4, p. 358–359.

Several fossils, including mollusks, said to have been collected from the center of Ovalau, exact locality unknown. No specific identifications were made, but some of the mollusks were compared with Miocene species of Australasia. The fossils were imbedded in clay and sandy clay. [No rock of this type has been reported from Ovalau, and it seems probable that the material was collected from the marls of nearby Viti Levu. H.S.L.]

1898. Dall, W. H., *in* Agassiz, Alexander, The Tertiary elevated limestone reefs of Fiji: Am. Jour. Sci., 4th ser., v. 6, p. 165.

Contains identification of examples of 10 still-living genera of mollusks. Expresses the belief that the rock is probably younger than Eocene, possibly Miocene or Pliocene.

1900. David, T. W. E., Preface to geological report by E. C. Andrews: Harvard Coll. Mus. Comp. Zoology Bull., v. 38, p. 5–10.

Mentions occurrence of large *Tridacna* in conglomerate exposed at Walu Bay on Viti Levu that suggests an age not older than late Tertiary.

1903. Woolnough, W. G., The continental origin of Fiji: Linnean Soc. New South Wales Proc., v. 28, p. 457–540.

1907. Woolnough, W. G., A contribution to the geology of Viti Levu, Fiji: Linnean Soc. New South Wales Proc., v. 32, p. 433–474.

Though Woolnough collected no specifically identifiable fossil mollusks, he records the occurrence of fragmentary shells of *Conus* and *Pecten,* believed to be Tertiary, at localities in the then little known interior of Viti Levu. [These clues led later workers to well-preserved molluscan faunas. H.S.L.]

1903. Guppy, H. B., Vanua Levu, v. 1, *of* Observations of a naturalist in the Pacific between 1896 and 1899: Macmillan and Co., 392 p.

Generic identification given for pelecypods in shell bed elevated a few feet above the sea, in limestones and in tuffs, some of the tuffs now lying more than 2,000 feet above sea level.

1918. Foye, W. G., Geological observations in Fiji: Am. Acad. Arts and Sci. Proc, v. 54, no. 1, p. 1–142.

On page 86 there is a list of 15 generic identifications of mollusks as made by Paul Bartsch; the genera are common tropical forms, each being followed by a query; Foye collected the material from three localities on Viti Levu.

1926. Mansfield, W. C., Fossils from quarries near Suva, Viti Levu, Fiji Islands * * * with annotated bibliography of the geology of the Fiji Islands: Carnegie Inst. Washington Pub. 344, p. 85–104.

Description of 4 gastropods and 14 pelecypods (including 3 new species). Tertiary age suggested, probably late Miocene or early Pliocene.

1927. Matley, C. A., and Davies, A. M., Some observations on the geology of Viti Levu: Geol. Mag. [Great Britain], v. 64, no. 752, p. 65–75.

Includes description of supposed fresh-water clam, *Nodularia vitiensis* Davies, from the marls above Nasongo; beds probably Tertiary, possibly Miocene.

1930. Davies, A. M., Fossils from Viti Levu: Geol. Mag. [Great Britain], v. 67, no. 787, p. 48.

Molds of bivalves from near Nasongo, referred in 1927 (Matley and Davies) to the fresh water clam *Nodularia,* are reassigned to marine Mactracea.

1934. Ladd, H. S., *in* Ladd and others, Geology of Vitilevu, Fiji: B. P. Bishop Mus. Bull. 119, 263 p.

One hundred and twenty-two mollusks (53 pelecypods, 3 scaphopods, 1 chiton, and 65 gastropods), most of which were collected during reconnaissance surveys in 1926 and 1928, are described and most of them figured; they are from beds ranging in age from Miocene to Recent. Brief discussion of paleoecological conditions.

1945. Ladd, H. S., *in* Ladd and Hoffmeister, J. E., Geology of Lau, Fiji: B. P. Bishop Mus. Bull. 181, 399 p.

Seventy-six mollusks, half pelecypods and half gastropods, most of them collected during a reconnaissance

survey in 1934, are described and many figured; they are from beds ranging in age from Miocene to Pleistocene. Brief discussion of paleoecological conditions (by Ladd and Hoffmeister).

1959. Charig, A. J., *in* Bartholomew, R. W., Geology of the Lautoka area north-west Viti Levu: Suva, Fiji, Geol. Survey Dept. Bull. 2, 25 p., geol. map.

Sixteen mollusks, 3 pelecypods and 13 gastropods, are identified by A. J. Charig and C. P. Nuttall (p. 18–19) from two localities in bedded tuffaceous sediments mapped as part of the Sambeto series. Twelve fossils are identified with still-living species, three others are compared with such forms. Only one species appears to represent an extinct species though several are known to occur as fossils in the Pliocene or later. A Pliocene age is thought probable, a late Miocene age possible.

1960. Ibbotson, Peter, Geology of the Suva area, Viti Levu: Suva, Fiji Geol. Survey Dept. Bull. 4, 47 p., geol. map.

Detailed report on quarter-degree sheet in southeastern Viti Levu that includes many of the late Tertiary localities in the Suva Formation that have yielded fossil mollusks. Identifications of Mansfield (1926), Davies (1927, 1930), and Ladd (1934) are listed.

1960. Bartholomew, R. W., Geology of the Nandi area, western Viti Levu: Suva, Fiji Geol. Survey Dept. Bull. 7, 27 p., geol. map.

A list of fossils identified by L. R. Cox in 1954 (p. 11) includes six molluscan generic determinations.

1961. Ibbotson, Peter, Geology of Ovalau, Moturiki and Naingani: Suva, Fiji Geol. Survey Dept. Bull. 9, p. 1–7, geol. map.

Quotes in full, Tenison-Woods' brief report of 1897, pointing out that it is the only report on fossiliferous material from Ovalau.

1963. Charig, A. J., The gastropod genus *Thatcheria* and its relationships: British Mus. (Nat. History) Bull., Geol. v. 7, no. 9, p. 257–297.

Includes description of *Thatcheria vitiensis* from tuffaceous marl of Vanua Levu Formation on Vanua Levu; age probably early Pliocene.

1963. Rickard, M. J., The geology of the Mbalevuto area: Suva, Fiji Geol. Survey Dept. Bull. 11, 36 p., geol. map.

Includes references (p. 30–33) to mollusks, identified by H. S. Ladd, from the Singatoka, Suva, and Mba series of upper Tertiary area.

1965. Ladd, H. S., Tertiary fresh-water fossils from Pacific islands: Malacologia v. 2, no. 2, p. 189–198.

Includes description of a species of *Melanoides* from beds formed in mangrove swamp on Viti Levu in late Tertiary time.

TONGA

1926. Mansfield, W. C., Fossils from * * * Vavao, Tonga Islands * * *: Carnegie Inst. Washington Pub. 344, p. 85–104.

Three mollusks, one identified with a living species and one related to a living form, are listed, and a post-Tertiary age is suggested.

1932. Hoffmeister, J. E., Geology of Eua, Tonga: B. P. Bishop Mus. Bull. 96, 93 p.

Records the occurrence of the nautiloid *Aturia* (p. 33) in bedded volcanic tuffs believed to be Miocene in age.

1935. Ostergaard, J. M., Recent and fossil marine Mollusca of Tongatabu: B. P. Bishop Mus. Bull. 131, 59 p.

A total of 39 fossil mollusks (26 gastropods and 13 pelecypods) from Tongatabu and Vavau are identified with Recent species. Limestones containing fossils believed to be late Pleistocene in age.

1941. Miller, A. K., An *Aturia* from the Tonga Islands of the central Pacific: Jour. Paleontology, v. 15, no. 4, p. 429–431.

Specimen collected by J. E. Hoffmeister from tuffs, believed to be Miocene, is described and figured as *Aturia* cf. *A. aturi* (Basterot).

COLLECTIONS

Most of the collections on which the present study is based were made by U.S. Geological Survey personnel; others were loaned for study by museums and other institutions. All important sources are given below:

Palau.—Most of the Palau material was collected by H. S. Ladd in 1958; other collections had been made earlier by several Geological Survey geologists, particularly in 1948 by a party headed by the late Arnold Mason.

Mariana Islands.—The largest collections of megafossils from any of the islands under consideration were made from Guam by the Pacific Islands Engineers under contract with the U.S. Navy in 1946–50; supplementary collections from Guam were made by a Geological Survey field party under the leadership of J. I. Tracey, Jr., in 1951–54 and by H. S. Ladd in 1958. Most of the Saipan material was collected by a Geological Survey field party headed by P. E. Cloud, Jr., in 1948–49, and minor additions were made by H. S. Ladd in 1958. The few fossil mollusks that have been obtained from Tinian were collected by the late Josiah Bridge in 1946 and by Cloud in 1949, both of the Geological Survey.

Marshall Islands.—Cores and cuttings were obtained from drill holes on Eniwetok and Bikini Atolls between 1947 and 1952.

Ellice Islands.—Cores and cuttings from drill holes obtained by the British on Funafuti Atoll between 1896 and 1898 (David and others, 1904). Material was borrowed from the British Museum (Natural History), the Australian Museum in Sydney, and the Museum of Comparative Zoology at Harvard.

New Hebrides.—Small collections were made by H. T. Stearns of the Geological Survey in 1943; some material

was borrowed from M. R. Abrard of the Museum National d'Histoire Naturelle in Paris.

Fiji.—The collections of larger mollusks described by Ladd in 1934 and 1945 have been supplemented by undescribed larger mollusks from Viti Levu collected by Ladd in 1934 and by micromolluscan material not previously described. Additional material collected in recent years has been furnished by the Geological Survey Department in Fiji and by William Briggs of the U.S. Geological Survey who visited Viti Levu in 1962.

Tonga.—A few Tertiary mollusks were collected by J. E. Hoffmeister in 1926 and 1928; post-Tertiary material was collected by J. Ostergaard in 1926 and was loaned by the Bernice P. Bishop Museum in Honolulu.

The largest molluscan collections are those from Eniwetok, Guam, and Fiji, in that order. The Eniwetok collections from drill holes are rich in well-preserved micromollusks. Those from Guam and Fiji are outcrop samples, and many of them are molds or calcite casts; they are comparatively poor in micromollusks.

ACKNOWLEDGMENTS

Prior to her retirement in 1952, the late Dr. Julia Gardner made preliminary determinations of many of the fossil mollusks collected by Geological Survey personnel in the Mariana Islands and Palau. Her identifications of Saipan mollusks were published in Professional Paper 280-A (Cloud and others, 1956). In connection with her studies, she assembled a useful index of references on island fossil mollusks. In 1947 she visited Palau where she collected from the Palau Limestone in the Koror area.

In 1945, I discussed Palauan geology with the late Prof. Risaburo Tayama in Sendai, Japan, and was given suggestions as to promising places in which to collect fossil mollusks. These suggestions proved invaluable during fieldwork in Palau in 1958. At that time I was cordially received and was given much assistance by Mr. R. P. Owen, staff entomologist with the Trust Territories in Koror.

The extensive collections of Recent mollusks at the U.S. National Museum contain many shells collected by Dr. J. P. E. Morrison and others in the Marshall Islands during Operation Crossroads in 1946–47 and later. These shells were particularly useful in studying fossils obtained from drill holes. The Academy of Natural Sciences in Philadelphia, through Dr. R. T. Abbott, curator, loaned Recent chitons for comparative studies and gave full access to the collections when I visited Philadelphia in 1964; the Bishop Museum, through Mr. E. H. Bryan, Jr., curator, loaned the fossil material from Tonga collected by Jens Ostergaard; the British Museum (Natural History), the Australian Museum, and the Museum of Comparative Zoology at Harvard loaned samples from the drill holes on Funafuti. Professor René Abrard of the Museum National d'Histoire Naturelle loaned fossil material described by him from the New Hebrides. Dr. C. Beets of Leiden, Netherlands, kindly checked identification of a species that appeared to be closely related to a form described by him from the Miocene of Borneo.

Mr. W. M. Briggs, Jr., and Mrs. Evelyn Bourne, both of the U.S. Geological Survey, aided in the preparation of much of the material, and Mr. Briggs made almost all the photographs of fossils. I am indebted to Drs. H. A. Rehder and J. P. E. Morrison, of the U.S. National Museum, and Dr. Robert Robertson, of the Academy of Natural Sciences, for assistance in the identification of certain mollusks. The manuscript has benefited from critical reviews by W. P. Woodring of the U.S. National Museum and by Dr. R. T. Abbott of the Academy of Natural Sciences.

GEOLOGY

STRATIGRAPHY

Detailed studies in recent years have greatly increased our knowledge of the Cenozoic sections in several of the island groups under consideration. In the Pacific Basin proper, a standard section has been established from results of deep drilling in the Marshall Islands (described in the numerous chapters of U.S. Geol. Survey Prof. Paper 260, especially Emery and others, 1954; Cole, 1958; Todd and Low, 1960; Ladd and Schlanger, 1960; Schlanger, 1963). Outside the basin, in the Mariana Islands (Cloud and others, 1956; Doan and others, 1960; Tracey and others, 1964); in Palau, (Mason and others, 1956); and in Fiji, (bulletins published by Geol. Survey Dept. of Fiji, including: Bartholomew, 1959, 1960; Houtz, 1959, 1960, 1963; Ibbotson, 1960, 1962; Rickard, 1963; Houtz and Phillips 1963; also Cole, 1960); detailed mapping and paleontological studies have established similar sections. In the Ellice Islands, in the New Hebrides, and in Tonga, available information is much less complete.

Each of the seven island groups has a section of Quaternary limestones and all except Funafuti in the Ellice group are known to have a Tertiary sequence as well. The known Tertiary in all groups, except that in the New Hebrides, extends downward into the Eocene. No Paleocene has been reported from any of the island groups.

The subdivisions of the Tertiary are based on the system developed for the East Indies by van der Vlerk and Umbgrove (1927). By using larger Foraminifera, the

TABLE 1.—*Distribution of Cenozoic sediments in the island area*

[×, present; question mark indicates uncertain identification]

	Indonesia[1]		Marshall Islands		Ellice	Mariana Islands			Palau	New Hebrides	Fiji		Tonga
			Eniwetok	Bikini		Guam	Saipan	Tinian			Viti Levu	Lau	
Quaternary		Recent	×	×	×	×	×	×	×	×	×	×	×
		Pleistocene	×	×	×	×	×	×	×		×	×	×
Upper Tertiary	*h*	Pliocene	×	×		×	?	×	×	×	×	×	
	g	Upper Miocene	×	×		×		?	×	×	×	×	×
	f	Lower Miocene	×	×		×		?	×	×	×	×	
	e		×	×		×	×	×		×	×	×	
Lower Tertiary	*d*	Oligocene											
	c		×?	×?		×					×		
	b	Eocene	×			×	×	×	×		×		×
	a[2]			×									

[1] Some workers (Bemmelen, 1949, p. 88) place part of Tertiary *g* into the Pliocene with Tertiary *h*.
[2] Occurrence of Tertiary *a* based on smaller Foraminifera on Sylvania Guyot adjoining Bikini (Hamilton and Rex, 1959).

Tertiary sequence was subdivided into six units, designated by the letters *a–f*. Later, two younger stages *g* and *h* were added (Leopold and van der Vlerk, 1931; table 1, this paper). This classification has proved to be exceedingly useful in the western Pacific island groups.

In the atoll groups (Marshall and Ellice Islands), the sedimentary rocks consist of reef limestone and dolomitized limestone. Similar limestones occur in the high island groups along with a variety of terrestrial and marine tuffs and coarser volcanic sediments. The Cenozoic sedimentary rocks are known to rest on volcanic rocks in most areas. In the Ellice Islands, no volcanic rocks are exposed nor have they been reached by the drill, but seismic evidence suggests such a foundation at a depth of about 1,800 feet (Gaskell and Swallow, 1953, p. 3). In Fiji (McDougall, 1963) and Tonga (Guest, 1959, p. 3), plutonic rocks are known; their presence records more complex histories than in other island groups. The Tongan plutonic rocks are thought to be of pre-Tertiary age.

Fossils from the section established by deep drilling in the Marshall Islands have been studied by several workers; their findings have been published as chapters of U.S. Geological Survey Professional Paper 260. The major divisions recognized are shown in table 2. With slight modification, this is the arrangement given by Cole (1958, p. 745).

EOCENE

The only known occurrence of lower Eocene (Tertiary *a*) sediments in the island area is the phosphatized *Globigerina* ooze described by Hamilton and Rex (1959) from the top of Sylvania Guyot adjacent to Bikini. The ooze contained no mollusks.

Limestones of late Eocene age (Tertiary *b*) are widely known in Eniwetok, the Marianas, Palau, Fiji, and Tonga. Mollusks occur in some of these limestones, but they are rare, and in many places they are poorly preserved; none from the families here treated has been specifically identified. In Fiji and Tonga the limestones have yielded diagnostic larger Foraminifera, but no other identifiable fossils. In Palau, numerous fragments of an upper Eocene limestone containing larger Foraminifera, algae, and unidentifiable mollusks occur in a volcanic breccia. In the Mariana Islands, upper Eocene rocks have yielded a considerable variety of fossils, including Foraminifera, radiolarians, discoasters, algae—and in

TABLE 2.—*Major stratigraphic subdivisions recognized in holes drilled in the Marshall Islands*

Stratigraphic divisions		Eniwetok	Bikini
		Depth (feet)	Depth (feet)
Post-Miocene		0–615	0–700
Upper Miocene	Tertiary *g*	615–860	700–980
Lower Miocene	Tertiary *f*	860–1,080	980–1,166
	Tertiary *e*	1,080–2,780	1,166–2,556+
Upper Eocene	Tertiary *b*	2,780–4,610	

some places fragmentary and poorly preserved mollusks have been found. In the Marshall Islands, some Eocene mollusks have been recovered from deep holes on Eniwetok. These include poorly preserved bivalves (*Arca* and *Pecten*), but most are the molds of minute gastropods, including turbinids and cyclostrematids, that are not identifiable.

OLIGOCENE

Limestones containing larger Foraminifera diagnostic of the lower Oligocene of the Indonesian section (Tertiary *c*) have been found in Fiji and in Guam (Cole 1960, 1963). The beds containing these fossils are restricted in their distribution and to date (1965) have yielded no identifiable mollusks. Some of the limestones on Guam that contained Oligocene larger Foraminifera also yielded an assemblage of smaller Foraminifera that is definitely early Oligocene (Tertiary *c*) in age (Ruth Todd, oral commun., 1963).

The section drilled in the Marshall Islands includes beds containing smaller Foraminifera that may represent the lower Oligocene (Tertiary *c*) but the correlation is questionable (Todd and Low, 1960). In drill holes F–1 and E–1 on Eniwetok, there is an interval of about 100 feet (2,687–2,780 ft) that Cole (1958, p. 745, 748) labeled "unknown" because it yielded no diagnostic larger Foraminifera. Above this interval the beds contain lower Miocene Foraminifera (Tertiary *e*) and below they contain upper Eocene species (Tertiary *b*). Along with the smaller Foraminifera that are suggestive of the lower Oligocene, the questionable beds yielded three specimens of *Rissoina ailinana* Ladd, n. sp., a species that occurs in some Tertiary *e* samples in both Eniwetok and Bikini. Also recovered were nine specimens (from four samples) of a well-preserved Miocene *Ampullina*, described from East Borneo by Beets (1941) as *Globularia berauensis*.[1] Because of the occurrence of these mollusks, I have tentatively assigned the unknown interval to the Miocene.

No beds that would represent the upper Oligocene (Tertiary *d*) have been found in any of the island groups here considered. The Fina-sisu Formation of Saipan, previously assigned to the late Oligocene (Todd and others, 1954) on the basis of smaller Foraminifera, is now regarded as early Miocene in age (Ruth Todd, oral commun., 1963).

MIOCENE

Miocene sedimentary rocks have been recognized in all the island groups except in the Ellice Islands. In the Eniwetok drill holes, shallow-water lagoonal limestones exceed 2,000 feet (table 2). All three major subdivisions of the Miocene (Tertiary *e*, *f*, and *g*) are represented, but the section is not complete, inasmuch as a solution unconformity appears at the top of Tertiary *e* (Schlanger, 1963, p. 995). Miocene reef limestones are also found in Palau. The total section exceeds 750 feet, but some parts may be younger than Miocene (Cole, 1950; Mason and others, 1956, p. 55–59). In at least two areas in Palau the Miocene includes thin tuffaceous limestone and marl that are here assigned to the upper Miocene (Tertiary *g*). On Saipan and Tinian in the Mariana Islands, the lower Miocene (Tertiary *e*) limestones are 750 to nearly 1,000 feet in maximum thickness and include some tuffaceous facies (Cloud and others, 1956, p. 62–77; Doan and others, 1960, p. 60–62). Tertiary *e* rocks on Guam exceed 2,000 feet, but most of the sequence consists of volcanic flows and breccias. Although some of the included limestones are of shallow-water origin, *Globigerina*-rich sediments, of deeper water origin, are present. On Guam the Tertiary *e* rocks are overlain by several hundred feet of younger limestones; some of these are definitely of Tertiary *f* age, others may be Tertiary *g*. (Tracey and others, 1964). In Fiji the Miocene sequence is dominantly volcanic. It consists of many thousands of feet of agglomerates, tuffs, and marls, some water laid, together with a variety of igneous rocks. Limestones of shallow-water origin are at least 200 feet thick in some areas. Miocene rocks of comparable types have been reported from the less well known New Hebrides (Mawson, 1905; Abrard, 1946). In Tonga the known Miocene is thin; it consists of a series of volcanic tuffs totaling 200–300 feet in thickness (Hoffmeister, 1932, p. 30, 33).

POST-MIOCENE

In the island area it is difficult, if not impossible, to recognize age boundaries in the post-Miocene sediments. Diagnostic larger Foraminifera which are so useful in subdividing the Miocene and older Tertiary beds have not been found. Other organisms, especially planktonic smaller Foraminifera, discoasters, and radiolarians, offer great promise, but these organisms are not everywhere present, and their geologic distribution in the islands has not yet been adequately determined. Mollusks, even where well preserved and abundant, are of limited usefulness in determining exact post-Miocene ages.

In the Marshall Island drill holes, the top of the Miocene has been agreed upon by those who have studied the Foraminifera from cores and cuttings. The post-Miocene section ranges from 510 to 700 feet in thickness, but it has not been subdivided accurately (Cole 1958, p. 745; Todd and Low, 1960, p. 802, 807). These limestone beds thought to be mostly lagoonal, have not yielded

[1] Mr. Beets kindly checked the identification of this species by comparing an Eniwetok shell with his type in the museum in Leiden.

assemblages of discoasters or radiolarians. The smaller Foraminifera in the elevated post-Miocene reef limestones of Fiji, Tonga, and Palau, are preserved mostly as unidentifiable molds, as are those in most of the Quaternary sediments drilled on Funafuti. The post-Tertiary limestone of the Mariana Islands contains both larger and smaller Foraminifera, but no extinct species are included and hence no exact stratigraphic boundaries are indicated. Some of the elevated limestones of the New Hebrides contain molluscan species previously reported from the Pliocene of Java (Abrard and La Rüe, 1937).

PLIOCENE

The Pliocene-Pleistocene boundary is perhaps the most difficult Cenozoic boundary to recognize in the island area. Environmental conditions in the tropical islands seem to have been little affected by the onset of glaciation in other parts of the world, and no clear stratigraphic break appears.

In cores of deep-sea sediments containing layers of ice-rafted materials, the earliest of these can be taken as the base of the Pleistocene, and correlations with other deep-sea sections can be made on the basis of wide-ranging Foraminifera or other planktonic organisms. Eventually a system of this sort may be successfully applied to some of the sediments of the island area.

PLEISTOCENE AND RECENT

In the absence of definitive paleontologic evidence, it is not possible to recognize Pleistocene beds with certainty, though suggestive physiographic evidence has been called upon in several areas. In the Bikini drill holes, three rock units above 294 feet, characterized by distinctive species of still-living smaller Foraminifera, seem to be related to present physiographic features. These rock units are thought to represent three late stages of reef growth, probably separated by two periods of emergence representing Pleistocene shifts in sea level (Emery and others, 1954, p. 2, 75, 132–133).

On Saipan, the name Mariana was applied to limestones now as much as 500 feet above existing sea level and the name Tanapag to limestones below 100 feet. The Mariana includes reef and lagoonal deposits, whereas the Tanapag represents rock of an elevated fringing reef. The Mariana was assigned an early, and the Tanapag a younger, Pleistocene age. These interpretations are supported by a period of faulting that intervened between the benching of the Mariana and the deposition of the Tanapag. Carbon-14 analyses of the Tanapag seem to support the postulated younger Pleistocene age (Cloud and others, 1956, p. 2, 79–80, 87). On Guam, the Mariana Limestone yielded no diagnostic larger Foraminifera but was assigned a Pleistocene, or possibly Recent, age (Cole, 1963, p. E1, E10).

In eastern Fiji (Lau), the Fulanga Limestone is composed of elevated veneers of reef limestone, occurs on two or three islands, and has been referred tentatively to the Pleistocene. Paleontologically it yielded two previously undescribed echinoids, a new decapod crustacean, and a few species of still-living mollusks. Among the mollusks are species that no longer live in Fiji. The preceding data suggest an appreciable age for the Fulanga, but they do not clearly indicate Pleistocene. That interpretation was based almost entirely on field evidence (Ladd and others, 1945, p. 267, 313, 322, 380).

CORRELATION

Age determinations and correlations involving major stratigraphic units in the several island groups are based on the letter classification established for Indonesia (van der Vlerk and Umbgrove, 1927; Leopold and van der Vlerk, 1931). 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 (Glaessner, 1943, 1959; Todd and others, 1954; Cloud, 1956; Eames and others, 1962). The exact ages (by the Indonesian letter system) of some of the Tertiary units in the islands are in question because of conflicting interpretations of faunal evidence, notably that of the larger versus the smaller Foraminifera. These differences are still being discussed vigorously. (Cole and others, 1960; Glaessner, 1960; Eames and others, 1962). The mollusks, which rarely occur in beds with diagnostic Foraminifera, are not deeply involved with questions of exact correlation. The correlations shown in table 3 are based more heavily on evidence from the larger Foraminifera than on that of other groups of fossils. It is recognized, however, that eventually the evidence of such mobile planktonic groups as some of the smaller Foraminifera, the Radiolaria (Riedel, 1959), and especially the discoasters (Bramlette and Riedel, 1954) may offer modified, and perhaps sounder, correlations. Boundaries and units that are questionable are so marked in table 3, and it should, perhaps, be repeated that the exact ages of all post-Miocene units in the island area are debatable.

PALEONTOLOGY

GEOGRAPHIC AND GEOLOGIC DISTRIBUTION OF SPECIES

The geographic distribution of all the species treated is shown in table 4. The Marshall Island faunas are the richest, and more than half of the total number of named forms are recorded from Eniwetok alone. Fiji ranks second in number, Palau a poor third. Faunas from the other island groups are smaller but none of these areas, except the Mariana Islands, has been adequately collected.

SYSTEM	EPOCH		LETTER CLASSIFICATION	MARSHALL		ELLICE	PALAU	MARIANA			NEW HEBRIDES	FIJI		TONGA
				ENIWETOK	BIKINI	FUNAFUTI		SAIPAN	TINIAN	GUAM		VITI LEVU	LAU	
QUATERNARY	Recent			Reef complex, chiefly lagoonal and forereef	Reef limestone, chiefly lagoon bed	Reef limestone	Beach deposits	Raised sands	Raised beach sand and gravel	Beach deposits	Reef limestone	Alluvium and laterite	Mango Odinite	Reef limestone
	Pleistocene						Peleliu Limestone	Tanapag Limestone	Mariana Limestone	Mariana Limestone		Vatia Series Tavua Series	Fulanga Limestone	Reef limestone
UPPER TERTIARY	Pliocene		*h*				Palau Limestone	Mariana Limestone ? Terrace deposits			Reef limestone	Thuvu Marls Mba Series	Ndalithoni Limestone	?
	Miocene	Upper	*g*			?	Airal clay and lignite	?		Alifan Limestone / Janum Formation / Barrigada Limestone	Water-laid tuff and limestone	Suva Series	Koro Mbasanga Volcanics	Tuff
		Lower	*f*							Bonya Limestone			Futuna Limestone Lau Volcanics	
			e				?	Tagpochan Limestone Fina Sisu	Tagpochan Limestone	Umatac Formation		Singatoka Series		
LOWER TERTIARY	Oligocene	Upper	*d*		?		? ?							
		Lower	*c*	?	?		Ngeremlengui Formation			Alutom Formation		Tholo Plutonics and limestone		
	Eocene	Upper	*b*	Reef complex	?		? ? Aimelik Formation	Matansa Fm. Densinyama Fm. Hagman Fm	Pyroclastic rocks			Wainimala Series and limestone		Limestone
		Lower	*a*		Globigerina ooze[1]		? Babelthuap Formation ?					?		?

[1] Occurrence on Sylvania Guyot adjoining Bikini (after Hamilton and Rex, 1959)

TABLE 3.—*Correlation of Cenozoic units in the island area*

[Vertical shading indicates hiatus; blank areas show unknown parts of section. In Lau, Fiji, the Lau Volcanics include tuff of Tertiary *c* age according to R. M. Kleinpell, B. P. Bishop Mus. Bull. 211, 1954]

The geologic distribution of species is shown in table 5. The numbers of named species from each of two stages of the Miocene (Tertiary *f* and *g*) exceed those recorded from all other divisions of the Cenozoic.

PALEOECOLOGY

Many of the Cenozoic sediments that crop out on the islands, or have been reached by the drill below sea level, are limestones that were formed in shallow water on reefs or in adjacent lagoons. Such sediments dominate in the sections drilled below the three atolls—Eniwetok, Bikini, and Funafuti. Similar reef limestones crop out extensively in the Mariana Islands, in Palau, and in eastern Fiji. At Eniwetok and in the Mariana Islands, the shallow-water limestones occur with off-reef limestones that appear to have been accumulated in somewhat deeper water, the indicated depths being not less than 100 fathoms (Todd, 1957, p. 271; Todd and Low 1960, p. 812–815; Schlanger 1963, p. 999–1002). Among the high islands, particularly in Fiji and the New Hebrides, are thick sequences of tuffs and marls, many of which were deposited in marine water. *Globigerina*-rich beds in these sections point to water of at least moderate depths, but lenticular masses of shallow-water limestones are included between them. Such associations raise many problems that have not, as yet, been satisfactorily solved. On most islands, both lateral and vertical changes in facies are abrupt and even repetitious. Paleoecological interpretations of a given fossiliferous bed can be made without great difficulty but the environmental history recorded by sequence of appreciable thickness is much more complicated.

Mollusks occur in most of the kinds of rocks mentioned above but the species described in the present report were all derived from shallow-water deposits that formed on reefs, reef flats, shore platforms, and in lagoons adjacent to reefs. This report deals with the scanty record left by the chitons, and the fuller records of 15 families of gastropods. Taken together, the fossils represent only about one-sixth of the collections available, and hence full paleoecological interpretations are not attempted at this time.

In Palau, the thick sections of cavernous rock that form the Palau Limestone of southern Babelthuap and the numerous islands that lie to the south are of reef origin. Mollusks are abundant in the Palau, but most of them are unidentifiable molds of common reef types, including trochids and turbinids. Locally, however, at the base of the Palau, tuffaceous and marly beds carry a rich molluscan fauna of late Miocene (Tertiary *g*) age. On the Goikul Peninsula of southeast Babelthuap, a thin wedge of marl lies between the Airai Lignite and a thick section of cavernous Palau Limestone. Around the peninsula today there is a broad shore platform bordered by mangrove swamps. This flat is nearly awash at low tide and is partly covered by waving eel grass. Shore-flat mollusks are abundant. Apparently, conditions were similar during the late Miocene. Many bedding planes in the marls are crossed by carbonaceous stripes, thought to represent eel grass, and the same genera of shallow-water mollusks are common, though the species are different. All but 2 of the 18 Palauan mollusks described in the present report were obtained from the marl on the Goikul Peninsula.

In the Mariana Islands, particularly on Saipan and Guam, Cenozoic reef-associated limestones and certain *Globigerina*-rich sediments that suggest deeper waters have been mapped and studied in detail. Paleoecological interpretations, based in large part on the distribution of Foraminifera, have been offered (Todd and others, 1954, p. 677; Cloud and others, 1956, p. 68, 80–81, 86–88; Hanzawa, 1957, p. 33–34; Todd, 1957, p. 265, 273–283; Cole, 1963, p. E11–E12).

Mollusks left a meager fossil record on Saipan, particularly as to the kinds considered in the present report. Mollusk collections from Guam are larger and more varied, but most of those here described are types commonly found near the reef edge or on the reef flat. Collecting localities on Guam are concentrated in the waist of the island where the several facies of the Mariana Limestone are widely exposed. This same area is notably poor in Foraminifera, because many of these organisms lived in moderate to fairly deep water.

The limestone sections drilled beneath Eniwetok and Bikini in the Marshall Islands are all reef associated. Many of the highly fossiliferous beds, especially those rich in mollusks, appear to have been deposited in lagoons, but other environments—reef wall, open shoal, and off-reef deposits—are also found. Paleoecological interpretations have been summarized and graphically portrayed by Schlanger (1963, p. 998–1001).

Of particular interest is a thick zone that roughly encompasses the beds assigned to Tertiary *g* and *f*. This zone was found in all the deep holes drilled on Eniwetok and Bikini. The section, referred to by Schlanger (1963, p. 1000) as the "Coral-mollusk-rich zone," apparently never was raised above the sea to be leached and recrystallized. Its fossils are almost perfectly preserved, many mollusk shells even retaining traces of their original color patterns. The beds are unconsolidated and core recovery was difficult, but rich concentrations of mollusks were obtained in some core runs. The cored material appeared to be far richer in mollusk shells than any sediments dredged from the floors of the existing lagoons.

TABLE 4.—*Geographic distribution of species*

Species	Palau	Guam	Saipin and Tinian	Eniwetok	Bikini	Funafuti	New Hebrides	Fiji	Tonga
Schizochitonidae:									
Schizochiton incisus goikulensis Ladd, n. subsp	×								
marshallensis Ladd, n. sp				×	×				
Loricella sp. A				×					
Chitonidae:									
Lucilina russelli Ladd, n. sp				×					
sp. A	×								
sp. B				?				×	
sp						×			
Acanthochitonidae:									
Acanthochitona sp				×	×				
Cryptoplax cf. *C. menkrawitensis* Beets								×	
sp. A				×	×				
sp. B				×					
sp								×	
Haliotidae:									
Haliotis (*Padollus*) *ovina* Gmelin		×							
cf. *H. clathrata* Reeve		×	×						
turuthaensis Ladd								×	
sp								×	
Scissurellidae:									
Scissurella (*Scissurella*) *declinans* Watson				×	×				
(*Scissurella*) *coronata* Watson				×					×
(*Anatoma*) *equatoria* Hedley				×		×			
Fissurellidae:									
Emarginula (*Emarginula*) *bicancellata* Montrouzier				×		×			
(*Emarginula*) cf. *E. peasei* (Thiele)				×					
aff. *E. clypeus* A. Adams				×					
(*Subzeidora*) *souverbiana* Pilsbry				×					
(*Subzeidora*) sp. A					×				
sp. B				×					
Hemitoma (*Hemitoma*) sp								×	
(*Montfortia*) *bikiniensis* Ladd, n. sp				×	×				
(*Montfortia*) sp. A				×					
(*Montfortista*) *excentrica* (Iredale)							×		
Rimula exquisita A. Adams					×				
sp				×					
Scutus (*Nannoscutum*) sp. A				×					
(*Nannoscutum*) sp. B				×					
Diodora (*Elegidion*) *marshallensis* Ladd, n. sp	×			×	×				
(*Elegidion*) aff. *D. granifera* (Pease)				×					
sp. A	×								
Patellidae:									
Patella (*Scutellastra*) *stellaeformis* Reeve				×					
Cellana aff. *C. sagittata* (Gould)								×	
sp. A			×						
? sp								×	
Trochidae:									
Euchelus (*Euchelus*) cf. *E. quadricarinatus* (Dillwyn)				×					
(*Herpetopoma*) *instrictus* (Gould)				×					
(*Herpetopoma*) *instrictus suvaensis* Ladd, n. subsp								×	
(*Vaceuchelus*) *angulatus* Pease				×	×			×	
(*Vaceuchelus*) sp. A				×					
Hybochelus cancellatus orientalis Pilsbry				×					
karoricus Ladd								×	
Thalotia (*Thalotia*) *berauensis* (Beets)				×					
(*Thalotia*) aff. *T. elongatus* (Wood)		×							
(*Beraua*) sp			×						
Turcica (*Perrinia*) *morrisoni* Ladd, n. sp					×				
Gibbula (*Gibbula*) *engebiensis* Ladd, n. sp				×					
Fossarina (*Minopa*) *hoffmeisteri* Ladd, n. sp				×	×				
Astele (*Callistele*) *engebiensis* Ladd, n. sp				×					
Trochus (*Trochus*) *maculatus* Linnaeus		×	×				×		
(*Trochus*) *histrio* (Reeve)				×				×	
incrassatus Lamarck									×
tubiferus Kiener									×
Clanculus (*Clanculus*) *clanguloides fijiensis* Ladd								×	
Tectus (*Tectus*) *mauritianus* (Gmelin)							×		
(*Tectus*) *pyramis* (Born)			×						×
cf. *T. bomasensis* (Martin)								×	
(*Rochia*) *niloticus* (Linnaeus)							×		
Isanda (*Parminolia*) *apicina* (Gould)				×	×				
Monilea (*Monilea*) *mateana* Ladd								×	
(*Monilea*) *marshallensis* Ladd, n. sp				×	×				
lifuana Fischer				×					
belcheri (Philippi)								×	
Stomatellidae:									
Pseudostomatella (*Pseudostomatella*) *maculata* (Quoy and Gaimard)								×	
Stomatia cf. *S. phymotis* Helbling		×							
Synaptocochlea concinna (Gould)				×					
rosacea (Pease)				×	?				
lekalekana (Ladd)								×	
marshallensis Ladd, n. sp				×					
Angariidae:									
Angaria delphinus (Linnaeus)		?						×	

TABLE 4.—*Geographic distribution of species*—Continued

Species	Palau	Guam	Saipin and Tinian	Eniwetok	Bikini	Funafuti	New Hebrides	Fiji	Tonga
Turbinidae:									
Astraea (Astralium) rhodostoma (Lamarck)		×	×				×	×	×
(*Astralium*) aff. *A. rhodostoma* (Lamarck)						×			
enivetokensis Ladd, n. sp				×					
waluensis Ladd, n. sp								×	
sp. A				×					
sp. B					×				
sp. C				×	×			?	
(*Bellastraea*) sp. D				×	×				
(*Bellastraea*) sp. E				×					
(*Vitiastraea*) *holmesi* Ladd, n. sp								×	
Arene (Arene) metallilana Ladd, n. sp					×				
(*Arene*) sp. A					×				
Liotina (Austroliotia) cf. *L. botanica* (Hedley)				×					
(*Dentarene*) *loculosa* (Gould)				×	×				
(*Dentarene*) sp. A				×					
sp. B					×				
Turbo (Turbo) petholatus Linnaeus		×					×	×	×
(*Turbo*) *petholatus thanus* Ladd								×	
(*Marmarostoma*) *chrysostomus* Linnaeus		×					×		
(*Marmarostoma*) *argyrostomus* Linnaeus		×	×	×		?	×		×
setosus Gmelin?		?				×			
crassus Wood									×
perlatus Abrard							×		
sp. A								×	
Cynisca pacifica Ladd, n. sp				×					
Leptothyra maculosa (Pease)				×	×	×		×	×
inepta (Gould)				×					
harlani Ladd, n. sp				×	×				
aff. *L. laeta* Montruzier				×	?				
aff. *L. candida* (Pease)				×					
balnearii Pilsbry				×					
wellsi Ladd, n. sp				×	×			×	
glareosa marshallensis Ladd, n. subsp				×	×				
picta (Pease)				×					
emenana Ladd, n. sp				×	×				
sp. A				×					
Phasianellidae:									
Phasianella sp				×	×			×	
Gabrielona raunana Ladd, n. sp				×					
Tricolia (Hiloa) variabilis (Pease)				×	×				
(*Hiloa*) sp. A								×	?
Neritopsidae:									
Neritopsis (Neritopsis) radula Linnaeus	×	×	×	×	×	?		×	
Neritidae:									
Nerita (Amphinerita) insculpta Recluz				×					
(*Amphinerita*) aff. *N. polita* Linnaeus				×					
(*Ritena*) *palauensis* Ladd, n. sp	×								
(*Ritena*) aff. *N. undata* Linnaeus									×
(*Theliostyla*) cf. *N. semirugosa* Recluz								×	
(*Theliostyla*) sp. A								×	
sp. B								×	
Neritina (Vitta) oualaniensis Lesson		×							
Clithon (Clithon) corona (Linnaeus)								×	
Neritilia traceyi Ladd					×				
Smaragdia (Smaragdia) jogjacartensis (Martin)	×			×					
(*Smaragdia*) aff. *S. rangiana* (Recluz)	×								
colei Ladd, n. sp				×	×				
sp. A				×	?				
Pisulina subpacifica Ladd, n. sp					×				
Littorinidae:									
Tectarius (Subditotectarius) rehderi Ladd, n. sp				×	×				
Iravadiidae:									
Iravadia gardnerae Ladd, n. sp				×	×				
Rissoidae:									
Putilla (Pseudosetia) morana Ladd, n. sp				×					
(*Parrisetia*) *goikulensis* Ladd, n. sp	×								
(*Parrisetia*) *suraensis* Ladd, n. sp								×	
Cingula (Peringiella) parryensis Ladd, n. sp				×					
(*Peringiella*) cf. *C. roseocincta* (Suter)	×			×					
Amphithalmus (Cerostraca) jeffcoati Ladd, n. sp				×	×				
(*Cerostraca?*) *myersi* Ladd, n. sp				×					
(*Pisinna*) *bikiniensis* Ladd, n. sp					×				
Alvania (Taramellia) corayi Ladd, n. sp				×					
(*Taramellia*) *kenneyi* Ladd, n. sp				×					
Merelina (Merelina) pisinna (Melvill and Standen)				×	×			×	
(*Linemera*) *telkibana* Ladd, n. sp	×								
Parashiela beetsi Ladd, n. sp				×					

TABLE 4.—*Geographic distribution of species*—Continued

Species	Palau	Guam	Saipin and Tinian	Eniwetok	Bikini	Funafuti	New Hebrides	Fiji	Tonga
Rissoidae—Continued									
Zebina (Cibdezebina) metaltilana Ladd, n. sp.				×	×			×	
(Morchiella) cf. *Z. cooperi* (Oliver)				×	?				
(Morchiella) killeblebana Ladd, n. sp.				×					
(Ailinzebina) abrardi Ladd, n. sp.				×	×				
? sp. A					×				
Rissoina (Schwartziella) gracilis (Pease)									×
(Schwartziella) aff. *R. flexuosa* Gould		×		×	×				
aff. *R. indrai* Beets				×					
mejilana Ladd, n. sp.				×					
jirikana Ladd, n. sp.					×				
rilebana Ladd, n. sp.					×				
(Zebinella) emnanana Ladd, n. sp.				×					
(Zebinella) tenuistriata Pease				×	×				
aff. *R. supracostata* Garrett				×					
(Phosinella) clathrata A. Adams							×	×	
(Phosinella) briggsi Ladd, n. sp.	×								
balteata Pease				×	×				
bikiniensis Ladd, n. sp.				×	×				
transenna Watson				×	×				
alexisi Ladd, n. sp.				×					
Rissoina (Rissoina) abbotti Ladd, n. sp.				×	×				
(Rissoina) mijana Ladd, n. sp.				×	×				
ailinana Ladd, n. sp.				×	×				
lomaloana Ladd, n. sp.				×	×				
goikulensis Ladd, n. sp.	×								
waluensis Ladd, n. sp.								×	
ekkanana Ladd, n. sp.				×					
ambigua Gould				×	×				
ambigua parryensis Ladd, n. subsp.				×					
concinna A. Adams				×	×				
sp. A								×	
(Rissolina) turricula Pease				×	×			×	
(Rissolina) marshallensis Ladd, n. sp.				×	×				
ephamilla Watson				×	×				
kickarayana Ladd, n. sp.	×								
herringi Ladd, n. sp.				×					
harti Ladd, n. sp.					×				
bourneae Ladd, n. sp.								×	
plicata A. Adams				×					
sp. B								×	
Barleeia (Barleeia) meiauhana Ladd, n. sp.	×								
Assimineidae:									
Assiminea nitida eniwetokensis Ladd, n. subsp.				×	×				
Adeorbidae:									
Haplocochlias sp. A				×					
Leucorhynchia caledonica Crosse				×					
crossei Tryon				×					
? *stephensoni* Ladd, n. sp.				×					
? *lilli* Ladd, n. sp.					×				
Lophocochlias minutissimus (Pilsbry)				×	×			×	×
paucicarinatus Ladd, n. sp.				×					
Munditiella qualum (Hedley)				×					×
parryensis Ladd, n. sp.				×					
Teinostoma (Esmeralda) engebiense Ladd, n. sp.				×					
(Esmeralda) marshallense Ladd, n. sp.				×	×				
sp. A								×	
Solariorbis tricarinata (Melvill and Standen)				×	×				
? sp.								×	
Lydiphnis eniwetokense Ladd, n. sp.				×					
Cyclostremiscus emeryi Ladd, n. sp.				×					
(Ponocyclus) novemcarinatus (Melvill)				×					
(Ponocyclus) cingulifera (A. Adams)	×								
Cochliolepis diangalana Ladd, n. sp.	×								
Vitrinella sp. A					×				
Total of 208 occurrences	18	14	8	122	66	8	10	47	14

The thousands of feet of reef-associated limestones that underlie Eniwetok and Bikini do not record slow and continuous subsidence. On the contrary, as Schlanger (1963) has shown, the section is interrupted by "solution unconformities" that record periods when the atolls stood above the sea as high islands, and their limestones were leached and recrystallized. This interpretation is strengthened by the occurrence of spores and pollen that indicate a richer and more varied flora during part of the Miocene than is found in the area today (E. B. Leopold, unpub. data). It is strengthened, likewise, by the occurrence of high-island fossil land shells of the genus *Ptychodon* at both Eniwetok and Bikini (Ladd, 1958) and by the occurrence of fresh- and brackish-water mollusks—*Neritilia* and *Gyraulus*—in the Miocene beds beneath Bikini, an area where no such animals live

today. When it stood above the sea, Bikini evidently contained both fresh- and brackish-water pools near sea level, as do many elevated limestone islands today (Ladd, 1965).

Shallow-water mollusks occur in normal abundance in the reef limestones that lie beneath Funafuti Atoll, but because much of the rock that was drilled is leached, recrystallized, or dolomitized, shells are poorly preserved. Only eight mollusks from Funafuti are named in this report, and half of these are small forms recovered from the unaltered sands obtained at depths of less than 100 feet. None of the mollusks was found in the parts of the section that yielded *Cycloclypeus*. According to the interpretation of Grimsdale (1952), the limestones containing this foraminifer were deposited under open-sea conditions on a reef talus slope or a submerged bank.

I have not visited the New Hebrides and have no first-hand information about the fossil associations in the sediments of those islands. From all accounts, the exposed rock sections are similar to those of Fiji: Miocene marls with included shallow-water limestones that contain many of the mollusks and brachiopods that have been recorded from Viti Levu (Abrard, 1946), and terraced reef limestones of post-Miocene age appear to be similar to those of eastern Fiji (Lau).

An attempt to interpret the ecological conditions under which the several types of fossiliferous sediments of Viti Levu, Fiji, were accumulated was made by Ladd in 1934 (in Ladd and others, 1934, p. 87–97), and a similar discussion on the sediments of eastern Fiji (Lau) was made by Ladd and Hoffmeister in 1945 (in Ladd, Hoffmeister, and others, 1945, p. 260–264). These discussions could be somewhat amplified now (1965), but a full analysis depends on complete studies of other groups of mollusks. Two short papers involving Fijian paleoecology have been written since the two general discussions mentioned above were published. G. F. Elliott described the first fossil example of the deepwater brachiopod *Abyssothyris* which was collected from limestones in the upper Tertiary Suva Series near Suva, Fiji. (Elliott in Muir-Wood 1960, p. 256). Additional specimens of this rare brachiopod have since been collected by William Briggs of the U.S. Geological Survey and by others of the Geological Survey Department of Fiji from the marls that enclose the Suva Limestone. Heinz Lowenstam of the California Institute of Technologoy is making analyses of the shell substance in an attempt to determine the temperature—and hence the depth—under which the brachiopod may have lived.

In a recent paper I (1965) reinterpreted the Suva beds that yielded the river snail *Clithon corona* Linnaeus as a reef flat or shore platform. I also described an unusual upper Tertiary deposit from northern Viti Levu that appears to have been laid down in the fresh or slightly brackish waters of a coastal swamp or bog. The deposit contains numerous examples of a fresh-water snail, *Melanoides*, with lignitic material and the pollen and spores of land plants, including mangrove.

The only Tertiary mollusk that has been described from Tonga is a nautiloid collected by Hoffmeister (1932) from bedded tuffs on the island of Eua that are probably Miocene in age (Miller 1941). Quaternary mollusks collected on Tongatabu and elsewhere by Ostergaard (1935) were obtained from elevated reef limestones that are probably Pleistocene in age. None of the 14 species identified in the present report is extinct. The abundant forms are trochids and turbinids that live today on reefs in the same area.

FAUNAL RELATIONS

A full discussion of this subject, like that of paleoecology, must await the completion of studies of other groups of mollusks, but it is possible, at this time, to consider briefly certain relationships that are suggested by the group of more than 200 species described in the present report.

The assemblages of fossil mollusks from the island area are clearly Indo-Pacific in general aspect, the strongest discernible ties being with the living and fossil faunas of tropical Indonesia rather than with faunas from more southerly areas (south Australia and New Zealand) or more northerly areas (the Ryukyu Islands and Japan). Most biogeographers, including those concerned with marine mollusks, have recognized this relationship and have supported the conventional interpretation that Indonesia is the center of dispersal and that there is a gradual attenuation in numbers of species from Indonesia eastward and north eastward into the open Pacific (Hedley, 1899a, p. 397–401; 1899b; Edmondson, 1940, p. 598; Ekman, 1953, p. 18; Solem, 1958, p. 18).

One of the objections to this theory of origin and dispersal is the fact that the prevailing winds, the storm winds, and the strongest ocean currents all trend from the island area toward Indonesia, rather than away from it. Consequently, some workers have postulated circuitous routes of migration, and I have suggested that much of the traffic may have been in the opposite direction. The known geological history of the area indicates that during the Tertiary many more reef and island stepping stones were available in the western Pacific than are there now (Hamilton, 1956), and it would have been much easier for many marine animals to make their way from Hawaii in the central Pacific to Indonesia (Ladd, 1960; Durham, 1963, p. 356). Hawaii is not

TABLE 5.—*Geologic distribution of species*

Species	Tertiary				Quaternary		
	e	*f*	*g*	*h*			
	Lower Miocene	Miocene	Upper Miocene	Pliocene	Pleistocene	Recent	Living
Schizochitonidae:							
Schizochiton incisus goikulensis Ladd, n. subsp			—				
marshallensis Ladd, n. sp	—	—	—				
Loricella sp. A						—	
Chitonidae:							
Luculina russelli Ladd, n. sp				—			
sp. A			—				
sp. B		—		—			
sp						—	
Acanthochitonidae:							
Acanthochitona sp			—	—			
Cryptoplax cf. *C. menkrawitensis* Beets		—					
sp. A	—		—				
sp. B	— ?		—				
sp		—					
Haliotidae:							
Haliotis (*Padollus*) *ovina* Gmelin				— ?	—		—
cf. *H. clathrata* Reeve			— ?	—	—		
tuvuthaensis Ladd		— ?					
sp		— ?					
Scissurellidae:							
Scissurella (*Scissurella*) *declinans* Watson			—			—	—
(*Scissurella*) *coronata* Watson					—	—	—
(*Anatoma*) *equatoria* Hedley						—	—
Fissurellidae:							
Emarginula (*Emarginula*) *bicancellata* Montrouzier						—	—
(*Emarginula*) cf. *E. peasei* (Thiele)						—	
aff. *E. clypeus* A. Adams						—	
(*Subzeidora*) *souverbiana* Pilsbry						—	—
(*Subzeidora*) sp. A	—						
sp. B						—	
Hemitoma (*Hemitoma*) sp				—			
(*Montfortia*) *bikiniensis* Ladd, n. sp						—	
(*Montfortia*) sp. A						—	
(*Montfortista*) *excentrica* (Iredale)					— ?	—	—
Rimula exquisita A. Adams				— ?	—	—	—
sp	— ?					—	
Scutus (*Nannoscutum*) sp. A			—				
(*Nannoscutum*) sp. B			—				
Diodora (*Elegidion*) *marshallensis* Ladd, n. sp		— ?	—				
(*Elegidion*) aff. *D. granifera* (Pease)						—	
sp. A			—				
Patellidae:							
Patella (*Scutellastra*) *stellaeformis* Reeve						—	—
Cellana aff. *C. sagittata* (Gould)				—			
sp. A						—	
? sp		—					
Trochidae:							
Euchelus (*Euchelus*) cf. *E. quadricarinatus* (Dillwyn)			— ?			—	
(*Herpetopoma*) *instrictus* (Gould)			— ?			—	—
(*Herpetopoma*) *instrictus suvaensis* Ladd, n. subsp		—					
(*Vaceuchelus*) *angulatus* Pease		—			— ?	—	—
(*Vaceuchelus*) sp. A						—	
Hybochelus cancellatus orientalis Pilsbry						—	—
kavoricus Ladd				—			
Thalotia (*Thalotia*) *berauensis* (Beets)		—	—				
(*Thalotia*) aff. *T. elongatus* (Wood)					—		
(*Beraua*) sp	—						
Turcica (*Perrinia*) *morrisoni* Ladd, n. sp		— ?				—	—
Gibbula (*Gibbula*) *engebiensis* Ladd, n. sp		—					
Fossarina (*Minopa*) *hoffmeisteri* Ladd, n. sp	—		—		— ?	—	—
Astele (*Callistele*) *engebiensis* Ladd, n. sp		—					
Trochus (*Trochus*) *maculatus Linnaeus*			— ?	—	—	—	—
(*Trochus*) *histrio* (Reeve)		—				—	—
incrassatus Lamarck					—		—
tubiferus Kiener					—		—
Clanculus (*Clanculus*) *clanguloides fijiensis* Ladd				—			
Tectus (*Tectus*) *mauritianus* (Gmelin)					— ?	—	—
(*Tectus*) *pyramis* (Born)					—		—
cf. *T. bomasensis* (Martin)			— ?	—			
(*Rochia*) *niloticus* (Linnaeus)					— ?	—	—
Isanda (*Parminolia*) *apicina* (Gould)	—					—	—
Monilea (*Monilea*) *mateana* Ladd		—					
(*Monilea*) *marshallensis* Ladd, n. sp	—	—	—	—	—	—	—
lifuana Fischer						—	—
belcheri (Philippi)		—					—

TABLE 5.—*Geologic distribution of species*—Continued

Species	Tertiary				Quaternary		
	e	*f*	*g*	*h*			
	Lower Miocene		Upper Miocene	Pliocene	Pleistocene	Recent	Living
Stomatellidae:							
Pseudostomatella (*Pseudostomatella*) *maculata* (Quoy and Gaimard)							
Stomatia cf. *S. phymotis* Helbling				?			
Synaptocochlea concinna (Gould)							
rosacea (Pease)							
lekalekana (Ladd)							
marshallensis Ladd, n. sp							
Angariidae:							
Angaria delphinus (Linnaeus)				?			
Turbinidae:							
Astraea (*Astralium*) *rhodostoma* (Lamarck)							
(*Astralium*) aff. *A. rhodostoma* (Lamarck)							
eniwetokensis Ladd, n. sp							
waluensis Ladd, n. sp							
sp. A							
sp. B							
sp. C							
(*Bellastraea*) sp. D							
(*Bellastraea*) sp. E							
(*Vitiastraea*) *holmesi* Ladd, n. sp							
Arene (*Arene*) *metaltilana* Ladd, n. sp							
(*Arene*) sp. A							
Liotina (*Austroliotia*) cf. *L. botanica* (Hedley)							
(*Dentarene*) *loculosa* (Gould)	?						
(*Dentarene*) sp. A							
sp. B							
Turbo (*Turbo*) *petholatus* Linnaeus							
(*Turbo*) *petholatus thanus* Ladd							
(*Marmarostoma*) *chrysostomus* Linnaeus							
(*Marmarostoma*) *argyrostomus* Linnaeus							
setosus Gmelin?				?			
crassus Wood							
perlatus Abrard							
sp. A							
Cyniscа pacifica Ladd, n. sp							
Leptothyra maculosa (Pease)							
inepta (Gould)							
harlani Ladd, n. sp							
aff. *L. laeta* Montrouzier							
aff. *L. candida* (Pease)							
balnearii Pilsbry							
wellsi Ladd, n. sp							
glareosa marshallensis Ladd, n. sp							
picta (Pease)	?						
emenana Ladd, n. sp							
sp. A							
Phasianellidae:							
Phasianella sp							
Gabrielona raunana Ladd, n. sp							
Tricolia (*Hiloa*) *variabilis* (Pease)	?						
(*Hiloa*) sp. A							
Neritopsidae:							
Neritopsis (*Neritopsis*) *radula* Linnaeus							
Neritidae:							
Nerita (*Amphinerita*) *insculpta* Recluz							
(*Amphinerita*) aff. *N. polita* Linnaeus							
(*Ritena*) *palauensis* Ladd, n. sp							
(*Ritena*) aff. *N. undata* Linneaus							
(*Theliostyla*) cf. *N. semirugosa* Recluz					?		
(*Theliostyla*) sp. A							
sp. B		?					
Neritina (*Vitta*) *oualaniensis* Lesson		?					
Clithon (*Clithon*) *corona* Linnaeus				?			
Neritilia traceyi Ladd							
Smaragdia (*Smaragdia*) *jogjacartensis* (Martin)							
(*Smaragdia*) aff. *S. rangiana* (Recluz)							
colei Ladd, n. sp							
sp. A							
Pisulina subpacifica Ladd, n. sp	?	?					
Littorinidae:							
Tectarius (*Subditotectarius*) *rehderi* Ladd, n. sp							
Iravadiidae:							
Iravadia gardnerae Ladd, n. sp							

TABLE 5.—*Geologic distribution of species*—Continued

Species	Tertiary				Quaternary		
	e	*f*	*g*	*h*			
	Lower Miocene		Upper Miocene	Pliocene	Pleistocene	Recent	Living
Rissoidae:							
Putilla (*Pseudosetia*) *morana* Ladd, n. sp.	▬		▬				
(*Parvisetia*) *goikulensis* Ladd, n. sp.			▬				
suvaensis Ladd, n. sp.		▬					
Cingula (*Peringiella*) *parryensis* Ladd, n. sp.			▬				
(*Peringiella*) cf. *C. roseocincta* (Suter)			▬			▬	
Amphithalmus (*Cerostraca*) *jeffcoati* Ladd, n. sp.	▬	▬	▬			▬	
(*Cerostraca?*) *myersi* Ladd, n. sp.			▬				
(*Pisinna*) *bikiniensis* Ladd, n. sp.	▬						
Alvania (*Taramellia*) *corayi* Ladd, n. sp.						▬	
(*Taramellia*) *kenneyi* Ladd, n. sp.	▬		▬				
Merelina (*Merelina*) *pisinna* (Melvill and Standen)	▬	▬	▬				▬
(*Linemera*) *telkibana* Ladd, n. sp.			▬				
Parashiela beetsi Ladd, n. sp.						▬	
Zebina (*Cibdezebina*) *metaltilana* Ladd, n. sp.	▬	▬	▬	▬	▬	▬	▬
(*Morchiella*) cf. *Z. cooperi* (Oliver)	▬ ?	▬	▬	▬	▬	▬	▬
(*Morchiella*) *killeblebana* Ladd, n. sp.		▬					
(*Ailinzebina*) *abrardi* Ladd, n. sp.	▬	▬	▬	▬	▬	▬	▬
? sp. A	▬						
Rissoina (*Schwartziella*) *gracilis* (Pease)					▬	▬	▬
(*Schwartziella*) aff. *R. flexuosa* Gould	▬ ?	▬	▬	▬	▬	▬	▬
aff. *R. indrai* Beets		▬	▬ ?				
mejilana Ladd, n. sp.		▬					
jirikana Ladd, n. sp.	▬						
rilebana Ladd, n. sp.			▬				
(*Zebinella*) *emnanana* Ladd, n. sp.		▬	▬				
(*Zebinella*) *tenuistriata* Pease		▬	▬	▬	▬	▬	▬
aff. *R. supracostata* Garrett		▬					
(*Phosinella*) *clathrata* A. Adams		▬	▬	▬	▬	▬	▬
(*Phosinella*) *briggsi* Ladd, n. sp.			▬				
balteata Pease	▬	▬	▬	▬	▬	▬	▬
bikiniensis Ladd, n. sp.	▬	▬	▬				
transenna Watson		▬	▬	▬	▬	▬	▬
alexisi Ladd, n. sp.	▬	▬					
(*Rissoina*) *abbotti* Ladd, n. sp.		▬	▬				
(*Rissoina*) *mijana* Ladd, n. sp.		▬					
ailinana Ladd, n. sp.	▬						
lomaloana Ladd, n. sp.		▬	▬				
goikulensis Ladd, n. sp.			▬				
waluensis Ladd, n. sp.		▬					
ekkanana Ladd, n. sp.						▬	
ambigua Gould						▬	▬
ambigua parryensis Ladd, n. subsp.			▬				
concinna A. Adams	▬	▬	▬				▬
sp. A		▬					
(*Rissolina*) *turricula* Pease	▬ ?	▬		▬		▬	▬
(*Rissolina*) *marshallensis* Ladd, n. sp.	▬	▬	▬				
ephamilla Watson		▬	▬	▬	▬	▬	▬
kickarayana Ladd, n. sp.			▬				
herringi Ladd, n. sp.			▬				
harti Ladd, n. sp.	▬						
bourneae Ladd, n. sp.		▬					
plicata A. Adams		▬					▬
sp. B		▬					
Barleeia (*Barleeia*) *meiauhana* Ladd, n. sp.			▬				
Assimineidae:							
Assiminea nitida eniwetokensis Ladd, n. subsp.	▬		▬				
Adeorbidae:							
Haplocochlias sp. A			▬				
Leucorhynchia caledonica Crosse						▬	▬
crossei Tryon						▬	▬
? *stephensoni* Ladd, n. sp.							
? *lilli* Ladd, n. sp.	▬						
Lophocochlias minutissimus (Pilsbry)	▬	▬	▬	▬	▬	▬	▬
paucicarinatus Ladd, n. sp.	▬						
Munditiella qualum (Hedley)					▬		▬
parryensis Ladd, n. sp.			▬			▬	
Teinostoma (*Esmeralda*) *engebiense* Ladd, n. sp.						▬	▬
(*Esmeralda*) *marshallense* Ladd, n. sp.	▬	▬					
sp. A		▬					
Solariorbis tricarinata (Melvill and Standen)		▬	▬	▬	▬	▬	▬
? sp.		▬					
Lydiphnis eniwetokense Ladd, n. sp.		▬	▬	▬			

TABLE 5.—*Geologic distribution of species*—Continued

Species	Tertiary				Quaternary		
	e	*f*	*g*	*h*			
	Lower Miocene	Miocene	Upper Miocene	Pliocene	Pleistocene	Recent	Living
Cyclostremiscus emeryi Ladd, n. sp.	▬	▬	▬				▬
(*Ponocyclus*) *novemcarinatus* (Melvill)		▬					▬
(*Ponocyclus*) *cingulifera* (A. Adams)			▬				▬
Cochliolepis diangalana Ladd, n. sp.			▬				
Vitrinella sp. A	▬						▬

included in the present study, but geological evidence suggests that the group may have been in existence since Cretaceous time (Ladd, 1961, p. 714-715; Menard and Hamilton, 1963, p. 203; Durham, 1963 p. 358). In this connection it should be noted that shallow-water mollusks, perhaps of Miocene age, recently have been dredged from a depth of 500–520 meters off the island of Oahu in Hawaii (Menard and others, 1962). The present study offers no decisive evidence on the important questions of origin and migration, but the past and present distribution patterns of some of the mollusks provide evidence, as shown below.

Many mollusks that live today in the island area have been there since late Tertiary time. A total of 33 such species are listed in table 6. Twenty five of these were recovered from deep drill holes in the Marshall Islands and 11 from outcrops in Fiji. Table 6 also shows the distribution of a few Indo-Pacific species that no longer live in the island area though they were there during the Tertiary. The island-area species that now live in Indonesia and the Indian Ocean are more numerous than those that now live in the Ryukyu Islands and Japan.

Not listed in table 6 are numerous living Indo-Pacific species that had close relatives, some of which perhaps were ancestral, in the island area during the late Tertiary. Such relationships are noted in the discussions of individual species in the systematic section. Several of these may be significant. The presence in the upper Miocene of Bikini of a species of the neritid *Pisulina,* which has a characteristically large median tooth, extends the range of that genus geographically as well as geologically. *Pisulina* has been known previously only from a few species living near India and Ceylon. An even greater geographic gap separates the single lower Miocene *Cynisca* of Eniwetok from a half dozen Recent species, all of which live today at the extreme western end of the Indo-Pacific, off the Cape of Good Hope, South Africa.

The reef chiton *Schizochiton,* which has extraordinary large eyes, is another genus not previously reported as a fossil. Representatives lived on Eniwetok during the Miocene (Tertiary *e* and *g*) and in Palau (Tertiary g). The genus lives today in the Philippines, Shouten Islands, and northern Australia. On the basis of available information, it can be regarded as a genus that started in the island area and migrated to the southwest where it has persisted.

Evidence of the type given above is suggestive but certainly not conclusive. If more were known about the Tertiary of Indonesia, India, and South Africa, it might be discovered that the genera cited were living in those places as well as in the island area during the Miocene.

Suggestive evidence of another sort is found in the occurrence of *Haplocochlias* in the upper Miocene of Eniwetok. This genus, not previously reported as fossil, is known only from the waters off Baja California, from the southern tip of the peninsula to Bahía Magdalena 175 miles to the northwest. An eastward migration from the Marshalls to the west coast of North America is difficult to explain even with the help of the Equatorial Counter Current. Two species of *Arene* have also been found in the Miocene of Bikini. This group is West Indian where it has been represented from the Miocene to Recent. More information is needed on the geological and geographical distribution of the rare genera *Haplocochlias* and *Arene.*

Some ties between the island-area fossil faunas and those described from the upper Tertiary of Indonesia have been recognized. *Thalotia berauensis* described by Beets (1941, p. 13) from the upper Miocene of East Borneo occurs in the lower Miocene (Tertiary *f*) of Eniwetok. The lower Miocene Topochau Limestone of

TABLE 6.—*Living Indo-Pacific mollusks that also occur in upper Tertiary sediments of island area*

Species	Living				Upper Tertiary				
	Indian Ocean	Indonesia and northern Australia	Ryukyu and Japan	Island area	Palau	New Hebrides	Fiji	Mariana Islands	Marshall Islands
Scissurella (Scissurella) declinans Watson		×		×					×
Rimula exquisita A. Adams		×	×	×					×
Euchelus (Herpetopoma) instrictus (Gould)			×	×					×
(Vaceuchelus) angulatus Pease	×	×		×			×		
Turcica (Perrinia) morrisoni Ladd, n. sp				×					×
Fossarina (Minopa) hoffmeisteri Ladd, n. sp				×					×
Trochus (Trochus) maculatus Linnaeus	×	×	×	×				×	
(Trochus) histrio (Reeve)		×	×	×			×		
Isanda (Parminolia) apicina (Gould)				×					×
Pseudostomatella (Pseudostomatella) maculata (Quoy & Gaimard)		×		×			×		
Synaptocochlea rosacea (Pease)				×					×
Angaria delphinus (Linnaeus)	×	×	×				×	×?	
Liotina (Dentarene) cyclοma Tomlin			×						×
Turbo (Turbo) petholatus Linnaeus	×	×	×	×			×	×	
(Marmarostoma) chrysostomus Linnaeus			×	×				×?	
(Marmarostoma) argyrostomus Linnaeus	×	×	×	×				×?	
Leptothyra maculosa (Pease)				×			×		×
balnearii Pilsbry				×					×
glareosa marshallensis Ladd, n. sp				×					×
Neritopsis (Neritopsis) radula Linnaeus	×	×	×	×	×		×	×	×
Nerita (Amphinerita) insculpta Récluz		×	×	×					×
Clithon (Clithon) corona (Linnaeus)	×			×			×		
Merelina (Merelina) pisinna (Melvill and Standen)				×					×
Zebina (Cibdezebina) metaltilana Ladd, n. sp				×					×
(Ailinzebina) abrardi Ladd, n. sp				×					×
Rissoina (Zebinella) tenuistriata Pease				×					×
(Phosinella) clathrata A. Adams	×	×		×		×	×		
balteata Pease				×					×
transenna Watson				×					×
(Rissolina) turricula Pease	×			×			×		×
ephamilla Watson				×					×
plicata A. Adams	×			×					×
Lophocochlias minutissimus (Pilsbry)				×			×		×
Solariorbis tricarinata (Melvill and Standen)				×					×
Cyclostremiscus (Ponocyclus) novemcarinatus (Melvill)	×			×					×
(Ponocyclus) cingulifera (A. Adams)		×	×		×				
Total	11	13	12	33	2	1	11	6	25

Saipan yielded a poorly preserved *Thalotia* referred to the subgenus *Beraua*, which was established by Beets (1941, p. 14) for *T. erinaceus* from the same Borneo beds. The Saipan shell closely resembles Beets' type species. The Borneo beds and the lower Miocene of Eniwetok also have in common the Recent species *Cyclostremiscus novemcarinatus* (Melvill), and an Eniwetok lower Miocene rissoid seems closely related to Beets' *Rissoina indrai*. A chiton described by Beets as *Cryptoplax menkrawitensis* has a close relative in the Miocene of Fiji.

The neritid described by Martin from the lower Miocene of Java as *Neritina jogjacartensis* is a *Smaragdia* that occurs throughout the Miocene under Eniwetok and in the upper Miocene of Palau. Another of Martin's lower Miocene Java species, *Tectus bomasensis*, may be identical with a species from the Miocene of Fiji. Several still-living species are common to the upper Tertiary of the island area and Indonesia.

SYSTEMATIC PALEONTOLOGY

The systematic order followed is, in general, that used in "Indo-Pacific Mollusca" under the editorship of R. T. Abbott (1959); this arrangement, in turn, is based on Thiele (1929–31) and Wenz (1938–44). An exception is made for the chitons. They are considered before the gastropods rather than after them, and the systematic order given in the "Treatise on Invertebrate Paleontology" is followed (Smith, 1960).

Drill-hole specimens taken from cores are so identified; all other drill-hole specimens were picked from cuttings.

Depths of many cuttings samples have been rounded to the nearest foot.

The following new subgenera are proposed:

Vitiastraea, subgenus of *Astraea*, Turbinidae.
Type: *Tectarius rehderi* Ladd, n. sp.
Suva Formation, lower Miocene (Tertiary *f*), Fiji, page 45. Gender feminine.

Subditotectarius, subgenus of *Tectarius*, Littorinidae.
Type: *Tectarius rehderi* Ladd, n. sp.
lower Miocene (Tertiary *f*), Bikini, Marshall Islands, page 59. Gender masculine.

Ailinzebina, subgenus of *Zebina*, Rissoidae.
Type: *Zebina abrardi* Ladd, n. sp.
Recent. Bikini, Marshall Islands, page 65. Gender feminine.

One-third of the 75 new species and subspecies described are represented by only 1 or 2 specimens. Of these 25 poorly represented forms, 2 are from Palau, 2 from Fiji, and the balance from drill holes in the Marshall Islands. Future collecting in Palau and Fiji may yield additional specimens of rare species, but there is little prospect of additional drilling in the Marshall Islands. The rare Marshall Island species can be looked for, however, when reef drilling is undertaken in Hawaii or another part of Polynesia.

CHITONS

Most chitons are rock clingers and are found most abundantly on rocky shores. They are not limited to such shores, however; even along beach coasts they may find some sort of hard surface—such as the shell of a dead oyster—to which they may adhere.

As a group, the chitons of the existing seas are particularly abundant in the Australian region where some 200 species have been identified. In that area also, fossil forms have been described from upper Tertiary and Pleistocene beds.

Many reef-encircled islands in the Pacific offer favorable niches for chitons. Chitons may be particularly abundant in the nips that are developed at high-tide level along most limestone coasts, and they may also be found on blocks of reef rock on reef flats. Coral itself is not a choice base because most chitons feed on vegetation. Hull (1925, p. 12), in working on the Great Barrier Reef, found that only carnivorous species of *Cryptoplax*, *Schizochiton*, and some species of *Acanthochitona* are to be expected on living coral. Some of these chitons are specialized forms adapted to living in holes or crevices in coral. Only a single specimen of one of the three genera mentioned by Hull was collected from the Recent fauna in the Marshall Islands during the investigations of 1945–46 (a *Cryptoplax* found between tide levels on Eniwetok), but representatives of all three genera were recovered from the Tertiary sections drilled in the Marshall Islands. In addition, a *Cryptoplax* was collected from the Miocene reef and reef-flat deposits in Fiji and Palau; the Palau deposits also yielded *Schizochiton*.

No fossil chitons were obtained in the Mariana or the New Hebrides Islands, and only a single undetermined valve has come from Tonga. The Marshall Island drill holes and the marly upper Tertiary deposits of Palau and Fiji yielded the most specimens. In addition to the described material, a total of 26 undetermined specimens were obtained in the island area.

Order NEOLORICATA
Family SCHIZOCHITONIDAE

Genus SCHIZOCHITON Gray

Gray, 1847, Zool. Soc. London Proc., p. 65, 68, 169.

Type (by monotypy): *Chiton incisus* Sowerby. Philippines, Torres Straits, northeast Australia.

Schizochiton includes elongate chitons characterized by a deep fissure in the tail valve and by the development of lines of prominent ocelli on all valves. On reefs they live in protected spots, under blocks, or in crevices in dead coral.

Schizochiton incisus goikulensis Ladd, n. subsp.

Plate 1, figures 1–3

Tail valve large, thick; dorsal ridge flattened, lateral pleural areas gently concave, lateral posterior areas tricostate; entire surface covered by strong slightly flattened ribs that are distinctly narrower than the flattened areas between; ribs tend to parallel anterior margin of lateral pleural areas but follow a zigzag course, best developed on the left side; 22 ribs on right side, 21 on left. Lateral-posterior areas less strongly ribbed than lateral pleural areas, those of the left side more irregularly angled than those on the right; 15 ribs are distinguishable on right side, 19 on left; large eyepits present where ribs meet diagonal costae of lateral-pleural areas. Deeply excavated caudal sinus with pustulose surface leads to prominent mucro; on sides of sinus the pustules are roughly alined in rows. Interior of valve smooth near center, irregularly ridged at sides; sinus broadly V-shaped with low rounded projections into apex of V; sutural plates broad and regular; posterior insertion plates cut by three prominent slits on each side; teeth stout, distinctly crenulated outside.

Measurements of valve (holotype), USNM 648208: length 10.0 mm, width 9.6 mm, convexity 4.5 mm.

The above description is based on a single well-preserved specimen. It has been compared with specimens of the Recent *S. incisus* Sowerby (Sowerby, 1841, p. 61;

Pilsbry, 1892, p. 235–236, pl. 51, figs. 1–8) from the nearby Philippines and Schouten Islands. The fossil is larger and has a greater number of ribs and an unusually well developed pustulose surface in the caudal sinus.

Occurrence: Marl facies at base of the Miocene (Tertiary *g*) Palau Limestone (USGS 21301), near village of Goikul, Babelthuap, Palau.

Schizochiton marshallensis Ladd, n. sp.

Plate 1, figures 4–9

Head valve with six prominent lines of close-set ocelli; each of two outermost rows having about 20 pits each, the inner four rows with about 30 each; surface between rows marked by close-set zigzag ridges separated by grooves of about the same width. In the single worn specimen, the ridges form a series of chevrons between each two rows of ocelli, the angle formed by the ridges, pointing forward.

Intermediate valves beaked, lateral areas narrow and slightly elevated, separated from central area by a strong diagonal bearing a dozen or more ocelli; surface of entire valve crossed by flattened more or less zigzag ridges that on most specimens are much narrower than the spaces separating them; dorsal ridge broadly rounded having flattened longitudinal ridges that meet with the ridges of the central area to enclose irregular and diamond-shaped depressions. On valves believed to represent second valves, the flattened ridges of the central area extend only one-third to one-half way to the main dorsal ridge before meeting a series of longitudinal ridges to form a diamondback pattern; insertion plates with single slit.

Tail valve large, thick; dorsal ridge rounded; lateral pleural areas concave; lateral posterior areas with 4 prominent ocelli-bearing costae on the right side and 4 or 5 on left; insertion plates with 4 prominent slits on each side; sculpture similar to that of other valves; flattened ribs on lateral pleural areas range from 14 to 20; surface of caudal sinus rough with traces of chevron-shaped ridge pattern pointing toward mucro.

Measurements of the types (in mm):

	Length	*Width*	*Convexity*
Holotype (a tail valve, E-1, Eniwetok, 870–880 ft), USNM 648209	8.2	7.8	4.6
Paratype A (a head valve, F-1, Eniwetok, 740–750 ft), USNM 648210	5.5	5.7	3.0
Paratype B (a second valve, F-1, Eniwetok, 750–760 ft), USNM 648211	7.2	6.4	3.9
Paratype C (a second valve, 2A, Bikini, 1,030–1,034 ft) USNM 648212	[1]3.1	—	—
Paratype D (an intermediate valve, E-1, Eniwetok, 830–840 ft), USNM 648213	4.1	4.0	1.4
Paratype E (an intermediate valve, 2A, Bikini, 893–899 ft), USNM 648214	[1]3.3	—	—

[1] Incomplete.

S. marshallensis differs from the Recent *S. incisus* Sowerby and the new subspecies *S. incisus goikulensis* by having four or five posterior ridges on each side of the posterior valve. *S. incisus goikulensis* does not show the chevron-shaped ridge pattern in the caudal sinus exhibited by *S. marshallensis* and by some specimens of *S. incisus*. The Recent *S. polyps* Iredale and Hull has a jugum that is smooth or nearly so.

Occurrence: Nineteen separate valves, believed to represent a single species, were recovered from cuttings from the three deep holes on Eniwetok and one of the deep holes on Bikini. The youngest specimen, from a depth of 660–670 feet, is in beds assigned to Tertiary *g*, and the oldest, from a depth of 2,610–2,620 feet, is in beds referred to Tertiary *e*. The valves are rare, and only twice were two specimens found in a single sample. The stout tail valves show the most diagnostic features, and a total of seven such valves were recovered; one of these, from a depth of 870–880 feet in drill hole E–1 on Eniwetok, is the holotype. Only one head valve was found, paratype A, depth 740–750 feet in hole F–1 on Eniwetok. The remaining 11 specimens are intermediate valves, 3 being No. 2 valves showing the jugum.

Genus LORICELLA Pilsbry

Pilsbry, 1892, Manual Conchology, v. 14, p. 288.

Type (by monotypy): *Lorica angasi* H. Adams (in Adams, H., and Angas, G. F., 1864, Zool. Soc. London Proc., p. 193). Recent, Australia.

Loricella sp. A

Plate 1, figures 10–12

Head valve broadly arched, nearly twice as wide as long; insertion plate narrow, pectinate, cut by 10 slits. Upper surface of valve smooth near median apex; remainder of surface with 13 radial rows of beads; the beads elongated parallel to anterior margin of valve; beads in row next to posterior margin on each side rise from a moderately strong rib. Measurements of the figured head valve (F–1, 55–60 ft), USNM 648215: length 1.6 mm, width 2.8 mm, convexity 1.1 mm.

Intermediate valve highly arched and slightly beaked; jugum smooth; remainder of valve crossed by 14 ribs on

each side, the 3 ribs nearest the jugum being smaller than the others; lateral areas each with 4 diagonal ribs, the anterior and posterior ones larger than the others and bearing obscure ocelli on the beads formed by the crossing of the vertical ribs. On the single fossil available, the insertion plates are not preserved. Measurements of the figured intermediate valve (E–1, 35–40 ft), USNM 648216: length (minus insertion plates) 2.0 mm, width 3.6 mm, convexity 1.5 mm.

The fossils do not appear to be closely related to described species, but they may be immature and a specific name is withheld. The species may be still living in the Marshall Islands, though no specimens have yet been collected. The genus is widely known from the Australia-Indonesia area but appears not to have been previously reported from the islands of the open Pacific.

Occurrence: One head valve and one intermediate valve from drill hole E–1 on Eniwetok Atoll at depth of 35–40 feet and one head valve from F–1 at depth of 55–60 feet; age, Recent.

Family CHITONIDAE

Genus LUCILINA Dall

Dall, 1882, U.S. Natl. Mus. Proc., 4, p. 284, 287, (= *Lucia* Gould, 1862, Boston Soc. Nat. History Proc., v. 8, p. 283; [not] Swainson, 1833).

Type (by monotypy): *Chiton confossus* Gould. Recent, Fiji.

Lucilina russelli Ladd, n. sp.

Plate 1, figures 13–15

Tail valve small, moderately arched, thick; mucro prominent, lying directly above the posterior edge of the valve; profile below and above mucro gently convex; sinus wide, its flat bottom pectinated; anterior insertion plates broadly rounded, their outer edges pectinated above; posterior insertion plates short, thick, inclined forward, strongly grooved outside and cut by numerous (about 16) slits. In front of a broad ridge extending from the mucro to the anterior corners, the surface bears numerous slightly curved vertical riblets; surface posterior to ridge microscopically punctate with scattered larger pits that represent ocelli; obscure elevated horizontal lines cross the post mucral area.

Measurements of the holotype (only specimen), USNM 648217: length 4.1 mm, width 6.2 mm, convexity 2.7 mm.

The Eniwetok fossil is very closely related to the Recent *L. confossus* (Gould) (USNM 30763), but the Recent shell does not show the vertical riblets on the anterior part of the valve that are so well developed on the fossil; the Recent shell likewise has a stronger ridge from mucro to the anterior corners.

Occurrence: Drill hole K1–B on Eniwetok Atoll at a depth of 537–548 feet; age, probably Pliocene.

Lucilina sp. A

Plate 1, figure 16

Tail valve small, gently arched, moderately thick; mucro about one-third the length from the posterior margin; area behind broadly convex, surface in front nearly flat; bottom of sinus pectinated; posterior insertion plates short, inclined forward, strongly grooved outside, and cut by numerous slits. A narrow and prominent ridge extends from the mucro to the anterior corners; ahead of the ridge the jugum is smooth, but the remainder of the central area bears an irregular series of pitted grooves that are best developed near the anterior margin; low elevated lines cross the entire central area parallel to the anterior margin of the valve. Posterior to the mucro the surface is smooth except for scattered ocelli and obscure elevated lines that parallel the posterior margin.

Measurements of the figured specimen, USNM 648219: length (insertion plates missing) 2.1 mm, width 3.9 mm, convexity 1.2 mm.

This species superficially resembles *L. confossus* (Gould), but its well-developed pitted grooves are not found on the Recent shell. *Lucilina* sp. A differs from *L. russelli* in having more widely spaced vertical grooves and a more prominent ridge from mucro to the anterior corners. The single specimen is incomplete, and a specific name is withheld.

Occurrence: Marl facies at base of the Palau Limestone (USGS 21304), near village of Goikul, Babelthuap, Palau; age, late Miocene (Tertiary *g*).

Lucilina sp. B

Plate 1, figure 17

Tail valve medium in size, moderately arched, thick; mucro prominent, situated almost directly above posterior margin; surface below mucro slightly concave; sinus broad, flat-bottomed, and pectinate; anterior insertion plates wide and flat; insertion plates along the posterior and lateral margins thick, strongly grooved externally, and cut by numerous shallow slits. Surface of valve eroded but showing traces of close-set riblets that diverge from a broad ridge that extends from the mucro to the anterior corners of the valve.

Measurements of the figured specimen (Fiji sta. 110B), USNM 648218: length 6.5 mm, width 10.3 mm, convexity 4.0 mm.

On a poorly preserved intermediate valve from the same locality, a low, narrow ridge separates the pleural areas from the central area; traces of fine vertical riblets are preserved on the jugum and a fanlike pattern of

similar lines is discernible on the rest of the central area. The valve measures 19.2 mm in width.

The illustrated Fijian fossil resembles the Recent *L. confossus* described by Gould from Fiji but has a lower mucro and the vertical riblets of the central area that are well developed on the fossil are not present on the Recent shell.

Occurrence: In the Ndalithoni Limestone; age, probably Pliocene (Tertiary *h*); Vanua Mbalavu, Fiji (sta. 110B). Two similar but more coarsely ribbed tail valves from the Miocene Suva Formation; age, Tertiary *f;* Viti Levu, Fiji (sta. FB20), and from drill hole F–1 on Eniwetok at a depth of 320–330 feet (Tertiary *h* or Pleistocene) are questionably referred to this species.

Lucilina sp.

Plate 1, figures 18, 19

Intermediate valve minute, width greatly exceeding length, moderately arched; beak and dorsal area smoothly rounded; lateral areas divided on each side by a nodose ridge extending from near the beak to about the midpoint of the lateral margin of valve; on posterior side of ridge there is a prominent row of eye spots (eight on each side in figured specimen); lateral area crossed by rounded longitudinal ridges that are better developed on anterior side of diagonal eye-bearing ridge. Insertion plates short, pectinated, each with a single slit at side; insertion plates separated by a shallow denticulated sinus.

Measurements of the figured specimen (MCZ 28020): length 0.9 mm, width 3.0 mm, convexity 0.6 mm.

Represented by two intermediate valves, both obtained from the same small sample. The specimens may be immature. They seem similar in general features to *L. picta* (Reeve), a Recent species from the Torres Straits, but I have not seen specimens.

Occurrence: Cuttings from a drill hole on Funafuti Atoll at depth of 70 feet; age, Recent.

Family ACANTHOCHITONIDAE

Genus ACANTHOCHITONA Gray

Gray, 1821, Nat. Arrangement Mollusca, London Med. Repository, v. 15, p. 234.

Type (by monotypy): *Chiton fascicularis* Linnaeus. Recent, Mediterranean.

Acanthochitona sp.

Plate 1, figures 20, 21

Intermediate valve thin, highly arched; exposed part of valve semicircular in outline, lateral areas densely pustulose, the pustules in indistinct radial lines; dorsal area narrowly triangular with traces of longitudinal grooves; beak inconspicuous; insertion plates wide, each with a single slit near posterior edge.

Measurements of the figured specimen (E–1, Eniwetok, 770–780 ft), USNM 648220: length 1.1 mm, width 2.5 mm, convexity 0.8 mm.

Occurrence: Two slightly worn specimens from drill hole E–1 on Eniwetok Atoll, depth 560–780 feet; a similar intermediate valve was recovered from drill hole 2B on Bikini at depth of 873–884 feet; the figured specimen and the Bikini specimen are from beds referred to late Miocene (Tertiary *g*). The younger Eniwetok specimen (560–570 ft) may be Pliocene.

Genus CRYPTOPLAX Blainville

Blainville, 1818, Dictionnaire Sci. Nat., v. 12, p. 124.

Type (by subsequent designation, Herrmannsen 1852, Indicis Generum Malacozoorum Primordia, supp., Cassellis, p. 39): *Chiton larvae-formis* Burrow, Recent, southwest Pacific islands.

A group of vermiform chitons with well-developed fleshy girdles; adapted to living in burrows and other holes in coral or other rock. J. P. E. Morrison collected numerous specimens beneath pieces of coral rubble on the barrier reef off Noumea in New Caledonia. He noted that the chitons were completely light fugitive (J. P. E. Morrison, oral commun., 1961). Insertion plates are extended forward; head valve with three slits; others unslit. Though specialized, species in the same advanced state have been described from the Tertiary of Australia and Indonesia, and the occurrence of representatives in the Miocene of the Marshall Islands and Fiji is not unexpected.

Cryptoplax cf. C. menkrawitensis Beets

Plate 1, figure 22

Three incomplete intermediate valves and a tail valve from the Miocene (Tertiary *f*) Suva Formation of station 160, Viti Levu, Fiji, bear the pustulose sculpture of *C. menkrawitensis* Beets (1941, p. 8–9, pl. 1, 1–3; 1942, p. 242, pl. 26, 4–6) from the upper Miocene of East Borneo.

Measurements of the figured Fijian specimen, an intermediate valve, USNM 648221: length (incomplete) 1.7 mm.

The tail valve from Fiji is proportionately longer and more highly arched longitudinally than that of *Cryptoplax* sp. A from Bikini (below); in the Fijian specimen the continuous insertion plate is extended slightly forward.

Cryptoplax sp. A

Plate 1, figures 23–27

Head valve small, slightly longer than wide, central areas more than a semicircle; apex small; insertion plate

broad, bearing three grooves that end in shallow slits or notches; surface covered by close-set pustules arranged in rows paralleling lateral margins; shallow groove parallels anterior and lateral margins.

Measurements of the figured specimen (pl. 1, figs. 23, 24; E–1, Eniwetok, 750–760 ft), USNM 648222: length 1.4 mm, width 1.2 mm.

Intermediate valves known only from one specimen that is unbroken but shows no trace of surface sculpture. Measurements (pl. 1, fig. 25; 2B, Bikini, 1,891–1,902 ft), USNM 648223: length 2.1 mm, width 1.2 mm.

Tail valve small, slightly longer than wide, mucro rounded, central area wide, bordered on each side by three rows of heavy pustules; insertion plate thick, extending posteriorly beyond the mucro. Measurements of the figured specimen (pl. 1, figs. 26, 27; 2B, Bikini, 1,870–1,881 ft), USNM 648224: length 1.1 mm, width 0.9 mm, convexity 0.4 mm.

The sculpture of the Bikini tail valve is similar to that of the Recent *C. striatus* Lamarck, but in the Recent species the central area is narrower, and the insertion plate is directed forward. The Marshall Island specimens probably represent an undescribed species.

Occurrence: Head valve from drill hole E–1, Eniwetok Atoll, depth 750–760 feet; late Miocene (Tertiary *g*). Intermediate and tail valves from drill hole 2B, Bikini Atoll, at depths of 1,891 ½–1,902, 1,870 ½, and 1,881 feet respectively; in beds referred to early Miocene (Tertiary *e*).

Cryptoplax sp. B

Plate 1, figures 28–30

Two valves of a larger species of *Cryptoplax* were recovered from cuttings in drill hole F–1, Eniwetok Atoll: a tail valve from a depth of 720–730 feet and an intermediate valve from a depth of 800–810 feet, both occurrences in beds referred to Tertiary *g*. Save for the median ridge, all traces of sculpture have been eroded from the valves. A specific determination is not possible, but both valves probably represent the same species. The general shape and proportions of the intermediate valve (USNM 648225; length 7.3 mm, width 3.0 mm, convexity 1.3 mm) are similar to *C. menkrawitensis* Beets from the upper Miocene of Borneo.

Measurements of the tail valve, USNM 648226: length 5.5 mm, width 3.1 mm, convexity 1.6 mm.

The tail valve of *C.* sp. B differs from *C.* sp. A in having the insertion plate projecting forward. A small and badly worn tail valve from drill hole E–1 at a depth of 890–900 feet (Tertiary *e*) may represent *C.* sp. B; a small incomplete head valve from this same horizon is proportionately wider than *C.* sp. A and may represent *C.* sp. B.

Cryptoplax sp.

Four badly worn intermediate valves and one tail valve occurring with *C.* cf. *menkrawitensis* in the Suva Formation at station 160 (early Miocene, Tertiary *f*) on Viti Levu may represent a distinct species. All the valves except one are much longer than wide, and all are marked by strong longitudinal ribs rather than lines of pustules.

GASTROPODS

Family HALIOTIDAE

Genus HALIOTIS Linnaeus

Linnaeus, 1758, Systema naturae, 10th ed., p. 779.

Type (by subsequent designation, Montfort, 1810, Conchyliologie systématique, v. 2, p. 119): *Haliotis asinina* Linnaeus. Recent, Indo-Pacific seas.

Haliotis is widely distributed in the warm and temperate seas of the world today. Species are particularly numerous in the Australian area but are not uncommon in Japan and others areas in the western Pacific and along the west coast of North America. Some species also occur on reefs encircling the islands of the open Pacific.

Cretaceous species have been reported from California (Anderson, 1958, p. 146) and Puerto Rico (N. F. Sohl, oral commun., 1964). Miocene forms have been described from Australia, Japan, Fiji(?), and the west coast of North America and Europe. Most species cling to rocks in shallow waters; fossil occurrences are rare. A total of nine specimens are found in the present collections—six from Guam, two from Fiji, and one from Tinian. All, unfortunately, are preserved as internal molds but appear to be identical with, or closely related to, species known to inhabit reefs in these same areas today. All, with the possible exception of the Fijian occurrences, appear to be post-Miocene in age.

Subgenus PADOLLUS Montfort

Montfort, 1810, Conchyliologie systématique, v. 2, p. 115.

Type (by original designation): *Padollus rubicundus* Montfort, Recent, Indo-Pacific seas.

Haliotis (Padollus) ovina Gmelin

Plate 2, figures 1, 2

Haliotis ovina Gmelin, 1791, Systema naturae 13, p. 3681.
Pilsbry, 1890, Manual Conchology, v. 12, p. 124, pl. 19, figs. 7, 8.

Ovinotis ovina (Gmelin), Cotton, 1943, Royal Soc. South Australia Trans., v. 67, no. 2, p. 179.
Cotton, 1952, Royal Soc. South Australia, Malacological Sect., no. 1, fig. 20.

A medium-sized, elongate-oval, moderately convex species marked by strong radial folds that are clearly reflected on internal molds of the shell. The folds extend more than half way across the last whorl, ending in prominent knobs. A flattened area separates the knobs from a series of elevated perforations that rise from a low keel; below the line of perforations a concave strip extends to a sharp peripheral keel that is marked by spiral threads; columellar plate wide and flat.

Measurements of the figured specimen (Guam, USGS 20489), USNM 648227: length 58.2 mm, width 37.5 mm, height 18 mm.

Represented in the collections by four internal molds, two of which are immature.

Occurrence: Guam, USGS 20489, 20687, 20619, 20602. Age, Mariana Limestone in Reef facies, Detrital facies, and Agana argillaceous member; Pliocene and Pleistocene.

Recent shells have been reported from Australia and many islands in the western Pacific (Philippines, Ryukyu, Fiji, Ellice, Marshalls, Samoa, and others).

Haliotis (Padollus) cf. H. clathrata Reeve

Plate 2, figures 3–5

Three internal molds, two from Guam and one from Tinian, may represent this Recent species described from the Philippines (Reeve, 1846a, p. 57; 1846b, pl. 17, fig. 71) and also known from the Marshall Islands. The following notes are based on the fossils.

A small elongate-oval species with body whorl flattened and spire low. The surface of the body whorl is marked by prominent radial folds that are crossed by numerous waved spiral ribs; the folds terminate at a low-angled carina bearing the molds of large elevated perforations. Below the perforated carina there are strong spiral ribs; the peripheral carina is moderately rounded. The columnar plate is wide and flat.

Measurements of the figured specimen from Guam (USGS 20994), USNM 648228: length 24.8 mm, width 22.2 mm, height 6.6 mm; figured specimen from Tinian (USNM 648229): length 15.9 mm, width 8.9 mm, height about 5 mm.

Localities: Guam, USGS 20994 and 20639 (immature specimen); Tinian, USGS 21611. Collected by Josiah Bridge.

Horizon: Guam occurrences from detrital facies of Mariana Limestone; age, Pliocene and Pleistocene (figured specimen) and Alifan Limestone, (Miocene, Tertiary *g* or *h*); Tinian specimen from limestone terrace at altitude of 120 feet, probably equivalent to Mariana Limestone of Guam.

Haliotis s. l.
Haliotis tuvuthaensis Ladd

Haliotis tuvuthaensis Ladd, 1945, B. P. Bishop Mus. Bull. 181, p. 351, pl. 50, figs. E, F.

The single internal mold on which this species is based does not show the radial folds that characterize *H. ovina* Gmelin but there are two rows of secondary nodes inside the keel that bears the nodular openings.

Occurrence: Island of Tuvuthá in Lau (eastern Fiji) at an altitude of 650 feet. Collected by E. C. Andrews. Probably Futuna Limestone, early Miocene (Tertiary *f*).

Haliotis sp.

Haliotis sp. Ladd, 1945, B. P. Bishop Mus. Bull. 181, p. 351.

A single incomplete internal mold resembling *H. ovina* Gmelin but with a higher spire and a more convex body whorl.

Occurrence: Island of Ngillangilla off coast of Vanua Mbalavu in Lau (eastern Fiji) at an altitude of 10 feet. Collected by E. C. Andrews. Possibly Futuna Limestone, early Miocene (Tertiary *f*).

Family SCISSURELLIDAE

Genus SCISSURELLA d'Orbigny

d'Orbigny, 1824, Soc. Hist. Nat. Paris Mem., 1, p. 341.

Subgenus SCISSURELLA s.s.

Type (by subsequent designation, Gray, 1847, Zool. Soc. London Proc., pt. 15, p. 146): *Scissurella laevigata* d'Orbigny. Recent, Mediterranean Sea.

Scissurella (Scissurella) declinans Watson

Plate 2, figure 6

Scissurella declinans Watson, 1886, *Challenger* Rept., Gastropoda, p. 115, pl. 8, fig. 2.
Pilsbry, 1890, Manual Conchology v. 12, p. 57, pl. 65, figs. 6–8.

Minute, depressed, thin, transparent; upper half of whorl with a strong carina with elevated edges; above the carina the surface of the whorl is flattened, below the carina it is at first concave, then broadly convex; last whorl very large; carina the site of a narrow deep slit extending backward from the aperture; umbilicus wide and deep, funnel shaped, marked by fine lines parallel to inner lip and bordered by a distinct carina; aperture ovate, oblique. Sculpture of last whorl consisting of fine spiral striae and lines of growth; on earlier whorls, stronger oblique axial riblets are present both above and below the carina.

Measurement of the figured specimen, USNM 648230: diameter 1.3 mm, height 0.7 mm.

Occurrence: In drill hole E–1 on Eniwetok Atoll at depth of 30–45 feet, a single well-preserved Recent shell;

in hole 2B on Bikini Atoll at depth of 884–894 feet (figured specimen); late Miocene (Tertiary *g*). Recent examples were recovered from drift on Rongelap and Rongerik in the Marshalls and on Ifaluk Atoll; in the Carolines, D. P. Abbott collected the species alive from algae growing on dead coral of patch reefs on lagoon shelf 75 feet from shore in very shallow water (0–4 ft). The type material was collected by the *Challenger* near Cape York Peninsula, northeast Australia, in coral sand at a depth of 155 fathoms.

Scissurella (Scissurella) coronata Watson

Plate 2, figures 7, 8

Scissurella coronata Watson, 1886, *Challenger* Rept., Gastropoda, p. 114, pl. 8, fig. 4.
Pilsbry, 1890, Manual Conchology, v. 12, p. 56, pl. 65, figs. 11–13.

Very small; spire flattened, thin; upper part of whorl flat, bordered by a strong carina with erect margins; below carina the whorl is slightly concave, then broadly convex; umbilicus moderately wide and deep; aperture large, ovate, oblique. Sculpture consisting of strong, curved axial ribs that are prominently developed on the flat area above the carina and on the convex area below, dying out near the umbilicus; fine spiral threads are present above and below carina.

Measurements of the figured specimen (E–1, Eniwetok, 30–35 ft), USNM 648329: diameter 1.9 mm, height 1.3 mm.

On the three Tongan fossil specimens the spiral sculpture is obscurely preserved, but they seem clearly to represent this strongly ribbed Recent species.

Occurrence: Drill hole E–1, Eniwetok, 30–35 feet; age, Recent. Station 3, sea cliff at Houma, Tongatabu, Tonga (B. P. Bishop Mus., geology No. 1338); from material filling specimens of *Turbo argyrostomus*. Collected by J. M. Ostergaard at an altitude of 35 feet; age, probably Pleistocene. Type material collected in the harbor of Tahiti, Society Islands, near the reefs at a depth of 20 fathoms.

Subgenus ANATOMA Woodward

Woodward, 1859, Zool. Soc. London Proc., p. 204.

Type (by original designation): *Scissurella crispata* Fleming. Recent, North Sea.

Scissurella (Anatoma) equatoria Hedley

Plate 2, figures 9, 10

Scissurella equatoria Hedley, 1899, Australian Mus. Mem. 3, pt. 9, p. 551.

The following description is based on the fossil material:

Minute; spire moderately high, thin; periphery of whorls located near midpoint and bears a strong carina leading to a slit whose edges are slightly reflected outward; above, carina whorls are gently convex; immediately below carina is a concave zone below which the remainder of the base is tumid; aperture subquadrate, oblique; inner lip slightly reflected below; umbilicus narrow, partly shielded by inner lip. Sculpture consisting of minute close-set curved lines of growth that are more distinct above the carina than below it; spiral threads obscure.

Measurements of the figured specimen, MCZ 28021: diameter 0.8 mm, height 0.6 mm.

Occurrence: Two specimens in cuttings from a drill hole on Funafuti Atoll, at a depth of 65 feet; nine specimens from drill hole E–1, Eniwetok Atoll, at depths of 20–40 feet; occurrences at both places probably Recent. The single type described by Hedley was dredged from a depth of 200 fathoms off Funafuti.

Hedley recognized that *S. equatoria* is closely related to *S. aedonia* Watson, a Recent species obtained by the *Challenger* near Tristan da Cunha in the South Atlantic at depths of 100–150 fathoms. Hedley noted that *S. equatoria* was the largest species of the genus (major diameter 3.0 mm) and that it also differed from *S. aedonia* in having a contracted zone beneath the carina and a lesser development of spiral sculpture. Some of the fossil specimens appear to be adults; they are much smaller than the type, but the fossils show the other diagnostic features mentioned by Hedley.

Family FISSURELLIDAE

Genus EMARGINULA Lamarck

Lamarck, 1801, Systéme des Animaux sans Vertèbres, p. 69.

Subgenus EMARGINULA s.s.

Type (by monotypy): *Emarginula conica Lamarck* (=*Patella fissura* Linnaeus). Recent, European seas.

Emarginula (Emarginula) bicancellata Montrouzier

Plate 2, figures 11, 12

Emarginula bicancellata Montrouzier, 1860, Jour. conchyliologie, v. 8, p. 112, pl. 2, fig. 9.
Pilsbry, 1890, Manual Conchology, v. 12, p. 256, pl. 64, fig. 42.

Small, solid, oval, highly convex; apex narrow, fairly sharp, back slope below apex flattened. Slit narrow, open for about one-third its length; closed section crossed at fairly regular intervals by erect lamellae. Sculpture consisting of about 30 radial ribs, alternately larger and smaller, that are crossed by less prominent concentric ribs to give the shell a latticed appearance.

Measurements of the figured specimen (British Mus. 1964, 23): length (incomplete) 3.0 mm, width 2.3 mm, height 2.5 mm.

Occurrence: A single specimen from the first boring on Funafuti Atoll in the Ellice Islands, depth 65–74 feet; two other specimens from drill holes F–1 and E–1, Eniwetok Atoll, at depths of 55–100 feet; all occurrences probably Recent. Originally described from New Caledonia; also collected in Samoa where it was found under coral blocks and in pieces of dead coral at intertidal levels.

Emarginula (Emarginula) cf. E. peasei (Thiele)

Plate 2, figures 13, 14

Small, elongate-oval, depressed; side margins slightly arched so that shell rests on extremities; apex inconspicuous, located about one-third of the length from the posterior end; slit narrow, less than one-fourth of total length of shell. Sculpture consisting of about 21 strong radial ribs which on the posterior half of the shell alternate with secondary ribs, the total number of ribs being about 31; ribs crossed at fairly regular intervals by concentric lirae that form deep pits between ribs.

Measurements of the figured specimen, USNM 648231: length 3.3 mm, width 2.0 mm, convexity 0.6 mm.

The fossil appears to be most closely related to *E. peasei*, a Recent species originally described from the Pacific islands (Thiele, 1915, p. 87). The single fossil shell is less than half the size of that of the living species and may be immature. Immaturity may explain the absence on the fossil of the finest sculpture exhibited on the primary ribs and in the pits of the living species. The secondary ribs of the fossil have not been noted on the living shell.

Occurrence: In drill hole E–1 on Eniwetok Atoll at a depth of 90–110 feet; age, Recent.

Emarginula (Emarginula) aff. E. clypeus A. Adams

Plate 2, figures 15, 16

Small, broadly oval, narrowed anteriorly, depressed; apex posterior, slightly more than two-thirds of the total length of the shell; anterior slope gently convex, posterior slope flat; shell margin crenulated, moderately arched below; slit narrow, open for one-fifth of its length. Sculpture consisting of about 33 radial ribs, of which about 6—3 on each side—are larger than the others; shell surface latticed by regularly spaced concentric lirae.

Measurements of the figured specimen (F–1, Eniwetok, 60–70 ft), USNM 648232; length 4.3 mm, width 2.9 mm, convexity 1.1 mm.

The Eniwetok fossils are similar to *E. clypeus* A. Adams (1851, p. 83), a Recent species from the Philippines. Pilsbry (1890, p. 265, pl. 28, fig. 7) noted that the species "has some prominent ribs." The fossils are smaller than the examples figured by Thiele (1915, p. 97, pl. 11, figs. 24, 25). I have not seen specimens of *E. clypeus*. The fossils probably represent a distinct species; they may be immature.

Occurrence: Nine specimens from drill holes on Eniwetok Atoll down to depths of 60–70 feet; age, Recent.

Subgenus SUBZEIDORA Iredale

Iredale, 1924, Linnean Soc. New South Wales Proc., v. 49, p. 217.

Type (by original designation): *Emarginula connectens* Thiele. Recent, Kermadec Islands.

Emarginula (Subzeidora) souverbiana Pilsbry

Plate 2, figures 17, 18

Emarginula maculata Souverbie, 1872, Jour. conchyliologie, v. 20, p. 55, pl. 1, fig. 6.

Emarginula souberbiana Pilsbry, 1890, Manual Conchology, v. 12, p. 262, pl. 64, fig. 28.

Small, thin, moderately convex, elongate-oval in outline, slightly narrowed in front; sides arched so that shell rests on extremities; apex posterior, incurved; anterior slope gently convex, posterior slope flat; slit narrow, exceeding one-third total length of shell; margin of shell finely crenulated; nacreous within. Sculpture consisting of 24 primary radial ribs, alternating with an equal number of secondary ribs; surface cancellated by close-set concentric lirae.

Measurements of the figured specimen (E–1, Eniwetok, 10–20 ft), USNM 648233: length 3.0 mm, width 1.9 mm, convexity 0.9 mm.

The two fossil specimens referred to *E. souverbiana* are small and may be immature; they are proportionately flatter than the typical Recent shells.

Occurrence: Drill hole E–1, Eniwetok Atoll at a depth of 10–20 and 30–35 feet; age, Recent. The Recent types were collected in New Caledonia.

Emarginula (Subzeidora) sp. A

Plate 2, figures 19, 20

Minute, broadly oval, highly arched forward from posterior; incurved apex, profile beneath apex gently convex; split open for about one-third of total length. Sculpture consisting of about 20 strong radial ribs beaded by concentric lirae. Internally the platform beneath the apex is inconspicuous.

Measurements of the figured specimen, USNM 648234: length 2.1 mm, width 0.9 mm, convexity 0.6 mm.

The single fossil appears close to, and may be identical with, the Recent type species *E. connectens* Thiele from the Kermadecs, but it is even smaller than that species and may be immature. Adequate figures of the

type species are not available, and I have not seen specimens. *E.* sp. A also appears to be closely related to *E. sublathrata* Pilsbry from Hawaii, but the fossil is narrower and more inflated posteriorly than is the Recent shell.

Occurrence: Drill hole 2B, Bikini Atoll at a depth of 1,807–1,819 feet; early Miocene (Tertiary *e*).

Emarginula (Subzeidora) sp. B

Plate 2, figures 21, 22

Minute, highly arched, laterally compressed; outline from below subrectangular; apex posterior, strongly incurved, anterior slope gently convex; posterior slope flattened below apex; slit long and narrow, open for more than one-third of total length. Sculpture consisting of about 20 strong primary radial ribs alternating with an equal number of finer secondary ribs; close-set concentric lirae over entire shell give a cancellated appearance; the more prominent lirae forming beads where they cross primary ribs. Anterior part of shell, below a line extending from upper end of slit to margin on each side at points below the apex, colored dark green; a small spot of green crosses selenizone a short distance above slit; remainder of shell white and translucent.

Measurements of the figured specimen, USNM 648235: length 2.2 mm, width 1.4 mm, convexity 1.0 mm.

The single fossil specimen appears to be much more compressed laterally than other described species. The fossil may represent an unnamed species, but it could be an unusual or immature specimen. A name is withheld pending the recovery of additional material.

Occurrence: Drill hole F–1 on Eniwetok Atoll at a depth of 20–45 feet; age, Recent.

Genus HEMITOMA Swainson

Swainson, 1840, Treatise on malacology, p. 356.

Subgenus HEMITOMA s.s.

Type (by monotypy): *Patella tricostata* Sowerby (=*Patella octoradiata* Gmelin). Recent, West Indies

Hemitoma (Hemitoma) sp.

Plate 2, figure 23

Large, low, ovate in outline; posterior slope flat; selenizone inconspicuous; slit a shallow marginal indentation. Sculpture consisting of about a dozen rather regularly spaced broad but sharp-crested ribs that cause crenulation on the margin of the shell; two or more secondary ribs lie between each two primary ribs; all ribs made slightly scaly by irregular concentric lirae.

Measurements of the figured specimen, USNM 648449: length 28.8 mm, width 22.6 mm.

The single Fijian fossil, seated upon a worn coral pebble, is incomplete, the apical area being worn away. It is larger, less convex, and less regularly ribbed than *H. ossea* (Gould), a Recent species known only from Fiji.

Occurrence: In the Ndalithoni Limestone; age, probably Pliocene (Tertiary *h*); Vanua Mbalavu, Fiji (sta. 110B).

Subgenus MONTFORTIA Recluz

Recluz, 1843, I. Travaux inédits catalogue descriptif de plusicurs nouvelles espèces de coquilles des mers de la France, p. 259.

Type (by subsequent designation, Iredale, 1915, New Zealand Inst. Trans. and Proc., v. 47, p. 435): *Emarginula australis* Quoy and Gaimard. Recent, Australia.

Hemitoma (Montfortia) bikiniensis Ladd, n. sp.

Plate 2, figures 24, 25

Small, moderately arched, broadly ovate in outline; anterior slope convex, posterior slope concave immediately below apex; anterior slit broad and short; internal groove distinct. Sculpture consisting of about a dozen large rounded radial ribs, between each two of which lie one to three small rounded ribs; concentric lirae form low nodes that are particularly prominent on the larger ribs; margin of shell crenulated.

Measurements of the holotype, USNM 648236: length 4.8 mm, width 3.6 mm, convexity 2.0 mm.

H. bikiniensis is smaller than the type species *H. australis*, is less convex, and has more strongly developed concentric structure.

Occurrence: Holotype from drill hole 2 on Bikini Atoll at a depth of 105 feet; a second specimen in hole F–1 on Eniwetok at depth of 45–55 feet; both occurrences probably Recent.

Hemitoma (Montfortia) sp. A

Plate 2, figures 26, 27

Small, depressed, subrectangular in outline, thin; anterior slope gently convex, posterior slope (below apex) flat; apex about two-thirds of length from anterior margin; slit narrow, moderate in length; internal groove shallow. Sculpture consisting of about 20 poorly marked radial ribs of which 4, extending roughly to the corners, are larger than the others; concentric lirae obscurely developed.

Measurements of the figured specimens (E–1 Eniwetok, 35–40 ft), USNM 648237: length 3.0 mm, width 2.1 mm, convexity 1.2 mm.

The fossils may be related to *H. ossea* (Gould), a Recent species collected in Fiji. *H. ossea,* however, is a larger, heavier, and more coarsely marked shell whose apex is more centrally located. The type and only speci-

men of *H. ossea* is worn, and detailed comparisons are not possible.

Occurrence: Represented by a total of 10 specimens, all small and possibly immature, from shallow depths (30–60 ft) in drill holes E–1 and F–1 on Eniwetok Atoll; age, Recent.

Subgenus MONTFORTISTA Iredale

Iredale, 1929, Queensland Mus. Mem., v. 9, p. 267.

Type (by original designation): *Montfortia excentrica* Iredale. Recent, North Queensland.

Hemitoma (Montfortista) excentrica (Iredale)

Plate 2, figures 28, 29

Montfortia (Montfortista) excentrica Iredale, 1929, Queensland Mus. Mem., v. 9, p. 267, pl. 31, figs. 14, 15.

Medium, highly elevated, slightly compressed laterally; anterior slope broadly convex, posterior slope concave. Sculpture consisting of about 20 strong ribs, the anterior rib being strongest; traces of secondary ribs between some of main ribs; strong concentric lirae give the shell a deeply pitted appearance.

Measurements of the figured specimen, USNM 648238: length (incomplete) 9.2 mm, width (incomplete) 6.6 mm, height 7.7 mm.

The single fossil specimen is incomplete, but there appears to be little doubt that it represents *H. excentrica*, a Recent shell from the Queensland coast.

Occurrence: From coral pit (USGS 21029) on Espiritu Santo, New Hebrides, at altitude of 215 feet; age, Pleistocene or Recent.

Genus RIMULA Defrance

Defrance, 1827, Dictionnaire Sci. Nat., v. 45, p. 471.

Type (by subsequent designation, Gray, 1847, Zool. Soc. London Proc., v. 15, p. 147): *Rimula blainvilli* Defrance. Eocene, France.

Rimula closely resembles *Emarginula* but the slit is partly closed, leaving a hole about half way up the anterior slope. This feature first appeared on species that developed during the Lower Cretaceous. Living examples are widely distributed in the warmer parts of the Pacific and the Atlantic. The only fossil representatives of the genus in the Pacific island collections are from the Marshall Islands. A single specimen identified as *R. exquisita* was obtained from beds probably of Pliocene age on Bikini. Three small Recent shells from near the surface on Eniwetok are probably immature. A single somewhat worn shell from a depth of more than 2,000 feet on Eniwetok is Miocene (Tertiary *e*) and appears to represent a second species.

Rimula exquisita A. Adams

Plate 2, figures 30, 31

Rimula exquisita A. Adams, 1851, Zool. Soc. London Proc., 19, p. 226.
Sowerby, 1862, Thesaurus conchyliorum 3, p. 210, figs. 3, 4.
Pilsbry, 1890, Manual Conchology, v. 12, p. 270, pl. 64, figs. 3, 4.

Medium in size, oval in outline; anterior slope broadly convex, posterior slope flattened; perforation long, slightly narrowed anteriorly; sculpture consisting of about 34 ribs that tend to alternate in size and are beaded by regularly spaced concentric lirae. Measurements of the figured specimen, USNM 648239: length 4.4 mm, width 3.0 mm, convexity 1.6 mm.

Occurrence: The single immature fossil was obtained in drill hole 2A on Bikini Atoll at a depth of 447–453 feet; age, post-Miocene, probably Pliocene. Recent shells have been collected from the Philippines, Japan, and the Mariana Islands.

Rimula sp.

Plate 2, figures 32, 33

Small, oval in outline; margin crenulated, moderately convex, translucent; apex strongly recurved; perforation short, subrectangular. Sculpture consisting of about 20 strong radiating ribs that alternate with smaller secondary ribs; primary ribs conspicuously beaded by regularly spaced concentric lirae. Two of the three specimens available show traces of about eight broad radial bands of greenish brown. Measurements of the figured specimen, USNM 648240: length 1.9 mm, width 1.4 mm, convexity 0.9 mm.

Occurrence: Drill hole E–1 on Eniwetok Atoll at a depth of 10–20 feet; age, Recent. A single worn shell from hole F–1, Eniwetok, may represent this species; it was obtained from cuttings at a depth of 2,010–2,020 feet in Miocene beds (Tertiary *e*) but may have been derived from a higher level.

Genus SCUTUS Montfort

Montfort, 1810, Conchyliologie systématique, v. 2, p. 58–59.

Type (by original designation): *Scutus antipodes* Montfort. Recent, southeast Australia.

Subgenus NANNOSCUTUM Iredale

Iredale, 1937, Australian Zoology, v. 8, pt. 4, p. 244.

Type (by original designation): *Nannoscutum forsythi* Iredale. Recent, Lord Howe Island, Australia.

The shell of the type species of *Nannoscutum* is strongly lined concentrically, but even in this definitive feature it does not differ markedly from some of the shells ordinarily referred to *Scutus* s.s. Iredale, however,

has pointed out that the animal is unlike that of any previously described *Scutus*. Only two specimens of scutid shells are found in the collections of island fossils. Both are from drill hole on Eniwetak Atoll in beds referred to Tertiary *g*. Both are small, as is the type of *Nannoscutum*, both show strong concentric sculpture, and each has a thickened margin that indicates adulthood. They differ in detailed sculpture, however, and may represent distinct species. Neither shell is complete, and this fact coupled with their rarity makes it unwise to attach specific names. They are described and figured as species A and B.

The scutids are an Indo-Pacific group. In life the animals appear sluglike, because the flattened shells are partly or completely covered by the mantle. They are know to inhabit shallow water and to be light sensitive. Iredale found the type species of *Nannoscutum* living under stones.

Scutus (Nannoscutum) sp. A

Plate 2, figures 34, 35

Shell small, depressed, stout, marked posteriorly (anterior end missing) by six strong concentric ridges whose interior margins are wavy; outer ribs widely spaced with fine secondary ribs in the intervening depressions.

Measurements of the figured specimen, USGS 648241: width 7.1 mm, convexity 2.8 mm.

Occurrence: Drill hole F–1, Eniwetok Atoll at depth of 720–730 feet; late Miocene (Tertiary *g*.)

Scutus (Nannoscutum) sp. B

Plate 2, figures 36, 37

Shell small, thin, outer parts marked by wavy concentric ridges; area near apex comparatively smooth but bearing fine concentric lines that are bent backward along the median line of the shell.

Measurements of the figured specimen, USNM 648242: length (incomplete) 5.3 mm, convexity 1.5 mm.

The single incomplete shell resembles the genotype *N. forsythi* but appears to have been more strongly indented anteriorly. A comparison with actual specimens of the type might reveal other distinctions.

Occurrence: Drill hole K–1B, Eniwetok Atoll at a depth of 768–779 feet; late Miocene (Tertiary *g*).

Genus DIODORA Gray

Gray, 1821, Nat. Arrangement of Mollusca, London Med. Repository, v. 15, p. 233.

Type (by monotypy): *Patella apertura* Montagu (= *Patella graeca* Linnaeus). Recent, Mediterranean Sea.

Subgenus ELEGIDION Iredale

Iredale, 1924, Linnean Soc. New South Wales Proc., v. 49, p. 220, pl. 35, figs. 5, 6.

Type (by original designation): *Elegidion audax* Iredale. Recent, Australia.

Elegidion includes species in which the perforation lies wholly on the anterior slope.

Diodora (Elegidion) marshallensis Ladd, n. sp.

Plate 3, figures 1, 2

Small, ovate, conical; slopes nearly straight; apex prominent, perforation broadly oval or elliptical, located immediately anterior to apex. Sculpture consisting of about 18 sharply elevated ribs that increase in size from apex to shell margin where they form hollow crenulations on the inner surface of the shell; a single secondary rib is intercalated between each 2 primary ribs, but the secondaries are small and cause only minor crenulations on the shell margin; both sets of ribs crossed by concentric lirae that become progressively larger near the shell margin where they form prominent beads on the primary ribs. The type specimens retain traces of eight dark green rays, the color being limited in each specimen to a single primary rib.

Measurements of the holotype (pl. 3, figs. 1, 2; E–1, Eniwetok, 700–710 ft), USNM 648243: length 3.4 mm, breadth (incomplete) 2.4 mm, height 1.5 mm.

Shells referred to this species can be easily differentiated from those of *D.* aff. *D. granifera* (Pease) (see below), which occur in post-Tertiary beds in Eniwetok drill holes. *D. marshallensis* is heavier, has a much sharper sculpture, and a greater contrast in size between the two sets of ribs. The perforation of *D. marshallensis* is oval to elliptical rather than elongate and is closer to the apex than in the younger species; likewise, in *D. marshallensis* each of the green rays is limited to a single primary rib.

Occurrence: The types and a half dozen other specimens from deep drill holes on Eniwetok in cuttings from depths of 700–852 feet in beds assigned to late Miocene (Tertiary *g*); two apical fragments from lower levels (873–915 ft) are from section referred to Tertiary *f* and may have been derived from younger beds. On Bikini a single apical fragment was recovered in hole 2B from the 789–800 feet interval (Tertiary *g*). Identifiable fragments also obtained from the marls at the base of the Palau Limestone in the Goikul area, Babelthuap, Palau (USGS 21301); late Miocene (Tertiary *g*).

Diodora (Elegidion) aff. D. granifera (Pease)

Plate 3, figures 3, 4

Small, oval in outline, slightly narrower in front, conical; posterior slope slightly concave near apex, other

slopes nearly straight; apex prominent, projecting posteriorly; perforation elongate, located on the anterior slope. Sculpture consisting of 30 or more radial ribs with a tendency to alternate in strength; ribs beaded by weaker concentric lirae. Two of the five fossil specimens show traces of about 10 green radial bands visible inside and outside the shell.

Measurements of the figured specimen, USNM 648244: length (incomplete) 3.0 mm, width 2.4 mm, height 1.4 mm.

The Eniwetok fossils are identical with several Recent shells collected in surface float on the atoll and appear to be closely related to the variable *D. granifera* known from many localities in Hawaii. (Pease, 1861, p. 244; Pilsbry 1890, p. 407, pl. 63, fig. 13). The Eniwetok shells on the average are smaller, and their radial ribs have a stronger tendency to alternate in size than do those of the Hawaiian shells.

Occurrence: Five specimens from four drill holes on Eniwetok Atoll at depths of 5–20 feet.

Diodora (Elegidion) sp. A

Plate 3, figures 5, 6

Medium in size, ovate, highly conical; slopes gently convex; perforation small, broadly oval, located only slightly anterior to apex. Sculpture consisting of about 40 strong radial ribs that alternate with a second set of much smaller ribs; ribs conspicuously beaded by concentric lirae that increase only slightly in size from apex to shell margin.

Measurements of the figured specimen, USNM 648245: length 14.8 mm, width 10.1 mm, height (incomplete) 8.6 mm.

D. sp. A does not appear to be closely related to described fossil or Recent species. It may represent a new form, but neither of the two specimens available would make a satisfactory type.

D. sp. A is much larger, proportionately higher, has more convex slopes, and is more conspicuously cancellate than *D. marshallensis* Ladd, n. sp., which occurs with it. The concentric lirae of *D.* sp. A are, likewise, more uniform in size than those of *D. marshallensis*.

Occurrence: Two specimens from the marls at the base of the Palau Limestone in the Goikul area, Babelthuap, Palau (USGS 21304); age, late Miocene (Tertiary *g*). An incomplete and poorly preserved specimen from the Palau Limestone close to the volcanic contact on Auluptagel (USGS 17715) may represent *D.* sp. A.

Family PATELLIDAE

Genus PATELLA Linnaeus

Linnaeus, 1758, Systema naturae, 10th ed., p. 780.

Type (by subsequent designation): Fleming, 1818, Enclopedia Britannica, supp.—not seen: *Patella vulgata* Linnaeus. Recent, seas of Europe.

Subgenus SCUTELLASTRA H. and A. Adams

Scutellastra H. and A. Adams, 1854, Genera Recent Mollusca, v. 1, p. 466.

Type (fide Keen, 1960, Treatise on invertebrate paleontology, Mollusca 1, p. I235): *Patella plicata* Born = *Patella barbara* Linnaeus. Recent, southwest Pacific.

Patella (Scutellastra) stellaeformis Reeve

Plate 3, figure 7

Patella stellaeformis Reeve, 1842, Conchyliologie systématique, v. 2, pl. 136, fig. 3.

Pilsbry, 1891, Manual Conchology, v. 13, p. 98, pl. 17, figs. 25–27; pl. 61, figs. 62–65.

An internal mold believed to represent this variable and widely distributed western Pacific species was obtained from a shallow drill hole, F-23C at depth of 85–88 feet, on Engebi Island, Eniwetok; age, probably Recent. The mold is low, conic, irregularly oval in outline; six major ribs radiate from the near-central apex; margin crenulated. Measurements of the figured specimen USNM 648246: length 9.1 mm, width 6.7 mm.

The species occurs from east Africa to eastern Polynesia and is found in abundance today on the reefs of Eniwetok and other Marshall Island atolls.

Genus CELLANA H. Adams

H. Adams, 1869, Zool. Soc. London Proc., p. 273.

Type (by original designation): *Nacella cernica* Adams. Recent, Mauritius.

Cellana aff. C. sagittata (Gould)

Helcioniscus aff. *sagittata* Ladd, 1945, B. P. Bishop Mus. Bull. 181, p. 350, pl. 50, fig. D.

No additional material was collected, and identification remains uncertain. As previously pointed out, the fossil shells (14 specimens) from the Ndalithoni Limestone, probably Pliocene (Tertiary *h*), on Vanua Mbalavu, Fiji (stas. 110B, 110C) are slightly more elongate and somewhat less convex than the Recent shells (Gould 1846, p. 148; 1852, p. 337; 1856, Atlas, figs. 449a–c) and may represent a distinct species. Recent shells of *C. sagittata* have apparently not been found outside Fiji.

Cellana sp. A

Plate 3, figure 8

Medium in size, thick, oval, a little narrowed anteriorly, depressed conical; apex slightly anterior. Sculpture consisting of about 22 strong rounded radiating ribs, each of which, near the margin of the shell, bears 3 or 4

low secondary riblets; concentric lines of growth are obscure on the worn shell but more prominent near the margins than elsewhere.

Measurements of the figured specimen, USNM 648247: length 28.2 mm, width 24.3 mm, height (apex slightly broken) 8.6 mm.

The marginal secondary riblets seem to differentiate the fossil from described species, but the single specimen is worn and broken.

Occurrence: In the Tanapag Limestone of Saipan (USGS 17891); age, probably Recent.

Cellana? sp.

Helciniscus? sp. Ladd, 1934, B. P. Bishop Mus. Bull. 119, p. 200, pl. 34, figs. 13, 14.

Occurrence: A single specimen from the marls of the Suva Formation, Viti Levu, Fiji (sta. 305); age, Miocene (Tertiary *f*). No additional material collected; identification remains questionable.

Family TROCHIDAE

Trochids are well represented on the island reefs today and apparently they were equally abundant during all of late Tertiary and Quaternary time. A total of 28 fossil species have been recognized. These have been placed in 12 genera and 15 subgenera. There are, in addition, numerous internal molds of trochids that are too poorly preserved even for generic determination. Many of these are large forms, and most of them were collected from elevated and recrystallized reef limestones.

Genus EUCHELUS Philippi

Philippi, 1847, Zeitschr. Malakozool., v. 4, p 20.

Subgenus EUCHELUS s.s.

Type (by subsequent designation, Herrmannsen, 1847, Indicis Generum Malacozoorum 1, p. 430: *Trochus quadricarinatus* Dillwyn. Recent, Indian Ocean.

Euchelus (Euchelus) cf. E. quadricarinatus (Dillwyn)

Plate 3, figures 9, 10

Small, globose; whorls rounded, sutures impressed; deep umbilicus partly filled by a spiral fold; aperture subcircular, columella thin, straight with a poorly developed basal tooth. Sculpture consisting of 12 spiral ribs of which 4 are more prominent than the others; larger ribs beaded by axial lamellae; secondary ribs between primary ribs are inconspicuously beaded; 4 or 5 ribs cover the base; on the figured specimen the rib bounding the umbilicus is larger than the other basal ribs.

Measurements of the figured specimen (K–1B, Eniwetok, 663–674 ft), USNM 648253: height 3.7 mm, diameter 3.4 mm.

Occurrence: Eight specimens from four drill holes on Eniwetok Atoll at depths to 120 feet; age, Recent; a single specimen from a fifth hole (K–1B) at a depth of 663–674 feet is from sediments referred to the late Miocene (Tertiary *g*), but this specimen is incomplete and may have been derived from a higher level.

The fossil specimens appear to be closely related to, if not identical with, the type species that lives in the Indian Ocean (Pilsbry, 1889, p. 439, pl. 38, figs. 9–11). The fossils are immature and deeply umbilicate, as are young shells of the living species; the basal columellar tooth is only poorly developed on the fossils.

Subgenus HERPETOPOMA Pilsbry

Pilsbry, 1889, Manual Conchology, v. 11, p. 430.

Type (by original designation): *Euchelus scabriusculus* A. Adams and Angas. Recent, Australia.

Euchelus (Herpetopoma) instrictus (Gould)

Plate 3, figures 11–13

Trochus (*Monodonta*) *instrictus* Gould, 1849, Boston Soc. Nat. History Proc., v. 3, p. 107.
Gould, 1852, U.S. Explor. Exped., Mollusca, p. 190.
Gould, 1856, U.S. Explor. Exped., atlas, fig. 225a–c.
Euchelus instrictus Gould, 1862, Otia Conchologica, p. 245.
Pilsbry, 1889, Manual Conchology, v. 11, p. 440, pl. 67, figs. 62, 63.
Johnson, 1964, U.S. Natl. Mus. Bull. 239, p. 92.

Small, ovate-conic, stout; whorls moderately inflated, separated by a prominent channel; body whorl with 10–11 sharply elevated spiral ribs, the 3 nearest the periphery being the most prominent; ribs beaded by close-set axial lamellae; base rounded; umbilicus narrow; columellar tooth large, with a deep basal notch below; outer lip strongly lirate within, its thin edge crenulated by the surface ribs.

Measurements of the figured specimen (E–1, Eniwetok, 30–40 ft) USNM 648254: height 4.1 mm, diameter 3.8 mm.

Occurrence: Represented by 14 specimens from drill holes on Eniwetok at depths as much as 120 feet in Quaternary beds. A single shell from E–1 at a depth of 620–630 feet is in the top of the section referred to the Miocene (Tertiary *g*) but may have been derived from a higher horizon. Gould's type specimen, a Recent shell (USNM 5625), was collected in the Pacific, exact locality not stated. Living specimens have been collected in Fiji, and the species is common in the northern Marshall Islands.

Euchelus (Herpetopoma) instrictus suvaensis Ladd, n. subsp.

Plate 3, figures 14–16

Small, conic, thick; whorls moderately inflated, the body whorl separated from penultimate by channel;

body whorl with nine strong spiral ribs that are coarsely beaded by axial lamellae; base convex, umbilicus closed; columellar tooth stout with deep basal notch below; inner edge of outer lip strongly lirate.

Measurements of the holotype, USNM 648255: height 3.6 mm, diameter 3.3 mm.

The fossil resembles Recent examples of *E. instrictus* from the same area but is more coarsely sculptured and has a covered umbilicus.

Occurrence: Represented by a single specimen from the conglomerate at the base of the limestone in the type section of the Suva Formation, Viti Levu, Fiji (sta. 160); age, Miocene (Tertiary *f*).

Subgenus VACEUCHELUS Iredale

Iredale, 1929, Queensland Mus. Mem. 9, p. 272.

Type (by original designation): *Euchelus angulatus* Pease. Recent, Anaa, Tuamotu Archipelago.

Euchelus (Vaceuchelus) angulatus Pease

Plate 3, figures 17–19

Euchelus angulatus Pease, 1867, Am. Jour. Conchology, v. 3, p. 283, pl. 23a, fig. 27.

Euchelus foveolatus angulatus Pease, Pilsbry, 1889, Jour. Conchology, v. 11, p. 437, pl. 38, fig. 1.

Euchelus (Vaceuchelus) angulatus Pease, Iredale, 1929, Queensland Mus. Mem. 9, p. 272.

Small, globular, turreted, stout, nacreous within, imperforate or narrowly umbilicate; columella without basal tooth; whorls convex, marked with strong spiral ribs crossed by well-developed axial lamellae that give ribs a beaded appearance and form deep pits in spaces between ribs. Body whorl with six to eight ribs, the three nearest the periphery larger than the others.

Measurements of the figured specimen (E–1, Eniwetok, 40–50 ft), USNM 648256: height 3.0 mm, diameter (incomplete) 2.5 mm.

The fossil occurrences are apparently the first to be recorded. The strongly cancellated sculpture and the absence of a columellar tooth easily distinguish this form from all related species. Comparison with several lots of Recent shells indicates that the fossils fall within the limits of variation of such shells. The strong ribs vary in number from five to seven and the relative prominence of the peripheral members of the series also varies somewhat. The presence or absence of a narrow umbilicus does not seem to be a feature of significance.

Occurrence: A single specimen from the conglomerate at the base of the limestone section of the Miocene (Tertiary *f*) Suva Formation, Viti Levu, Fiji. Two specimens from Quaternary beds in drill holes 2 and 2A on Bikini Atoll, depths of 100–285 feet; two specimens were recovered from drill hole E–1 on Eniwetok at depths of 10–50 feet; age, Recent.

Type locality of Recent shell is the island of Anaa in the Tuamotus; species also collected in the Society and Marshall Islands and reported from Fiji, Philippines, and Ceylon.

Euchelus (Vaceuchelus) sp. A

Plate 3, figures 20–22

Minute, conical, stout, narrowly perforate; aperture subcircular, columella straight, thin, without basal tooth; whorls flattened, sutures deeply impressed. Sculpture consisting of strong spiral ribs, 10 being present on body whorl; peripheral rib and the one immediately below it are larger than those above and than the 5 on the base; ribs crossed by slightly oblique axial lamellae to produce a pitted surface. Upper surface of whorls marked at fairly regular intervals by narrow reddish-brown axial bands.

Measurements of the figured specimen (E–1, Eniwetok, 30–40 ft), USNM 648257: height 2.8 mm, diameter 2.6 mm.

Easily differentiated from *E.* cf. *quadricarinatus*, previously described, by the flatness of the whorls and the absence of the basal tooth. In general form and sculpture the fossil resembles *Antillachelus* (Miocene to Recent, West Indies), but in that group there is a wide umbilicus and a heavy basal tooth and the aperture is lirate within.

Occurrence: Two specimens at shallow depths (22–40 ft) from drill holes on Eniwetok Atoll; age, Recent.

Genus HYBOCHELUS Pilsbry

Pilsbry, 1889, Manual Conchology, v. 11, p. 430.

Type (by original designation): *Stomatella cancellata* Krauss. Recent, Cape of Good Hope.

Hybochelus cancellatus orientalis Pilsbry

Plate 3, figures 23, 24

Euchelus (Hybochelus) cancellatus orientalis Pilsbry, 1904, Acad. Nat. Sci. Philadelphia Proc., p. 35, pl. 6, figs. 57, 57a.

Small, turbinate, depressed; body whorl large, suture deep; aperture ovate, oblique; umbilicus narrow, deep. Sculpture consisting of strong spiral ribs alternating with smaller secondary ribs, there being 10 primary spirals at the beginning of the last whorl; spirals crossed by oblique axial ribs to form deep, narrow pits; lowest of primary ribs spirals into the umbilicus. Traces of spots of brown on some of spiral ribs.

Measurements of the figured specimen (E–1, 50–60 ft), USNM 648258: height (incomplete) 3.6 mm, diameter (incomplete) 4.7 mm.

The fossil specimens are small; one is incomplete, the other immature, neither specimen shows the threads of a third order mentioned by Pilsbry, though some of the Recent Marshall Island specimens do show this feature.

Occurrence: Two specimens from drill holes on Eniwetok Atoll at a depth of 29–60 feet; age, probably Recent. The species is a common one on the atoll today and was also collected at nearby Rongelap and Rongerik Atolls; Pilsbry's types were collected in Japan.

Hybochelus kavoricus Ladd

Plate 3, figures 25, 26

Euchelus (Hybochelus) kavoricus Ladd, 1945, B. P. Bishop Mus. Bull. 181, p. 353, pl. 50, figs. J, K.

No additional material collected. Holotype and only specimen from Ndalithoni Limestone; age, probably Pliocene (Tertiary *h*); Vanua Mbalavu, Fiji, (sta. 110B). As noted in the original description, *H. kavoricus* differs from *H. cancellatus orientalis* chiefly in having fewer spiral ribs.

Genus THALOTIA Gray

Gray, 1840, Synop. contents British Mus., p. 147.

Subgenus THALOTIA s.s.

Type (by subsequent designation, Gray, 1847, Zool. Soc. London Proc., p. 145): *Trochus pictus* Wood= *Monodonta conica* Gray. Recent, Australia.

Thalotia (Thalotia) berauensis (Beets)

Plate 3, figures 27, 28

Cantharidus (Cantharidus) berauensis Beets, 1941, Geol.-mijnb. genootsch. Nederland en Kolonien Verh., Geol. ser., v. 13, pt. 1, p. 13–14, pl. 9, figs. 338–340.

Small, broadly conical, stout, imperforate; spire flat, periphery of body whorl rounded; aperture ovate, lirate within; columella inclined with a strong nearly horizontal basal tooth. Whorls marked by spiral ribs conspicuously beaded by inclined axial lamellae; on body whorl the 5–6 ribs above the strong peripheral rib are subequal in size; the 5–6 ribs on the base below the periphery are variable in size; axial wrinkles are well developed on the early whorls, 9–11 being on the penultimate whorl.

Measurements of the figured specimen, USNM 648259: height 5.2 mm, diameter 3.4 mm.

Occurrence: Originally described from the upper Miocene of East Borneo. Three specimens found in drill hole K1–B on Eniwetok Atoll at a depth of 1,070–1,081 feet in beds referred to lower Miocene (Tertiary *f*).

Thalotia (Thalotia) aff. T. elongatus (Wood)

Plate 3, figure 29

Narrowly conical, heavy; periphery rounded, sutures slightly impressed, imperforate. Sculpture consisting of two spiral rows of heavy nodes and finer spiral ribs; base with close-set spiral ribs.

Measurements of the figured specimen, USNM 648260: height 22.2 mm, diameter 15.3 mm.

The single fossil is complete, but the shell is recrystallized and most sculptural features are obscured. It resembles the Recent *T. elongatus* (Wood, 1828, pl. 5, fig. 19) in its unusual height of spire and its heavy nodes that tend to form longitudinal plications. On the fossil, the nodes are larger and the rows are more distinctly separated than on the Recent shells. When better material is obtained, the fossil may prove to be a distinct species. *T. elongatus* was described from New Caledonia (Pilsbry, 1889, p. 143, pl. 45, fig. 56), but it is also known from Japan. During Operation Crossroads in the Marshall Islands, a single dead shell was collected from the lagoon shore of Eniwetok Atoll.

Occurrence: In the Mariana Limestone of Guam (USGS 20574); age, probably Pleistocene.

Subgenus Beraua Beets

Beets, 1941, Geol.-mijnb. genootsch. Nederland en Kolonien Verh., Geol. ser., v. 13, pt. 1, p. 14.

Type (by original designation): *Cantharidus erinaceus* Beets. Upper Miocene, Borneo.

Thalotia (Beraua) sp.

Plate 3, figure 30

Small, high-conical; base convex; early whorls flat sided with low axial plications; last two whorls with strong sutural nodes, all whorls and base bearing fine spiral ribs.

Measurements of the figured mold, USNM 648261: height 9.7 mm, diameter 7.5 mm.

The single specimen from Saipan is an incomplete external mold, but it does show the unique sutural nodes that characterize *Beraua*. It closely resembles the plumper form of the type species *T. erinaceus*, described by Beets from the Miocene of Borneo, but appears to have a more convex base. Specific identification must await better material.

Occurrence: Inequigranular facies of Miocene (Tertiary *e*) Tagpochau Limestone, Saipan, Mariana Islands (USGS 17904).

Genus TURCICA A. Adams

A. Adams, 1854, Zool. Soc. London Proc., p. 37.

Type (by monotypy): *Turcica monilifera* A. Adams. Recent, Morton Bay, Australia.

Subgenus PERRINIA H. and A. Adams

H. and A. Adams, 1854, Genera Recent Mollusca, 1, p. 419.

Type (by subsequent designation, Pilsbry, 1889, Manual Conchology, v. 11, p. 419): *Monodonta angulifera* A. Adams. Recent, Philippine Islands.

Turcica (Perrinia) morrisoni Ladd, n. sp.

Plate 3, figure 31; plate 4, figures 1–5

Small, conic, stout, imperforate, nacreous within. Whorls with a prominent peripheral carina which is extended into a series of flattened triangular spines that are regularly spaced (about 13 on the last whorl) and that give the shell a stellate appearance when viewed from above; suture impressed. Above the peripheral carina are three beaded spirals, the uppermost one coarser than the other two; base has four beaded concentric spirals, the outer one the coarsest, its beads spinose. Aperture semi-elliptical, lirate within; columella strong, granulate, with a broad basal tooth; outer lip thin, its edge crenulated by the surface ribs.

Measurements of the holotype, a Recent shell (pl. 3, fig. 31; pl. 4, figs. 1, 2), USNM 648262: height 3.3 mm, diameter 2.8 mm.

Euchelus morrisoni is closely related to *E. stellata* described by A. Adams from the China Seas, but both Recent and fossil examples of *E. morrisoni* are much smaller, have a broader apical angle (roughly 65° as against 45° for *E. stellata*), and the concentric ribs on the base are strongly beaded whereas those of *E. stellata* are not.

Occurrence: Type lot (five specimens) collected alive from the undersides of coral blocks on the reef flat behind the seaward margin on the south side of Bokororyuru Island, Bikini Atoll. This area is the "zone of blocks" in a measured traverse (Emery, Tracey, and Ladd 1954, p. 170–171); it lies 115–225 feet from the seaward edge, and its surface is covered by a foot of water at low tide. Collected by J. P. E. Morrison.

A few dead shells were found in drift samples from half a dozen localities on several islands of Bikini Atoll and of Eniwetok Atoll; dead shells were found in abundance in a drift sample taken on Bock Island, Rongerik Atoll.

Only two fossil shells have been found. One of these shells is from a depth of 27½ feet in drill hole 2 on Bikini Island and is Recent in age; the other (USNM 648263, pl. 4, figs. 3–5) from a depth of 1,461–1,472 feet in drill hole 2B on Bikini Island is from beds referred to the Miocene (Tertiary *f*), but the single fossil picked from the drill cuttings is slightly worn and may have been derived from a younger horizon.

Genus GIBBULA Risso

Risso, 1826, Histoire naturelle des principales productions de l'Europe méridionale, v. 4, p. 134.

Subgenus GIBBULA s.s.

Type (by subsequent designation, Herrmannsen, 1848, Indicis Generum Malacozoorum Primordia, p. 437): *Trochus magus* Linnaeus. Recent, Mediterranean Sea.

Gibbula (Gibbula) engebiensis Ladd, n. sp.

Plate 4, figures 6, 7

Shell small, conical, distinctly turreted with sutures impressed; moderately thick; aperture subcircular, smooth and pearly within; umbilicus narrow, bordered by a thick beaded spiral ridge; inner lip callused, expanded a little above, more extensively below where it covers the end of the umbilical ridge. Sculpture consisting of primary and secondary spiral ribs inconspicuously beaded by fine axial lines of growth; on the body whorl there are four primary ribs, the middle two being slightly larger and forming a biangular periphery; secondary ribs are present between all primary ribs and on the base which is set off from the rest of the whorl by a sharp angle. Traces of original color in the form of wide, regularly spaced reddish-brown bands appear on the last two whorls and extend across the base of the body whorl; inner lip white.

Measurements of the holotype, only specimen, USNM 648264: height 2.9 mm, width 2.9 mm.

The fossil species is tentatively referred to *Gibbula* s.s. because it seems to fit better there than in any one of the numerous subgenera that have been recognized. The type of the genus, *G. magus* (Linnaeus), is a medium-sized shell from the Mediterranean with a wider umbilicus than that shown by the fossil and a less well developed columellar callus. The fossil is much more closely related to *G. gradata* (Gould), a species described from the Pacific islands (Gould, 1849, p. 91) and later from the West Indies (as *G. pisum* Philippi, Pilsbry, 1889, p. 241, pl. 31, figs. 38–40). The Recent shell is considerably larger than the fossil, is more distinctly ribbed, and on the body whorl the uppermost of the four primary ribs is the largest; the Recent shell likewise has a wider umbilicus than does the fossil.

Occurrence: Drill hole K1–B on Engebi Island, Eniwetok Atoll, at a depth of 926–936 feet in beds referred to early Miocene (Tertiary *f*).

Genus FOSSARINA A. Adams and Angas

A. Adams and Angas, 1863, Zool. Soc. London Proc., p. 423.

Type (by subsequent designation, Suter, 1913, Manual New Zealand Mollusca, p. 139): *Fossarina patula* A. Adams and Angas. Recent, Australia.

Subgenus MINOPA Iredale

Iredale, 1924, Linnean Soc. New South Wales Proc., v. 49, p. 226.

Type (by original designation): *Fossarina legrandi* Petterd. Recent, South Australia.

Fossarina (Minopa) hoffmeisteri Ladd, n. sp.

Plate 4, figures 8–10

Small, globose, thin; whorls inflated; suture impressed, descending at aperture; aperture subcircular, oblique; peristome slightly projecting at base of columella. Sculpture consisting of faint spiral threads and fine lines of growth; spirals are better developed on earlier whorls than on body whorl. Many examples from younger beds retain traces of original color in the form of widely spaced oblique bands and irregular pointed cross bands of reddish brown.

Measurements of the holotype (Mu–4, Eniwetok, 40 ft), USNM 648265: height 4.1 mm, diameter 3.8 mm.

Occurrence: Twenty-four specimens from five drill holes on Eniwetok Atoll from near the surface to a depth of 670 feet; age, Recent to late Miocene (Tertiary *g*); two drill holes on Bikini Atoll yielded five specimens, one from post-Miocene beds (core) at 235½ feet and four others from early Miocene (Tertiary *e*) beds 1,335–1,892 feet. The species still lives in the Marshall Islands but appears to be rare, as only a single dead shell was collected during Operation Crossroads.

Genus ASTELE Swainson

Swainson, 1955, Royal Soc. Van Diemensland Papers, v. 3, p. 38.

Type (by monotypy): *Trochus subcarinatus* Swainson. Recent, Tasmania.

Subgenus CALLISTELE Cotton and Godfrey

Cotton and Godfrey, 1935, South Australian Naturalist, v. 16, no. 2, p. 20.

Type (by original designation): *Astele calliston* Verco. Recent, Australia.

Astele (Callistele) engebiensis Ladd, n. sp.

Plate 4, figures 11–13

Small, conical, thin; protoconch of about 1½ smooth whorls; sides flat, base gently convex; aperature quadrate, nacreous within; columella nearly vertical, slightly callused; umbilicus narrow, smooth sided; periphery sharply angled, scalloped. Sculpture consisting of fine, closely spaced spiral ribs, five above periphery on body whorl, nine below periphery on base; ribs and interspaces crossed by numerous fine oblique lines.

Measurements of the holotype, USNM 648266: height 2.7 mm, diameter 2.9 mm.

The Recent shell *A. calliston* Verco described from Spencer Gulf, South Australia, has been the only species referred to *Callistele*. I have not seen specimens, but Verco's figures show that the Recent shell has a more prominently projecting peripheral carina and fewer ribs on the base than does the fossil.

Occurrence: Holotype and only specimen from drill hole K-1B on Engebi Island, Eniwetok Atoll at a depth of 968–978 feet in beds assigned to early Miocene age (Tertiary *f*).

Genus TROCHUS Linnaeus

Linnaeus, 1758, Systema naturae, 10th ed., p. 756.

Subgenus TROCHUS s.s.

Type (by subsequent designation, Iredale, 1912, Malacological Soc. London Proc., v. 10, p. 225): *Trochus maculatus* Linnaeus. Recent, Indo-Pacific.

Trochus (Trochus) maculatus Linnaeus

Plate 4, figures 14, 15

Trochus maculatus Linnaeus, 1758, Systema naturae, 10th ed., p. 756.

Trochus (Infundibulum) maculatus Linnaeus, Pilsbry, 1889, Manual Conchology, v. 11, p. 24, pl. 9, figs. 100, 1, 2, 3.

Trochus maculatus Linnaeus, Demond, 1957, Pacific Sci., v. 11, no. 3, p. 285.

Identifiable specimens of the variable type of *Trochus* s.s. were recovered from 13 localities in the detrital deposits and Agana Argillaceous Members of the Pliocene and Pleistocene Mariana Limestone of Guam (figured specimen from USGS 20636, USNM 648248) and from one additional locality (USGS 21383) on the island that may be referred to the upper Tertiary Alifan Limestone. Incomplete specimens that probably represent this species were also collected from Quaternary beds on Saipan (Tanapag Limestone) and from an unnamed coastal limestone on Espiritu Santo Island in the New Hebrides. These fossil occurrences are not the first, because the species has been reported from the Pliocene of Java and Quaternary of Timor and Billiton. Recent shells are widely known from Samoa to Fiji, the Philippines, the Ryukyus, Japan, Indonesia, and the Indian Ocean.

Trochus (Trochus) histrio (Reeve)

Plate 4, figures 16–18

Turbo histrio Reeve, 1848, Zool. Soc. London Proc., pt. 16, p. 52.

Trochus histrio Reeve, 1861, Conchlogica Iconica, v. 13, pl. 15, fig. 90.

Trochus calcaratus Pilsbry, 1889, Manual Conchology, v. 11, p. 30, pl. 2, fig. 15; pl. 8, figs. 83, 84.

Trochus histrio histrio Reeve, Demond, 1957, Pacific Sci., v. 11, no. 3, p. 285, fig. 1.

Small; upper surface of whorls bearing six rows of rounded circular, elongate, and slightly oblique granules; basal row on upper whorls forming prominent open pustules, 15 on penultimate whorl; on last whorl granules become smaller, more uniform in size, and pustules are not open; base with 10 concentric rows of beads; on outer half of base, rows of fine beads alternate with rows of larger beads; pseudoumbilicus with 2 smooth spiraling plicae. Faded traces of original color, broad red axial bands on the spire and spiral lines of short red dashes on the base, are preserved on both fossil specimens from Eniwetok.

Measurements of the figured specimen, USNM 648249: height 11.2 mm, diameter 13.4 mm.

Occurrence: Cuttings from drill hole F-1, Eniwetok, at a depth of 110–120 feet (figured specimen); a fragment was also recovered from cuttings in the same hole at a depth of 80–90 feet; age, Recent. A worn specimen from the Miocene (Tertiary *f*) Suva Formation at Viti Levu (sta. 160), probably represents the same species. Recent shells were collected on reef at Eniwetok and from beach drift there and at Bikini. The species also is known from other western Pacific islands including Palau, Mariana, Ellice, Loyalty, Ryukyu, and Line groups and from southern Japan and the South China Sea.

Trochus (Trochus) incrassatus Lamarck

Trochus incrassatus Lamarck, 1822, Hist. Nat. Animaux sans Vertèbres, v. 7, p. 20.
Reeve, 1861, Conchologica Iconica, v. 13, fig. 77.
Pilsbry, 1889, Manual Conchology, v. 11, p. 26, pl. 6, figs. 48–50.
Trochus incrassatus creniferus Kiener, Pilsbry, 1889, Manual Conchology, v. 11, p. 27, pl. 7, figs. 67, 68.
Ostergaard, 1935, [part], B. P. Bishop Mus. Bull. 131, p. 46–47.

Represented by four incomplete and poorly preserved fossils from the shore rocks at Houma, Tongatabu, Tonga (sta. 3). J. M. Ostergaard collected the fossils and identified them with Recent shells from the same area referring them to *T. incrassatus creniferus* Kiener. The fossils, however, are not strongly tuberculate around the periphery, as are shells commonly referred to Kiener's variety. The base of the fossils is marked by 11 or 12 concentric ribs rather than the 7 or 8 normally shown by *T. incrassatus*. The fossils are probably Pleistocene. Recent shells have been reported from various island groups, including Tonga, Samoa, and Japan.

Trochus (Trochus) tubiferus Kiener

Plate 4, figure 19

Trochus tubiferus Kiener, Fischer, 1880, Species general des coquilles, vivantes, Troque, v. 37, fig. 3.
Pilsbry, 1889, Manual Conchology, v. 11, p. 31, pl. 6, figs. 62, 63.
Ostergaard, 1935, B. P. Bishop Mus. Bull. 131, p. 47.

Four specimens of this species, characterized by a row of pustules at the base of each whorl and by numerous lirae on the flattened base, were collected by Ostergaard from elevated limestone on Tongatabu, Tonga (stas. 2–4); age, probably Pleistocene. Measurements of the figured specimen from station 2, B. P. Bishop Museum, geology No. 1339: diameter 25.9 mm, height (incomplete) 20.8 mm. The Recent shells have been reported from Tonga, Fiji, Ellice Islands, Loyalty Islands, and New Caledonia in the southwest Pacific.

Genus CLANCULUS Montfort

Montfort 1810, Conchyliologie systématique, v. 2, p. 191.

Subgenus CLANCULUS s.s.

Type (by original designation): *Trochus pharaonius* Linnaeus. Recent, Red Sea.

Clanculus (Clanculus) clanguloides fijiensis Ladd

Plate 4, figures 20–22

Clanculus (Clanculus) clanguloides fijiensis Ladd, 1945, B. P. Bishop Mus. Bull. 181, p. 352, pl. 50, figs. H, I.

Type material (four specimens) collected from the Ndalithoni Limestone, probably Pliocene (Tertiary *h*), on Vanua Mbalavu in eastern Fiji; an incomplete mold from the so-called older limestone (possibly Tertiary *f*) of the island of Fulanga in the same area (sta. L-78) may also represent this species.

Genus TECTUS Montfort

Montfort, 1810, Conchyliologie systématique, v. 2, p. 187.

Subgenus TECTUS s.s.

Type (by original designation): *Tectus pagodalis*= *Trochus mauritianus* Gmelin. Recent, Indonesia.

Tectus (Tectus) mauritianus (Gmelin)

Plate 4, figure 23

Trochus mauritianus Gmelin, 1791, Systema naturae, 13th ed., p. 3582.
Trochus (Tectus) mauritianus Gmelin, Pilsbry, 1899, Manual Conchology, v. 11, p. 23, pl. 2, figs. 11, 12; pl. 4, figs. 24, 25, 27.

A single incomplete example of this widely distributed Recent Indo-Pacific type of the genus was collected by Harold Stearns from a limestone pit (USGS 21028) on Espiritu Santo Island, New Hebrides, at an altitude of 240 feet; age, Quaternary. The characteristic projecting peripheral tubercles are well preserved on the fossil. Measurements of the specimen, USNM 648250: height (incomplete) 16.5 mm, width 17.4 mm.

Tectus (Tectus) pyramis (Born)

Trochus pyramis Born, 1778, Index Rerum Naturaeium Musei Caesarei Vindobonensis, pt. 1, Testacea, p. 338.
Trochus obeliscus Gmelin, 1791, Systema naturae, 13th ed., p. 3579.
Trochus (Tectus) obeliscus Gmelin, Pilsbry, 1889, Manual Conchology, v. 11, p. 19, pl. 2, figs. 13, 14.
Ostergaard, 1935, B. P. Bishop Mus. Bull. 131, p. 47.

Ten poorly preserved but identifiable examples of this widely distributed western Pacific species were collected by Cloud and by Ladd from the Pleistocene Tanapag Limestone of Saipan (USGS 17387 and 21407 respectively). Ostergaard collected six specimens (identified as *T. obeliscus* Gmelin) from the sea cliff near Houma (sta. 3) on Tongatabu, Tonga, in rock that is probably late Pleistocene in age.

Tectus (Tectus) cf. T. bomasensis (Martin)

Plate 4, figure 24

Medium in size, conical, higher than wide; base flat, meeting the body whorl at a sharp angle; nonumbilicate but with a strong columellar fold that is bordered by a broad smooth groove. Sculpture consisting of a prominent double nodose spiral ridge at the base of each whorl; lower part of ridge larger than upper; above the peripheral ridge each whorl bears three beaded riblets; on the body whorl the grooves between each two riblets contains a fine spiral cord; base marked by about eight beaded concentric cords.

Measurements of the figured specimen, USNM 648251: height 15.1 mm, diameter 13.6 mm.

The single Fijian fossil is incomplete, but it appears to be closely related to, if not identical with, *T. bomasensis* described by Martin (1917, p. 261, pl. 3, figs. 90a, b) from the lower Miocene of Java.

The fossil resembles *T. fenestratus* (Gmelin), a Recent species that occurs in Fiji and other Pacific and Indonesian islands. *T. fenestratus* is a variable species, and some shells show a dual ridge along the periphery, but it is not as prominent as in the fossil; the Recent shell is likewise much more strongly nodose than the fossil.

Occurrence: Conglomeratic facies of the Mba series at locality MR–20, about 3 miles south of Mba, Viti Levu, Fiji, collected by M. R. Rickard of the Fiji Geological Survey Department; age, probably Pliocene (Tertiary *h*).

Subgenus ROCHIA Gray

Gray, 1857, Guide Systematic Distrib. Mollusca British Mus., pt. 1, p. 148.

Type (by monotypy): *Trochus acutangulus* Chemnitz =*Trochus conus* Gmelin. Recent, Indo-Pacific. Also reported from the Pliocene or Quaternary of Timor.

Tectus (Rochia) niloticus (Linnaeus)

Plate 4, figure 25

Trochus niloticus Linnaeus, 1767, Systema naturae 12th ed., no. 579, p. 1227.
Pilsbry, 1889, Manual Conchology, v. 11, p. 17, pl. 1, figs. 5–8.
Demond, 1957, Pacific Sci., v. 11, p. 285.
MacNeil, 1960, U.S Geol. Survey Prof. Paper 339, p. 25, pl. 18, figs. 3, 5.
Trochus (Rochia) niloticus Linnaeus, Ladd, 1934, B. P. Bishop Mus. Bull. 119, p. 202.
Rippingale and McMichael, 1961, Queensland and Great Barrier Reef shells, Jacaranda Press, Brisbane, p. 31, fig. 19.

A large and well-preserved example of this widely distributed Recent species was collected by H. T. Stearns from a coral pit (USGS 21029) on Espiritu Santo Island in the New Hebrides at an altitude of 215 feet. Though part of the body whorl is broken, the shell (USNM 648252) shows its nacreous luster and traces of its original color pattern. The deposit is probably not older than Pleistocene. The species has also been reported from the Pliocene of Sumatra and Java and the Pliocene and Pleistocene of Okinawa.

Genus ISANDA H. and A. Adams

H. and A. Adams, 1854, Zool. Soc. London Proc., for 1853, p. 189.

Type (by original designation): *Isanda coronata* A. Adams. Recent, Australia.

The genus *Isanda* includes small heavy polished trochids having an open umbilicus and smooth interior. They are widespread in the Indo-Pacific and Australian area.

Subgenus PARMINOLIA Iredale

Iredale, 1929, Queensland Mus. Mem. 9, p. 271.

Type (by original designation): *Mineola agapeta* Melvill and Standen (1896)=*Monilea apicina Gould* (1861). Recent, South Pacific.

Isanda (Parminolia) apicina (Gould)

Plate 5, figures 1–4

Monilea apicina Gould, 1862, Boston Soc. Nat. History Proc., p. 16.
Monilea agapeta Melvill and Standen, 1896, Jour. Conchology [Leeds] v. 8, p. 312, pl. 11, fig. 77.
Monilea apicina Gould, Pilsbry, 1889, Manual Conchology, v. 11, p. 254.
Johnson, 1964, U.S. Natl. Mus. Bull. 239, p. 41, pl. 14, fig. 4.

The following description is based on the fossil material. Small, conical, solid; apex sharp, about five inflated whorls distinctly angled a short distance below suture and on body whorl, obscurely angled at periphery; aperture subcircular, outer lip thin, inner lip thickened, bearing a basal tooth and slightly scalloped by extensions

that cover the ends of two ribs that spiral into the umbilicus; outer of two umbilical ribs larger and beaded; umbilicus narrow and deep. Sculpture consisting of close-set spiral ribs crossed by fine axial lines; ribs wider on base near umbilicus. Two of the fossils retain patches of reddish-brown on the upper parts of penultimate and body whorls.

Measurements of the figured specimen, (E–1, 60–70 ft) USNM 648267: height 3.9 mm, diameter 4.0 mm. Gould's type USNM 24159 (pl. 5, figs. 3, 4) measures: height 4.9 mm, diameter 5.9 mm.

The Marshall Island specimens, both surface shells and those from drill holes, are smaller than Gould's type and are less sharply angled below the suture; the second (lower) funicle in the umbilicus is less well developed in the Marshall Island shells.

Occurrence: Eight specimens from drill holes on Eniwetok at depths from 1–243 feet; age, Recent; in Bikini drill holes, one specimen at 40 feet, three others at depths of 1,356–1,850 feet; the deeper specimens from the early Miocene (Tertiary *e*).

Gould's type (USNM 24159) is labeled "Coral Sea" but the published description cites Port Jackson [Sydney], Australia. The Recent shells described by Melville and Standen were collected in the Loyalty Islands. The species is common in collections of drift shells from both Eniwetok and Bikini.

Genus MONILEA Swanson

Swanson, 1840, Treatise on malacology, p. 352.

Subgenus MONILEA s.s.

Type (by monotypy): *Trochus calliferus* Lamarck. Recent, Indo-Pacific; also reported from Pliocene of Java.

Monilea (Monilea) mateana Ladd

Plate 5, figures 5–8

Monilea (Monilea) mateana Ladd, 1934, B. P. Bishop Mus. Bull. 119, p. 203, pl. 35, figs. 1, 2.

Small, solid; inner surface of outer lip has 10–12 strong lirations with small liration in interspaces; columella dentate below; umbilicus wide with a broad ridge or funicle spiraling up its side to terminate against the dentate part of the columella; funicle, in some specimens marked with a median groove. Sculpture consisting of strong spiral ribs beaded by axial striae. On the base the ribs are flattened and subequal in size; on the upper parts of the whorl, they are rounded, more strongly beaded and each second or third rib is larger than the others. Shell marked exteriorly by axial bands of reddish brown.

Holotype: B. P. Bishop Museum, geology No. 1196 (pl. 5, figs. 5, 6): height 7.0 mm, diameter 8.0 mm. Figured specimen, USNM 648392 (pl. 5, figs. 7, 8): height 6.7 mm, diameter 7.2 mm.

Examination of additional specimens collected from the type locality (Viti Levu, sta. 160) has shown that the median depression in the funicle is a variable feature and that the internal lirations and surface ribs are less constant than formerly thought.

M. mateana is most closely related to *M. (Monilea) marshallensis* Ladd, n. sp., a younger species from the Marshall Islands drill holes, described below.

Occurrence: Many specimens from stations 160 and 160A, Viti Levu, and a single shell from station L493, Lakemba, Fiji; age, Miocene (Tertiary *f*).

Monilea (Monilea) marshallensis Ladd, n. sp.

Plate 5, figures 9–12

Small, globular, solid; edge of outer lip thin, the thicker part within bearing 9 or 10 strong lirations; columella dentate below; umbilicus moderately wide, partly filled by a broad funicle. Sculpture consisting of strong spiral ribs beaded by axial striae; on the base the ribs may alternate with weaker ones.

Holotype: USNM 648270: height 3.9 mm, diameter 3.4 mm. Paratype A (USNM 648268): height 4.1 mm, diameter 4.1 mm.

The new species appears to be very closely related to *M. mateana* from the lower Miocene of Fiji. The Marshall Island fossils have a narrower umbilicus and show only one set of lirations within the aperature.

Examples of *M. marshallensis* were not found in the collections of Recent shells made at Bikini and Eniwetok Atoll.

Occurrence: Holotype from drill hole K–1B, Eniwetok Atoll at a depth of 1,248–1,259 feet; lower Miocene (Tertiary *e*); numerous other Eniwetok occurrences range from near the surface to 880 feet (Recent to Tertiary *f*). On Bikini, paratype A was recovered in drill hole 2A from core at a depth of 235 feet; age, post-Miocene; a dozen other Bikini occurrences range downward to 1,135 feet; age, Tertiary *e*.

Monilea (Monilea) lifuana Fischer

Plate 5, figures 13, 14

Trochus (Monilea) lifuanus Fischer, 1878, Jour. conchyliologie, v. 26, p. 63.

Monilea lifuana Fischer, Pilsbry, 1889, Manual Conchology, 11, p. 252, pl. 41, figs. 6, 7; pl. 59, figs. 64, 65.

Small, depressed, thin; body whorl inflated, broadly angled at periphery; aperture subquadrate, smooth within; inner lip thickened below; umbilicus narrow and

deep, partially filled by a heavy funicle. Sculpture consisting of fine spiral lines crossed by oblique axial lines of growth; axial lines more conspicuous on base near umbilicus than elsewhere. Measurements of the figured specimen, USNM 648269: height 5.2 mm, diameter 6.9 mm.

Occurrence: A single specimen from drill hole En–4, Eniwetok Atoll, at depth of 2 feet; age, Recent.

The species was described from the Loyalty Islands but has also been collected in Japan and on Bikini and Eniwetok Atolls in the Marshall Islands. One specimen was dredged alive from a depth of 180–200 feet in Bikini lagoon.

Monilea (Monilea) belcheri (Philippi)

Plate 5, figures 15, 16

Trochus belcheri Philippi, 1849, Zeitschr. Malakozool., p. 148.
Monilea (Monilea) belcheri Philippi, Pilsbry, 1889, Manual Conchology, v. 11, p. 250, pl. 61, figs. 3, 4.

Medium in size, depressed; whorls inflated, suture deeply incised; aperture subquadrate, smooth within; outer lip thin; columella oblique; umbilicus moderately wide, partially filled by a strong spiral funicle. Sculpture consisting of about 30 short close-set spiral ribs that, on the upper surface, show a tendency to alternate in size.

Measurements of the figured specimen, B. P. Bishop Museum, geology No. 1235: height 8.6 mm, diameter 11.1 mm.

Occurrence: Single specimen from station 320, Viti Levu, Fiji; age, late Tertiary; a specimen with fewer ribs but probably representing the same species was collected from the Futuna Limstone at station 304 on the island of Lakemba in eastern Fiji; age, Miocene (Tertiary *f*). Recent shells are known from Tonga, Fiji, New Caledonia, and Japan. The fossils are more strongly ribbed on the base and more uniformly ribbed above than are the Recent shells.

Family STOMATELLIDAE

Genus PSEUDOSTOMATELLA Thiele

Thiele, 1921, Revision des Systèmes Trochacea, p. 29.

Subgenus PSEUDOSTOMATELLA s.s.

Type (by original designation): *Stomatella papyracea* "Chemnitz," A. Adams. Recent, Indo-Pacific.

Pseudostomatella (Pseudostomatella) maculata (Quoy and Gaimard)

Plate 5, figures 17, 18

Stomatella maculata Quoy and Gaimard, 1834, Voyage de l'Astrolabe, Zoologie, v. 3, p. 305, pl. 66 (bis), figs. 13–16.
Reeve, 1874, Conchologica Iconica, v. 19, *Stomatella*, pl. 1, fig. 5.
Pilsbry, 1890, Manual Conchology, v. 12, p. 13, pl. 51, figs. 17–19; pl. 52, figs. 60, 61.

Small, moderately elevated, with four inflated whorls; columellar margin flattened; sculpture consisting of spiral ribs; above the periphery the strongest of three sets of ribs are beaded by oblique axial striae; the middle-sized set of ribs shows traces of beading; below the periphery the ribs are less conspicuous.

Measurements of the figured specimen, USNM 648271: height 10.5 mm, diameter (outer lip incomplete) 11.6 mm.

Occurrence: Six specimens collected from the Ndalithoni Limestone; age, probably Pliocene (Tertiary *h*); Vanua Mbalavu, Fiji (sta. 110B). The species, originally described from Recent shells from the Santa Cruz Islands, has since been collected westward to Torres Straits, eastward to the Society Islands, and northward to the Marshall Islands.

Genus STOMATIA Helbling

Helbling, 1779, Abh. Privatgesell., Prag, v. 4, p. 124, pl. 2, figs. 34, 35.

Type (by monotypy): *Stomatia phymotis* Helbling. Recent, Indo-Pacific.

Stomatia cf. S. phymotis Helbling

Plate 5, figure 19

Small, resembling a high-spired *Haliotis;* last whorl with double keel whose lower ridge bears prominent nodes; strong plicas present on body whorl immediately below suture.

Measurements of the figured specimen, USNM 648272: width 8.5 mm, height 7.3 mm.

Occurrence: USGS 20534 on outskirts of Taguag near west coast of Guam; probably Alifan Limestone; age, Tertiary *g* or *h*.

The single fossil is a mold showing the larger external markings. It seems closely related to, possibly identical with, the type *S. phymotis,* a variable and widely distributed Recent Indo-Pacific species. The body whorl of the fossil does not descend as deeply as on the Recent shells. The Guam specimen appears to be the first fossil record of the genus.

Genus SYNAPTOCOCHLEA Pilsbry

Pilsbry, 1890, Manual Conchology, 12, p. 6, 25.

Type (by original designation): *Stomatella montrouzieri* Pilsbry. Recent, New Caledonia.

Synaptocochlea concinna (Gould)

Plate 5, figures 20–23

Stomatella concinna Gould, 1845, Boston Soc. Nat. History Proc., v. 2, p. 26.
Adams, A., 1854, *in* Thesaurus Conchyliorum, 2, p. 831, pl. 173, figs. 20, 21.
Johnson, 1964, U.S. Natl. Mus. Bull. 239, p. 58, pl. 21, fig. 7.

Stomatella (Synaptocochlea) concinna Gould, Pilsbry, 1890, Manual Conchology, v. 12, p. 28, pl. 2, figs. 6, 7; pl. 55, figs. 27, 28.

Small, ovate, thin; body whorl large, aperture broadly oval; upper margin of outer lip turned down at junction with penultimate whorl. Sculpture consisting of fine spiral riblets, close set on most of shell but more widely separated near aperture; riblets beaded by lines of growth; on upper and lower thirds of shell the ribs are intermittently dark red, the streaks being discernible inside the aperture; on the middle (peripheral) third of the shell the ribs are uncolored.

Measurements of the figured specimen, USNM 648273: diameter 2.7 mm, height 3.0 mm.

The ornamentation and color pattern appear to distinguish this small species from all others assigned to the genus.

Occurrence: Figured specimen from drill hole F–1, Eniwetok Atoll, at a depth of 60–70 feet; three specimens in other drill holes even closer to surface; age, Recent; Recent shells were recovered from beach drift at Rongerik Atoll in the Marshall Islands. Gould's types were collected in Hawaii, and the species has also been reported from the Tuamotu (Paumotu) group.

Synaptocochlea rosacea (Pease)

Plate 5, figure 24

Gena rosacea Pease, 1867, Am. Jour. Conchology, v. 3, p. 284, pl. 24 [a] fig. 1.
Pilsbry, 1890, Manual Conchology, v. 12, p. 41, pl. 55, fig. 12.

Small, elongate-oval, moderately convex; spire posterior, whorls slightly angulated, body whorl flattened near apex. Entire shell marked by close-set concentric striae, which become less conspicuous near the outer lip, and by fine lines of growth. Traces of irregular areas of brown are preserved on the body whorl.

Measurements of the figured specimen (E–1, 30–35 ft) USNM 648274: length 4.5 mm, breadth 3.0 mm, convexity 1.3 mm.

Occurrence: Two specimens from drill hole E–1, Eniwetok Atoll, at a depth of 30–35 feet; age, probably Recent. Pease described Recent material from the Tuamotu [Paumotu] Islands. A minute shell from drill hole 2B on Bikini Atoll at a depth of 1,555–1,566 feet (Tertiary *f*) probably represents this species.

Synaptocochlea lekalekana (Ladd)

Plate 5, figures 25, 26

Sinum lekalekanum Ladd, 1945, B. P. Bishop Mus. Bull. 181, p. 357, pl. 50, figs. O, P.

No additional material collected. Species based on four specimens collected from the Ndalithoni Limestone, probably Pliocene (Tertiary *h*), Vanua Mbalavu (stas. 110B and 110C), Fiji.

Synaptocochlea marshallensis Ladd, n. sp.

Plate 5, figures 27, 28

Minute, ovate; spire low; aperture very large, wider than high, upper margin meeting penultimate whorl at midpoint; sculpture consisting of fine spiral ribs, cut by close-set axial lines.

Measurements of the holotype (K–1B, 757–769 ft), USNM 648275: height 1.5 mm, diameter 2.3 mm.

S. marshallensis is smaller and more strongly sculptured than *S. lekalekana* (Ladd) from the Ndalithoni Limestone, probably Pliocene, of Vanua Mbalavu, Fiji.

Occurrence: Two specimens from K–1B, Eniwetok Atoll, at depth of 757–769 feet; age, late Miocene (Tertiary *g*). An incomplete specimen from E–1 at depth of 870–880 feet (Tertiary *f*) probably represents the same species.

Family ANGARIIDAE (DELPHINULIDAE)

Genus ANGARIA Röding

Röding, 1798, Mus. Boltenianum, pt. 2, p. 71.

Type (by subsequent designation, Fischer, Spécies général et Iconographie des coquilles vivantes * * * p. 58, Paris, 1875): *Turbo delphinus* Linnaeus. Recent, Indo-Pacific; also reported from the upper Miocene of Java and Nias, the Pliocene and Pleistocene of Okinawa, and the Quaternary of Soemba.

Angaria delphinus (Linnaeus)

Plate 5, figures 29–34

Turbo delphinus Linnaeus, 1758, Systema naturae, 10th ed., p. 764.
Angaria delphinus Röding, 1798, Mus. Boltenianum, pt. 2, p. 71.
MacNeil, 1960, U.S. Geol. Survey, Prof. Paper 339, p. 29, pl. 16, figs. 6, 11–12.
Delphinula distorta (Linnaeus) Ladd, 1934, B. P. Bishop Mus. Bull. 119, p. 205–206, pl. 35, fig. 9.

A reexamination of the two Fijian fossils described by Ladd in 1934 and an additional specimen collected from the same locality (USNM 648393) indicate that all fall within the range of the highly variable Recent type of the genus. The Fijian fossils are from the conglomerate at the base of the limestone section in the Miocene Suva Formation (Tertiary *f*) on Walu Bay, Viti Levu.

On a single coarsely recrystallized specimen from Guam, the surface plicae are poorly preserved but the general form and arrangement strongly suggest the type species. The specimen, USNM 648276, measures: height 30.2 mm, diameter 30.6 mm. It was collected from the Alifan Limestone (Tertiary *g* or *h*) at USGS locality 20720.

Family TURBINIDAE

Genus ASTRAEA Röding

Röding, 1798, Mus. Boltenianum, pt. 2, p. 79.

Type (by subsequent designation, Suter, 1913, Manual New Zealand Mollusca, p. 166): *Trochus imperialis* Gmelin=*T. heliotropium* Martyn. Recent, New Zealand.

Subgenus ASTRALIUM Link, 1807

Link, 1807, Beschreibung der Naturalien-Sammlung der Universitat zu Rostock, p. 135.

Type (by subsequent designation, Fischer, *in* Kiener, 1875, Spécies général et Iconographie des Coquilles vivantes, Genre *Turbo*, p. 5): *Turbo calcar* Linnaeus. Recent, Indo-Pacific.

Astraea (Astralium) rhodostoma (Lamarck)

Plate 6, figures 1–5

Trochus rhodostomus Lamarck, 1822, Hist. Nat. Animaux sans Vertèbres, v. 7, p. 13.

Astralium (Cyclocantha) petrosum Martyn, Pilsbry, 1888, Manual Conchology, v. 10, p. 234, pl. 64, figs. 65, 66.

Astralium petrusum virescens Pease, Ostergaard, 1935, B. P. Bishop Mus. Bull. 131, p. 17.

Astraea (Calcar) confragosum Gould, Ladd, 1945, B. P. Bishop Mus. Bull. 181, p. 354.

Trochus (Infundibulum) calcaratus Souverbie, Abrard, 1946, Annales de paléontologie, v. 32, 48, pl. 4, fig. 9.

Sculpture variable but characteristically having two distinct rows of peripheral spines, those in the upper row numbering about 12 on the body whorl, those of the lower row smaller and more numerous; the columella is wide, has a shallow groove, and bears a denticle near its base.

Measurements of the figured specimen, USNM 648285: height 29.1 mm, diameter 25.3 mm.

The best preserved of Ostergaard's four Tongan fossils has many small subequal wrinkles, and the peripheral spines are not prominent.

Occurrence: A common and widespread species; fossil occurrences from Saipan (figured specimen from USGS 21407; questionable specimen from USGS 17387); Guam (USGS 17416, 20574, 20616, 20634, 20636, 20732, 20981); Fiji (sta. 148, Ongea); Tonga (sta. 7, Tongatabu); New Hebrides (USGS 21028, Espiritu Santo and Eromanga) (Abrard); all occurrences in beds of post-Tertiary age.

The Recent shells have been collected from many island groups in the Pacific, from the Marshall Islands to Fiji.

Astraea (Astralium) aff. A. rhodostoma (Lamarck)

Plate 6, figure 6

An external mold of an *Astralium* from the Main boring at Funafuti Atoll has sculpture similar to the variable *A. rhodostoma* but probably represents a distinct species. The shell had two rows of peripheral spines, but those in the lower row are twice as numerous as those in the upper; both rows are more oblique than in *A. rhodostoma*, the spines of the lower row on the fossil making an angle of slightly less than 45° with the base. Measurements of the figured impression, USNM 648286: height 19.7 mm, diameter 18.7 mm.

Occurrence: In core 528A (British Mus. Nat. History), dolomitic limestone from a depth of 1,006 feet, Main Boring, Funafuti Atoll; age, probably Pleistocene.

Astraea (Astralium) eniwetokensis Ladd, n. sp.

Plate 6, figures 7–9

Medium size, depressed conic; base slightly convex with narrow shallow umbilicus; whorls convex above, concave below; body whorl with 15 prominent rounded nodes above periphery with lesser number of smaller nodes that end as open scaly processes; on body whorl rows of smaller nodes lie between two main series; base with nine concentric spinose ribs; columella with low obliquely pinched tubercle.

Measurements of the holotype and only specimen, USNM 648290: height 7.9 mm, diameter 10.4 mm.

Resembles *A. calcar* (Linnaeus), type of the subgenus, but has a lower spire.

Occurrence: Drill hole F–1, Eniwetok Atoll, at depth of 790–800 feet; age, late Miocene (Tertiary *g*).

Astraea (Astralium) waluensis Ladd, n. sp.

Plate 6, figures 10–12

Astraea (Calcar) sp. A, Ladd, 1934, B. P. Bishop Mus. Bull. 119, p. 205, pl. 35, figs. 7, 8.

Shell medium in size, thick, trochoid; aperture ovoid, channeled at the periphery, nacreous within; columella wide with shallow depression and an elongate basal tooth; whorls flattened; body whorl with seven or eight broad-based spines lying well above the periphery; small oblique wrinkles cover the areas between the large spines; periphery marked by a row of small close-set spines; base flattened, bearing numerous concentric spinose ribs.

Measurements of the holotype, USNM 648291: height 12.9 mm, diameter 10.8 mm.

One of the two additional specimens representing this species has been designated the holotype. The form is closely related to the Recent *A. rhodostoma* Lamarck, but the fossils are smaller and less distinctly bicarinate. On the fossils the spines in the upper row are fewer and proportionately much larger.

Occurrence: Five specimens from the Suva Formation, Viti Levu, Fiji (sta. 160); age, early Miocene (Tertiary *f*).

Astraea (Astralium) sp. A

Plate 6, figures 13–15

Medium in size, trochoid; whorls flattened; base gently convex near middle, concave near periphery and near middle, concave near periphery and near columella; nonumbilicate; body whorl with about 10 low spiral ribs that are beaded by oblique ribs; spiral ribs on lower half of whorls scaly, especially the marginal rib which is more prominent than those above; base with a dozen concentric spinose ribs; aperture broken.

Measurements of the figured specimen, USNM 648292: height (incomplete) 11.2 mm, diameter (incomplete) 13.9 mm.

Resembles *Astraea eniwetokensis* n. sp. from slightly younger beds in the same drill hole but has a sharper spire and finer sculpture. May represent an undescribed form, but the single specimen available is too incomplete to be made a type.

Occurrence: Drill hole F–1, Eniwetok Atoll, at a depth of 840–850 feet; late Miocene (Tertiary *g*).

Astraea (Astralium) sp. B

Plate 6, figures 16–18

Small, trochoid; base flat and nonumbilicate; periphery carinate, extended into broad flattened regularly spaced spines, 10 being present on body whorl; whorls flattened above periphery, with 4 subequal beaded spiral ribs; base flat with 6 fine spiral ribs.

Measurements of the figured specimen, USNM 648293: height 1.8 mm, diameter 2.1 mm.

The single fossil appears to be immature; it has not been identified with a described species.

Occurrence: Drill hole 2, Bikini Atoll, from core at a depth of 115 feet; age, Recent.

Astrea (Astralium) sp. C

Plate 6, figures 19–20

The opercula described below appear to belong to a species of *Astralium*, possibly to one of the two large shells, *A. eniwetokensis* and *A.* sp. A, already described from the same Tertiary section in one of the drill holes that yielded some of the opercula. Each of the two shells recognized is represented by only a single specimen, and it is of course possible that still other species are completely unrepresented in the drill-hole samples. There are a total of 19 specimens of the heavy opercula. These structures are nearly indestructible, and hence the high ratio of opercula to shells is understandable. The opercula show little variation and probably represent a single species.

Operculum broadly ellipsoidal, heavy; inner face flattened with a rounded edge and a broad shallow spiral depression near the suture; nucleus below and to the left of the midpoint, the last whorl covering most of the inner face; outer face highly convex, broadly excavated near the margin except on the lower left side where the structure thickens to a rounded apex; to the left of the apex and below the midpoint there is a shallow spiral depression; surface more or less puckered by irregular shallow grooves.

Measurements of the figured specimen (K–1B, 937–947 ft), USNM 648294: width 3.3 mm, height 2.8 mm.

Occurrence: A total of 15 opercula were recovered from the 3 deep holes on Eniwetok Atoll at depths of 558–947 feet; four specimens were recovered from drill hole 2A on Bikini Atoll at depths of 925–1,063 feet. Age, late Tertiary (Tertiary *f–h* at Eniwetok; *f–g* at Bikini). A closely similar operculum was recovered from the Suva Formation on Viti Levu, Fiji (sta. FB–20); age, Miocene (Tertiary *f*).

Subgenus BELLASTRAEA Iredale

Iredale, 1924, Linnean Soc. New South Wales Proc., v. 49, p. 182, 232.

Type (by original designation): *Bellastraea kesteveni* Iredale (=*Astraea fimbriata* auct.). Recent, Australia.

Astraea (Bellastraea) sp. D

Plate 6, figures 21–23

Minute, lenticular; apex flattened, periphery with prominent flattened spines, 11 on last whorl; umbilicus wide and deep, bordered by a broad beaded rib. Measurements of the figured specimen (K–1B, Eniwetok, 841–853 ft) USNM 648295: height 1.1 mm, diameter 2.9 mm.

Occurrence: Figured specimen and six other examples from drill hole K–1B, Eniwetok Atoll, at depth of 841–853 feet in beds assigned to late Miocene (Tertiary *g*); two additional specimens from same drill hole at depth of 863–873 feet, early Miocene (Tertiary *f*); one specimen from hole F–1, Eniwetok, at depth of 1,210–1,220 feet (Tertiary *e*); a single specimen was found in drill hole 2A on Bikini Atoll at a depth of 1,030–1,034 feet (Tertiary *f*). The 11 small fossils are probably immature.

Astraea (Bellastraea) sp. E

Plate 6, figures 24–26

Minute, planoconvex; spire depressed; periphery with a row of broad flattened upturned spines (nine on body whorl); suture impressed, scalloped near aperture by peripheral spines of preceding whorl; below periphery, whorl is semicircular in section with a low median ridge bearing prominent widely spaced, rounded knobs; this basal ridge spirals into the wide umbilicus as does an

obscurely beaded rib bordering that structure; aperture subcircular.

Measurements of the figured specimen, USNM 648296: height 1.2 mm, diameter 3.2 mm.

The aperture of the single small fossil is incomplete. It is possible that the shell is immature, but comparisons with large astraeids that have depressed early whorls do not support this possibility. The fossil probably represents an undescribed species, possibly an undescribed subgenus, but a new name must await better type material. The species differs markedly from *Astrea* sp. D that has been recovered from the same horizon on Eniwetok. The form described as sp. E is flatter and has an impressed suture; it has fewer peripheral spines, and these are strongly upturned. The whorl is more convex below and bears a strongly beaded ridge.

Occurrence: Drill hole K–1B on Eniwetok Atoll at a depth of 1,196–1,207 feet; from early Miocene (Tertiary *e*).

Subgenus VITIASTRAEA Ladd, n. subgen.

Type: *Astraea (Vitiastraea) holmesi* Ladd, n. sp.

Small; spire low; early whorls with a nodose keel or shoulder from the base of which a flat scalloped fringe spreads outward to conceal the suture; shoulder becomes obsolete on the body whorl and below it the scalloped fringe changes into a peripheral keel which, in turn, dies out before reaching the aperture; a third keel appears on the body whorl below the peripheral keel; it descends below the periphery and dies out before reaching the aperture. Aperture circular; umbilicus narrow, surrounded by a coarsely puckered rib.

The scalloped fringe that overlaps the suture on the early whorls indicates clearly that *A. holmesi* is an astraeid, but the pattern set by the other disappearing keels is not to be matched closely in any of the numerous subgenera of *Astraea*. The closest approach seems to be in *Ormastralium* Sacco, known from the Miocene and Pliocene of Europe. In that group there is a spiny peripheral keel that, on the early whorls, covers the suture. Later whorls also have two other major keels, one above and one below the periphery. Both of these are armed with blunt knobs. None of the keels dies out before reaching the aperture, and the shell is imperforate.

Astraea (Vitiastraea) holmesi Ladd, n. sp.

Plate 6, figures 27–29

Small, low spired; apex flat; early whorls with a strong nodose keel or shoulder from the base of which a thin flat scalloped fringe extends outward to conceal the suture completely; shoulder dies out on body whorl and scalloped fringe changes to a sharp peripheral keel which also dies out before reaching aperture, a third spiral keel —strong and beaded—appears below the periphery on the body whorl; it descends gradually and dies out before reaching aperture. Aperture circular, outer lip thin, inner lip callused and broadly expanded below; umbilicus narrow, surrounded by a coarsely puckered rib.

Measurements of the holotype, USNM 648297: height 2.4 mm, diameter 3.0 mm.

Occurrence: Holotype and only specimen from the Miocene (Tertiary *f*) Suva Formation on Viti Levu, Fiji (sta. 160).

Genus ARENE H. and A. Adams

H. and A. Adams, 1854, Genera Recent Mollusca, v. 1, p. 404.

Type (by subsequent designation, Woodring, 1928, Carnegie Inst. Washington Pub. 385, p. 422): *Turbo cruentatus* Megerle von Mühlfeld. Recent, West Indies.

Arene (Arene) metaltilana Ladd, n. sp.

Plate 7, figures 1–6

Minute, strongly turreted; apex flattened; a smooth gently convex whorl of protoconch followed by 2½ sculptured whorls; aperture subcircular, inner lip expanded below; umbilicus moderately wide and deep. Sculpture consisting of three spiral ribs that form a flattened peripheral band on the body whorl; uppermost rib strongest, turned upward and scalloped into rounded scales that are most prominent on the earlier whorls; middle peripheral rib smaller than other two; flattened areas above and below peripheral band bear obscure axials; a broad puckered rib spirals into the umbilicus.

Measurements of the holotype, USNM 648298: height 1.2 mm, diameter 1.3 mm. Paratype, USNM 648299: height 1.2 mm, diameter 1.6 mm.

A. metaltilana is characterized particularly by the comparatively smooth flattened areas that lie above and below the strongly ribbed peripheral band.

Occurrence: Represented by only two shells, both from drill hole 2B on Bikini Atoll; holotype from a depth of 1,702–1,713 feet and paratype from a depth of 2,297–2,307 feet; age, early Miocene (Tertiary *e*).

Arene (Arene) sp. A

Plate 7, figures 7, 8

Very small; spire moderately high, turreted; apex depressed; about four whorls, flattened above a prominent shoulder; aperture subcircular; umbilicus narrow and deep, bordered by a heavy spiral. Sculpture consisting of three strong spiral ribs that form a flattened peripheral band on the body whorl; on earlier whorls the upper two of the primary whorls are conspicuously scalloped; three secondary spirals are present on the body whorl above

the peripheral band and others occur on the base; still finer spirals occur between the primary spirals; close-set oblique axials, present over the entire shell, cause beading of the secondary spirals and a puckering of the umbilical rib.

Measurements of the figured specimen, USNM 648300: height 2.3 mm, diameter (incomplete) 2.6 mm.

The species is represented by a single specimen on which the peristome is not preserved. There seems little question about the generic reference, but I have not found a close living relative in the Pacific. The fossil is similar in many ways to *A. mineata* Dall, a Recent species from Santo Domingo and other parts of the Caribbean, but it has a more depressed apex, a more prominent peripheral band, and more conspicuously scalloped early whorls.

Occurrence: Drill hole 2A, Bikini Atoll, at a depth of 742–747 feet; age, late Miocene (Tertiary *g*).

Genus LIOTINA Munier-Chalmas (*in* P. Fischer)

Munier-Chalmas *in* Fischer, P., 1885, Manual Conchology, p. 831.

Type (by subsequent designation) Cossman, 1888, Catalogue Illustre Coquilles Fossiles * * *, v. 3, p. 53): *Delphinula gervillei* Defrance. Middle Eocene, France.

Subgenus AUSTROLIOTIA Cotton

Cotton, 1948, Royal Soc. South Australia Trans., 72, p. 31.

Type (by original designation): *Liotia botanica* Hedley. Recent, New South Wales.

Liotina (Austroliotia) cf. L. botanica (Hedley)

Plate 7, figures 9–11

Small, lenticular, solid; about four whorls, gently convex above a weak shoulder, strongly and uniformly convex below; suture impressed; aperture circular and slightly oblique; peristome complete, outer lip thickened below shoulder to form a varixlike structure leading to a thick pad of callus that projects over part of the wide umbilicus. Sculpture consisting of 10 spiral ribs; the 3 that lie above the shoulder are weak, the others, including 1 that spirals into the umbilicus, are strong; spirals crossed by axial ribs, about 20 on body whorl, giving the shell a latticed appearance.

Measurements of the figured specimen, USNM 648301: height 1.4 mm, maximum diameter 3.3 mm, minimum diameter 2.3 mm.

The single fossil is somewhat worn but seems to agree in all essential features with the larger *L. botanica* (Hedley, 1915, p. 710), type species of *Austroliotia*.

Occurrence: In drill hole F–4–A, Elugelab Island, Eniwetok Atoll, at a depth of 6–12 feet; age, Recent.

Subgenus DENTARENE Iredale

Iredale, 1929, Queensland Mus. Mem., v. 9, p. 274.

Type (by original designation): *Dentarene sarcina* Iredale, new name for *Delphinula crenata* Kiener. Recent, Philippines.

Liotina (Dentarene) loculosa (Gould)

Plate 7, figures 12–14

Liotia loculosa Gould, 1862, Otia Conchologica, p. 114.
Johnson, 1964, U.S. Natl. Mus. Bull. 239, p. 103, pl. 5, fig. 15 above [not fig. 12].
Liotina cycloma Tomlin, 1918, Jour. Conchology, v. 15, no. 10, p. 305, pl. 10, figs. 1, 2.
Liotina (Dentarene) loculosa (Gould), Kuroda, 1960, Catalogue of molluscan fauna of Okinawa Islands, p. 5.

Medium in size, heavy, discoidal; spire low, body whorl descending to a circular aperture surrounded by a strong erect varix; umbilicus narrow and deep, with a ridge that merges with the varix surrounding the lip. Whorls of protoconch smooth, remainder of shell covered by fine close-set axial lamellae. Six spiral cords recognizable on the body whorl; the smallest of these, next to the suture, bears regularly spaced spiny elevations; a second cord, somewhat larger, forms a low shoulder and bears similar spiny elevations; two very strong cords form the periphery and their prominent spines are connected by the bundles of axial lamellae that form the spines; a fifth cord near the middle of the base is comparable in size to the cord at the shoulder; a sixth cord that encircles the umbilicus is deeply notched like a cog wheel.

Measurements of the figured specimen (E–1, Eniwetok, 110–120 ft) USNM 648302: height 3.6 mm, diameter 5.1 mm.

L. loculosa is similar to *L. crenata* (Kiener), type of the subgenus *Dentarene*, but that of Recent species, reported from the Philippines, Australia, and Ceylon, has a smooth base. *L. infensa* Finlay, a Recent Australian species, has wide umbilicus. *L. chinenensis* described by MacNeil (1960, p. 29, pl. 11, figs. 29–31) from the Pliocene of Okinawa is a larger and proportionately higher form with a wide umbilicus and fewer peripheral spines.

Occurrence: Rare examples, total of seven specimens, in four drill holes on Eniwetok Atoll at depths of 2–120 feet; all Eniwetok occurrences probably Recent. Common in beach drift at Rongerik Atoll; a single shell found at Bikini. The type, a Recent shell, was collected in the Ryukyu Islands. A single specimen from hole 2 on Bikini at depth of 86–87 feet is probably Recent; a worn specimen in the same hole from a depth of 1,366–1,377 feet (Tertiary *e*) may have been derived from a higher level.

Liotina (Dentarene) sp. A

Plate 7, figures 15–17

Medium in size; spire depressed, suture impressed; umbilicus moderately wide, deep. Whorls of protoconch smooth, remainder of shell covered by fine close-set axial lamellae. Six spiral cords recognizable on the body whorl: the uppermost of these is broad and low, lying about one-third of the distance from suture to periphery; the peripheral cord is the strongest and is extended into sharp spiny processes that give the shell a stellate appearance when viewed from above or below; four cords with low regularly spaced spiny projections occur below the periphery, the lowest closely encircling the umbilicus; spiny projections on basal cords merge to form distinct axial ribs.

Measurements of the figured specimen (E–1, 2,590–2,600 ft), USNM 648303: diameter (incomplete) 3.4 mm, height (incomplete) 1.9 mm.

Liotina sp. A is clearly distinct from *L. loculosa* Gould found in Recent beds at higher levels in Eniwetok drill holes. The Miocene shells have a lower spire, a wider umbilicus, and a single prominent peripheral cord; likewise, on the Tertiary shells the axial ribs below the periphery are much more conspicuous than on *L. loculasa*. The Miocene shells clearly represent an undescribed species but, because none of the available specimens has the aperture preserved, a specific name is withheld.

Occurrence: Five specimens from drill holes E–1 and K–1B on Eniwetok Atoll at a depth of 936–2,600 feet; age, early Miocene (Tertiary *e* and *f*).

Liotina (Dentarene) sp. B

Plate 7, figures 18–20

A single incomplete specimen (USNM 648304) from a drill hole on Bikini Atoll closely resembles *Liotina* sp. A from Eniwetok but has more numerous cords on the body whorl—three above the peripheral cord and four below—and lacks well-developed axial ribs on the base. The Bikini shell may represent a distinct species, but the single specimen does not show the apertural features and has, therefore, not been given a specific name. Measurements: diameter (incomplete) 2.2 mm, height (incomplete) 1.4 mm.

Occurrence: Drill hole 2B, Bikini Atoll, at a depth of 1,629–1,639 feet in beds referred to early Miocene (Tertiary *f*).

Genus TURBO Linnaeus

Linnaeus, 1758, Systema naturae, 10th ed., p. 761.

Subgenus TURBO s.s.

Type (by subsequent designation, Montfort, 1810, Conchyliologie systématique, v. 2, p. 203): *Turbo petholatus* Linnaeus. Recent, Indo-Pacific; also reported from upper Miocene and Pliocene of Java, the Pliocene and Quaternary of Timor and Okinawa, the Pliocene of Taiwan, the Quaternary of Celebes, and the Pleistocene(?) of Tonga.

Turbo (Turbo) petholatus Linnaeus

Plate 7, figures 21, 22

Turbo petholatus Linnaeus, 1758, Systema naturae, 10th ed., p. 762.
Reeve, 1848, Conchologica Iconica, v. 4, *Turbo*: pl. 3, fig. 12.
Sowerby, 1886, Thésaurus Conchyliorum *Turbo*, p. 191, pl. 40, fig. 46.
Pilsbry, 1888, Manual Conchology, v. 10: p. 193, pl. 40, fig. 14.
Ostergaard, 1935, B. P. Bishop Mus. Bull. 131, p. 48.
Ladd, 1945, B. P. Bishop Mus. Bull. 181, p. 354.
MacNeil, 1960, U.S. Geol. Survey Prof. Paper 339, p. 31, pl. 18, fig. 12.

Shell medium in size, turbinate, imperforate, solid; aperture circular, outer lip thin, inner lip callused; sculpture consisting of inconspicuous axial lines of growth.

Measurements of the figured specimens from Guam: (USGS 20653), USNM 648277: height (incomplete) 23.8 mm, diameter 23.8 mm; (USGS 20720), USNM 648278: height 29.4 mm, diameter 27.9 mm.

Occurrence: On Guam, single specimens from half a dozen localities in the reef facies and Agana Argillaceous Member of the post-Miocene Mariana Limestone and from beds that probably belong to the late Tertiary Alifan Limestone (Tertiary *g* or *h*). Previously described (single specimen) from the Futuna Formation, early Miocene (Tertiary *f*) from Lakemba in eastern Fiji, the upper Miocene and Pliocene of Java. Common in post-Tertiary beds in the New Hebrides (USGS 21028, Espiritu Santo). Recent shells have been collected from many parts of the Indo-Pacific region.

Turbo (Turbo) petholatus thanus Ladd

Plate 7, figure 23

Turbo (Turbo) petholatus thanus Ladd, 1934, B. P. Bishop Mus. Bull. 119, p. 203, pl. 35, fig. 3.

Four additional specimens have been collected from the type locality in Suva, Fiji—one juvenile and three adults. The color pattern, though faded, is recognizable as a series of revolving broken lines of dark spots and irregular areas, basically similar to those exhibited by living examples of *T. petholatus*.

Measurements of the figured specimen (Viti Levu, Fiji, sta. 160) USNM 648279: height 23.2 mm, diameter (incomplete) 23.2 mm.

Occurrence: Five specimens from station 160, Walu Bay, Suva, Fiji; age, Miocene (Tertiary *f*), Suva Formation. Two small specimens that apparently represent

this subspecies were collected from the Ndalithoni Limestone on Vanua Mbalavu in eastern Fiji (sta. 110C); age, probably Pliocene (Tertiary *h*).

A dozen heavy opercula, apparently referable to this species, were collected with the shells at stations 160, 160A, FB–20.

Subgenus MARMAROSTOMA Swainson

Swainson, 1829, Zool. Illus., 2d ser., v. 1, pl. 14.

Type (by original designation): *Turbo chrysostomus* Linnaeus. Recent, Pacific islands.

Turbo (Marmarostoma) chrysostomus Linnaeus

Plate 7, figure 24

Turbo chrysostomus Linnaeus, 1758, Systema naturae, 10th ed., p. 762.

Marmarostoma chrysostomus Linnaeus, Swainson, 1829, Zool. Illus., 2d ser., v. 1, pl. 14.

Turbo (Turbo) chrysostomus Linnaeus, Pilsbry, 1888, Manual Conchology, v. 10, p. 200, pl. 40, fig. 19.

A dozen specimens referable to this spirally ribbed and variable species were collected from several localities on Guam and one from the New Hebrides. Shells from both areas are strongly shouldered, the central part of each whorl being conspicuously flattened with strong scaly ribs at the top and bottom of the flattened band; ribs of two or three sizes alternate; on well-preserved specimens the scales on the main ribs are prominent open nodes.

Measurements of the figured specimen from Guam, USNM 648280: height 22.0 mm, diameter 22.9 mm.

Occurrence: Guam at USGS localities 20636 (figured specimen), 20533, 20732, and 21377 (all from the Agana Argillaceous Member of the Pliocene and Pleistocene Mariana Limestone); single incomplete specimen from New Hebrides, USGS 21028 in beds believed to be no older than Pleistocene. Recent shells have been collected in many island groups in the southwest Pacific.

Turbo (Marmarostoma) argyrostomus Linnaeus

Plate 7, figures 25, 26

Turbo argyrostomus Linnaeus, 1758, Systema naturae, 10th ed., p. 764.

Reeve, 1848, Conchologica Iconica, v. 4, pl. 2, fig. 7.

Pilsbry, 1888, Manual Conchology, v. 10, p. 197–198, pl. 40, fig. 18; pl. 42, fig. 41; pl. 46, fig. 8.

Ostergaard, 1935, B. P. Bishop Mus. Bull. 131, p. 47.

Demond, 1957, Pacific Sci., v. 11, p. 268–269.

Marmarostoma argyrostoma (Linnaeus), MacNeil, U.S. Geol. Survey Prof. Paper 339, p. 31, pl. 18, fig. 4.

This species seems to be the most abundant of several large strongly ribbed turbos that are widely distributed in the island area today, and the fossil collections suggest that this species was also most abundant in Pleistocene time. Plate 7, figure 25, shows a specimen with heavy operculum in place.

Measurements of the figured specimens: (1) specimen from Saipan (USGS 17387), USNM 648281; height (tip of spire broken) 59.5 mm, diameter 54.5 mm; (2) specimen from Guam, (USGS 20679) USNM 648282; height (spire incomplete) 62.6 mm, diameter 55.1 mm.

T. argyrostomus is closely related to *T. setosus* Gmelin, which is a species that has been reported over much of the same range although in less abundance. The two species show a distinct tendency to intergrade. End members of the two series exhibit four rather striking differences: *T. argyrostomus* has a strong shoulder, its ribs are spinose, it is distinctly umbilicate, and the inner side of its heavy operculum is flat or slightly convex. *T. setosus* shows no shoulder, its ribs are smooth except for growth lines, it is nonumbilicate, and the inner side of its operculum is distinctly concave. However, in a large series of Recent shells of *T. argyrostomus* there is a considerable variation in the development of the shoulder, the spines, and the umbilicus. The inner face of the operculum seems a constant character, but unfortunately one that can only rarely be used in studying fossils. At Funafuti, Hedley (1899a, p. 408) found *T. argyrostomus* on the west (lee) side of the atoll and *T. setosus* on the east (windward) side.

Occurrence: One of the commonest species in the Pliocene and Pleistocene Mariana Limestone of Guam, in the Pleistocene Tanapag Limestone of Saipan, and in limestones of Quaternary age in the New Hebrides and Tonga; an immature but typical specimen recovered from drill hole MU–5 on the island of Mujinkarikku, Eniwetok Atoll, at a depth of 18–21½ feet is Recent in age. An immature shell from a depth of 680–690 feet in drill hole F–1 on Eniwetok seems to represent this variable species. Though still preserving traces of the original color pattern on the spire, the single shell shows evidence of wear. The beds from which it is recorded are referred to the late Miocene (Tertiary *g*); it may have been derived from a higher horizon. Opercula that probably represent this species were recovered from three drill holes on Eniwetok at depths of 66–340 feet and molds from drill hole on Funafuti at depths of 922–1,053 feet; age, post-Miocene.

The species has been described from the Pliocene and Pleistocene of Okinawa. Living examples have been collected from many parts of the Indo-Pacific, from Aldabra Island in the western Indian Ocean through Indonesia to Australia, and the Pacific islands from Japan to the Tuamotus. It lives along the seaward reef edge, on the reef flats, and on lagoonal reefs.

Turbo (Marmarostoma) setosus Gmelin?

Plate 7, figure 27

Turbo setosus Gmelin, 1791, Systema naturae, 13th ed., p. 3494.
Reeve, 1848, Conchologica Iconica, v. 4, pl. 8, fig. 37.
Pilsbry, 1888, Manual Conchology, v. 10, p. 195, pl. 63, fig. 32.
Demond, 1957, Pacific Sci., v. 11, p. 387.

An incomplete mold from core piece 276 obtained at Funafuti in the Ellice Islands at a depth of 526–546 feet very probably represents this species. There is no indication of a shoulder nor of spines on the ribs such as characterize *T. argyrostomus* Linnaeus, described above; the broad ribs are wider than the interspaces, and secondary ribs are present. Figured specimen USNM 648283 is a cast whose height is 24 mm; it was taken from a core loaned by the British Museum; age post-Miocene. An incomplete and poorly preserved specimen from the post-Miocene Mariana Limestone of Guam (USGS 21373) may possibly represent the same species.

T. setosus has been reported from many island groups in the western Pacific. Hedley (1899a, p. 408) found it abundantly on the east side of Funafuti at low water on the outer reef.

Turbo (Marmarostoma) crassus Wood

Plate 8, figures 1, 2

Turbo crassus Wood, 1828, Index Testaceologicus supp., pl. 6, fig. 43.
Reeve, 1848, Conchologica Iconica, v. 4, fig. 10.
Pilsbry, 1888, Manual Conchology v. 10, p. 194, pl. 47, fig. 20.
Ostergaard, 1935, B. P. Bishop Mus. Bull. 131, p. 48.
Turbo canaliculatus Reeve, 1848, Conchologica Iconica, v. 4, fig. 27.

Shell large and heavy with broad flat spiral ridges separated by narrow shallow grooves. On many shells there is a strong spiral keel on the upper part of the whorl; above the keel the surface is deeply concave, below the keel a similar concavity, if present, is shallow. On the fossil specimens from Tonga, identified as this species by Ostergaard, the keel is present but not strongly developed.

Measurements of the figured specimen, B. P. Bishop Museum, 202976: height 79.3 mm, diameter 63.3 mm.

Occurrence: Two specimens from limestone near Houma village, Tongatabu, Tonga at an altitude of 35 feet; probably Pleistocene. Ostergaard also collected the species alive on a wave bench at the foot of a sea cliff below the fossil locality. I found it rare on the reefs on both sides of the entrance to Suva harbor, Fiji. Recent shells have also been collected from Samoa, the Admiralty and Solomon Islands, New Caledonia, and northern Australia.

Turbo (Marmarostoma) perlatus Abrard

Turbo (Senectus) perlatus Abrard, 1946, Annales de paléontologie, v. 32, p. 50, pl. 4, fig. 11.

As pointed out by the author of the species, *T. perlatus* is closely related to *T. chrysostomus* Linnaeus and *T. radiatus* Gmelin, differing from these by having well-developed beads on the spiral cords. The beads are not cut by the axial lamellae and are particularly conspicuous on the lower parts of the whorls and on the base. Some Recent shells of *T. chrysostomus* from New Caledonia, Palau, and the Philippines show a moderate development of beading on the lower spiral cords, but in no specimen was this feature as strongly marked as in *T. perlatus*.

The type, from the upper Miocene of Epi, New Hebrides, is probably a young shell. The species has not been found in the Miocene or in younger beds elsewhere in the islands.

Turbo (Marmarostoma) sp. A

Plate 8, figures 3, 4

Turbo sp. *a* Mansfield, 1926, Carnegie Inst. Washington Pub. 344, p. 88, pl. 3, fig. 2.
Turbo sp. *b* Mansfield, 1926, Carnegie Inst. Washington Pub. 344, p. 88, pl. 3, fig. 3a, 3b.
Turbo (Ocana) cf. *gruneri* Philippi, Ladd, 1935, B. P. Bishop Mus. Bull. 119, p. 204, pl. 35, figs. 4, 5.

Examination of additional material has shown that this strongly ribbed form should be placed in *Marmarostoma*. On the middle and upper parts of the whorls, large ribs alternate with small ribs, and on the base, the ribs are subequal in size. All ribs are beaded, those on the base and the upper parts of the whorls most conspicuously so.

Occurrence: Numerous molds from stations 160, 295 (figured specimen, B. P. Bishop Mus., geology No. 1228), and 297, Viti Levu, Fiji; age, probably early Miocene (Tertiary *f*).

Genus CYNISCA H. and A. Adams

H. and A. Adams, 1854, Genera Recent Mollusca, v. 1, p. 406.

Type (by original designation): *C. granulata* A. Adams=*Delphinula granulosa* [Dunker ms.] Krauss. Recent, off South Africa.

Cynisca pacifica Ladd, n. sp.

Plate 8, figures 5–7

Small, depressed-turbinate, thick; sutures channeled; umbilicus moderately wide, deep; aperture circular, faintly lirate within; upper edge of outer lip extended onto base of penultimate whorl. Sculpture consisting of strong spiral ribs all of which are made granulose by

axial lines; the peripheral rib and the three above it are larger than the five ribs on the base; of the basal ribs the two next to the umbilicus are more strongly beaded than the others.

Measurements of the holotype, only specimen, USNM 648284: height 4.1 mm, diameter 4.5 mm.

The Miocene shell from Eniwetok appears to be the only known fossil occurrence. At least six species have been referred to *Cynisca* and all were collected from the seas off South Africa—the extreme western edge of the Indo-Pacific region. *C. pacifica* is very closely related to the type *C. granulosa* and to four other species, the chief differences being in sculpture. *C. pacifica* has fewer ribs than the type *C. granulosa* Krauss; the beading of the ribs is not restricted to the upper ribs as in that species, and the apertural lirae are less well developed. *C. pacifica* appears to be most closely related to *C. forticostata* Smith, but that species has only seven spiral ribs. The three species named by Bartsch (1915, p. 163–166)—*C. gloriosa*, *C. alfredensis*, and *C. africana*—are based on worn beach shells, and the apertural features are obscure or wanting. *C. gloriosa* bears 11 ribs, *C. alfredensis* 7 ribs, and *C. africana* 8 ribs. On none of these three species is the beading developed on all ribs as in *C. pacifica*.

Occurrence: Drill hole E–1 on Eniwetok at a depth of 1,000–1,010 feet; age early Miocene (Tertiary *f*).

Genus LEPTOTHYRA Pease

Pease, 1869, Am. Jour. Conchology, v. 5, p. 70.

Type (by monotypy). *Leptothyra costata* Pease. Recent, Hawaii.

Leptothyra maculosa (Pease)

Plate 8, figures 8–13

Collonia maculosa Pease, 1868, Am. Jour. Conchology, v. 4, p. 91, pl. 11, fig. 1.

Leptothyra maculosa (Pease), Pilsbry, 1888, Manual Conchology 10, p. 256, pl. 57, fig. 60.

Shell minute, nacreous within; apex blunt, umbilicus narrow, aperture circular; edge of outer lip thin, basal edge of inner lip reflected outward; sculpture consisting of three strong primary spiral ribs, with secondary spirals between and below; uppermost of primary spirals, spiral nearest the suture, and one next to umbilicus beaded. Each of the primary ribs, and in some specimens, the basal ribs, spotted at regular intervals with reddish brown.

Measurements of the figured specimen (E–1, Eniwetok, 40–45 ft), USNM 648305: height 1.7 mm, diameter 1.6 mm.

Occurrence: The species is common in the post-Miocene parts of several holes on Eniwetok and Bikini Atolls. The shells are so characteristically marked that well-preserved specimens may be recognized with ease. The globular shells are so small and so light that they circulate freely in drilling mud, and occurrences of white glistening shells among buff-colored Tertiary fossils are not to be trusted. Some of the fossil occurrences, however, are preserved as are other Tertiary shells, and there is no reason to question the depths. A few of these fossils retain faint traces of original color. Unquestioned fossils were found in beds referred to Tertiary *f* and *g*, the maximum depth being 830–842 feet in hole K–1B on Eniwetok. The species also is abundant in the Miocene Suva Formation (Tertiary *f*) on Viti Levu (sta. 160). The Fijian shells are somewhat larger than those from the Marshall Islands and are badly worn, but there is little doubt that they represent the same species. Rare specimens were also found in the limestone of Tongatabu, Tonga (B. P. Bishop Mus., cat. 202980; sta. 3), probably Pleistocene, and in the Recent sediments drilled on Funafuti at depths of 65 and 70 feet.

The Recent shell was originally described from the Tuamotu [Paumotu] Islands. It has also been collected in Hawaii and is common in the northern Marshalls.

Leptothyra inepta (Gould)

Plate 8, figures 14–22

Monilea inepta Gould, 1861, Boston Soc. Nat. History Proc., v. 8, p. 16.

Pilsbry, 1889, Manual Conchology, v. 11, p. 254.

Johnson, 1964, U.S. Natl. Mus. Bull. 239, p. 91, pl. 4, fig. 2.

Minute, turreted; apex flattened or slightly depressed. Body whorl divided into three subequal parts by two spiral angulations; uppermost part flattened, middle section (between two angulations) gently convex, lowest part (base) convex. Suture impressed, aperture subcircular, outer lip thin, inner lip callused and extended below; umbilicus moderately wide, plicate. Sculpture consisting of about 20 strong spiral ribs, those at the angulations being larger than the others, except the rib encircling the umbilicus which is large and coarsely beaded; ribs on penultimate whorl beaded; on the base, small secondary ribs developed between some of the primary ribs. On the holotype (USNM 1372), axial bands of reddish brown cross the upper part of the whorls and near the aperture there are larger areas of pink; several of the fossils preserve remnants of this color pattern.

Measurements of the figured specimen (Mu–4; Eniwetok, 40½–41 ft), USNM 648306: height 2.8 mm, diameter 2.8 mm. Gould's type, USNM 1372 (pl. 8, figs. 19–22) measures: height 2.3 mm, diameter 2.5 mm.

The two angulations that enclose a nearly flat peripheral area particularly characterize this species.

Occurrence: Nine specimens from several drill holes at depths above 80 feet on Eniwetok Atoll; age, Recent. Gould's Recent type was collected at Kagoshima, Japan, in sand under 5 feet of water.

Leptothyra harlani Ladd, n. sp.
Plate 9, figures 1–3

Minute; spire low, turreted; apex depressed; body whorl with inconspicuous shoulder; suture impressed; aperture subcircular, outer lip thin, callus of inner lip extended below; umbilicus wide and deep. Sculpture consisting of spiral ribs of which three or four near the periphery are a little larger than the others; above and below peripheral zone, ribs beaded by axial striae; a coarse puckered rib surrounds the umbilicus. Well-preserved specimens retain traces of broad axial bands of brown color.

Measurements of the holotype (K–1B, Eniwetok, 663–674 ft), USNM 648307: height 1.9 mm, diameter 2.5 mm.

Resembles *L. inepta* but has a lower spire, is less strongly shouldered, and is less flattened around the periphery.

Occurrence: Eight specimens from drill holes E–1 and K–1B on Eniwetok Atoll at depths of 642–950 feet; age, Miocene (Tertiary *f–g*). A single specimen from drill hole 2B on Bikini at depth of 820–831 feet (Tertiary *g*) may represent the same species.

Leptothyra aff. L. laeta Montrouzier
Plate 9, figures 4–6

Small, slightly turreted; apex flattened, shell thick; body whorl with inconspicuous shoulder; outer lip thickened inside, its upper edge descending sharply at the aperture; suture impressed; aperture subcircular, strongly oblique; inner lip thickened below at termination of wide puckered rib surrounding the deep umbilicus. Sculpture consisting of numerous spiral ribs; near the periphery large ribs alternate with smaller ones; above the shoulder on early whorls the ribs are conspicuously beaded; ribs on base weakly beaded. Holotype and one other specimen retain faint traces of axial bands of brown color.

Measurements of the figured specimen (K–1B, Eniwetok, 957–968 ft), USNM 648312: height 2.9 mm, diameter 3.2 mm.

The four fossil specimens differ from Recent examples of *L. laeta* by having an inconspicuous shoulder; they are smaller than the Recent shells and may be immature; this would account for the fact that the columella is not excavated next to the umbilicus and for the absence of well-developed crenulations within the aperture. *L. laeta* has been reported from Australia, New Caledonia, Fiji, and the Solomon Islands (Pilsbry, 1888, p. 258); Hedley (1899a, p. 408) found the shells common on the lagoon beach at Funafuti.

Occurrence: Four specimens from drill holes E–1 and K–1B on Eniwetok Atoll at depths of 957–1,985 feet; age, early Miocene (Tertiary *e–f*); a single specimen from hole 2B on Bikini at 1,902–1,913 feet (Tertiary *e*) may represent the same species.

Leptothyra aff. L. candida (Pease)
Plate 9, figures 7–9

Minute, globose; whorls inflated; suture impressed, descending slightly at aperture; aperture circular, outer lip thin, inner lip expanded below; umbilicus narrow, plicate. Sculpture consisting of about 10 spiral ribs, 4 of which on the broad periphery are larger than the others; fine secondary ribs are discernible under magnification; ribs near the suture and those on the base are beaded.

Measurements of the figured specimen (drill hole BO–2–1, depth 7 inches), USNM 648308: height 1.7 mm, diameter 2.2 mm.

L. aff. *candida* appears to be characterized particularly by the uniform rate of curvature of its inflated whorls and the absence of a shoulder or strong peripheral rib. The ribs of the specimens from Eniwetok are more conspicuously beaded than ribs of shells from Hawaii.

Occurrence: Two specimens from Eniwetok Atoll: in drill hole BO–2–1 on island of Bogallua, at a depth of only 7 inches and in drill hole E–1, Parry Island at depth of 40–45 feet; age, Recent. The Eniwetok specimens appear to be closely related to *L. candida* from Hawaii, the area from which the shells described by Pease (1860, p. 436, as *Collonia? candida*) were obtained.

Leptothyra balnearii Pilsbry
Plate 9, figures 10–12

Leptothyra balnearii Pilsbry, 1920, Acad. Nat. Sci. Philadelphia Proc., v. 72, p. 378, fig. 14.

Minute, globose, wider than high; apex flattened, perforate, thick; aperture oblique, outer lip thin, inner lip expanded below. Sculpture consisting of smooth spiral ribs of which three or four on the gently rounded periphery are larger than the others; above there is a single beaded rib and, next to the suture, a wide beaded band; on the base three or four slightly beaded riblets and a larger beaded rib spirals into the umbilicus. On some shells, secondary threads are developed between the peripheral ribs. Well-preserved fossil specimens, like some

Recent shells, are red except for the first whorl and the umbilical area, which are colorless. Two older fossils retain traces of brown spots on the peripheral ribs of the body whorl, a pattern likewise found on the shells of living specimens.

Measurements of the figured specimen (drill hole F–1, Eniwetok Atoll, depth 55–60 ft), USNM 648309: height 0.7 mm, diameter 1.0 mm.

Occurrence: Represented by a total of seven specimens from five drill holes on Eniwetok Atoll. Five specimens from depths of 20–70 feet are Recent; one from a depth of 620–630 feet is late Miocene (Tertiary *g*); the oldest from a depth of 904–916 feet is early Miocene (Tertiary *f*).

Pilsbry's types were collected in Hawaii, off Waikiki at a depth of 25–50 fathoms. Shells have also been collected at other localities on Oahu and on Molokai and Kauai.

The Marshall Island fossils are smaller than the Hawaiian shells but appear identical in all other features. The species is similar to the type species *L. costata* Pease, a Recent species from Hawaii that has a different color pattern; *L. cotata* also differs by having a thicker outer lip.

Leptothyra wellsi Ladd, n. sp.

Plate 9, figures 13–15

Minute; spire flat or nearly so, umbilicus wide and deep; aperture oblique, outer lip thin, inner lip expanded below. Sculpture consisting of three or four smooth spiral ribs in the peripheral zone and smaller beaded ribs immediately above and below; a large rib that borders the umbilicus and two others that spiral into it are conspicuously beaded. The holotype, paratype B, and several other well-preserved specimens retain traces of radial brown bands on the crests of the ribs.

Measurements of the types: Holotype (F–1, Eniwetok, 690–700 ft), USNM 648310: height 0.9 mm, diameter 1.2 mm; paratype A (E–1, Eniwetok, 770–780 ft), USNM 648311, and paratype B (Viti Levu, Fiji, sta. 160), USNM 648406 have the same measurements as the holotype.

L. wellsi resembles *L. balnearii* that occurs most commonly in younger beds but has a lower spire and a much wider umbilicus. In two samples in which the species occur together they can be differentiated without difficulty.

Occurrence: More than 50 specimens from 30 levels in 3 drill holes on Eniwetok Atoll at a depth of 230–1,993 feet; 3 specimens from 2 deep holes on Bikini Atoll at depth of 862–884 feet; abundant in the Suva Formation at station 160 on Viti Levu, Fiji. Age, Recent or Pleistocene to early Miocene (Tertiary *e*).

Leptothyra glareosa marshallensis Ladd, n. subsp.

Plate 9, figures 16–20

Small, globose, thick; body whorl inflated but showing a suggestion of a shoulder; shoulder more prominent on earlier whorls, giving the shell a turreted appearance; suture impressed, descending at aperture; apex flattened; aperture circular, inner lip expanded below; umbilicus narrow and deep, partially filled by a low heavy beaded funicle. Sculpture consisting of fine close-set spiral ribs (about 24 on body whorl), the rib at the shoulder slightly larger than the others; ribs on earlier whorls and those near umbilicus beaded by axial lines. Colored pale brown or reddish brown with indistinct darker axial bands; apex and umbilical area white. Operculum: inside convex, warped, multispiral; outside with deep excentric pit with beaded margin, partially surrounded by five concentric flaring ridges.

Measurements of the holotype, a Recent shell from Bikini, USNM 648313: height 2.3 mm, diameter 2.6 mm. Operculum of paratype, a Recent shell occurring with holotype, USNM 648314: maximum diameter 1.1 mm, minimum diameter 0.9 mm.

Recent shells and fossils from the Marshall Islands have been compared with the types of Gould's *Monilea glareosa* (USNM 971 and 24227), with Recent shells collected in the Ryukyu (Loo Choo) Islands, and with shells from Japan and the Bonin Islands. The Marshall Island specimens, both Recent and fossil, differ only in the possession of a shoulder that is marked on the body whorl by an enlarged spiral rib. The species described by Pease as *Collonia granulosa* (1868, p. 92) and referred by Pilsbry to *Leptothyra* (1888, p. 259, pl. 57, fig. 59) appears to be identical with Gould's *Monilea glareosa*. Pease's type was collected on Ponape in the Caroline Islands, not far from the Marshalls, but it does not possess a distinct shoulder. A shoulder like that on the Marshall Islands specimens is found on Recent shells from New Caledonia (Acad. Nat. Sci. Philadelphia 271717).

Occurrence: Abundant in the Marshall Islands today. Holotype, a Recent shell dredged alive from a depth of 30 fathoms in Bikini lagoon. Six fossil specimens from three drill holes on Bikini were recovered from a depth of 110–295 feet; probable age, Recent to Pliocene (Tertiary *h*). Also present in numerous drill holes on Eniwetok Atoll at depths of 1–890 feet; age, Recent and Miocene (Tertiary *f* and *g*). Many opercula representing this species were recovered from several

Eniwetok drill holes from near the surface to 1,777 feet; age, Recent to Tertiary *e*.

Leptothyra picta (Pease)

Plate 9, figures 21–23

Collonia picta Pease, 1868, Am. Jour. Conchology 4, p. 91, pl. 11, fig. 1.

Leptothyra picta (Pease), Pilsbry, 1888, Manual Conchology, v. 10, p. 256, pl. 69, fig. 35.

Minute, strongly turreted; apex flat; suture impressed, descending abruptly at aperture; aperture circular, outer lip thin, inner lip thick and broadly expanded below; umbilicus exceedingly narrow, bordered by a broad beaded rib. Sculpture consisting of about 10 strong spiral ribs alternating fairly regularly with weak secondary ribs. Strong ribs at the suture, the shoulder, near the upper margin of the base, and next to the umbilicus are larger than the others; ribs on earlier whorls, those bordering the suture and near umbilicus are beaded.

Measurements of the figured specimen (E–1, 35–40 ft), USNM 648315: height 2.1 mm, diameter 2.3 mm.

Occurrence: Many specimens from drill hole E–1 on Parry Island, Eniwetok Atoll, at depth of 30–110 feet; age, Recent.

Originally described as a Recent shell from the Tuamotu Islands; later, reported from Tahiti, Society Islands; rare in the northern Marshalls. The fossils agree in all essential features with the types of *L. picta* (Acad. Nat. Sci. Philadelphia 38416), but the turreting in the fossils is a little stronger, particularly the strength of the strong spiral rib at the upper edge of the aperture.

Leptothyra emenana Ladd, n. sp.

Plate 9, figures 24–26

Small; spire low to medium, turreted; apex flat: suture impressed, descending at aperture; aperture subcircular, oblique; outer lip thin, inner lip thickened and on some specimens expanded below; umbilicus narrow, bordered by a large conspicuously beaded spiral rib. Sculpture variable, consisting of about 15 spiral ribs, the 4 that occur on the gently convex peripheral band being larger than those above and below; secondary spirals may alternate with larger spirals above the peripheral band; below the peripheral band the spirals are subequal in size, all being smaller than the rib next to the umbilicus; all spiral ribs except the lowest three of the peripheral band are more or less beaded. Well-preserved shells show traces of broad radial brown bands.

Measurements of the holotype (drill hole F–1, Eniwetok, depth 940–950 ft), USNM 648316: height 2.7 mm, diameter 2.8 mm. Paratype (F–1, 880–890 ft), USNM 648317: height 2.3 mm, diameter 2.6 mm.

This somewhat variable species is characterized particularly by the nearly flat peripheral band bearing four strong spiral ribs.

Occurrence: In all deep holes on Eniwetok and Bikini. On Eniwetok, 40 specimens were recovered from 26 samples. Most of these were in beds referred to the Miocene (Tertiary *e–g*); rare in beds that probably are Pliocene (Tertiary *h*); on Bikini a total of six specimens were recovered from the Miocene (Tertiary *e* and *g*).

Leptothyra sp. A

Plate 9, figures 27–29

Minute; spire medium, apex flattened; aperture subcircular; outer lip thin, inner lip slightly thickened, expanded below; umbilicus narrow, deep, puckered by a wide riblike elevation. Sculpture consisting of spiral ribs that are beaded and scalloped by axial lines; on the body whorl four ribs, larger than those above and below, form a peripheral band; three somewhat smaller spirals lie above the band and five obscure spirals lie below it; under magnification, fine threads can be seen between the ribs of the peripheral band and between those that lie above it; the uppermost of the peripheral ribs and the third one in the series are extended as a frill that is scalloped on part of the body whorl and on earlier whorls. Body whorl retains traces of broad radial bands of brown.

Measurements of the figured specimen, USNM 648318: height 2.0 mm, diameter 2.4 mm.

The single specimen described may represent an undescribed species, but its thin fluted outer lip indicates immaturity, and a specific name is withheld. The whiteness of the shell with its traces of brown suggests that the shell may have been derived from a higher level. It appears to be most closely related to *L. emenana*, differing chiefly by having scalloped peripheral ribs.

Occurrence: Drill hole K–1B, Eniwetok Atoll, at a depth of 642–653 feet; age, late Miocene (Tertiary *g*).

Family PHASIANELLIDAE

Genus PHASIANELLA Lamarck

Lamarck, 1804, Annales Mus. Histoire Naturelle, v. 4, p. 295.

Type (by ruling of Comm. Zool. Nomenclature, Zool. Nomenclature Bull., 1962, v. 19, p. 140): *Buccinum austrae* Gmelin. Recent, south coast of Australia.

Phasianella sp.

Plate 10, figures 10, 11

Eight specimens of phasianellid opercula were recovcrede from Miocene beds in three drill holes on Eniwetok and three from hole 2A on Bikini. Six of the opercula from Eniwetok occur in sediments referred to Tertiary *g* (642–898 ft); the remaining two, both incomplete, came

from a slightly lower level, 873–884 feet, in the top of the Tertiary *f* section. The Bikini specimens are from beds referred to Tertiary *f* (877–936 ft). Two opercula from the Tertiary marls of the Suva Formation (sta. FB–20) on Viti Levu, Fiji, appear to be identical with the Marshall Island specimens.

Operculum convex externally with a broad longitudinal off-center bulge, surface polished; internal surface concave with excentric paucispiral nucleus, surface striate. The striae meet the margin at right angles.

Measurements of the figured specimen (K–1B, Eniwetok, 841–853 ft), USNM 648327: maximum diameter 3.4 mm, minimum diameter 2.5 mm, convexity 1.1 mm.

Most of the opercula are too large to be assigned to any of the phasianellids recognized from the drill holes. Their size suggests that they belonged to shells having a height of at least 12 mm.

Genus GABRIELONA Iredale

Iredale, 1917, Malacological Soc. London Proc., v. 12, p. 327.

Type (by monotypy): *Phasianella nepeanensis* Gatliff and Gabriel. Recent, Australia.

Gabrielona raunana Ladd, n. sp.

Plate 10, figures 1–5

Small, globose, thin; spire low; smooth whorl of protoconch followed by about three rapidly increasing sculptured whorls; aperture broadly ovate, peristome thin, inner lip expanded below; umbilicus narrow; sculpture consisting of axial riblets that are coarser on the upper part of each whorl and near the umbilicus than elsewhere. Operculum (preserved in place in holotype) is paucispiral and gently concave externally, this face being marked on the last volution by an outer band of spiral ridges inside which is a wider band of curved axial ridges. Operculum of paratype C, USNM 648322, measures: maximum diameter 0.8 mm, minimum diameter 0.5 mm; the interior face is flattened by a shallow spiral depression and a rounded outer edge. Well-preserved shells have a pink tinge with irregular brown axial streaks extending downward from the suture; on paratype B, similar markings occur on the lower part of the body whorl.

Measurements of the holotype (F–1, Eniwetok, 20–45 ft), USNM 648319: height 1.4 mm, diameter 1.4 mm. Paratype A (F–1, Eniwetok, 20–45 ft), USNM 648320: height 2.0 mm, diameter 1.9 mm. Paratype B (E–1, Eniwetok, 40–45 ft), USNM 648321: height 1.5 mm, diameter 1.5 mm.

Differs from the type species, *G. nepeanensis* (Gatliff and Gabriel) by having the inner lip expanded below.

Occurrence: Thirty-four specimens recovered from shallow depths (20–110 ft) in five drill holes on Eniwetok Atoll; age, Recent. A single specimen from hole E–1 at a depth of 1,865–1,895 feet (Tertiary *e*) shows evidence of wear and was probably derived from a higher horizon. Not represented in the extensive Recent collections made on Eniwetok and nearby atolls.

Genus TRICOLIA Risso

Risso, Histoire naturelle des principales productions de l'Europe Meridionale, v. 4, p. 122.

Type (by subsequent designation, Gray, 1897, Zool. Soc. London Proc., pt. 15, p. 144): *Turbo pullus* Linnaeus. Recent, European seas.

Subgenus HILOA Pilsbry

Pilsbry, 1917, Acad. Nat. Sci. Philadelphia Proc., p. 207.

Type (by original designation): *Phasianella thaanumi* Pilsbry. Recent, Hawaii.

Tricolia (Hiloa) variabilis (Pease)

Plate 10, figures 6, 7

Collonia variabilis Pease, 1860, Zool. Soc. London Proc., p. 436.
Phasianella variabilis (Pease), Pilsbry, 1888, Manual Conchology, v. 10, p. 176, pl. 39a, figs. 21, 22.
Pilsbry, 1917, Acad. Nat. Sci. Philadelphia Proc., p. 207.

Small, thin, ovate; about four whorls, ventricose; suture deeply impressed; aperture subcircular, inner lip callused, slightly extended below and with a deep groove behind it in the umbilical region. Sculpture consisting of fine oblique axial lines; close-set spiral striae visible under magnification on some specimens. Specimens retaining traces of color show nearly continuous close-set brownish-red spiral lines or lines of dots and may show short thick red axial lines immediately below the suture; axial lines may be bunched in groups of three or four.

Measurements of the figured specimens (pl. 10, fig. 6; E–1, Eniwetok, 30–40 ft), USNM 648323: height 1.4 mm, diameter 1.1 mm; (pl. 10, fig. 7; E–1, Eniwetok, 40–45 ft), USNM 648324: height 1.9 mm, width 1.3 mm.

Occurrence: Common in many drill holes on Eniwetok Atoll from near the surface to a depth of 852 feet (Recent to upper Miocene, Tertiary *g*); four specimens from hole 2B on Bikini at depth of 1,482–1,870 feet (lower Miocene, Tertiary *e*). Recent shells were collected from Bikini, Eniwetok, Rongerik, and Rongelap Atolls. The fossils and the Recent Marshall Island shells are smaller on the average than the shells described by Pease from Hawaii, and they have a somewhat different color pattern. The pattern on the Hawaiian shells, as Pease's name suggests, is exceedingly variable, but on most shells the axial bands seem to dominate over the

spiral markings. Some Recent Hawaiian shells, however, exhibit close-set lines of red dots, a pattern that is strongly suggestive of that shown by the Marshall Island material.

Tricolia (Hiloa) sp. A

Plate 10, figure 9

Minute, thin, ovate; about three smooth ventricose whorls; suture impressed; aperture subcircular; inner lip expanded below with a shallow groove behind it in the umbilical region.

Measurements of the figured specimen, USNM 648326: height 0.9 mm, diameter 0.7 mm.

Tricolia sp. A should, perhaps, be placed with *T. variabilis* (Pease), but it has fewer whorls, a less prominent groove in the umbilical region, and a more expanded basal inner lip. The single Tongan specimen retains traces of spiral lines of short red dashes on body whorl.

Occurrence: Three specimens from the Miocene (Tertiary *f*) Suva Formation on Viti Levu, Fiji (sta. 160); a single specimen from Tongatabu in Tonga (B. P. Bishop Mus., cat. 202976) may represent this species; age, probably Pleistocene.

Family NERITOPSIDAE

Genus NERITOPSIS Grateloup

Grateloup, 1832, Soc. Linn. Bordeaux Actes, v. 5, p. 129.

Subgenus NERITOPSIS s.s.

Type (by monotypy): *Neritopsis moniliformis* Grateloup. Miocene, southern France.

Neritopsis (Neritopsis) radula (Linnaeus)

Plate 10, figures 12–14

Nerita radula Linnaeus, 1758, Systema naturae, 10th ed., p. 777.
Neritopsis radula (Linnaeus), Gray, 1899, Zoology, "Blossom," p. 138.
Neritopsis radula (Linnaeus), new subspecies?, Ladd, 1934, B. P. Bishop Mus. Bull. 119, p. 207, pl. 35, fig. 13.
Neritopsis radula (Linnaeus), Ladd, 1945, B. P. Bishop Mus. Bull. 181, p. 355, pl. 50, fig. L.

N. radula has been reported from the Recent fauna in many parts of the Indo-Pacific region (Marshall, Ellice and Loyalty Islands, New Caledonia, Java, and Mauritius) and has previously been found in the Tertiary and younger rocks of Fiji (sta. 160, Viti Levu; stas. L-24, L-35, L-45, L-46, Fulanga; L-120, Ongea; 110B, 110C, Vanua Mbalavu). Single typical specimens were collected on Guam from three localities (USGS 20534, 20614, and 20869) in the Mariana Limestone. In Palau the species was found in the Palau Limestone on Urukthapel (USGS 18322) and on Saipan in the Miocene Tagpochau Limestone (USGS 17723); a mold that may represent *N. radula* was recovered from the Quaternary beds drilled on Funafuti (core 563A, depth 1,015–1,025 ft).

In the Marshall Island drill holes, small unbroken specimens were recovered from cuttings from Bikini (2A, depth 284–290 ft) and from Eniwetok at depths ranging from 20 to 1,715 feet. Three of the six Eniwetok specimens are from the Miocene (two from Tertiary *f* and one from Tertiary *e*). The small Tertiary specimens, like the large specimen from the upper Tertiary of Viti Levu (Ladd and others, 1934), appears to be more coarsely sculptured than most Recent shells, but the differences are not great and hardly seem to justify the naming of a new subspecies.

Measurements of the figured specimen (F–1, Eniwetok, 960–970 ft), USNM 648238: height 2.8 mm, diameter 2.6 mm.

Family NERITIDAE

Genus NERITA Linnaeus

Linnaeus, 1758, Systema naturae, 10th ed., p. 776.

Type (by subsequent designation, Montfort, 1810, Conchyliologie systématique 2, p. 347): *Nerita peloronta* Linnaeus. Recent, West Indies.

Subgenus AMPHINERITA Martens

Martens, 1887, Systematische Conchylien-Cabinet, v. 2, pt. 11, p. 9.

Type (by subsequent designation, Baker, 1923, Acad. Nat. Sci. Philadelphia Proc., v. 75, p. 164): *Nerita umlaasiana* Krauss. Recent, Africa.

Nerita (Amphinerita) insculpta Récluz

Plate 10, figures 15, 16

Nerita insculpta Récluz, 1841, Rev. Zool., Soc. Cuvierienne, p. 152.

Small, stout; spire low; sculpture consisting of 10 broadly rounded spiral ribs separated by narrow interspaces and crossed by fine growth lines; outer lip crenulated by spiral ribs; inner lip and columellar deck smooth. Traces of dark spots are preserved along several of the spiral ribs.

Measurements of the figured specimen, USNM 648332: height 4.6 mm, diameter 5.3 mm.

Occurrence: Eniwetok Atoll, drill hole F–1, at depths of 680–690 feet and 690–700 feet (figured specimen); late Miocene, Tertiary *g*.

The two fossil specimens are smaller than Recent shells from the same area but probably are immature. They have fewer and coarser ribs than most Recent shells. The type specimen is a Recent shell from Timor; Hedley (1899a, p. 410) found the species living in the lagoon at Funafuti.

Nerita (Amphinerita) aff. N. polita Linnaeus

Plate 10, figures 17, 18

Small, globose, thick, highly polished; spire low, suture distinct; aperture polished within, outer lip thick, descending at the aperture; columellar deck convex, white, bounded posteriorly by a shallow groove; inner lip feebly dentate. Sculpture consisting of fine growth lines that may be prominent on the upper part of the body whorl close to the suture.

Measurements of the figured specimen (F–1, Eniwetok, 930–940 ft), USNM 648333: height 3.4 mm, diameter 4.1 mm.

The fossils resemble the Recent species *N. polita* Linnaeus (Tryon, 1888, p. 30, pl. 6, figs. 7–11, pl. 7, figs. 12–23) that occurs in abundance in the Marshall Islands and in many other parts of the Indo-Pacific region. The fossil differs in that its outer lip descends at the aperture, and its columellar callus is set off by a shallow but distinct groove.

Occurrence: Eight specimens (one immature) from three deep holes on Eniwetok Atoll at depth of 830–978 feet; age, Miocene (Tertiary *f–g*).

Subgenus RITENA Gray

Gray, 1858, Zool. Soc. London Proc., pt. 26, p. 92.

Type (by original designation) *Nerita plicata* Linnaeus. Recent, Indo-Pacific seas.

Nerita (Ritena) palauensis Ladd, n. sp.

Plate 10, figure 19

Shell medium sized, spire low; columellar deck irregularly tuberculated, inner lip with two large teeth; edge of outer lip thin, dentate within; sculpture of body whorl 14 or more heavy flattened ribs separated by narrower interspaces.

Holotype: USNM 648330: height 17.3 mm, diameter 20.9 mm.

N. palauensis is related to the Recent *N. lineata* Gmelin (Rippingale and McMichael, 1961, p. 41, pl. 3, fig. 7) from Indonesia and Australia, but the Recent shells have thinner and more numerous ribs and a smooth columellar deck.

Occurrence: Holotype and one other specimen from the breccia at the base of the Palau Limestone on Auluptagel Island (USGS 23642), Palau; late Miocene (Tertiary *g*); two other specimens from the same horizon nearby, USGS 17715 and 21290.

Nerita (Ritena) aff. N. undata Linnaeus

Several clusters of external molds of a large ribbed neritid similar in general features to the variable and widespread Recent *N. undata* were collected in 1899 by the U.S.F.C. steamer *Albatross* from Alofi on the western side of the island of Niue, an island in Tonga lying to the east of the main island group. The samples were collected from the third terrace; age, probably Pleistocene. On some of the fossils the ribs are beaded by axial lines, a feature not shown by *N. undata*.

N. undata has also been reported from the upper Miocene of Java.

Subgenus THELIOSTYLA Mörch

Mörch, 1852, Catalogus Conchyliorum D. A. d'Aguirra et Galdea, Comes de Yoldi, pt. 1, p. 167.

Type (by subsequent designation, Kobelt, 1879, Illustrirtes Conchylienbuch 2, p. 147): *Nerita albicilla* Linnaeus. Recent, Indo-Pacific.

Nerita (Theliostyla) cf. N. semirugosa Recluz

Nerita (Theliostyla) semirugosa Recluz, Ladd, 1945, B. P. Bishop Mus. Bull. 181, p. 355, pl. 50, fig. M.

Three incomplete and partly crushed specimens from stations 110B and 110C, Ndalithoni Limestone; age, probably Pliocene (Tertiary *h*), Vanua Mbalavu, Lau, Fiji may be identical with the Recent species (Tryon, 1888, p. 20, pl. 3, figs. 41–43). No additional material collected.

Nerita (Theliostyla) sp. A

Plate 10, figures 20, 21

Nerita (Theliostyla?) sp. Ladd, 1934, B. P. Bishop Mus. Bull. 119, p. 208, pl. 35, figs. 14, 15.

Shell small, subglobose, thick; spire low; columellar deck slightly concave and covered with circular and oval pustules; inner lip bearing rounded widely spaced denticles. Outer lip incomplete but apparently dentate within, bordered by a narrow grove and channeled posteriorly at its junction with the parietal wall. Surface of body whorl somewhat worn but showing traces of low close-set rounded spiral ribs and fine wavy lines of growth.

Measurements of single incomplete specimen, B. P. Bishop Museum, geology No. 1195: height 11.3 mm, diameter 12.8 mm.

This specimen was originally referred questionably to *Theliostyla* and compared with its type species *N. albicilla* Linnaeus. Following reexamination and comparison with additional Recent material it seems certain that the fossil is a *Theliostyla* and that it is similar to but not identical with *N. albicilla*. The most important difference between the fossil and the Recent shells is in the spiral ribs. Those of the fossil are lower and much more numerous than those of any specimens of the variable and widespread Recent species. The fossil probably

represents an undescribed species, but better type material should be obtained before it is named.

Occurrence: Viti Levu, Fiji (sta. 59); age, probably Miocene.

Nerita (Theliostyla) sp. B

Plate 10, figure 22

Nerita sp. Ladd, 1945, B. P. Bishop Mus. Bull. 181, p. 356.

Shell large, heavy; spire low; sculpture consisting of 14 heavy spiral ribs whose upper surfaces are nearly flat and whose sides are undercut; spaces between ribs flattened and slightly wider than ribs; ribs and interspaces crossed by numerous fine lines of growth that are slightly oblique to axes of ribs; growth lines near aperture especially prominent; outer lip crenulated by the ribs, coarsely dentate within; columellar deck pustulose.

Diameter of figured specimen, USNM 648331: 31.0 mm.

Appears to be closely related to *N. exuvia* Linnaeus, a Recent Indo-Pacific species, but that species shows a small median rib in each depression between the major ribs. The fossil may represent an undescribed species, but the single specimen is incomplete and the apertural features are somewhat obscured by recrystallization.

Occurrence: Single specimen from the island of Mango, Fiji (sta. M2D); age, probably Miocene. Collected by J. E. Hoffmeister.

Genus NERITINA Lamarck

Lamarck, 1816, Encyclopédie méthodique, Histoire naturelle des vers, v. 3, pl. 455; Liste p. 11.

Type (by subsequent designation, Children, 1823, Lamarck's genera of shells, p. 111): *Neritina pulligera* (*Nerita pulligera* Linnaeus). Recent, fluviatile, India and Melanesia.

Subgenus VITTA Mörch

Mörch, 1852, Catalogus Conchyliorum D. A. d'Aguirra et Galdea, Comes de Yoldi, pt. 1, p. 166.

Type (by subsequent designation, Baker, 1923, Acad. Nat. Sci. Philadelphia Proc., v. 75, p. 137): *Nerita virginea* Linnaeus. Recent, southern Florida to northern South America, estuarine and marine.

Neritina (Vitta) oualaniensis Lesson

Plate 10, figures 23–25

Neritina oualaniensis Lesson, 1830, Voyage de *La Coquille*, Zoologie, v. 2, p. 379.

Neritina ulanensis[2] Lesson, Tryon, 1888, Manual Conchology, v. 10, p. 41, pl. 13, figs. 56–68.

[2] "Ulan" is an old name for the island of Kusaie in the eastern Carolines. Tryon in substituting *ulanensis* for Lesson's *oualaniensis* appears to have attempted to correct Lesson's spelling of the type locality.

Shell small, spire moderately elevated, outer lip thin; inner lip callused, slightly convex, bearing small denticles; color pattern consisting of dark wavy lines interrupted by white triangular areas in spiral series, each triangle pointing forward, its sides outlined by a dark line.

Measurements of the figured specimens (pl. 10, figs. 23, 24), USNM 648334: height 6.3 mm, diameter 5.6 mm; (pl. 10, fig. 25) USNM 648335: height (incomplete) 5.0 mm.

Occurrence: Two specimens from the Pliocene and Pleistocene of Guam (USGS 20600 and 21377). Recent shells have been widely reported in the Indo-Pacific region, including Queensland, Australia. The species has also been reported from the lower and upper Miocene of Java.

Genus CLITHON Montfort

Montfort, 1810, Conchyliologie systématique, v. 2, p. 327.

Type (by original designation): *Nerita corona* Linnaeus. Recent, rivers of Asia and Indonesia to Melanesia.

Subgenus CLITHON s.s.

Clithon (Clithon) corona (Linnaeus)

Nerita corona Linnaeus, 1758, Systema naturae, 10th ed., p. 777.
Neritina brevispina Lamarck, 1822, Hist. Nat. Animaux sans Vertèbres, v. 6, pt. 2.
Theodoxus corona (Linnaeus), Baker, 1923, Acad. Nat. Sci. Philadelphia Proc., v. 75, p. 155.
Theodoxus (Clithon) corona (Linnaeus), Ladd, 1934, B. P. Bishop Mus. Bull. 119, p. 208, pl. 35, fig. 16, pl. 36, fig. 1.
Clithon (Clithon) corona (Linnaeus), Ladd, 1965, Malacologia, v. 2, p. 191.

A single worn specimen of this widespread and somewhat variable river snail was described and figured by Ladd from the Miocene Suva Formation (Tertiary *f*) of station 160, Viti Levu, Fiji. No other fossil examples have been collected in the island area.

Genus NERITILIA Martens

Martens *in* Martini and Chemnitz, 1879, Systematische Conchylien-Cabinet p. 18.

Type (by original designation): *Neritina rubida* Pease. Recent; fresh water, Tahiti.

Neritilia traceyi Ladd

Plate 10, figures 26, 27

Neritilia traceyi Ladd, 1965, Malacologia, v. 2, p. 191.

Minute, obliquely elliptical, smooth, thick; aperture lunate; inner lip convex, its margin edentulous; columellar deck convex, heavily callused, posterior margin of callus broadly convex.

Measurements of the holotype, USNM 648336: height 1.9 mm, diameter 2.5 mm.

N. traceyi has the edentulous inner lip that is characteristic of *Neritilia*, but the lip margin is convex, whereas in typical *Neritilia* it is straight. The inner lip of the fossil is more heavily callused than that of *N. rubida* (Pease), the type of the genus, but a callused lip comparable to that of the fossil is present on a small brackish-water *Neritilia* found in abundance of J. E. P. Morrison near the mouths of a coastal river in New Caledonia. The outer lip of the fossil is worn, and this fact explains, in part, the apparent great thickness of the shell and the shortness of its elliptical outline.

Occurrence: Holotype (only specimen) from drill hole 2B, Bikini Atoll at a depth of 2,154–2,165 feet; age, early Miocene (Tertiary *e*).

Genus SMARAGDIA Issel

Issel, 1869, Malacologia del Mare Rosso, p. 212.

Subgenus SMARAGDIA s.s.

Type (by subsequent designation, Kobelt, *in* Martini and Chemnitz, 1879, Systematische Conchylien-Cabinet v. 2, p. 246: *Nerita viridis* Linnaeus, Recent, Mediterranean Sea.

Smaragdia (Smaragdia) jogjacartensis (Martin)

Plate 10, figures 28–31; plate 11, figures 1, 2

Neritina jogjacartensis Martin, 1916; Die Altmiocäne faunades West-Progogebirges auf Java, Geol. Reichs-Mus. Leiden Samml., v. 2, no. 6, p. 259, pl. 3, figs. 82, 83.

Small; callus thick and broadly convex except near base of inner lip where it becomes the lining of a shallow depression; inner lip bearing fine denticles that are slightly coarser above; outer lip thin. Color pattern consisting of three broad spiral bands made up of close-set parallel axial brown lines; lined areas separated by narrow white spiral bands with short stubby extensions.

Measurements of the figured specimens (pl. 10, figs. 28, 29; Eniwetok drill hole F–1, 830–840 ft) USNM 648337: height 5.2 mm, diameter 5.9 mm; (pl. 10, fig. 30; K–1B, 841–853 ft) USNM 648401: height 2.5 mm, diameter 2.7 mm; (pl. 10, fig. 31; K–1B, 873–884 ft) USNM 648402: height 3.0 mm, diameter 3.6 mm; (pl. 11, figs. 1, 2); from Palau (USGS 21308) USNM 648403: height 2.6 mm, diameter 3.3 mm.

The color pattern exhibited by *S. jogjacartensis*, like that of most Smaragdias, is variable. The relative widths of the clear and shaded bands vary as do the lengths and orientation of the secondary branches.

Occurrence: Described originally from the lower Miocene of Java. In samples from 14 intervals in three deep holes on Eniwetok Atoll (F–1, 830–960 ft; E–1, 860–1,130 ft; K–1B, 842–988 ft) but never in great abundance. All the intervals are Miocene (Tertiary *e–g*); rare specimens were also found at three localities in the marl facies at the base of the late Miocene Palau Limestone in the Goikul area, Babelthuap, Palau.

Smaragdia (Smaragdia) aff. S. rangiana (Recluz)

Plate 11, figures 3, 4

Small, obliquely elongate; spire low, whorls with a well-developed shoulder close to the suture; suture descending sharply at aperture. Columellar deck heavily callused above, unevenly depressed below, delimited by a groove that deepens along the base; inner lip denticulate, the largest denticles lying immediately above the midpoint.

Measurements of the figured specimen, USNM 648338: height (incomplete) 3.2 mm, diameter 3.3 mm.

The Palauan fossil closely resembles the variable Recent species that has been reported from many parts of the Indo-Pacific area (Tryon, 1888, p. 55, pl. 18, figs. 89–92), but seems to have a stronger shoulder; no trace of color pattern is preserved on the single fossil.

Occurrence: Single incomplete specimen from late Miocene (Tertiary *g*) marls at the base of the Palau Limestone near Goikul, Babelthuap Island, Palau (USGS 21308).

Smaragdia (Smaragdia) colei Ladd, n. sp.

Plate 11, figures 5–7

Small, obliquely elongate; spire low; body whorl inflated, with obscure shoulder close to suture. Upper two-thirds of columellar deck covered by thick pad of callus that is separated by a groove from the depressed but gently convex lower third; inner lip denticulate, one or two teeth near the midpoint larger than the others; outer lip thin (broken in most specimens). Color pattern consisting of spiral lines of brown dots. On some specimens, including the holotype, lines are arranged in bands of three lines each; on other shells (pl. 11, fig. 7) the lines of dots cover the entire shell uniformly; on a few shells the lines of dots are reduced or entirely absent.

Measurements of the holotype (F–1, Eniwetok, 880–890 ft), USNM 648339: height 5.6 mm, diameter (outer lip incomplete) 5.4 mm. Paratype (F–1, Eniwetok, 830–840 ft), USNM 648405: height 3.8 mm, diameter 4.1 mm.

S. colei is characterized particularly by its depressed lower columellar deck; in the types and many other specimens this deck is sharply set off from the callus above; in a few shells the line of demarkation is less sharp. The color pattern appears variable, as in many neritids. Specimens showing the dots uniformly dis-

tributed strongly resemble the pattern on a specimen from the upper Miocene of East Borneo (Beets, 1941, p. 21, pl. 1, fig. 30). The Borneo specimen was referred to the Recent *S. rangiana* (Récluz), widely reported from the Indo-Pacific area.

Occurrence: Abundant (33 lots containing 77 specimens) in all 3 deep holes on Eniwetok Atoll at depths of 780–1,688 feet; age, Miocene (Tertiary *e–g*). A single poorly preserved specimen from drill hole 2A on Bikini, depth 967–978 feet (Tertiary *g*), probably represents the same species.

Smaragdia (Smaragdia) sp. A

Plate 11, figures 8, 9

Shell minute, thin; spire low; callus large, moderately convex, very thick above, slightly thickened below; color pattern of body whorl consisting of two spiral rows of short axial brown dashes; in the upper row the lines are paired, in the lower row arranged in groups of three.

Measurements of the figured specimen (K–1B, Eniwetok, 715–727 ft), USNM 648340: height 1.4 mm, diameter 1.4 mm.

Smaragdia sp. A is smaller than *S. semari* Beets from the late Miocene of East Borneo (Beets, 1941, p. 22, pl. 1, figs. 31–43) and has one less spiral row of axial dashes.

Occurrence: In drill holes K–1B (depth 716–727 ft) and F–1 (depth 660–670 ft) on Eniwetok Atoll in beds referred to late Miocene (Tertiary *g*).

The two specimens from Eniwetok are not given a name because they are probably immature. Fragments from drill holes 2A (depth 1,082½–1,088 ft) and 2B (depth 1,576½–1,587 ft) on Bikini in beds referred to Tertiary *f* and *e*, respectively, show a somewhat different color pattern but may represent the same species.

Genus PISULINA Nevill and Nevill

Nevill and Nevill, 1869, Jour. Asiatic Soc. Bengal, v. 38, pt. 2, no. 2, p. 160, pl. 17, fig. 4.

Type (by monotypy): *Pisulina adamsiana* G. and H. Nevill. Recent, Ceylon.

Pisulina subpacifica Ladd, n. sp.

Plate 11, figure 10

Minute, globular; spire very low, aperture semilunar; outer lip thick, inner lip thinly callused with a large tooth centered below the midpoint and occupying fully one-third of the length of the lip; no trace of color pattern.

Measurements of the holotype, USNM 648341: height 1.2 mm, diameter 1.3 mm.

Occurrence: Holotype, the only specimen, from drill hole 2B on Bikini at depth of 789–799 feet; age, late Miocene (Tertiary *g*).

The single large tooth differentiates this species from all other neritids reported from the island area. The genus has previously been known only from a few species living in India and Ceylon. The type species is a larger shell (the single fossil may be immature) with a higher spire.

Family LITTORINIDAE

Genus TECTARIUS Valenciennes

Valenciennes, 1833, Coquilles, *in* Humboldt and Bonpland, Voyage aux régions équinoxiales du Nouveau Continent, v. 2, p. 271.

Type (by monotypy): *Tectarius coronatus* Valenciennes. Recent, Indo-Pacific.

Subgenus SUBDITOTECTARIUS Ladd, n. subgen.

Type: *Tectarius (Subditotectarius) rehderi* Ladd, n. sp., Miocene (Tertiary *f*), Bikini Atoll.

Small, stout; spire conical, base convex; marked with beaded spiral ribs and slightly oblique axial lines; strongly lirate within.

Distinguished by subdued sculpture; the strong tubercles that characterize other subgenera are represented only by small beads.

Tectarius (Subditotectarius) rehderi Ladd, n. sp.

Plate 11, figures 11–13

Small, conical; whorls flat, base convex, imperforate; aperture broadly ovate, columella thickened below by a broad tooth; outer lip thin, strongly lirate within. Sculpture above the periphery consisting of five or six regularly spaced spiral ribs, the ribs close to the periphery being the strongest; on the base a strong rib lies immediately below the periphery and smaller ones lie between it and the columella.

Measurements of the holotype, USNM 648342: height 2.8 mm, diameter 2.4 mm.

The apertural features including the lirate interior and the columellar tooth seem to place the fossils clearly in the genus *Tectarius*. In general form and outline the shells resemble *Plesiotrochus*, a cerithid that occurs with them. The sculpture of the fossils is basically similar to that of *Tectarius* s.s. but is much subdued. It is not known to be closely related to any living species.

Occurrence: Holotype from drill hole 2A on Bikini Atoll from a depth of 1,051–1,057 feet; a second specimen from F–1, Eniwetok at a depth of 960–970 feet; age, early Miocene (Tertiary *f*).

Family IRAVADIIDAE

Genus IRAVADIA W. T. Blanford

Blanford, W. T., 1867, Jour. Asiatic Soc. Bengal, v. 36, pt. 2, no. 1, p. 56–58, pl. 13, figs. 13, 14.

Type (by monotypy): *Iravadia ornata* Blanford. Brackish water, Recent, India.

Small *Rissoina*-like shells with strong spiral ribs and a callused unbroken aperture that is effusive anteriorly. Shell covered with a heavy periostracum. The type species lives in the brackish waters of the Irrawaddy delta, but another species lives under stones at extreme low water (Nevill, 1885, p. 97), and it is apparently marine.

Iravadia gardnerae Ladd, n. sp.

Plate 11, figures 14, 15

Shell small, slender. Protoconch consisting of about two smooth whorls; later whorls gently convex, sutures impressed; body whorl with eight strong spiral ribs that are slightly narrower than the spaces between; penultimate whorl with four exposed ribs, earlier whorls with less; aperture oval, continuous, with a distinct anterior canal; interior of outer lip with three low elongate ridges.

Measurements of the holotype, USNM 648343: height 3.3 mm, diameter 1.3 mm.

The fossil species closely resembles *I. annulata* Dunker (=*I. trochlearis* (Gould)) from Japan and the China coast, but shells of the Recent species are larger and stouter and the aperture is more heavily callused and less effusive anteriorly. The ridges inside the outer lip of the Recent shells are obscured by callus; most specimens show only one ridge (posterior), a few show two, and on rare shells all three are discernible.

Occurrence: A total of 41 specimens were found in the cuttings from the three deep holes on Eniwetok (F–1, 850–910 ft; E–1, 670–790 ft; K–1B, 800–936 ft); one specimen was recovered from a core in hole 2A on Bikini at 935 feet, 6 inches. Most of the occurrences are in beds referred to Tertiary *g*, but a few are from beds (below 860 ft) that are referred to Tertiary *f*. The holotype is one of a dozen specimens from hole K–1B, depth, 831–842 feet.

Family RISSOIDAE

The rissoids include a great variety of small or minute high-spired shells that are extraordinarily abundant today in coral reef environments, particularly in lagoons. This abundance is not reflected in collections of fossils made from elevated reefs because preservation in such structures is generally poor. Well-preserved rissoids are found in abundance in drill holes through lagoonal beds on reef islands and in marly sediments laid down in shallow waters near volcanic islands.

In the present report the arrangement of genera and subgenera given by Wenz (1938–44) has been followed fairly closely. A total of 9 genera, 17 subgenera (1 described as new), and 54 species and subspecies has been recognized. Because many are represented by one or by only a few specimens, it is difficult or impossible to determine limits of variation. If more material were available, the species list might be shortened.

Genus PUTILLA A. Adams

A. Adams, 1867, Zool. Soc. London Proc., p. 312, 315.

Type (by monotypy): *Putilla lucida* A. Adams. Recent, Japan.

Includes very small short-spired shells with smooth or striate rounded whorls and a thickened outer lip.

Subgenus PSEUDOSETIA Monterosato

Pseudosetia Monterosato, 1884, Conchiglie Littorali Mediterranee, p. 33.

Type (by subsequent designation, Bucquoy, Dautzenberg, and Dollfus, 1898, Mollusques Marins du Roussillon, v. 2, p. 772): *Rissoa turgida* Jeffreys. Recent, Norway.

Putilla (Pseudosetia) morana Ladd, n. sp.

Plate 11, figures 16, 17

Minute, elongate, with blunt apex; smooth convex whorl of protoconch followed by 3½ gently convex sculptured whorls; imperforate; aperture broadly oval, slightly constricted, peristome entire, inner lip thinly callused, edge of outer lip sharp, slightly thickened behind. Sculpture consisting of fine spiral striae over the entire surface of the postnuclear whorls.

Measurements of the holotype, USNM 648344: height 1.1 mm, diameter 0.4 mm.

The Eniwetok fossil resembles the larger *Putilla semistriata* Montague, a Recent European species, but the fossil is stouter and has a more blunt apex.

Occurrence: Single specimen from drill hole E–1, Eniwetok Atoll, at a depth of 1,805–1,835 feet; age, early Miocene (Tertiary *e*).

Subgenus PARVISETIA Monterosato

Monterosato, 1884, Nomenclatura generica e spezifica di alcune conchiglie mediterranee, p. 73, Palermo.

Type (by monotypy): *Rissoa scillae* Seguenza. Recent, Sicily.

Putilla (Parvisetia) goikulensis Ladd, n. sp.

Plate 11, figures 18–20

Minute, ovate, with short spire and blunt apex; about four smooth convex whorls; imperforate, aperture broadly rounded, slightly constricted, peristome entire, outer lip thin, on some specimens slightly thickened behind.

Measurements of the holotype, USNM 648345: height 1.1 mm, diameter 0.5 mm. Paratype, USNM 648346 measures: height 0.9 mm, diameter 0.5 mm.

P. goikulensis closely resembles *P. scillae* (Seguenza), the type of *Parvisetia*, but is smaller, more robust, and has a relatively smaller aperture.

Occurrence: Abundant in the late Miocene (Tertiary *g*) marls at the base of the Palau Limestone on the Goikul Peninsula, Babelthuap Island, Palau. (USGS 21301, 21308 (types), 21310).

Putilla (Parvisetia) suvaensis Ladd, n. sp.

Plate 11, figures 21, 22

Minute, ovate, with short spire and blunt apex; about four smooth whorls, fattened below a weak shoulder; aperture subcircular, slightly constricted; peristome entire, margin of outer lip thin but thickened behind into a varix.

Measurements of the holotype, USNM 648347: height 0.9 mm, diameter 0.6 mm.

Putilla suvaensis has a shorter spire and less convex whorls than *P. (P.) goikulensis* from beds of comparable age in Palau.

Occurrence: Three specimens from the Suva Formation, Viti Levu, Fiji (stas. 160, FB–20 (holotype) and MR–20); age, Miocene (Tertiary *f*).

Genus CINGULA Fleming

Fleming, 1828, British animals, p. 297, 305.

Type (by subsequent designation, Gray, 1847, Zool. Soc. London Proc. p. 153): *Turbo cingillus* Montagu. Recent, Atlantic coasts of Europe.

Small shells with gently convex whorls that may be smooth or spirally striate; outer lip sharp or slightly thickened.

Subgenus PERINGIELLA Monterosato

Monterosato, 1878, Giorn. sci. nat. econ. Palermo, v. 13, p. 87.

Type (by monotypy): *Rissoa laevis* Monterosato. Recent, Mediterranean Sea.

Includes minute to small species with blunt apex and slightly thickened outer lip.

Cingula (Peringiella) parryensis Ladd, n. sp.

Plate 11, figures 23, 24

Small, elongate-oval with large body whorl, short spire, and blunt apex. Protoconch has about 1½ gently convex, polished, whorls showing fine axial lines under high magnification, coiled to form an apical depression; about three subsequent whorls, bearing faint spiral lines; suture slightly channeled, bordered below by an obscure elevated thread. Aperture oval, angled above, peristome complete; inner lip callused, slightly extended below; edge of outer lip sharp, thickened behind by a riblike callus.

Measurements of the holotype, USNM 648348: height 1.7 mm, diameter 0.8 mm.

Cingula parryensis resembles the Recent *C. lampra* described by Suter (1908, p. 29) from New Zealand, but that species does not have the depressed apex exhibited by the fossil.

Occurrence: Holotype and only specimen from drill hole E–1 on Eniwetok Atoll at a depth of 700–710 feet; age, late Miocene (Tertiary *g*).

Cingula (Peringiella) cf. C. roseocincta (Suter)

Plate 11, figures 25, 26

Minute, globose, with blunt apex, short spire, and large body whorl. Protoconch consisting of 1½ smooth convex whorls, followed by about 2½ smooth gently convex subsequent whorls. Suture well impressed, aperture broadly elliptical; peristome complete in adult specimens, flaring slightly below, with a deep groove behind inner lip in the umbilical region; edge of outer lip thin, thickened behind into an inconspicuous callus.

Measurements of the figured specimen, USNM 648349: height 1.0 mm, diameter 0.6 mm.

The fossil shells appear to be closely related to *C. roseocincta* (Suter, 1908, p. 29, pl. 2, fig. 26; 1913–15, p. 209, pl. 12, fig. 17) and may be identical with it. One of the characteristics of the living shells is the color pattern: pink early whorls and pink bands on the body whorl. The fossils show no trace of color and this lack coupled with the general simplicity of form of these minute shells would seem to make a positive identification unwarranted.

Occurrence: Abundant in the late Miocene marls (Tertiary *g*) at the base of the Palau Limestone on Goikul Peninsula, Babelthuap Island, Palau (USGS 21301, 21304 (figured specimen), 21308 and 21310); a single specimen from drill hole E–1, Eniwetok Atoll, at depth of 620–630 feet (Tertiary *g*); four specimens from drill hole MU–4 from a depth of 41 feet are Recent in age.

Genus AMPHITHALMUS Carpenter

Carpenter, 1864, British Assoc. Adv. Sci. Rept., 1863, p. 614, 656.

Type (by original designation): *Amphithalmus inclusus* Carpenter. Recent, California.

The genus *Amphithalmus* includes small elongate shells with a blunt apex. In *Amphithalmus* s. s. the oval aperture is surrounded by a double peristome.

Subgenus CEROSTRACA Oliver

Oliver, 1915, New Zealand Inst. Trans., v. 47, p. 521.

Type (by original designation): *Cerostraca iredalei* Oliver. Recent, Kermadec Islands.

Thin ovate shells with impressed suture; aperture entire, sometimes detached; outer lip with a varixlike callosity.

Amphithalmus (Cerostraca) jeffcoati Ladd, n. sp.

Plate 11, figures 27–31

Small, thin, ovate; about five convex whorls; suture impressed; aperture broadly lenticular to subcircular; margin of callus of inner lip distinct, in some shells separated from the body whorl; outer lip thin, slightly expanded with a conspicuous callosity a little distance behind the edge. Shell smooth or with rounded slightly oblique axial ribs that are best developed on the central part of the body whorl.

Measurements of the holotype (smooth shell from E–1, 840–850 ft) USNM 648350: height 1.9 mm, diameter 1.2 mm. Paratype A (weakly ribbed shell from K–1B, 968–978 ft), USNM 648351: height 1.9 mm, diameter 1.2 mm. Paratype B (strongly ribbed shell from E–1, 1,010–1,020 ft), USNM 648352: height 2.3 mm, diameter 1.3 mm.

Some of the Marshall Island fossils show a detached aperture comparable to that of the Recent type species *C. iredalei* Oliver, but on other specimens there is no gap between the inner lip and the shell, though the margin of the inner lip is distinct. Some of the fossils are smooth, as is the type specimen, others have well-developed axial ribs on the lower whorls, all gradations between these two conditions being recognizable.

Occurrence: In all three deep drill holes on Eniwetok Atoll at depths of 620–2,060 feet but never in abundance; age, Miocene (Tertiary *g–e*). A single specimen from hole F–1 at a depth of 55–60 feet is Recent. It is more slender than the older shells and has 6½ smooth whorls but is not recognized as a distinct species. One specimen in hole 2A on Bikini at a depth of 935–946 feet is referred to Tertiary *g*; three specimens in hole 2B on Bikini from 1,870–1,944 feet are referred to Tertiary *e*.

Amphithalmus (Cerostraca?) myersi Ladd, n. sp.

Plate 11, figures 32, 33

Very small, elongate-ovate, robust; about 1½ smooth convex whorls of protoconch followed by three gently convex sculptured whorls, each of the subsequent whorls with an obscure shoulder about a third of the way below the moderately impressed suture; aperture subcircular; inner lip thinly callused, outer lip sharp but expanded behind into an inconspicuous varixlike callosity. Sculpture consisting of fine spiral lines.

Measurements of the holotype, USNM 648353: height 1.5 mm, diameter 0.9 mm.

Reference of *A. myersi* to *Cerostraca* is questioned because of the presence of fine spiral sculpture. The species is smaller and more slender than *A. jeffcoati* that occurs with it in drill hole E–1 on Eniwetok.

Occurrence: Holotype and only specimen from drill hole E–1, Eniwetok Atoll, at a depth of 770–780 feet; age, late Miocene (Tertiary *g*).

Subgenus PISINNA Monterosato

Monterosato, 1878, Giorn. sci. nat. econ. Palermo, v. 13, p. 86.

Type (by monotypy): *Rissoa punctulum* Philippi (=*R. glabrata* auct.=*R. seminulum* Monts=*R. sabulum* Cantraine=*R. mandralisci* Aradas). Recent, Mediterranean Sea.

Small elongate-oval to pupoid shells with oval to subcircular aperture; smooth or with axial folds.

Amphithalmus (Pisinna) bikiniensis Ladd, n. sp.

Plate 12, figure 1

Minute, pupoid, stout, polished; 1½ moderately convex whorls of protoconch followed by about four flattened whorls; suture impressed; imperforate; aperture broadly ovate, slightly constricted; inner lip callused, its boundary sharply defined; outer lip sharp, thickened within. Shell smooth or with a few obscure axial folds on body whorl.

Measurements of the holotype (2B, Bikini, 1,839–1,850 ft), USNM 648354: height 1.7 mm, diameter 0.7 mm.

A. (P.) bikiniensis resembles the Recent *Rissoa subfusca* Hutton from the New Zealand area (Suter, 1913–15, p. 210, pl. 12, fig. 18). Iredale (1915, p. 254) later placed *R. subfusca* in *Estea* (=*Pisinna*), but that species has more whorls and shows traces of microscopic spiral striation.

Occurrence: In drill hole 2B on Bikini Atoll; total of 17 specimens in 8 lots at depths of 1,807–1,892 feet; age, early Miocene (Tertiary *e*).

Genus ALVANIA Risso

Risso, 1826, Histoire naturelle des principales productions de l'Europe méridionale, v. 4, p. 140.

Type (by subsequent designation, Monterosato, 1884, Conchiglie Littorali Mediterranee, p. 19): *Rissoa montaqui* Payraudeau=*R. sardea* Risso. Recent, Mediterranean Sea.

Alvania s.s.

Small robust conical shells with a sharp apex and an elongate-oval aperture; bearing strong axial ribs and weaker spirals; outer lip thickened.

Subgenus TARAMELLIA Seguenza

Seguenza, 1903, Palaeontographica Italica, v. 9, p. 53–54.

Type (by monotypy): *Turbo zetlandica* Montagu. Recent, Europe.

Small elongate to conical shells with strong spiral ribs and equally strong axial ribs except below periphery; aperture circular, peristome double.

Alvania (Taramellia) corayi Ladd, n. sp.

Plate 12, figure 2

Minute, broadly conical, stout; apex sharp; protoconch large, consisting of about two smooth whorls; later whorls flat, suture incised; imperforate; aperture subcircular; lip double, inner one continuous, outer one thickened. Sculpture consisting of strong spiral ribs and somewhat weaker axial ribs; axial sculpture much reduced on lower half of body whorl.

Measurements of the holotype, USNM 648355: height 1.6 mm, diameter 1.3 mm.

The Eniwetok fossil is not turreted as is the type species of *Taramellia;* its whorls are flatter and its outer lip is much thicker than in the type.

Occurrence: Seventeen specimens from several drill holes on Eniwetok Atoll to depths of 60 feet (holotype from Mu–4, depth 35–36 ft); all occurrences probably Recent.

Alvania (Taramellia) kenneyi Ladd, n. sp.

Plate 12, figure 3

Minute, conical, solid; protoconch large, bulbous, consisting of about 2½ smooth whorls; later whorls flat, suture deeply incised; imperforate; aperture circular; inner lip double. Sculpture of body whorl consisting of six strong spiral ribs, the upper two of which are cut into sharp upturned projecting points by axial ribs that give the shell a stellate appearance when viewed from above.

Measurements of the holotype (E–1, Eniwetok, 1,746–1,777 ft), USNM 648356: height 0.8 mm, diameter 0.5 mm.

A. kenneyi is smaller than *A. corayi*, has a more deeply incised suture and a thinner outer lip.

Occurrence: Six specimens from drill hole E–1, Eniwetok Atoll, at depths of 830–1,925 feet; age, Miocene (Tertiary *g* and *e*).

Genus MERELINA Iredale

Iredale, 1915, New Zealand Inst. Trans., v. 47, p. 449.

Type (by original designation): *Rissoa cheilostoma* Tenison-Woods. Recent, Tasmania.

Subgenus MERELINA s.s.

Includes moderately solid strongly clathrate shells; protoconch spirally striate, peristome continuous, duplicated internally.

Merelina (Merelina) pisinna (Melvill and Standen)

Plate 12, figures 4, 5

Alvania pisinna Melvill and Standen, 1896, Jour. Conchology [Leeds], v. 8, p. 305, pl. 11, fig. 60.

Very small, slender, stout; whorls of protoconch about two, convex, bearing spiral striae; subsequent whorls, three, gently convex, separated by a deeply lirate suture; imperforate; aperture rounded, outer lip thickened with a double wall. Sculpture clathrate, consisting of strong spiral ribs, (3 exposed on penultimate whorl, 5 on body whorl, below which are 2 or 3 short nearly smooth spirals) crossed by equally strong axial ribs (18 on body whorl), beaded at intersections with spirals; axial ribs obsolete on basal part of body whorl.

Measurements of the figured specimen (E–1, Eniwetok, 850–860 ft), USNM 648357: height 1.9 mm, diameter 0.9 mm.

M. pisinna is smaller and proportionately shorter than the type species *M. cheilostoma* (Tenison-Woods), but I have not seen specimens.

The clathrate sculpture pattern of *M. pisinna* is matched almost exactly by *M. granulosa* (Pease), a Recent species from Hawaii (USNM 345037), but the Hawaiian shells have a smooth and glossy protoconch. Only a few of the two dozen fossils from the Marshall Islands show traces of spiral sculpture on the whorls of the protoconch, and these traces can be clearly seen only under high magnification.

Occurrence: In drill holes on Eniwetok at depths of 620–930 feet; in beds referred to Miocene (Tertiary *f* and *g*); in drill holes on Bikini at depths of 925–1,944 feet; early Miocene (Tertiary *e* and *f*); two specimens were recovered from the Suva Formation on Viti Levu, Fiji (sta. FB–20); age, Miocene (Tertiary *f*). The species was originally described from the Loyalty Islands and has been reported from the Kermadecs.

Subgenus LINEMERA Finlay

Finlay, 1924, New Zealand Inst. Trans., v. 55, p. 483.

Type (by original designation): *Rissoa gradata* Hutton. Recent, New Zealand.

Includes shells with clathrate sculpture as in *Merelina* s.s., but with smooth and glossy protoconch and a single rimmed aperture.

Merelina (Linemera) telkibana Ladd, n. sp.

Plate 12, figures 6, 7

Very small, robust; about two smooth convex whorls of protoconch followed by about three flattened sculptured whorls; suture deeply incised; aperture broadly ovate, peristome entire, umbilical chink present, outer lip thickened to form a varix. Sculpture consisting of moderately strong axial ribs that become obsolete on the basal part of the body whorl and weak spirals that are prominent only on the base of the last whorl.

Measurements of the holotype, USNM 648358: height 1.9 mm, diameter 1.0 mm.

The axial ribs of *M. telkibana* are much finer and more numerous than those of *Rissoa gradata* Hutton, the type of *Linemera*.

Occurrence: A total of 14 specimens from late Miocene (Tertiary *g*) marls at the base of the Palau Limestone near Goikul, Babelthuap Island, Palau (USGS 21301).

Genus PARASHIELA Laseron

Laseron, 1956, Australian Jour. Marine and Freshwater Research, v. 7, no. 3, p. 439.

Type (by original designation): *Parashiela ambulata* Laseron. Recent, Great Barrier Reef, Australia.

Short broad shells with widely spaced axial ribs and a single spiral rib at the shoulder.

Parashiela beetsi Ladd, n. sp.

Plate 12, figures 8, 9

Minute, short, white, translucent; protoconch of 1½ glassy rapidly enlarging whorls followed by about 3½ strongly shouldered sculptured whorls; aperture subcircular, peristome complete; outer lip with a double wall that is thickened behind to form a low varix. Sculpture consisting of fine widely spaced axial ribs and a single spiral rib at the shoulder.

Measurements of the holotype, USNM 648368: height 1.4 mm, diameter 0.9 mm. Paratype, USNM 648369: height 1.5 mm, diameter 1.0 mm.

P. beetsi has the unusual sculpture that characterizes the type species (and only other known species) *P. ambulata*, but it differs by possessing a double-walled outer lip that is thickened behind to form a low varix. A similar type of open sculpture is exhibited by *Rissoa invisibilis* Hedley from a Funafuti lagoon beach (Hedley, 1899a, p. 418), but that species has three prominent spiral ribs.

Occurrence: Two specimens from drill hole F–8–C on Eniwetok Atoll a depth of 19–22 feet; age, Recent.

Genus ZEBINA H. and A. Adams

H. and A. Adams, 1854, Genera Recent Mollusca, v. 1, p. 328.

Type (by subsequent designation, G. Nevill, 1885, Hand list Mollusca Indian Mus., pt. 2, p. 93): *Rissoina coronata* Recluz. Recent, Mauritius.

Subgenus ZEBINA s.s.

The type species is smooth except for the early whorls which are axially ribbed; the outer lip is thickened with one or more tubercles on the anterior part. No examples of *Zebina* s.s. have been found in the fossil faunas of the island area.

Subgenus CIBDEZEBINA Woodring

Woodring, 1928, Carnegie Inst. Washington Pub. 385, p. 369.

Type (by original designation): *Rissoina browniana* d'Orbigny. Recent, West Indies.

Small smooth shells with flat whorls and a varicose outer lip that is extended forward; outer lip with a denticle near the posterior angle and a second denticle near the base.

Zebina (Cibdezebina) metaltilana Ladd, n. sp.

Plate 12, figure 10

Small, slender, smooth, and polished; about three convex whorls of protoconch, six flattened subsequent whorls; suture linear or lightly impressed; aperture oval with acute posterior angle and broad shallow anterior channel; inner lip callused, outer lip thickened into a smooth varix and extended forward; outer lip with a broad but prominent denticle near the posterior angle and a less conspicuous dentical near the base; siphonal fasciole slightly swollen.

Measurements of the holotype (drill hole 2B, Bikini Atoll, 1,860–1,870 ft), USNM 648359: height 3.5 mm, diameter 1.4 mm. Paratype (drill hole A–1, Eniwetok Atoll, 136–138 ft), USNM 648360: height 3.1 mm, diameter 1.2 mm.

The Marshall Island shells agree in all important features with the type of *Cibdezebina—Rissoina browniana*—known from Miocene to Recent in the Caribbean area (Woodring, 1928, p. 370), but it is distinctly more slender in outline. The holotype of *Z. metaltilana* shows both denticles on the outer lip, but in many specimens, both Miocene and Recent, the anterior denticle is not developed.

Occurrence: In many drill holes on Bikini and Eniwetok Atolls at depths of 1–2,349 feet but never in great abundance; age, Recent to early Miocene (Tertiary *e*).

A single specimen was recovered from the Suva Formation on Viti Levu, Fiji (sta. FB–20); age, Miocene (Tertiary *f*); a few specimens were dredged from a depth of 25 fathoms in the Bikini lagoon.

Subgenus MORCHIELLA G. Nevill

Nevill, 1885, Hand list Mollusca Indian Mus., pt. 2, p. 88.

Type (by original designation): *Rissoina gigantea* Deshayes. Recent, Philippine Islands.

Small to medium-sized solid shells whose apical whorls are characteristically more strongly sculptured than later whorls.

Zebina (Morchiella) cf. Z. cooperi (Oliver)

Plate 12, figures 11, 12

Medium in size, stout; about 1½ smooth convex whorls of protoconch and five or six flattened subsequent whorls; most, or all, of the whorls above the body whorl bear slightly oblique axial ribs and these are strongest near the apex; suture hardly discernible; aperture sublenticular, posterior angle sharp, anterior channel indistinct, inner lip callused; outer lip thickened and extended forward, with one or two broad low denticles inside, one near the base, the other, if present, at about the midpoint.

Measurements of the figured specimen, USNM 648361: height 5.7 mm, diameter 2.3 mm; another specimen, USNM 648362, probably immature, measures: height 3.3 mm, diameter 1.5 mm.

Some of the Marshall Island specimens are slightly more slender than the shell described from the Kermadecs (Oliver, 1915, p. 520), and show two rather than three low tubercles inside the outer lip; they likewise have a less distinct posterior canal. In describing the Kermadec shell, Oliver mentioned "3 minute longitudinal plications" on the parietal wall near the posterior canal. These do not appear on his published figure nor on specimens from the type area identified by Oliver, nor can they be seen on the Marshall Island shells here described.

Occurrence: Two specimens from drill hole E–1 on Parry Island, Eniwetok Atoll, at depth of 110–120 feet (figured specimen) and 10–20 feet (immature specimen); age, Recent. A single Recent shell was also collected from drift on Enybarbar Island, Rongelap Atoll. A fossil from drill hole 2B on Bikini Atoll at a depth of 2,235–2,246 feet; age, early Miocene (Tertiary *e*); it may be a Recent shell pumped in from the mud pits.

Zebina (Morchiella) killeblebana Ladd, n. sp.

Plate 12, figures 13, 14

Medium in size, stout, polished; spire short, diameter of shell slightly exceeding one-half the height. Whorls of spire about six, first three showing faint traces of axial ribs, early whorls flat sided, later whorls gently convex; suture not impressed; aperture semicircular; inner lip heavily callused, with a denticle next to the acute posterior angle, anterior channel broad and shallow; outer lip sharp but thickened behind the peristome and slightly extended forward, bearing two or three low denticles inside.

Measurements of the holotype, USNM 648363: height 5.6 mm, diameter 3.0 mm. Paratype, a smaller shell that may be immature, USNM 648364: height 3.2 mm, diameter 1.8 mm.

The fossil is closely related to the Recent *Z. tridentata* Michaud, widely distributed in the Indo-Pacific area, but the Recent shell is appreciably more slender.

Occurrence: Eniwetok Atoll in drill hole E–1, depth 960–970 feet (holotype) and in drill hole F–1, 930–940 feet (paratype); age, early Miocene (Tertiary *f*).

Subgenus AILINZEBINA Ladd, n. subgen.

Type: *Zebina (Ailinzebina) abrardi* Ladd, n. sp.

Small, slender; protoconch consisting of two smooth whorls coiled at a slight angle to remainder of spire; early subsequent whorls bearing heavy axial ribs that become finer and more numerous on later whorls; spiral sculpture conspicuous only on body whorl; siphonal fasciole heavy but ill defined.

Resembles *Morchiella* in that there is a progressive reduction in axial sculpture, but in *Ailinzebina* the axials are not obliterated, even on the body whorl.

Zebina (Ailinzebina) abrardi Ladd, n. sp.

Plate 12, figures 15–18

Small, slender; two smooth whorls of protoconch coiled at slight angle to axis of spire; about six gently convex subsequent whorls; the early ones bearing heavy slightly oblique axial ribs that become progressively smaller and more numerous on later whorls; suture impressed; aperture lenticular, posterior channel narrow and moderately deep; anterior channel broad and shallow; outer lip thickened and extended forward; spiral threads are most conspicuous on the body whorl on and near the heavy siphonal fasciole.

Measurements of the holotype (pl. 12, figs. 15, 16) a Recent shell from Bikini, USNM 648365: height 3.9 mm, diameter 1.3 mm. Paratype A, (pl. 12, fig. 17) a fossil from drill hole En–4, depth 11 feet, Eniwetok, USNM 648366: height 2.9 mm, diameter 0.9 mm. Paratype B, (pl. 12, fig. 18) a fossil from drill hole 2B, depth 1,450–1,461 feet, Bikini, USNM 648367: height (incomplete) 2.3 mm, diameter 0.9 mm.

Occurrence: Living in the northern Marshall Islands (Bikini and Rongerik); the holotype is a Recent shell

dredged from the Bikini lagoon at a depth of 20 fathoms. Fourteen fossils were recovered from several drill holes on Eniwetok to depths of 60 feet, and two specimens were obtained from drill hole 2B on Bikini at depths of 1,450–1,608 feet in early Miocene (Tertiary *e–f*).

Genus ZEBINA s. l.

Zebina? sp. A

Plate 12, figure 19

Small, stout; whorls gently convex, with strong axial ribs; 27 ribs and fine spiral threads on last whorl; inner lip with a single strong denticle anteriorly; outer lip with low widely spaced internal ribs.

Measurements of the figured specimen, USNM 648370: height 2.7 mm, diameter 1.2 mm.

The single fossil has an incomplete outer lip. The well-developed axial ribs combined with the strong anterior denticle differentiates this species from others found in the area; if better type material were available, the species might be recognized as belonging to a new subgenus.

Occurrence: Drill hole 2B, Bikini Atoll at a depth of 2,112–2,128 feet; early Miocene (Tertiary *e*).

Genus RISSOINA d'Orbigny

d'Orbigny, 1840, Voyage dans l'Amérique méridionale, v. 5, p. 395.

Subgenus SCHWARTZIELLA Nevill

Nevill, 1884, Hand list Mollusca Indian Mus., pt. 2, p. 82.

Type (by original designation): *Rissoina bryerea* (Montagu) [*Turbo*]. Recent, Cuba.

Includes strongly ribbed species some of which also bear spiral striae; the oval aperture is slightly angled below.

Rissoina (Schwartziella) gracilis (Pease)

Plate 12, figure 20

Rissoa gracilis Pease, 1860, Zool. Soc. London Proc., p. 438.
Rissoina gracilis Garrett, 1873, Acad. Nat. Sci. Philadelphia, Proc., p. 211, pl. 2, fig. 8.
Tryon, 1887, Manual Conchology 9, p. 373, pl. 55, fig. 42.

Small, slender; about three glossy convex whorls of protoconch followed by six gently convex sculptured whorls; suture margined; aperture oval, anterior channel broadly rounded, moderately deep; inner lip callused, outer lip extended forward near its midpoint, thickened to form a varix. Sculpture consisting of strong slightly oblique axial ribs almost as wide as the intervening spaces; ribs flexuous on body whorl.

Measurements of the figured specimen, B. P. Bishop Museum, geology No. 1340: height 3.0 mm, diameter 0.9 mm.

The species appear to be well named, for it is more slender than any other *Rissoina* found in the island area.

Occurrence: One specimen, about 1 mile southwest of Houma, Tongatabu, Tonga; altitude 35 feet; age, probably Pleistocene. The Recent shell briefly described (without measurements) by Pease was collected in Hawaii; Garrett's specimens came from Fiji; Tryon mentions the Society Islands as well as Fiji.

Rissoina (Schwartziella) aff. R. flexuosa Gould

Plate 12, figures 21, 22

Small, stout; two smooth whorls of protoconch followed by about seven sculptured gently convex whorls; suture slightly impressed; aperture broadly lenticular, posterior channel narrow; anterior channel wide, slightly undercutting the columella; outer lip thickened; subsequent whorls bearing strong narrow, straight or slightly oblique axial ribs, 17–21 on the body whorl; traces of spiral sculpture are preserved on the lower part of the body whorl on most specimens. Siphonal fasciole low, not sharply defined.

Measurements of the figured specimen, USNM 648382: height 4.0 mm, diameter 1.5 mm.

The fossils are more slender than the Recent Australian shell (Gould, 1861, p. 400), and their spiral sculpture is less well developed.

Occurrence: Four specimens from drill hole E–1 on Eniwetok Atoll at depths of 40–45 feet (figured specimen) and 60–70 feet; age, Recent; a specimen from drill hole 2B on Bikini Atoll at a depth of 1,492–1,503 feet should be referred to Tertiary *e*, but it shows evidence of wear and may have been derived from a higher horizon. A single specimen from Guam from the Mariana Limestone at USGS locality 20600; age, probably Pleistocene.

Rissoina (Schwartziella) aff. R. indrai Beets

Plate 12, figures 23, 24

Large, stout; about seven gently convex whorls with a slight suggestion of a shoulder; suture moderately impressed; aperture lenticular, posterior channel narrow and shallow, anterior channel broad and deep, peristome heavily callused, outer lip thickened and extended forward. Sculpture consisting of slightly curved axial ribs and spiral threads. Ribs are coarse on early whorls but become smaller and more numerous on later whorls (about 40 on penultimate whorl, about 50 on body whorl); spiral threads become increasingly prominent on later whorls as ribs decrease in size; on last two whorls, ribs are beaded by spirals; on base of body whorl and on thickened exterior of outer lip, the spirals dominate axial ribs.

Measurements of the figured specimen, USNM 648383: height 7.7 mm, diameter 3.1 mm.

The Eniwetok fossil appears to differ from the Borneo form in that the whorls have a slight shoulder, whereas in the Borneo fossils the whorls are thickest near the base.

Occurrence: A single specimen from drill hole F–1, Eniwetok Atoll, at a depth of 930–940 feet; early Miocene (Tertiary *f*). *R. indrai* was described by Beets (1941, p. 23, pl. 1, figs. 44–48, 52–56) from the Miocene (Tertiary *f*) of eastern Borneo.

Two incomplete specimens from younger (Tertiary *g*) beds in drill hole F–1 (690–700 ft) and K–1B (758–768 ft) may represent this species. Both are smaller than the figured specimen and are more coarsely ribbed, the discrepancy in size between the ribs on the early whorls and those of the later whorls being much less marked than in the figured specimen.

Rissoina (Schwartziella) mejilana Ladd, n. sp.
Plate 12, figures 25, 26

Small, short, stout; about 1½ smooth convex whorls forming protoconch, followed by five sculptured gently convex whorls; suture impressed; aperture lenticular, posterior angle acute, anterior channel broad and moderately deep; peristome callused, edge of outer lip thin but thickened behind to form a low varix. Sculpture consisting of weak to moderately strong axial ribs, 23 or more on body whorl; fine spiral threads are on the lower part of body whorl but visible only under high magnification.

Measurements of the holotype (K–1B, Eniwetok, 831–842 ft), USNM 648384: height 2.8 mm, diameter 1.1 mm.

Characterized particularly by its short stout form and numerous axial ribs.

Occurrence: Four specimens from three deep holes on Eniwetok at depths of 800–990 feet; age, early Miocene (Tertiary *f*).

Rissoina (Schwartziella) jirikana Ladd, n. sp.
Plate 12, figures 27, 28

Very small, stout; two smooth gently convex whorls form protoconch, followed by 3½ sculptured whorls likewise of slight convexity; suture deeply impressed; aperture lenticular, posterior angle acute, anterior channel broad and moderately deep; inner lip heavily callused; edge of outer lip thin but thickened behind to form a low varix. Sculpture consisting of weak widely spaced axial ribs.

Measurements of the holotype (2B, Bikini, 1,440–1,451 ft), USNM 648385: height 2.3 mm, diameter 0.9 mm.

This *Schwartziella* is smaller than *S. mejilana* from younger Miocene beds at Eniwetok, has fewer whorls, fewer axial ribs, and a more deeply impressed suture.

Occurrence: Two specimens from drill hole 2B, Bikini Atoll, at a depth of 1,419–1,451 feet; age, early Miocene (Tertiary *e*).

Rissoina (Schwartziella) rilebana Ladd, n. sp.
Plate 12, figures 29, 30

Small, pupoid, thick; protoconch of three smooth convex whorls followed by five gently convex sculptured whorls; suture obscure; aperture ovate, posterior angle acute, anterior channel broad and moderately deep, peristome callused, outer lip thickened externally. Sculpture consisting of 12 strong widely spaced continuous axial ribs.

Measurements of the holotype (2B, Bikini, 778–789 ft) USNM 648386: height 3.1 mm, diameter 1.3 mm.

Characterized particularly by its pupoid form and continuous axial ribs. *R. rilebana* appears to be very closely related to *R. triticea* Pease, a Recent species known from Hawaii and many parts of the Indo-Pacific, but that species is less pupiform and has a more clearly exposed suture.

Occurrence: Two specimens from drill hole 2B, Bikini Atoll, at a depth of 778–831 feet; age, late Miocene (Tertiary *g*).

Subgenus ZEBINELLA Mörch

Mörch, 1876, Malakozoologische Blätter, v. 23, p. 47.

Type (by subsequent designation, Nevill, 1885, Hand list Mollusca Indian Mus., pt. 2, p. 73, 87): *Rissoina decussata* (Montagu) [Helix]. Recent, West Indies.

Includes species with fine axial ribs and spiral threads; outer lip thickened into a varix and extended forward; anterior channel shallow, only slightly undercutting columella.

Rissoina (Zebinella) emnanana Ladd, n. sp.
Plate 12, figures 31, 32

Medium in size, moderately slender; protoconch of three smooth convex whorls followed by about six inflated whorls; suture impressed; aperture semicircular; posterior channel narrow and deep; anterior channel broad, slightly undercutting the callus of the inner lip; outer lip moderately thickened, extended slightly forward and flaring. Sculpture consisting of close-set oblique axial ribs that are slightly more prominent on the spire than on the body whorl; between axials are numerous fine spiral threads.

Measurements of the holotype (E–1, 1,010–1,020 ft), USNM 648387: height 4.8 mm, diameter 2.1 mm.

R. emnanana is characterized particularly by its inflated whorls and impressed suture; it differs in these features from the West Indian type species *R. decussata*

(Montagu) and from other Zebinellas from the Marshall Islands.

Occurrence: In drill holes E–1 and K–1B, Eniwetok Atoll, at depths of 620–1,020 feet (total of nine specimens); age, Miocene (Tertiary *f* and *g*).

Rissoina (Zebinella) tenuistriata Pease

Plate 12, figures 33, 34

Rissoina tenuistriata Pease, 1867, Am. Jour. Conchology, v. 3, p. 295, pl. 24, fig. 30.
Tryon, 1887, Manual Conchology, v. 9, p. 386, pl. 58, fig. 24.

Medium in size, slender; protoconch of about 2½ unmarked convex whorls followed by six gently convex whorls; suture lightly impressed; aperture lenticular, posterior channel narrow and deep, anterior channel broad and shallow, slightly undercutting the callus of the inner lip. Outer lip thickened and extended forward. Sculpture consisting of close-set slightly curved axial ribs, which become obsolete on the lower half of the body whorl, and fine spiral threads.

Measurements of the holotype En–4, Eniwetok, 5½ ft, USNM 648388: height 5.5 mm, diameter 2.3 mm.

Occurrence: Eighteen specimens from several drill holes on Eniwetok Atoll from near the surface to 30 feet; rare at greater depths to 915 feet; a single specimen from drill hole 2A on Bikini, depth 306–310 feet (Post-Miocene). Age, Recent to early Miocene (Tertiary *f*). The Miocene specimens are smaller than the Recent shells.

R. tenuistriata, first described from the Tuamotu [Paumotu] Islands, is now recognized in many parts of the Indo-Pacific.

Rissoina (Zebinella) aff. R. supracostata Garrett

Plate 12, figures 35, 36

Large, moderately slender; whorls, exclusive of protoconch; about seven uniformly convex; suture impressed; aperture large, broadly lenticular; inner lip callused, outer lip thickened; siphonal fasciole low, smooth. Sculpture consisting of slightly oblique axial ribs on upper whorls of spire and fine close-set spiral striae over all whorls.

Figured specimen, USNM 648389: height (without protoconch) 12.4 mm, diameter 2.9 mm.

Occurrence: A single specimen from drill hole E–1 on Eniwetok, depth 890–900 feet; age, early Miocene, Tertiary *f*. The large shell probably represents an undescribed species, but a name is withheld pending better type material.

Resembles *R. supracostata*, a Recent species described by Garrett (1873, p. 209) from Fiji, but in that species the whorls of the spire are distinctly turreted and the shell has a more elevated siphonal fasciole.

Subgenus PHOSINELLA Mörch

Mörch, Malakozoologische Blätter, v. 23, p. 51.

Type (by subsequent designation, Nevill, 1885, Hand list Mollusca Indian Mus., pt. 2, p. 73, 83): *Rissoa pulchra* C. B. Adams. Recent. West Indies.

Includes species with strong reticulate sculpture, a distinct siphonal fasciole, and an anterior channel that is broad and deep.

Rissoina (Phosinella) clathrata A. Adams

Plate 12, figure 37; plate 13, figures 1, 2

Rissoina clathrata A. Adams, 1851, Zool. Soc. London Proc., p. 265.
Tryon, 1887, Manual Conchology 9, p. 381, pl. 57, fig. 79.
Rissoina (Phosinella) clathrata A. Adams, Abrard, 1946, Annales de paléontologie, v. 32, p. 54, pt. 4, fig. 17.

Medium in size, stout; about eight gently convex whorls; aperture broadly lenticular, extended forward below; posterior angle slightly less than 90°; outer lip with a strong varix; anterior channel broad and deep. Sculpture reticulate; axial ribs (about 17 on last whorl) crossed by spiral ribs (5 on last whorl), most of which are stronger than axial ribs; intersections beaded; siphonal fasciole heavy and beaded, separated from the lowest spiral rib by a prominent sulcus.

Measurements of the New Hebrides specimen (pl. 12, fig. 37): height (incomplete) 8.7 mm, diameter 3.6 mm. The figured Fijian shell (pl. 13, figs. 1, 2), USNM 648391: height 7.2 mm, diameter 2.6 mm.

Occurrence: Island of Malekula, New Hebrides, in beds of Pliocene age; four specimens from Viti Levu, Fiji (stas. 160, 160A, and FB–20) in the Suva Formation of Miocene age (Tertiary *f*). Living shells have been reported from the Philippines, Australia, Singapore, and the Red Sea; rare in the Marshall Islands.

R. clathrata appears to be a somewhat variable species. The two Fijian fossils are worn and are smaller than the New Hebrides fossil and Recent shells.

Rissoina (Phosinella) briggsi Ladd, n. sp.

Plate 13, figures 3, 4

Small, slender; protoconch of two smooth whorls followed by about six sculptured whorls; aperture semicircular, inner lip slightly curved, posterior angle sharp, outer lip broadly rounded with a prominent varix; anterior channel broad and moderately deep. Sculpture sharply reticulate; strong axial ribs (13 on last whorl) crossing almost equally prominent spiral ribs (4 on last whorl); intersections beaded; siphonal fasciole strongly

beaded, separated from the spiral ribs by a broad deep sulcus.

Measurements of holotype (Palau, USGS 21301). USNM 648390: height 4.3 mm, diameter 1.8 mm.

R. briggsi is similar to *R. clathrata* A. Adams, a larger Recent Indo-Pacific species also known from the Pliocene of the New Hebrides and the Miocene of Fiji. *R. briggsi* has fewer and sharper axial and spiral ribs than does *R. clathrata*.

Occurrence: Abundant in the late Miocene (Tertiary *g*) marls at the base of the Palau Limestone, northwest of Goikul, Babelthuap Island, Palau. (USGS 21301, 21304).

Rissoina (Phosinella) balteata Pease

Plate 13, figures 5–8

Rissoina balteata Pease, 1869, Am. Jour. Conchology, v. 5, p. 72.
Rissoina multozona Tomlin, 1915, Jour. Conchology, v. 14, p. 321.

Small, slender, sides of spire nearly flat; protoconch of two smooth whorls followed by about six sculptured whorls; early whorls flat sided, ultimate and penultimate whorls may be gently convex; suture impressed; aperture small, lenticular with three (rarely four or five) low nodes inside outer lip; anterior channel narrow, moderately deep; outer lip varicose behind peristome. Sculpture consisting of fairly close-set axial ribs (about 19 on body whorl), crossed by slightly less conspicuous spiral ribs (about 7 on body whorl); rib intersections beaded; siphonal fasciole with fine close-set spirals. Figured specimen shows a yellow spiral band immediately above the suture (a similar band on living shells is reddish brown).

Measurements of the figured specimen (pl. 13, figs. 5, 6) from Recent sediment (drill hole 2, Bikini, 38–40 ft), USNM 648394: height 3.7 mm, diameter 1.4 mm; (pl. 13, figs. 7, 8) from Tertiary *f* (drill hole E–1, Eniwetok, 880–890 ft), USNM 648395: height 3.7 mm, diameter 1.4 mm.

Occurrence: In many drill holes on Bikini and Eniwetok Atolls, from surface to 1,541 feet (70 lots totaling some 200 specimens); age, Recent to early Miocene (Tertiary *e*). The Tertiary specimens seem, on the average, to have less well-developed spiral sculpture, flatter sides, and larger apertures, but these features are variable. Pease described the Recent shell from Hawaii where it occurs in great abundance. Living examples are rare in the Marshall Islands; also know from Tahiti in the Society Islands.

As pointed out by Tomlin, this species may be identical with the Recent shell described by Pease as *Rissoina costulata* from the Tuamotu [Paumotu] Islands. The very small aperture noted by Pease is certainly suggestive, but Pease located the brown band on the middle of the whorls. *R. cerithiformis* Dunker, a Recent species reported from the Red Sea to Hawaii, apparently is identical with *R. balteata*.

Rissoina (Phosinella) bikiniensis Ladd, n. sp.

Plate 13, figures 9, 10, 17, 18

Medium in size, slender, protoconch of three smooth whorls, the lowest of which is convex; seven or eight subsequent whorls all flattened; suture impressed; aperture broadly lenticular with three or four rounded nodes inside outer lip; posterior angle acute, anterior channel narrow and deep; outer lip slightly or moderately varicose. Sculpture consisting of strong axial ribs (about 23 on body whorl) crossed by broad close-set spirals (9 on the body whorl, 4 on penultimate whorl) that form beads on axial ribs. Spiral sculpture not equally developed on all specimens.

Measurements of the holotype (2A, Bikini, 1,056–1,063 ft), USNM 648396: height 4.9 mm, diameter 1.6 mm. Paratype (E–1, Eniwetok, 1,746–1,777 ft), USNM 648400: height 3.6 mm, diameter 1.4 mm.

The Eniwetok specimens have a mode deeply impressed suture and a more prominent siphonal fasciole than those from Bikini, and they lack apertural nodes. They may represent a distinct species.

R. bikiniensis is larger but more slender than *R. balteata* Pease; it has more numerous whorls and a deeper anterior channel.

Occurrence: Three specimens from Miocene beds in drill hole 2A on Bikini Atoll: one from a depth of 490 feet (core) is Tertiary *g;* two others from cuttings at lower levels (1,030–1,063 ft) are referred to Tertiary *f*. Three specimens from drill hole E–1, Eniwetok are from Tertiary *f* (960–970 ft) and Tertiary *e* (1,746–1,777 ft).

Rissoina (Phosinella) transenna Watson

Plate 13, figures 11, 12

Rissoina transenna Watson, 1886, *Challenger* Rept., v. 15, p. 620, pl. 46, fig. 10.
Tryon, 1887, Manual Conchology, v. 9, p. 382, pl. 58, fig. 10.

Small, slender, stout; protoconch of about two smooth convex glassy whorls followed by six sculptured whorls; aperture lenticular, posterior angle acute, anterior channel broad and deep, outer lip thickened into a heavy varix. Sculpture reticulate, strong axial ribs (about 16 on last whorl) crossed by equally prominent spirals of which there are 7 or 8 on the body whorl (lowest one on some specimens smaller than others) and 4 or 5 exposed on the penultimate whorl, all intersections beaded; siphonal fasciole heavy and conspicuously beaded.

Measurements of the figured specimen (hole Mu-4, Eniwetok Atoll, at 40 ft), USNM 648397: height 3.6 mm, diameter 1.5 mm.

Occurrence: In drill holes on Eniwetok (46 specimens) and Bikini (6 specimens) from near the surface to a depth of 873 feet; age, Recent to early Miocene (Tertiary *f*).

The fossils placed here are somewhat variable. Many specimens from levels below 200 feet have fewer axial ribs. They do not show the subsutural threadlet described by Watson on the type specimen, a Recent shell from Fiji.

Rissoina (Phosinella) alexisi Ladd, n. sp.

Plate 13, figures 13–16

Small, stout; protoconch of 2½–3 smooth convex whorls followed by about five sculptured whorls that may be slightly turreted; suture deeply impressed, aperture broadly lenticular, posterior angle acute, anterior channel broad and moderately deep, outer lip thickened. Sculpture reticulate, strong axial ribs (13–15 on last whorl) crossed by weaker spirals (5–6 on last whorl), intersections beaded; siphonal fasciole moderately strong, beaded.

Measurements of the holotype, USNM 648398: height 2.7 mm, diameter 1.1 mm. Paratype, USNM 648399: height 2.5 mm, diameter 1.0 mm.

Occurrence: Holotype from drill hole F–1, Eniwetok Atoll, at depth of 1,110–1,120 feet. Paratype A from same hole at depth of 1,100–1,110 feet; both early Miocene (Tertiary *e*). Two other specimens recovered from K–1B at depths of 863–1,000 feet; age, Tertiary *f*.

Subgenus RISSOINA s.s.

Type (by monotypy): *Rissoina inca* d'Orbigny. Recent, Pacific coast of South America.

Includes species with heavy axial ribs and fine spiral threads; the outer lip is thickened; a siphonal fasciole is not developed but the anterior channel deeply undercuts the columella.

Rissoina (Rissoina) abbotti Ladd, n. sp.

Plate 13, figures 19–21

Small to medium in size, stout; protoconch not preserved; about seven subsequent whorls, gently convex, suture impressed; aperture irregularly lenticular; posterior channel narrow; anterior channel broad and deep, undercutting the base of the columella; peristome heavily callused, outer lip thickened. Sculpture consisting of numerous curved axial ribs (25 or more on last whorl), crossed by fine close-set spirals; on lower half of body whorl the intersections are conspicuously beaded.

Measurements of the holotype (drill hole 2A, Bikini, 1,061–1,067 ft), USNM 648371: height (protoconch missing) 4.9 mm, diameter 2.1 mm. Measurements of the paratype (Palau, USGS 21301) USNM 648372: height (protoconch missing) 8.1 mm, diameter 3.0 mm.

Characterized particularly by its strong curved axial ribs and well-developed spiral striae. The single specimen from Palau is larger than the Marshall Island specimens, but in all other respects it is identical with them.

Occurrence: Two specimens from drill hole 2A, Bikini Atoll, at depths of 956–1,067 feet (Miocene, Tertiary *f* and *g*); six specimens from drill holes F–1 and K–1B, Eniwetok Atoll, at depths of 790–963 feet (Miocene, Tertiary *f* and *g*); one specimen from the marl at the base of the Palau Limestone northwest of Goikul, Babelthuap, Palau (USGS 21301); (late Miocene, Tertiary *g*).

Rissoina (Rissoina) mijana Ladd, n. sp.

Plate 13, figures 22–25

Medium in size with short spire and large body whorl; about five gently convex whorls but may be flattened near suture which is but little impressed; aperture broadly lenticular, posterior channel shallow, anterior channel broad and moderately deep, undercutting the columella; outer lip thickened. Sculpture consisting of moderately strong curved axial ribs and numerous spiral threads, which are most conspicuous on lower half of body whorl. Axial ribs smaller and more numerous on the body whorl than on earlier whorls (about 30 on body whorl, 22 or more on penultimate whorl).

Measurements of the holotype (pl. 13, figs. 24, 25), USNM 648374: height (incomplete) 4.3 mm, diameter 1.8 mm.

Occurrence: Holotype from drill hole E–1 on Eniwetok Atoll at a depth of 880–890 feet; another specimen from E–1 at depth of 890–900 feet; a third specimen was obtained from drill hole 2A on Bikini at 1,040–1,046 feet; age of all three early Miocene (Tertiary *f*). A specimen from beds of the same age in K–1B (pl. 13, figs. 22, 23) is assigned *R. mijana* with reservations. It is more slender than the other specimens and has flatter whorls and more numerous axial ribs.

Rissoina (Rissoina) ailinana Ladd, n. sp.

Plate 13, figure 26

Small, stout; protoconch of two smooth strongly convex whorls; four to five slightly convex subsequent whorls; aperture broadly lenticular, posterior angle acute, anterior channel moderately wide and deep, undercutting the columella; outer lip thickened without and heavily callused within, the callus rising to form a low protuberance near the posterior angle. Sculpture consisting of

about 20 strong axial ribs on body whorl and fine spiral lines that are visible only under magnification.

Measurements of the holotype (E–1, Eniwetok, 1,925–1,955 ft), USNM 648375: height 3.0 mm, diameter 1.3 mm.

R. ailinana is characterized particularly by the small number of post-nuclear whorls (four to five) and by the low knob of callus inside the outer lip near the posterior angle.

Occurrence: In drill holes F–1, and E–1 on Eniwetok Atoll at depths of 1,925–2,720 feet (10 specimens) and in drill hole 2B on Bikini at 1,724–1,975 feet (3 specimens); all occurrences early Miocene (Tertiary *e*).

Rissoina (Rissoina) lomaloana Ladd, n. sp.

Plate 13, figures 27, 28

Small, moderately slender; protoconch of two smooth convex whorls followed by about six gently convex subsequent whorls; suture but little impressed; aperture semicircular, posterior angle acute; anterior channel moderately deep, undercutting the base of the columella; inner lip callused, outer lip callused within and thickened into a varix immediately behind the peristome. Sculpture consisting of close-set axial ribs (about 29 on body whorl) and numerous fine spiral lines.

Measurements of the holotype (drill hole K–1B, Eniwetok, 842–852 ft), USNM 648376: height 4.1 mm, diameter 1.5 mm.

Occurrence: Seven specimens from two deep drill holes on Eniwetok Atoll at depths of 695–890 feet; single specimen in drill hole 2A on Bikini at 978–988 feet; age, Miocene (Tertiary *f–g*).

Rissoina (Rissoina) goikulensis Ladd, n. sp.

Plate 13, figure 29

Small, stout; protoconch of two smooth convex whorls followed by about six gently convex sculptured whorls; suture strongly impressed; aperture broadly lenticular; posterior angle rounded, anterior channel shallow; outer lip slightly thickened with low nodes inside. Sculpture consisting of 20 narrow axial ribs on last whorl, crossed by a few spirals on lower half of body whorl.

Measurements of the holotype, USNM 648377: height 3.7 mm, diameter 1.3 mm.

R. goikulensis resembles *R. ailinana* from the early Miocene of Bikini and Eniwetok but has more numerous whorls, a more sharply incised suture, and a shallower anterior channel.

Occurrence: Three specimens from the marl at the base of the Palau Limestone on Goikul Peninsula, Babelthuap Island, Palau (USGS 21304); age, late Miocene (Tertiary *g*).

Rissoina (Rissoina) waluensis Ladd, n. sp.

Plate 13, figure 30

Small, stout; protoconch of about three smooth convex whorls followed by about six flat-sided sculptured whorls; suture impressed; aperture lenticular, posterior angle acute; anterior channel broad and moderately deep, undercutting the columella; outer lip with two obscure elongate nodes within, slightly thickened behind. Sculpture consisting of about 20 slightly oblique axial ribs on the last whorl, crossed by a few spirals; intersections beaded.

Measurements of the holotype, USNM 648378: height 3.8 mm, diameter 1.5 mm.

R. waluensis has whorls that are more flat sided than those of *R. ailinana* from the early Miocene of Bikini and Eniwetok, and it has stronger spiral sculpture than that species.

Occurrence: Holotype and four other worn specimens from conglomerate layer at base of reef limestone in Suva Formation, Walu Bay, Suva, Fiji (sta. 160). Paratype and two other specimens from FB–20 (virtually same locality as sta. 160); age, early Miocene (Tertiary *f*).

Rissoina (Rissoina) ekkanana Ladd, n. sp.

Plate 13, figures 31, 32

Small, slender; protoconch of 1½ smooth bulbous whorls coiled at an angle with the axis of the spire and about six sculptured gently convex subsequent whorls; suture impressed; aperture lenticular, posterior angle acute, anterior channel broad and moderately deep, slightly undercutting the columella; edge of outer lip thin but thickened slightly behind. Sculpture consisting of strong widely spaced axial ribs, about 14 on body whorl, and spiral lines that are especially prominent on the lower part of the last whorl.

Measurements of the holotype, USNM 648379: height 3.2 mm, diameter 1.2 mm.

Occurrence: Forty eight shells from five drill holes on Eniwetok Atoll at depths to 110 feet (holotype from Mu–4 at 35 ft); age, Recent.

Rissoina (Rissoina) ambigua (Gould)

Plate 14, figures 23, 24

Pyramidella ambigua Gould, 1849, Boston Soc. Nat. History Proc. v. 3, p. 118 [1851].
Johnson, 1964, U.S. Natl. Mus. Bull. 239, p. 39.

Rissoa ambigua Gould, 1852, U.S. Explor. Exped., Mollusca, p. 217, pl. 15, pl. 261a–c.

Rissoina ambigua (Gould), Tryon, 1887, Manual Conchology, v. 9, p. 371, pl. 55, figs. 27, 29, 31, 35; pl. 54, fig. 7.
Hedley, 1899, Australian Mus. Mem. 3, pt. 7, p. 422.

Rissoina materinsulae Pilsbry, 1904, Acad. Nat. Sci. Philadelphia Proc., p. 27, pl. 5, figs. 43, 43a.

Large, elongate-conic, thick, milk white; protoconch of 2½ rounded smooth whorls; seven subsequent whorls, those above the body whorl showing a weak shoulder immediately below the suture; body whorl flattened, suture impressed. Aperture irregularly lenticular, inner lip concave, anterior channel deep, undercutting columella to form a rounded toothlike projection, outer lip thickened. Sculpture consisting of fine close-set axial ribs (more than 20 on body whorl, including 3 on thickened outer lip) and weak spirals that are limited to the base of the body whorl, below the posterior angle of the aperture.

Measurements of the figured specimen, USNM 648423 (Recent, Rujiyoru, Eniwetok): height 6.4 mm, diameter 2.3 mm. A fossil specimen from hole 1, Bikini, 5–10 feet, USNM 648424: height 6.4 mm, diameter 2.2 mm.

R. ambigua is characterized particularly by its elongate-conic form.

Occurrence: Originally described from the Tuamotu [Paumotu] Islands but later widely reported from the Indo-Pacific (Hawaii, Ellice Islands, Society Islands, Fiji, New Caledonia, New Guinea, Singapore, Ceylon, Mauritius, and Japan). Figured specimen and one other Recent shell from the island of Rujiyoru, Eniwetok Atoll. Recent shells were also collected at other localities on Eniwetok and on the nearby atolls of Bikini, Rongerik, and Rongelap. Three fossil specimens were found in shallow drill holes on Eniwetok and Bikini at depths to 10 feet; all Recent in age.

Rissoina (Rissoina) ambigua parryensis Ladd, n. subsp.

Plate 14, figures 25, 26

Large, elongate-conic, thick, whorls flattened; protoconch consisting of about two smooth whorls; seven subsequent whorls; suture not impressed. Aperture subsemicircular, inner lip concave, anterior channel deep, undercutting columella to form a rounded toothlike projection, outer lip thickened. Axial sculpture consisting of fine close-set ribs (37 on body whorl); spiral sculpture absent.

Measurements of the holotype, USNM 648425: height (protoconch incomplete) 6.8 mm, diameter 2.3 mm.

R. ambigua parryensis may be ancestral to the Recent shell. The new subspecies has more numerous axial ribs, lacks spiral sculpture, and its suture is less impressed.

Occurrence: Single specimen from drill hole E–1, Eniwetok, at depth of 620–630 feet in beds referred to late Miocene (Tertiary *g*).

Rissoina (Rissoina) concinna A. Adams

Plate 13, figure 33

Rissoina concinna A. Adams, 1851, Zool. Soc. London Proc., p. 266.
Tryon, 1887, Manual Conchology 9, p. 386, pl. 58, fig. 18.

Medium in size, slender, thick; protoconch not preserved; about six subsequent whorls, the earlier ones flattened, the later ones slightly convex; suture impressed; aperture semicircular, posterior angle acute, excavated to form a shallow channel; anterior channel broad and fairly deep, undercutting the columella; inner and outer lips heavily callused, outer lip thickened. Sculpture consisting of prominent slightly oblique axial ribs (about 29 on body whorl); fine spiral lines are limited to the lower part of the body whorl near the aperture.

Measurements of the figured specimen (drill hole E–1, Eniwetok, 970–980 ft) USNM 648380: height (incomplete) 6.4 mm, diameter 2.3 mm.

Occurrence: Two specimens from deep drill holes on Eniwetok at depths of 970–980 feet in beds referred to Miocene (Tertiary *f*). In drill hole 2A on Bikini, a single specimen from a depth of 852–857 feet; age late Miocene (Tertiary *g*); a single specimen from 2B at a depth of 1,020–1,100 feet is early Miocene in age (Tertiary *f*); one from 1,671–1,682 feet is in beds referred to Tertiary *e*.

The Recent shells described by Adams were collected in the Philippines.

Rissoina (Rissoina) sp. A

Plate 13, figures 34, 35

A single imperfect specimen of a distinctive species of *Rissoina* s.s. was collected from the Suva Formation in its type section on Walu Bay, Fiji (sta. 160); age Miocene (Tertiary *f*). The shell differs from other fossil Rissoinas from the island area in that its flattened whorls and unimpressed suture give the spire an overall convex outline. The narrow close-set ribs of each whorl are alined with those of the adjoining whorl; about 30 ribs are on the last whorl, 25 on the penultimate. Measurements of the single specimen, USNM 648381: height (apex missing) 4.8 mm, diameter 1.7 mm.

Rissoina sp. *A* resembles *Rissoina concinna* from beds of about the same age in the Marshall Islands, but its axial ribs are more nearly vertical, and it lacks spiral sculpture.

Subgenus RISSOLINA Gould

Gould, 1861, Boston Soc. Nat. History Proc., v. 7, p. 401.

Type (by subsequent designation, Nevill, 1885, Hand list Mollusca Indian Mus., pt. 2, p. 73, 77) *Rissoina plicatula* Gould, Recent, western Pacific.

Characterized particularly by a strong siphonal fasciole.

Rissoina (Rissolina) turricula Pease

Plate 13, figures 36, 37

Rissoina turricula Pease, 1860, Zool. Soc. London Proc., p. 438.
Tryon, 1887, Manual Conchology, v. 9, p. 377, pl. 56, fig. 63.

Small, stout, whorls convex, distinctly angled above; aperture ovate, slightly flattened below; anterior channel broad and deep; sculpture consisting of strong axial ribs, 11 or 12 on body whorl; spaces between ribs finely striate.

Measurements of figured specimen (F–1, Eniwetok, 20–45 ft), USNM 648407: height 2.7 mm, diameter 1.0 mm.

Occurrence: Nine specimens from Recent sediments in six drill holes at Eniwetok; greatest depth, 70–80 feet in hole E–1 on Parry Island; figured specimen from depth of 20–45 feet in hole F–1 on Elugelab; a single specimen from drill hole K–1B at depth of 968–978 feet is from early Miocene (Tertiary *f*); a broken but otherwise fresh-looking specimen from drill hole 2B on Bikini at a depth of 1,335–1,345 feet (Tertiary *e*) may have been derived from a higher level; four specimens were collected from the Suva Formation, Viti Levu, Fiji (sta. FB–20); age, Miocene (Tertiary *f*) and one from the Ndalithoni Limestone, Vanua Mbalavu, Fiji (sta. 110B); age, probably Pliocene (Tertiary *h*).

The species was originally described as a Recent shell from Hawaii; later reported from Fiji, Ceylon, and Mauritius; also found at Bikini (reef-flat drift) and other atolls in the northern Marshalls by J. P. E. Morrison.

Rissoina (Rissolina) marshallensis Ladd, n. sp.

Plate 13, figures 38–40; Plate 14, figures 1–4

Small to medium, robust; protoconch of two smooth convex whorls followed by five to six sculptured whorls that are uniformly convex or slightly angled above; aperture subsemicircular, inner lip gently convex, outer lip thickened, posterior angle acute, anterior channel broad and moderately deep. Sculpture consisting of strong axial ribs (12–19 on body whorl) separated by wide interspaces that may be nearly smooth or heavily striate. Siphonal fasciole conspicuously beaded; on some shells it is sharply elevated, on others it is not distinctly set off from the remainder of the whorl.

The measurements of the holotype and five paratypes selected to illustrate the variation in size, profile of whorls, development of siphonal fasciole, and spiral sculpture, are given in the following table.

Specimen	Drill hole	Depth (feet)	Height (mm)	Diameter (mm)	Profile of whorls	Siphonal fasciole	Spiral threads
Holotype USNM 648408	K–1B	894–905	5.0	1.9	Slightly turreted.	Strong	Weak.
Paratype A, USNM 648409	E–1	850–860	[1]3.8	1.5	Strongly turreted.	do	Absent.
Paratype B, USNM 648410	K–1B	1,049–1,060	7.4	2.7	Not turreted.	do	Strong.
Paratype C, USNM 648411	K–1B	842–852	4.2	1.6	Slightly turreted.	Weak	do
Paratype D, USNM 648412	K–1B	936–947	3.8	1.5	do	do	Weak.
Paratype E, USNM 648413	2B	1,020–1,100	5.2	2.1	Not turreted.	do	Strong.

[1] Incomplete.

R. marshallensis appears to be an exceedingly variable species. It is closely related to the Recent *R. turricula* Pease but is larger, has sharper and (on the average) more numerous ribs. *R. turricula* may have developed from *R. marshallensis;* in drill holes on Eniwetok where both occur there is a stratigraphic gap of nearly 600 feet between known occurrences of the two.

R. semari Beets from the late Miocene of East Borneo is larger than the Marshall Island fossil and does not have a strongly beaded siphonal fasciole.

Occurrence: An abundant species in the Miocene beds beneath Eniwetok and Bikini. Sixty-one lots were recovered from cuttings in three drill holes on Eniwetok (E–1, F–1, K–1B) at depths of 620–1,715 feet; age, Tertiary *e–g.* Nine lots were collected from two drill holes on Bikini (2A and 2B) at depths of 904–1,088 feet; Tertiary *f–g.* (One Bikini specimen from core at 936 ft).

Rissoina (Rissolina) ephamilla Watson

Plate 14, figures 5–8, 11, 12

Rissoina ephamilla Watson, 1886, *Challenger* Rept. 15, p. 617 [*R. scalariformis*], p. 719, pl. 46, fig. 6.

Rissoina scalariformis Watson, Tryon, 1887, Manual Conchology, 9, p. 378, pl. 54, fig. 1.

Very small, slender, polished; protoconch of 2½ whorls; later whorls about 5, uniformly convex or turreted; aperture semilunate, outer lip oblique with thick varix; siphonal fasciole heavy and beaded; anterior chan-

nel broad and shallow. Sculpture consisting of strong slightly oblique axial ribs (12–16 on last whorl), the spaces between smoothly polished or showing faint traces of spiral striae.

Measurements of figured specimen from Eniwetok (pl. 14, figs. 5, 6) USNM 648414: height 3.0 mm, diameter 1.2 mm. Figured specimen from Bikini (pl. 14, figs. 7, 8), USNM 648415: height 2.9 mm, diameter 1.1 mm. An unusually slender specimen from Eniwetok (pl. 14, figs. 11, 12) USNM 648417: height 3.0 mm, diameter 0.8 mm.

Easily distinguished by its slenderness from most other species of *Rissolina* in the Marshall Island area.

Occurrence: In all three deep holes on Eniwetok (30 specimens) at depths of 212–1,029 feet; age, Recent to early Miocene (Tertiary *f*); a single Recent specimen was also recovered from one of the shallow holes on Eniwetok (Mu–4) from a depth of 26–27 feet. Two specimens from hole 2B on Bikini Atoll at a depth of 447–464 feet are post-Miocene in age. The Recent shells described by Watson were collected from the reefs off Honolulu at a depth of 40 fathoms.

Rissoina (Rissolina) kickarayana Ladd, n. sp.

Plate 14, figures 9, 10

Small, slender; protoconch of two smooth whorls succeeded by about six gently convex slightly turreted and strongly ribbed later whorls; aperture semilunate, outer lip extended forward immediately above base and bordered by a heavy varix; siphonal fasciole inconspicuously beaded by extensions of axial ribs of body whorl; anterior channel broad and shallow. Sculpture consisting of strong erect slightly oblique axial ribs, 9–11 on body whorl.

Measurements of the holotype (USGS 21301), USNM 648416: height 4.1 mm, diameter 1.5 mm.

R. kickarayana is smaller and more slender than *R. marshallensis*, from the Miocene of the Marshalls; its axial ribs are more oblique and fewer in number.

Occurrence: In the late Miocene marls at the base of the Palau Limestone near Goikul, Babelthuap Island, Palau (in great abundance at USGS 21301 and 21304; single specimen at 21308).

Rissoina (Rissolina) herringi Ladd, n. sp.

Plate 14, figures 13, 14

Small, slender; protoconch of smooth convex whorls, coiled at a slight angle to the axis of the spire, followed by 6½ gently convex sculptured whorls; aperture lenticular, posterior angle acute, anterior channel broad and moderately deep, slightly undercutting the columella; outer lip thickened. Sculpture consisting of axial ribs (about 20 on last whorl) and fine spiral striae; spirals best developed on flattened triangular area lying adjacent to edge of inner lip; siphonal fasciole low, not sharply set off from remainder of whorl.

Measurements of the holotype, USNM 648418: height 4.8 mm, diameter 1.8 mm.

Occurrence: Four specimens from drill holes F–1 and E–1, Eniwetok Atoll, at depth of 710–860 feet (holotype from F–1, 710–720 ft); age, late Miocene (Tertiary *g*).

Rissoina (Rissolina) harti Ladd, n. sp.

Plate 14, figures 15, 16

Very small, stout; protoconch of 1½ smooth convex whorls, followed by about six convex sculptured whorls; body whorl slightly flattened in profile with a weak shoulder that extends forward from the posterior angle of the aperture; suture impressed; aperture broadly lenticular, posterior channel narrow and shallow, anterior channel shallow and indistinct. Sculpture consisting of strong slightly oblique axial ribs, 17–20 on body whorl; spiral striae weakly developed on body whorl; siphonal fasciole low, not sharply set off from rest of whorl.

Measurements of the holotype (2B, Bikini, 1,555–1,566 ft) USNM 648419: height 3.2 mm, diameter 1.3 mm.

Occurrence: Five specimens from drill hole 2B on Bikini Atoll at a depth of 1,429–1,829 feet; age, early Miocene (Tertiary *e*).

Rissoina (Rissolina) bourneae Ladd, n. sp.

Plate 14, figures 17, 18

Small, stout; protoconch of three smooth rounded whorls, followed by about five gently convex weakly shouldered sculptured whorls; aperture lenticular; outer lip thickened and extended forward; posterior angle acute, anterior channel broad, undercutting the columella. Sculpture consisting of strong oblique slightly curved axial ribs, 15–19 on last whorl; siphonal fasciole thick and beaded, separated from the remainder of whorl by a broad depression.

Measurements of the holotype from FB–20, USNM 648420: height 3.2 mm, diameter 1.2 mm.

R. bourneae resembles *R. kickarayana* Ladd, a species of about the same age occurring in Palau, but the Fijian shells are smaller and have more numerous axial ribs.

Occurrence: Represented by a dozen specimens from the conglomerate layer at the base of the reef limestone in the Suva Formation, Walu Bay, Suva, Fiji (stas. FB–20 and 160); age, early Miocene (Tertiary *f*).

Rissoina (Rissolina) plicata A. Adams

Plate 14, figures 21, 22

Rissoina plicata A. Adams, 1851, Zool. Soc. London Proc., p. 264. Tryon, 1887, Manual Conchology 9, p. 375, pl. 56, figs. 58–60, 68; pl. 54, fig. 8.

Shell large, heavy, thick, with strong widely spaced axial ribs, 10 on the last whorl and fine spiral striae. The siphonal fasciole is heavy, strongly elevated, and is smooth or weakly beaded by the axial ribs. Aperture lenticular, anterior channel broad and fairly deep, undercutting the columella.

Measurements of the figured specimen (F–1, Eniwetok, 870–880 ft), USNM 648422: height (apex missing) 6.9 mm, diameter 3.0 mm.

Occurrence: Two specimens from drill hole F–1 on Eniwetok Atoll at depth of 870–950 feet; age, early Miocene (Tertiary *f*).

Described from Recent shells from Philippines; also known from Samoa, Cook Islands, Fiji, Red Sea, and Mauritius.

Rissoina (Rissolina) sp. B

Plate 14, figures 19, 20

Small, stout; with strong curved axial ribs, 21 on body whorl; aperture semioval, outer lip thickened, anterior channel broad and deep; spiral striae, weak on early whorls, more prominent on last whorl, dominating the axials on the lower half of that whorl; siphonal fasciole low, faintly beaded.

Measurements of the figured specimen, USNM 648421: height (apex missing) 3.9 mm, diameter 1.6 mm.

Rissoina (Rissolina) sp. B differs from *R. bourneae* in that it has stronger spiral sculpture, more strongly curved axial ribs, and a smoother siphonal fasciole.

Occurrence: Two incomplete specimens from station 165, west of Nasongo, Viti Levu, Fiji; age, probably Miocene.

Genus BARLEEIA W. Clark

Clark, 1853, Annals and Mag. Nat. History, 2d ser. v. 12, p. 108.

Type (by monotypy): *Rissoa rubra* A. Adams. Recent, Atlantic.

Subgenus BARLEEIA s.s.

Minute, smooth, imperforate shells with blunt apex and large body whorl.

Barleeia (Barleeia) meiauhana Ladd, n. sp.

Plate 14, figure 27

Minute, ovate, apex blunt; about four whorls, inflated, smooth; suture impressed; aperture broadly oval, entire, slightly constricted, narrowed above, broadly rounded below; lips sharp.

Measurements of the holotype, USNM 648426: height 0.9 mm, diameter 0.6 mm.

B. meiauhana is much smaller and proportionately wider than the type species, *B. rubra* (Adams). The Palau fossil more closely resembles *B. carpenteri* Bartsch, a Recent species from Baja California, but that form has flattened slightly shouldered whorls.

Occurrence: Seven specimens from late Miocene (Tertiary *g*) marls at base of Palau Limestone on Goikul Peninsula, Babelthuap Island, Palau (USGS 21301).

Family ASSIMINEIDAE

Genus ASSIMINEA Fleming

Fleming, 1828, History of British animals, v. 5, p. 275.

Type (by monotypy): *Assiminea grayana* Fleming. Recent, England.

Assiminea nitida eniwetokensis Ladd, n. subsp.

Plate 10, figure 8

Small, spire low, apex blunt, robust; four to five whorls, smooth, gently and uniformly convex; suture lightly impressed; aperture broadly ovate, peristome not continuous, inner lip callused, slightly flaring below, with a groove behind it in the umbilical region; outer lip thin. The holotype and some other specimens show an obscure thread below the suture.

Measurements of the holotype (K–1B, Eniwetok, 831–842 ft), USNM 648325: height 1.8 mm, diameter 1.3 mm.

The Marshall Island fossils have been compared with the cotypes of the Recent *A. nitida* (Pease, 1864, p. 674, as *Hydrocena nitida*) from the Society Islands (USNM 591317) and with examples of many of the numerous subspecies that have been recognized from island groups in the southwest Pacific (Abbott, 1958). *A. nitida eniwetokensis* is smaller than *A. nitida nitida*, has fewer whorls, and the base of the body whorl is more uniformly rounded. The fossils have also been compared with the types and other specimens of *A. nitida marshallensis* Abbott (1958, p. 256) collected at Eniwetok and at other atolls in the Marshall group. The same differences in size and curvature of the body whorl are apparent, and the fossils are proportionately much shorter than adults of the elongate Recent shell. The fossil is represented by a total of 26 specimens all of which are small but some of which certainly are adults.

Assiminea nitida eniwetokensis belongs to a group of small amphibious air-breathing snails that has representatives living in the area today (Abbott, 1958).

Occurrence: Twenty-six specimens from deep holes (E–1 and K–1B) on Eniwetok Atoll at depths of 710–842 and 1,835–1,993 feet; and one specimen from Bikini (2B, 1,713–1,724 ft); age, Miocene (Tertiary *e* and *g*; no specimens recovered from beds assigned to Tertiary *f*).

Family ADEORBIDAE (VITRINELLIDAE)

Genus HAPLOCOCHLIAS Carpenter

Carpenter, 1864, Annals and Mag. Nat. History, 3d ser., v. 13, p. 476.

Type (by monotypy): *Haplocochlias cyclophoreus* Carpenter. Recent, west coast of Mexico.

Haplocochlias sp. A

Plate 14, figures 28, 29

Minute, inflated, naticoid in general outline; aperture subcircular, peristome continuous, outer lip thickened; umbilicus wide, bordered by a smooth ridge. Sculpture consisting of fine spiral striae.

Measurements of the figured specimen, USNM 648427: height 1.2 mm, diameter 1.1 mm.

This rare shell is unusual in that it combines the general outline of a naticid with a thickened outer lip that is suggestive of a rissoid. The single Eniwetok fossil appears to be closely related to the type species *H. cyclophoreus* Carpenter, a Recent species described from Cabo San Lucas at the southern tip of Baja California and reported also from Bahía Magdalena, 175 miles to the northwest. Carpenter's type lot of specimens (USNM 18112) contains three large shells (the largest measuring 4.5 mm in height and 5.1 mm in diameter) and one minute shell (height 1.3 mm, diameter 1.4 mm) that he regarded as a juvenile. The Eniwetok fossil resembles the smallest specimen in the type lot, but the two are not conspecific because the Recent shell is thicker, more coarsely striated, has a weaker umbilical ridge, and a less well developed varix on the outer lip. It is possible that the minute shell in the type lot is specifically distinct from the larger shells.

Occurrence: Single specimen from drill hole K–1B on Eniwetok Atoll at a depth of 831–842 feet; age late Miocene (Tertiary *g*).

Genus LEUCORHYNCHIA Crosse

Crosse, 1867, Jour. conchyliologie, 15, p. 319.

Type (by monotypy): *Leucorhynchia caledonica* Crosse. Recent, New Caledonia.

Leucorhynchia caledonica Crosse

Plate 14, figures 30, 31

Leucorhynchia caledonica Crosse, 1867, Jour. Conchyliologie, v. 15, p. 319, pl. 11, fig. 4.

Teinostoma (Leucorhynchia) caledonicum Crosse, Tryon, 1888, Manual Conchology 10, p. 106, pl. 35, figs. 85, 86.

Small, lenticular, smooth, perforate; periphery carinate, the carina becoming obsolete near the circular aperture; peristome entire, its basal edge extended laterally to form a thick pad of callus that projects over the umbilicus but does not come in contact with it.

Measurements of the figured specimen (Eb–2, Eniwetok, 21–21½ ft) USNM 648428: height 1.4 mm, diameter 2.5 mm.

Occurrence: From four drill holes on Eniwetok Atoll, from near the surface to depth of 60 feet (age, Recent) but not found living in the area today. The species was originally described from New Caledonia and has also been reported from Queensland, Australia (Cotton, 1959, p. 204).

All six fossil specimens are smaller than the Recent shells from New Caledonia.

Leucorhynchia crossei Tryon

Plate 14, figures 32, 33

Teinostoma (Leucorhynchia) crossei Tryon, 1888, Manual Conchology 10, p. 106, pl. 35, figs. 86a, 86b.

As noted by Tryon in defining the species, it differs from the genotype *L. caledonica* only by having a rounded, instead of a carinated, periphery.

Measurements of the figured specimen (E–1, Eniwetok, 35–40 ft), USNM 648429: height 1.2 mm, diameter 2.3 mm.

Occurrence: From five drill holes on Eniwetok Atoll, from near the surface to depth of 55 feet (age, Recent) but not found living in the area today. Originally described from Singapore, later reported from northwestern Australia and the Arabian Sea.

Represented by 20 fossil specimens from 10 localities and horizons. All the fossils are smaller than the Recent shells but seem not to differ in other respects. *L. crossei* appears to be very closely related to *L. caledonia*. The two should, perhaps, be combined though in the Eniwetok drill holes they were not found together in the same sample.

Leucorhynchia? stephensoni Ladd, n. sp.

Plate 14, figures 34, 35

Minute; spire flattened, body whorl rapidly expanding, periphery broadly angled; perforate; aperture circular; peristome entire; expanded below to form a broad flattened callus that extends over the umbilicus and partially obscures it. Under magnification the sculpture is seen to consist of fine close-set spiral lines and a ring of short widely separated axial lines radiate from the umbilicus.

Measurements of the holotype, USNM 648430: height 1.0 mm, diameter 2.0 mm.

The sculpture and the flattened spire distinguish this species from *L. caledonia* and *L. crossei* which occur at higher levels in Eniwetok drill holes.

Occurrence: Holotype, and only specimen, from drill hole K–1B on Eniwetok at a depth of 1,249–1,259 feet in sediments referred to early Miocene (Tertiary *e*).

Leucorhynchia? lilli Ladd, n. sp.

Plate 15, figures 1, 2

Small; spire low, body whorl rapidly expanding, periphery smoothly rounded; aperture circular, slightly constricted; peristome entire; umbilicus wide and deep, partially filled by a broad spiral rib. Sculpture consisting of fine close-set spiral lines over the entire shell, and, on the base, broad widely separated axials that are discernible only under magnification.

Measurements of the holotype, USNM 648432: height 1.6 mm, diameter 3.1 mm.

L.? lilli resembles *L.? stephensoni* in sculptural features but has a more elevated spire and lacks the thick pad of callus that partially covers the umbilicus in that species; its reference to *Leucorhynchia* is even less certain than in the case of *L.? stephensoni*.

Occurrence: Single specimen from drill hole 1 on Bikini Atoll at a depth of 40 feet; age, Recent.

Genus LOPHOCOCHLIAS Pilsbry

Pilsbry, 1921, Acad. Nat. Sci. Philadelphia Proc., p. 377.

Type (by monotypy): *Haplocochlias minutissimus* Pilsbry. Recent, Hawaii.

Lophocochlias minutissimus (Pilsbry)

Plate 15, figures 3–5

Haplocochlias (Lophocochlias) minutissimus Pilsbry, 1921, Acad. Nat. Sci. Philadelphia Proc., p. 377.
Edmondston, 1946, B. P. Bishop Mus., Spec. Pub. 22, p. 165.

Minute, turbinate; apex sharp, made up of smooth whorls; body whorl descending at aperture, bearing six strong spiral keels, the upper three forming a prominent slightly curved peripheral zone; a weak keel lies between the suture and the uppermost strong keel; two cords spiral into the wide umbilicus; aperture subcircular and oblique; peristome entire, outer lip thickened into a strong varix that on some specimens is slightly back from the lip edge; regularly spaced oblique axial threads most conspicuous in the wide flat depressions between keels. Well-preserved fossils from Recent beds retain the brownish-yellow color of the apex that is so characteristic of living specimens; remainder of shell white.

Measurements of the figured specimen (E–1, Eniwetok, 710–720 ft), USNM 648433: height 0.5 mm, diameter 0.7 mm.

Occurrence: In describing this species as a Recent shell from Hawaii, Pilsbry noted that it was the smallest marine shell known to him from that area. It now has the added distinction of being the most widespread species—both geographically and geologically—in the western Pacific island area.[3] Recent shells have been collected from the Marshalls and from the Tuamotu Islands (Raroia) far to the southeast. Numerous fossils from Eniwetok and Bikini range downward to the lower Miocene (Tertiary *e*) at depth of 2,164 feet. In Fiji the species was found in abundance in the Suva Formation (sta. 160) on Viti Levu; age, Miocene (Tertiary *f*); single specimen from Tongatabu, Tonga (B. P. Bishop Mus., cat 202980, sta. 3), age probably Pleistocene.

Lophocochlias appears to be closely related to *Lodderia* Tate 1899, a genus represented by several species in the Recent fauna of the Australian region. *Lophocochlias minutissimus* exhibits variation in sculpture at each of the localities from which Recent or fossil shells have been obtained. Most of the numerous Fijian and Eniwetok fossils and some of the Recent shells from Raroia show an additional secondary keel between the uppermost two primary keels.

Lophocochlias paucicarinatus Ladd, n. sp.

Plate 15, figures 6–8

Minute, turbinate; apex sharp, consisting of smooth whorls; body whorl descending at aperture, bearing three low primary keels, the upper one giving the shell a turreted appearance; obscure traces of secondary spirals are visible under high magnification, three on the base and one near the suture; umbilicus moderately wide, aperture subcircular, oblique; peristome entire, outer lip thickened into a strong varix that on one of the two available specimens lies a little back of the lip edge.

Measurements of the holotype, USNM 648434: height 1.0 mm, diameter 1.2 mm.

L. paucicarinatus has fewer primary keels and a narrower umbilicus than *L. minutissimus* and lacks the axial sculpture of that species.

Occurrence: Two specimens from drill hole E–1 on Eniwetok Atoll at a depth of 2,040–2,050 feet in beds assigned to lower Miocene (Tertiary *e*).

Genus MUNDITIELLA Kuroda and Habe

Kuroda and Habe, 1954, Venus, v. 18, no. 2, p. 86, 90–91.

Type (by original designation): *Cyclostrema ammonoceras* A. Adams. Recent, Japan.

Munditiella qualum (Hedley)

Plate 15, figures 9–11

Teinostoma qualum Hedley, 1899, Australian Mus. Mem. 3, pt. 7, p. 406, fig. 2.

Small, depressed; spire nearly flat; width twice the height; suture impressed; aperture circular; peristome

[3] I have identified specimens from a well drilled on the coastal plain of Guadalcanal in the Solomon Islands (Baker, 1950). The shells were recovered from a depth of 380–400 feet. Foraminifera from the same beds are thought to be Pleistocene but possibly Pliocene (Ruth, Todd, oral commun., 1964).

complete, thin inner lip extended below; umbilicus moderately wide, deep. Sculpture consisting of regularly spaced sharply elevated axial ribs (about 20 on body whorl) with fine, close-set spiral lines developed in interspaces; fine axial threads that override the spirals can be seen under high magnification; body whorl flattened and free of axial ribs immediately below suture and around the umbilicus.

Measurements of the figured specimen from Eniwetok, USNM 648435: height 1.0 mm, diameter 2.0 mm.

M. qualum is smaller than the type species *M. ammonoceras* and has a more depressed spire.

Occurrence: Single specimens from drill hole F–1, Eniwetok Atoll, at depth of 280–290 feet, and Tongatabu, Tonga, at an altitude of 35 feet (B. P. Bishop Mus., cat. 202980); age of both occurrences probably Pleistocene. Abundant in beach drift on Rongerik Atoll. Hedley's types were collected from the lagoon shore of Funafuti, Ellice Islands.

Munditiella parryensis Ladd, n. sp.

Plate 15, figures 12–14

Small, depressed; spire low, width more than twice the height; aperture circular, peristome complete; inner lip extended below; lower half of peristome thickened behind its edge by swellings at the ends of the spiral ridges; umbilicus wide and deep. Sculpture consisting of regularly spaced axial ribs (37 on body whorl) separated by wider interspaces bearing fine axial lines; spiral sculpture consisting of two obscure peripheral ridges, a third on the base, and a fourth that encircles the umbilicus; all ridges best developed on the anterior part of body whorl.

Measurements of the holotype, USNM 648436: height 1.1 mm, diameter 2.6 mm.

M. parryensis has continuous axial ribs and a thickened peristome suggestive of *M. archeri* (Tryon, 1888, p. 89, pl. 33, figs. 84, 85, as *Cyclostrema archeri*), Recent species from Singapore, but that species has spiral lirae between the axial ribs.

Occurrence: Represented by three specimens from drill hole E–1 on Parry Island, Eniwetok Atoll, at depths of 35–40 (holotype), 750–760, and 850–860 feet; age of holotype, Recent; age of other two, late Miocene (Tertiary *g*). The two Miocene specimens are smaller than the holotype and appear to be immature.

Genus TEINOSTOMA H. and A. Adams

H. and A. Adams, 1853, Genera Recent Mollusca 1, p. 122.

Type (by virtual monotypy): *Teinostoma politum* A. Adams. Recent, Ecuador.

Subgenus ESMERALDA Pilsbry and Olsson

Pilsbry and Olsson, 1952, Acad. Nat. Sci., Philadelphia Proc. 104, p. 37, 39.

Type (by original designation): *Teinostoma esmeralda* Pilsbry and Olsson. Recent, Ecuador.

Teinostoma (Esmeralda) engebiense Ladd, n. sp.

Plate 15, figures 15–17

Small; spire depressed; body whorl inflated, its periphery uniformly rounded; imperforate; last whorl descending near aperture which is subcircular and slightly contracted; peristome entire, upper part of lip extended forward; umbilical area covered by thin callus. Sculpture consisting of numerous fine spiral lines that are distinguishable on all save the earliest whorls but are more widely spaced near the umbilicus than elsewhere.

Measurements of the holotype, USNM 648437: height 2.4 mm, diameter 3.8 mm.

In size and shape, *T. engebiense* resembles *T. rotatum*, a Recent species described by Hedley from Funafuti, but that species is narrowly umbilicate, and on its base bears narrow radial bars of callus.

Occurrence: A single fossil, the holotype, from shallow drill hole, En–4, on Engebi Island, Eniwetok Atoll, at a depth of 1 foot; age, Recent. The species is living today in the Marshall Islands.

Teinostoma (Esmeralda) marshallense Ladd, n. sp.

Plate 15, figures 18–20

Minute, lenticular; spire depressed, base flattened; imperforate; aperture broadly ovate, oblique, slightly contracted; peristome entire; umbilical area covered by moderately thick pad of callus. Sculpture consisting of exceedingly fine spiral lines and, on the base, traces of radial lines visible under magnification.

Measurements of the holotype, USNM 648438: height 1.1 mm, diameter 2.2 mm.

T. marshallense is smaller and much less inflated than *T. engebiense* from Recent beds in the same area and has much finer spiral sculpture.

Occurrence: Holotype from drill hole K–1B, Eniwetok Atoll, at depth of 863–873 feet; five additional specimens from beds immediately below (873–884 ft); age, early Miocene (Tertiary *f*). A single specimen from drill hole 2B on Bikini Atoll at depth of 2,175–2,185 feet is from beds still lower in the Miocene (Tertiary *e*).

Teinostoma (Esmeralda) sp. A

Plate 15, figures 21–23

Minute, discoidal; spire depressed, thick; imperforate; aperture subcircular, slightly contracted; outer lip ex-

tended forward. Sculpture consisting of closely spaced spiral lines.

Measurements of the figured specimen, USNM 648439: height 0.7 mm, diameter 1.5 mm.

Teinostoma sp. A resembles *T. marshallense* but is smaller, has coarser sculpture, and is less heavily callused in the umbilical region.

Occurrence: Represented by two somewhat worn specimens from the conglomerate at the base of the limestone in the Suva Formation on Walu Bay, Suva, Fiji (sta. 160); age, early Miocene (Tertiary *f*).

Genus SOLARIORBIS Conrad

Conrad, 1865, Am. Jour. Conchology, v. 1, p. 30.

Type (by subsequent designation, Dall, 1892, Wagner Free Inst. Sci. Trans., v. 3, pt. 2, p. 414: *Delphinula depressa* Lea, Eocene (Claiborne Group) of Alabama.

Solariorbis tricarinata (Melvill and Standen)

Plate 16, figures 1–3

Leucorhynchia tricarinata Melvill and Standen, 1896, Jour. Conchology [Leeds], v. 8, p. 311, pl. 11, figs. 75a, b.

Shell discoidal, thick; spire low; periphery with three prominent keels separated by deep grooves, the middle keel larger than others and with a median depression close to the aperture; ends of keels truncated near aperture and covered by callus; whorls of protoconch smooth, subsequent whorls, including most of the body whorl, marked by low oblique radiating folds that extend less than half way across the otherwise smooth surface of the whorls. On the base, the exposed three-quarters of the body whorl bears 13 strong folds that radiate from the umbilicus; on the remainder of the base, the folds are covered by callus which thickens into a projecting pad that shields the umbilicus when viewed from below; callus also covers the keels above the columella.

Measurements of the figured specimen (drill hole E–1, 990–1,000 ft), USNM 648440: height 1.6 mm, diameter 2.8 mm.

Occurrence: A rare shell from seven drill holes on Eniwetok and Bikini Atolls in the Marshall Islands. Total specimens, 13. The range is from Recent rocks close to the surface to Miocene (Tertiary *e*) at a depth of 1,471 feet. No Recent shells were found at Bikini and Eniwetok Atolls in spite of intensive collecting, but many examples were found in collections of drift shells from the nearby atolls of Rongerik and Rongelap. All the Recent shells are badly worn.

This distinctive species is one of the few mollusks that can be traced in the drill holes from Recent to lower Miocene beds without detectable changes. The Recent shell was first described from the Loyalty Islands and was later reported by Hedley from the beach facing the Funafuti lagoon (Hedley 1899a, p. 406). Unusual features that distinguish it from other members of the genus are the strong peripheral ribs, the middle one being grooved near the aperture, and the thick pad of callus that shields the umbilicus.

Solariorbis? sp.

Plate 16, figures 4, 5

Small, thick; spire low, consisting of 3½ rounded whorls, the last with a low keel at the periphery; aperture subcircular; inner lip callused and somewhat extended below by an obscure ridge that issues from a narrow umbilicus. Sculpture consisting of fine close-set spiral striae over the entire shell and regularly spaced axial wrinkles on the base.

Measurements of the figured specimen, B. P. Bishop Museum, geology No. 1236: height 1.3 mm, diameter 1.9 mm.

The single fossil does not appear to be closely related to any described species, but the shell is worn and not suitable for a type. The reference to *Solariorbis* is questioned because the umbilicus is narrow, its ridge obscure, and there is no indication of a groove or channel at the junction of the upper edge of the outer lip with the parietal callus.

Occurrence: In the conglomerate at the base of the limestone in the Suva Formation exposed on Walu Bay, Suva, Fiji (sta. 160); age, early Miocene (Tertiary *f*).

Genus LYDIPHNIS Melvill

Melvill, 1906, Malacological Soc. London Proc., v. 7, p. 25.

Type (by monotypy): *Cyclostrema euchilopteron* Melvill and Standen. Recent, Gulf of Oman.

Lydiphnis eniwetokense Ladd, n. sp.

Plate 16, figures 6–8

Small, wider than high, strongly turreted; apex flat; protoconch of 1½ glossy convex whorls followed by 2½ dull flattened sculptured whorls; body whorl with two strong spiral keels with scalloped margins; the margin of the higher keel turned upward. Aperture subquadrate, broadly extended below the columella; umbilicus wide. Secondary sculpture consisting of a spiral rib between the two keels, a second spiral rib below the lower keel and a conspicuously beaded rib that spirals into the umbilicus; an obscure nodose rib developed on the body whorl immediately below the suture. Close-set tertiary spirals on the flattened upper surface of the body whorl. Axial growth lines are especially prominent in the area between the two keels. Both the holotype and paratype

retain traces of broad axial bands of brown on the upper part of the body whorl.

Measurements of the holotype (drill hole K–1B, 936–946 ft), USNM 648441: height 1.8 mm, diameter 2.1 mm. Paratype (E–1, 590–600 ft): height 1.1 mm, diameter 1.6 mm. Two other specimens from hole E–1 are smaller and appear to be immature.

The type species of *Lydiphnis*, *L. euchilopteron* (Melvill and Standen), is a larger Recent species in which the third or middle keel is much more prominent than on the Eniwetok fossils; the fossils likewise have a higher spire.

Occurrence: Four specimens from two drill holes on Eniwetok Atoll at depth of 590–946 feet; age, Pliocene to early Miocene (Tertiary *h–f*).

Genus CYCLOSTREMISCUS Pilsbry and Olsson

Pilsbry and Olsson, 1945, Acad. Nat. Sci. Philadelphia Proc., v. 97, p. 266.

Type (by original designation): *Vitrinella panamensis* C. B. Adams. Recent, Pacific coast of Panama.

Cyclostremiscus emeryi Ladd, n. sp.

Plate 16, figures 9–11

Minute; spire flat, apex sunken, diameter approximately twice the height; protoconch of single smooth whorl followed by two sculptured whorls; umbilicus wide and deep; aperture subcircular, peristome continuous, outer lip thin, slightly angled by carinae. Sculpture consisting of about nine spiral carinae, two at the periphery being larger than the others; all carinae except the peripheral pair are conspicuously beaded.

Measurements of the holotype (E–1, Eniwetok, 780–790 ft), USNM 648444: height 0.4 mm, diameter 0.9 mm. Paratype (E–1, Eniwetok, 990–1,000 ft); height 0.5 mm, diameter 1.0 mm.

The species is characterized particularly by its two strong almost smooth peripheral carinae with conspicuously beaded carinae above and below.

Occurrence: Eight specimens from drill hole E–1, Eniwetok Atoll, at depth of 630–1,589 feet; age, Miocene (Tertiary *e–g*). Two Recent specimens were recovered from beach drift on Rongerik Atoll and one was dredged from Bikini lagoon at a depth of 15 fathoms.

Subgenus PONOCYCLUS Pilsbry

Pilsbry, 1953, Acad. Nat. Sci. Philadelphia Mon. 8, p. 426.

Type (by orginal designation): *Adeorbis beaui* Fischer. Recent, southeastern United States and West Indies.

Cyclostremiscus (Ponocyclus) novemcarinatus (Melvill)

Plate 16, figures 12–14

Cyclostrema novem-carinatum Melvill, 1907. Malacological Soc. London Proc., v. 7, p. 22, pl. 3, figs. 3, 3a.

Vitrinella (Lydiphnis) novemcarinatum, Melvill, Beets, 1941, Geol.-mijnb. genootsch. Nederland en Kolonien Verh., Geol. ser., v. 13, pt. 1, p. 25, pl. 1, fig. 59, pl. 9, figs. 343–345.

Small; spire depressed; widely umbilicate, aperture oblique, subcircular. Sculpture consisting of strong spiral carinae, 8–10 on last whorl, the third and fourth from the top being larger than the others; radial striae visible under high power.

Measurements of the figured specimen (K–1B, 873–884 ft), USNM 648442: height 1.0 mm, diameter 2.0 mm.

The Eniwetok fossils are identical with Recent shells from the Cook Islands. The radial striae of the fossils appear to be less conspicuous than those originally described by Melvill on Recent shells from the Gulf of Oman, but I have not seen specimens from the type locality.

Occurrence: Four fossils from two drill holes on Eniwetok Atoll at a depth of 873–970 feet; age, early Miocene (Tertiary *f*). A single large worn shell collected from beach drift on Rongerik Atoll. Described by Beets from the upper Miocene of East Borneo.

Cyclostremiscus (Ponocyclus) cingulifera (A. Adams)

Plate 16, figures 15–17

Cyclostrema cingulifera A. Adams, 1850, Zool. Soc. London Proc., p. 43.

Sowerby, 1863, Thésaurus Conchyliorum, pt. 23, p. 250, pl. 255, figs. 13–14.

Tryon, 1888, Manual Conchology, v. 10, p. 93, pl. 32, figs. 72, 73.

Vitrinella cingulifera (A. Adams), Altena, 1938, Leidsche Geol. Mededel., v. 10, p. 298, fig. 17a–c. (See for additional citations.)

Medium size; spire low; widely umbilicate; aperture oblique, nearly circular with slight angle above; inner lip thinly callused. Sculpture consisting of strong uniformly spaced spiral carinae; 9–11 carinae of body whorl are subequal in size except for highest and lowest which are smaller; peristome thin, axial lines of growth appear on the early whorls and in the umbilicus but cannot be seen elsewhere except under high magnification.

Measurements of the figured specimen (Palau, USGS 21304), USNM 648443: height 2.4 mm, diameter 4.0 mm.

Occurrence: Eight specimens from the marls at the base of the Palau Limestone in the Goikul area (USGS 21301, 21304), Babelthuap, Palau; age, late Miocene (Tertiary *g*).

Recent shells have been reported from the Philippines, Japan, and other parts of the Indo-Pacific; fossil occurrence include the Pliocene and older beds of Java.

Genus COCHLIOLEPIS Stimpson

Stimpson, 1858, Boston Soc. Nat. History Proc., v. 6, p. 304.

Type (by monotypy): *Cochliolepis parasitica* Stimpson. Recent, South Carolina.

Cochliolepis diangalana Ladd, n. sp.

Plate 16, figures 18–20

Small, discoidal; width more than twice the height; about three whorls, the last rapidly expanding, flattened near suture, partly embracing the preceding whorl; suture impressed; aperture oblique, subquadrate; umbilicus moderately wide, deep. Sculpture consisting of close-set spiral lines and coarser, more widely spaced wrinkles of growth.

Measurements of the holotype, USNM 648445: height 0.8 mm, diameter 2.0 mm.

The Palauan fossil appears to be more strongly sculptured, both spirally and axially, than other fossil and Recent species.

Occurrence: Fifteen specimens from late Miocene (Tertiary *g*) marls at the base of the Palau Limestone in the Goikul area, Babelthuap Island, Palau (USGS 21301 (holotype) and 21304).

Genus VITRINELLA C. B. Adams

Adams, C. B., 1850, Monograph *Vitrinella,* p. 3.

Type (by subsequent designation Bush, 1897, Connecticut Arts and Sci. Trans., v. 10, p. 105, 122): *Vitrinella helicoidea* C. B. Adams. Recent, Jamaica.

Vitrinella sp. A

Plate 16, figures 21–23

Small, discoidal, depressed; aperture subcircular, oblique; inner lip thickened by slight expansions above and below; umbilicus narrow and deep, bordered by a beaded rib. Sculpture consisting of very fine spiral striae that are a little coarser near the umbilicus than elsewhere.

Measurements of the figured specimen, USNM 648446: diameter 1.5 mm, height 0.9 mm.

The small and possibly immature shells are tentatively assigned to *Vitrinella* because of the open umbilicus and spiral rib. They are, however, heavier and have stronger spiral sculpture than most Vitrinellas.

Occurrence: Single shell from drill hole 2B on Bikini Atoll at depth of 1,723–1,734 feet; age, early Miocene (Tertiary *e*); two Recent shells were collected from drift near Bikini Island.

LOCALITIES

Data on localities from which specimens studied were collected are given in the tables and illustrations that follow

Palau

[Babelthuap localities shown in fig. 2]

Island	USGS Cenozoic	Locality and collector
Auluptagel	17715	*Acropora* zone at base of Palau Limestone at contact with underlying volcanic (Ngarsul Member of Aimeliik Formation) at southeast part of volcanic area, on west end of northern peninsula. P.E. Cloud and Arnold Mason, 1948.
Do	18322	Road to lighthouse, altitude 350 ft. Arnold Mason and P.E. Cloud, 1948.
Do	21290	*Acropora* zone at base of Palau Limestone directly above contact with underlying volcanic (Ngarsul Member of Aimeliik Formation) immediately southeast of causeway to Malakal; altitude 0–6 ft. H.S. Ladd, 1958.
Do	23642	Upper foot of breccia in quarry at south end of bridge Malakal. G. Corwin and J.I. Tracey, Jr., 1964.
Babelthuap	21301	Marl facies at base of Palau Limestone, Goikul peninsula (exact loc. on fig. 2), H.S. Ladd, 1958.
Do	21304	Same as 21301 (fig. 2).
Do	21308	Do.
Do	21310	Do.

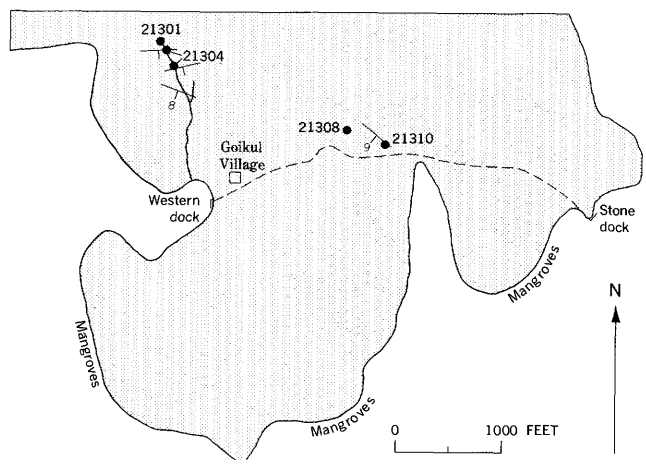


FIGURE 2.—Sketch map of Goikul peninsula showing fossil localities and attitude of marl beds, southeastern Babelthuap, Palau.

Mariana Islands

[Guam fossil localities shown in fig. 3; Saipan and Tinian localities in fig. 4]

Island	USGS Cenozoic	Locality; collector, Pacific Island Engineers, 1946–50, unless otherwise indicated
Guam	17416	West half of quarry at northeast corner of Harmon Field. P.E. Cloud, Jr., 1948.
Do	17446	About 2½ miles east-southeast of Wettengel Junction. P.E. Cloud, Jr. and R.G. Schmidt, 1949.
Do	17776	In bed of Talefac River south of Agat, about 150 ft from coast, close to high-tide level. P.E. Cloud, Jr. and R.G. Schmidt, 1948.
Do	20489	200 ft west of Fadian Point, east coast of island.
Do	20499	1,400 ft northeast of Tantapalo Point, west coast of island.
Do	20511	3,700 ft southeast of Ordot, waist of island.
Do	20517	3,400 ft north of Fadian Point, east coast of island.
Do	20526	3,050 ft south of Sinajana, waist of island.
Do	20531	About 2¼ miles east of Tamuning, waist of island.
Do	20533	4,000 ft southeast of Sinajana, waist of island.
Do	20534	About 600 ft south of Taguag, west coast of island.
Do	20536	1¼ miles east-southeast of Ordot, waist of island.
Do	20555	About 3,000 ft southeast of Toto, waist of island.
Do	20560	About 5,000 ft southeast of Toto, waist of island.
Do	20574	4,600 ft east-northeast of Sinajana, waist of island.
Do	20579	4,000 ft east-southeast of Sinajana, waist of island.
Do	20585	5,600 ft northwest of Fadian Point, waist of island.
Do	20590	About 3,000 ft east-northeast of Toto, waist of island.
Do	20600	About 4,700 ft southeast of Ordot, waist of island.

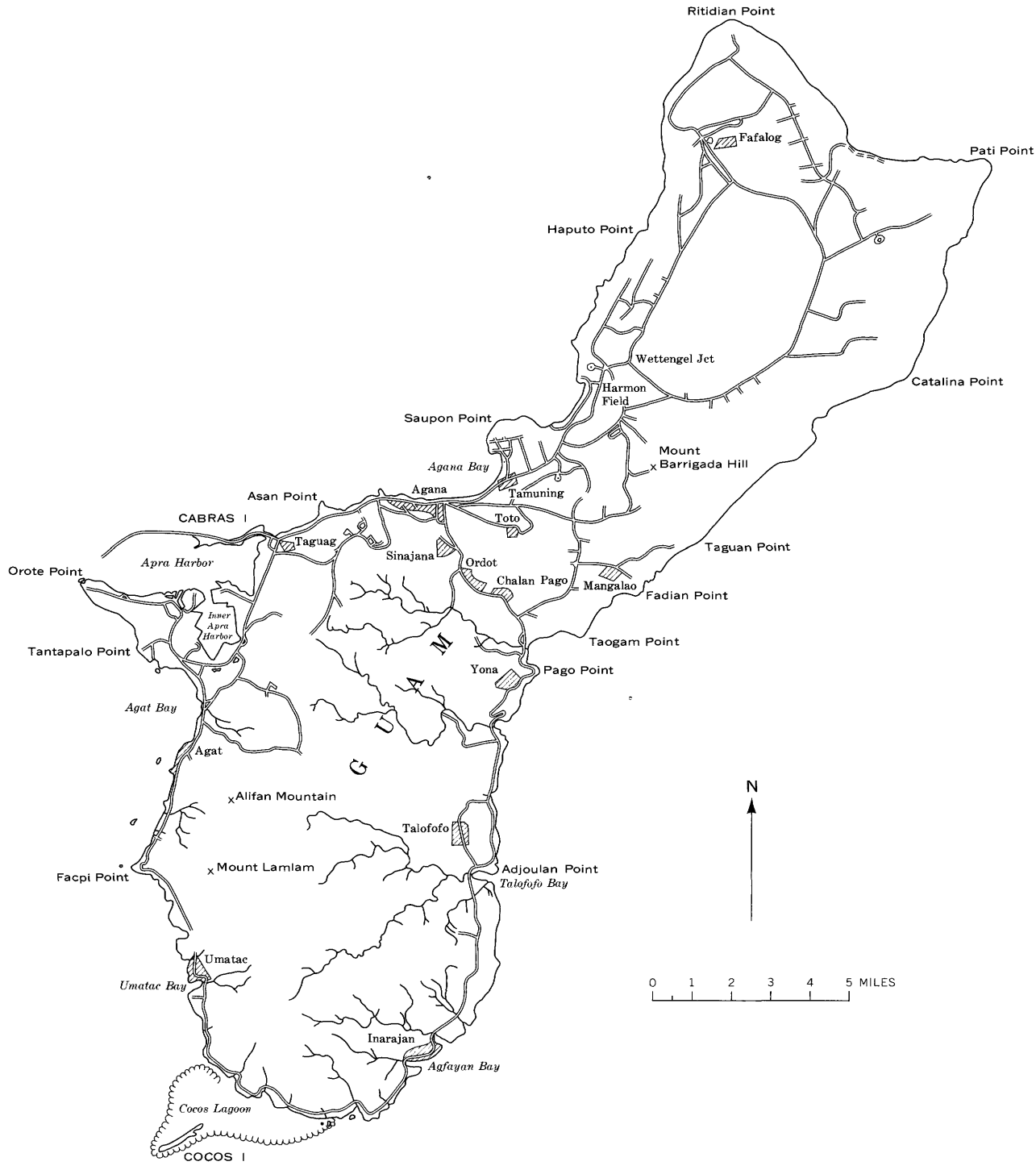


FIGURE 3.—Sketch map of Guam, Mariana Islands, showing villages and physiographic features used in placing fossil localities.

Mariana Islands—Continued

Island	USGS Cenozoic	Locality; collector, Pacific Island Engineers, 1946–50, unless otherwise indicated
Guam	20602	About 1,200 ft northeast of Barrigada Hill, waist of island.
Do	20613	About 1,700 ft northwest of Iates Point, waist of island.
Do	20614	About 5,000 ft west of Taogam Point, about 1,000 ft from shore, waist of island.
Do	20615	About 2,500 ft northwest of Pago Point, waist of island.
Do	20616	About 4,500 ft west-northwest of Taogam Point, about 1,000 ft from shore, waist of island.
Do	20619	West coast bluff at Tamuning, 2,000 ft from shore.
Do	20634	About 1 mile south of Sinajana, waist of island.
Do	20636	About 6,000 ft south of Sinajana, waist of island.
Do	20639	About 3,400 ft northeast of Mount Lamlam, southern part of island.
Do	20649	About 1 mile northwest of Adjoulan Point, southeast part of island.
Do	20650	500 ft northwest of head of Talofofo Bay, southeast coast.
Do	20653	About 0.8 mile northwest of Talofofo, southern part of island.
Do	20657	About 2,500 ft west of Fadian Point, waist of island.
Do	20678	West side of Route 4, south of Inarajan, near southeast coast.
Do	20679	Along road about 1 mile south of head of Talofofo Bay.
Do	20687	About 3,000 ft south-southeast of end of Asan Point, west of Agana, west coast.
Do	20709	About 1½ miles east of Agana, waist of island.
Do	20711	About 0.4 mile east of Agana, waist of island.
Do	20712	Eastern edge of Agana, on shore.
Do	20720	About 3,000 ft inland from midpoint on west side Inner Apra Harbor, west coast of island.
Do	20728	About 0.9 mile south-southwest of end of Asan Point, west of Agana.
Do	20732	1.3 miles south of Sinajana, waist of island.
Do	20861	On coast near Taguan Point, waist of island.
Do	20869	Right bank of Talofofo River about 3 miles northwest of head Talofofo Bay, south lobe of island.
Do	20981	Fafalog, northern end of island. D. Doan, 1952.
Do	20994	Roadside ledge south of Mangilao at point 0.65 mile southeast of junction with US 10. Fadian Point area, waist of island. P.E. Cloud, 1953.
Do	21369	Along secondary road about 0.85 mile southeast of Ordot, waist of island. H.S. Ladd, 1958.
Do	21373	Abandoned quarry near road, 1 mile south of Agfayan Bay, southeast coast. H.S. Ladd, 1958.
Do	21377	Abandoned quarry south side of road about 1 mile east of fork in road lying about 1 mile southeast of Chalan Pago; waist of island. H.S. Ladd, 1958.
Do	21382	Roadcut on south side of point of land projecting into southeast corner of Inner Apra Harbor, H.S. Ladd, 1958.
Do	21383	First roadcut east of sta. 21382, southeast corner of Inner Apra Harbor. H.S. Ladd, 1958.
Do	21591	Cabras Island, northeast side Apra Harbor. P.E. Cloud, 1954.
Do	21625	Large Fadian Point quarry. J.E. Tracey.
Saipan	17387	About 0.4 mile east-southeast of Agingan Point. R.G Schmidt and P.E. Cloud, 1948.
Do	17723	About 1,000 ft N. 59° W. from Donni Springs. R.G. Schmidt and P.E. Cloud, 1949.
Do	17891	About 2,900 ft north-northwest of Naftan Point; south end of island. P.E. Cloud, 1948.
Do	17895	About 2,300 ft west of Hasngot Beach on east coast. R.G. Schmidt, 1949.
Do	17904	About 1,500 ft east of Magpi Point, northern end of island. H.W. Burke, 1949.
Do	18285	About 3,600 ft north-northeast of Naftan Point (south tip of island) at a point 500 ft inshore from edge of sea cliff. P.E. Cloud, 1948.
Do	21407	Same as 17387, H.S. Ladd, 1958.
Tinian	21611	Surface of terrace at Marpo Point, altitude. 120 ft. J. Bridge, 1945.

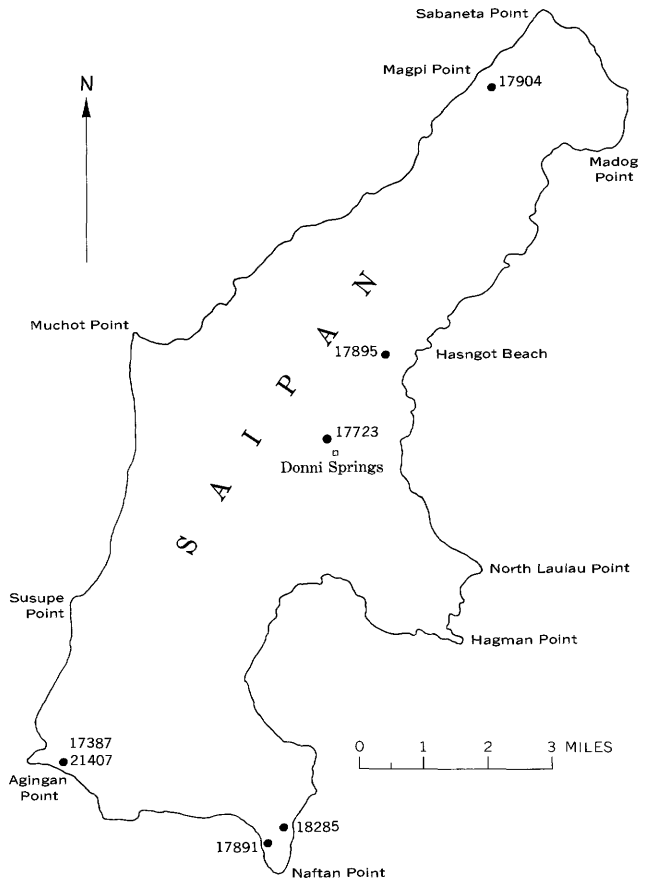


FIGURE 4.—Sketch map of Saipan, Mariana Islands, showing fossil localities.

Marshall Islands

[Eniwetok drill holes (except F– –A and F– –C) shown in figs. 5 and 6, Bikini drill holes in fig. 7. ONR, Office of Naval Research; USGS, U.S. Geological Survey; AEC, Atomic Energy Commission; JTF, Operation Crossroads, Joint Task Force One]

Atoll	Island	Drill hole	Total depth (feet)	Driller and date
Eniwetok	Elugelab	F–1	4,630	ONR and USGS, 1952.
Do	do	F– –A	100	AEC, 1952.
Do	do	F– –C	102.5	AEC, 1952.
Do	Parry	E–1	4,222	ONR and USGS, 1952.
Do	Engebi	K–1	443.5	ONR and USGS, 1951.
Do	do	K–1B	1,280	ONR and USGS, 1951.
Do	do	En–4	48	AEC, 1950.
Do	do	En–9	110	AEC, 1950.
Do	Mujinkarikku	Mu–4	48	AEC, 1950.
Do	do	Mu–5	80	AEC, 1950.
Do	do	Mu–6	100	AEC, 1950.
Do	Eberiru	EB–2	53.5	AEC, 1950.
Do	Aranit	A–1	200	AEC, 1950.
Do	Runit	RU–2	135	AEC, 1950.
Bikini	Bikini	1	300	JTF, 1947.
Do	do	2	190	JTF, 1947.
Do	do	2A	1,346	JTF, 1947.
Do	do	2B	2,556	JTF, 1947.

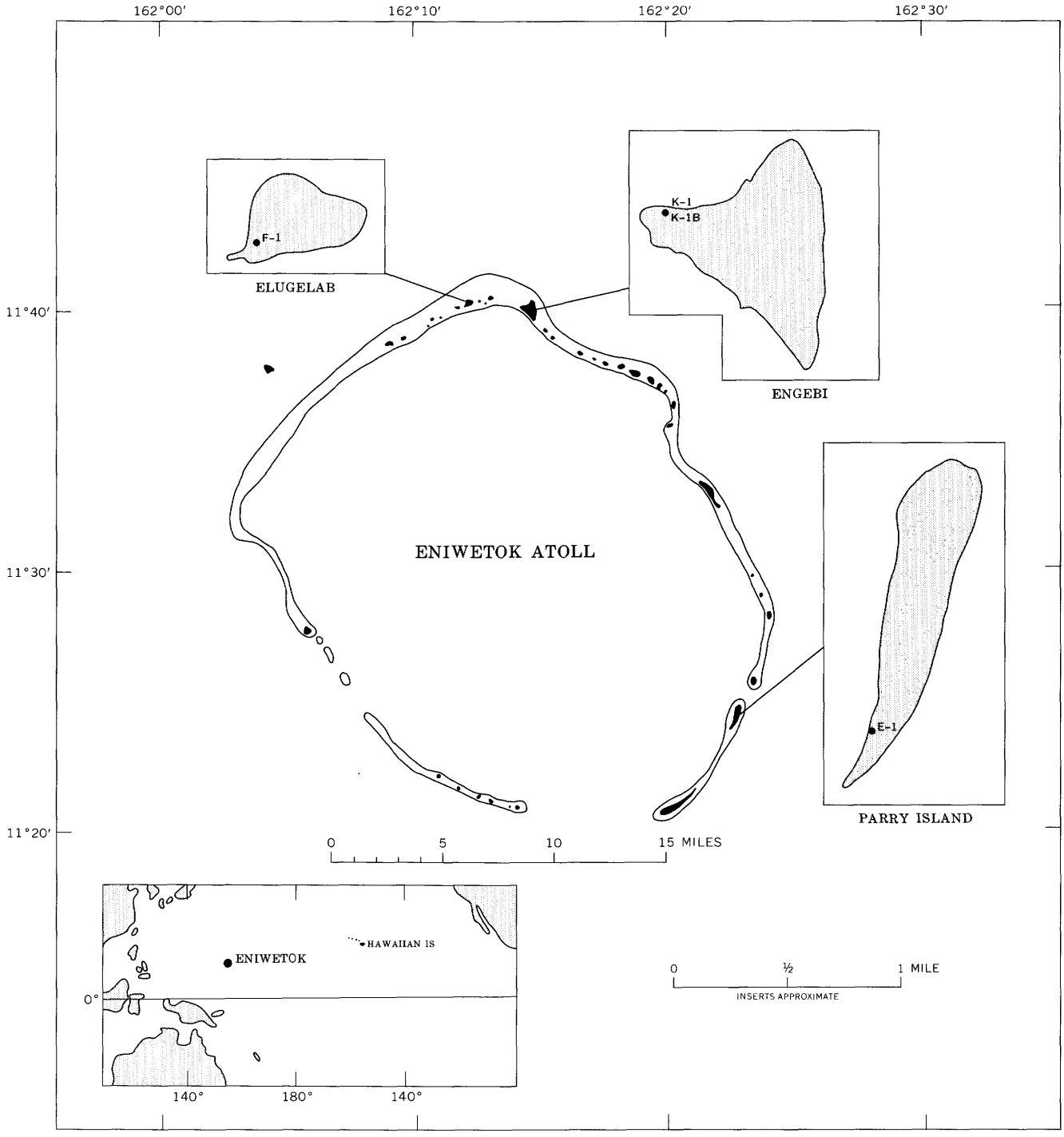


FIGURE 5.—Location of deep holes drilled on Eniwetok Atoll, Marshall Islands.

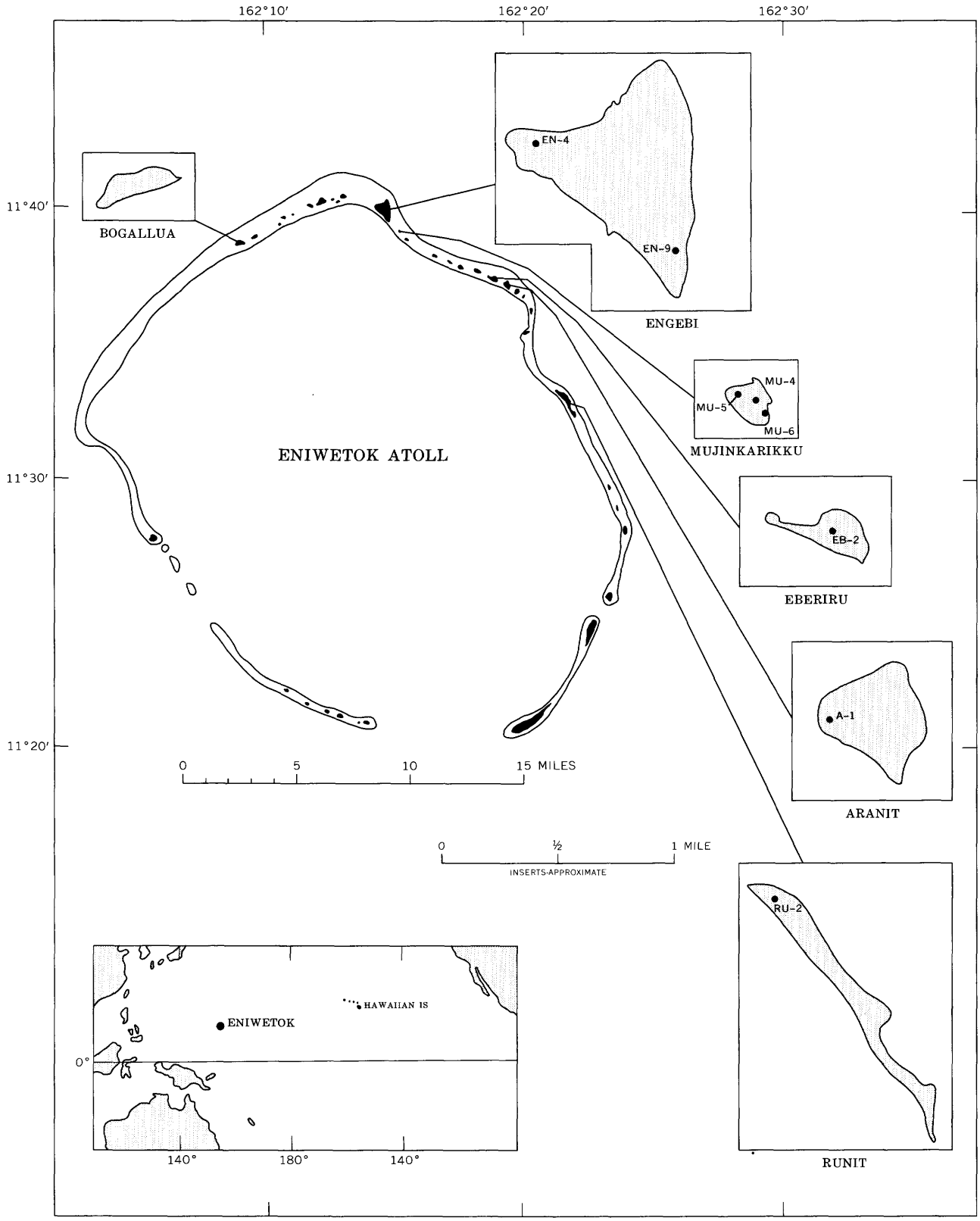


FIGURE 6.—Location of numbered shallow holes drilled on islands of Eniwetok Atoll, Marshall Islands.

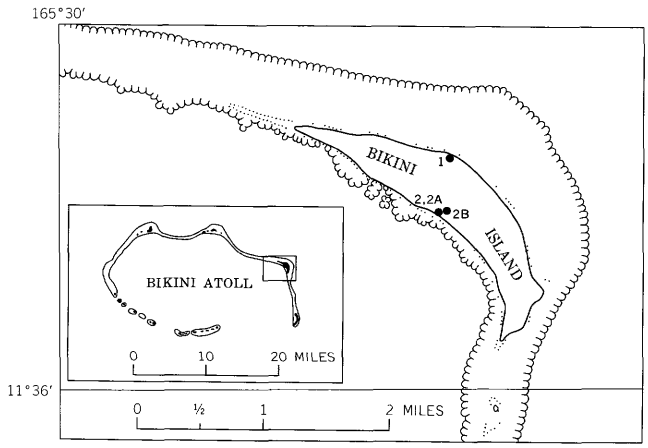


FIGURE 7.—Location of holes drilled on Bikini Atoll, Marshall Islands.

Ellice Islands—Funafuti Atoll

Island	Drill hole (fig. 8)	Depth (feet)	Driller and date
Funafuti	Main boring	0–698	Royal Society, T.W. Edgeworth David, 1897.
Do	do	698–1114½	Royal Society, A.E. Finckh, 1898.

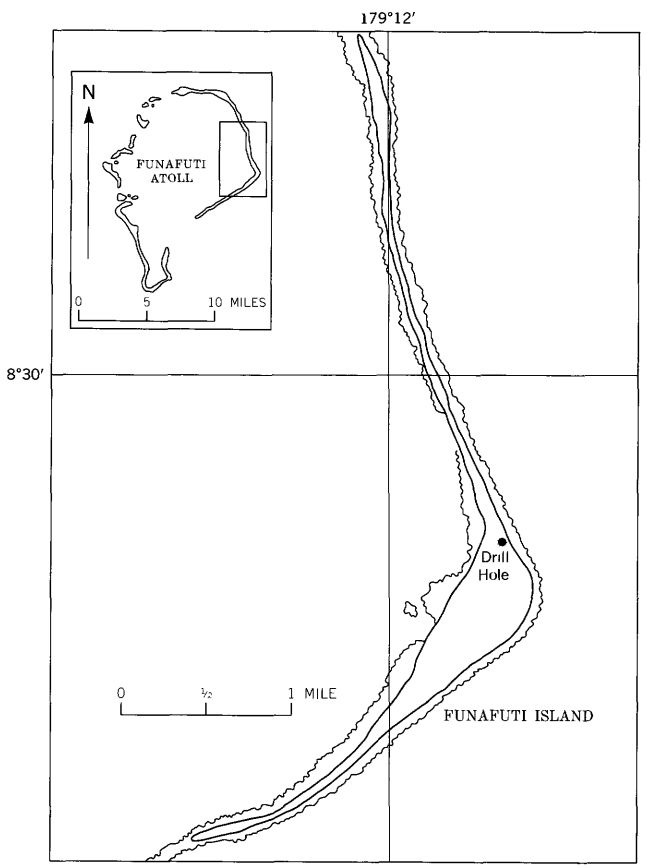


FIGURE 8.—Location of deep hole drilled on Funafuti Island, Ellice Islands.

New Hebrides

[Fossil localities shown in fig. 9]

Island	USGS Cenozoic	Station	Locality and collector
Espiritu Santo	21026	ES–4	Along road; altitude 150–250 ft. H.T. Stearns.
Do	21027	ES–5	Altitude 150 ft. H.T. Stearns.
Do	21028	ES–14	From engineers pit, altitude 240 ft. H.T. Stearns.
Do	21029	ES–2	From coral pit at altitude 215 ft. H.T. Stearns.
Do	21031		Gravel bar in Sarakata River near coast; north of Segond Channel. H.T. Stearns.
Malekula			Nua River; waist of island. Collected by E.A. de La Rüe; described by R. Abrard.
Epi			Bay of Foreland, about 3,200 ft north-northeast of Foreland Head. Collected by E.A. de La Rüe; described by R. Abrard.

Fiji

Island	Station	Locality shown in fig.—	Locality and collector
Viti Levu	59	10	Right bank of Wailoa River about 1 mile west of Nasongo; altitude 995 ft. H.S. Ladd.
Do	160	10	Conglomerate, quarry on south side of Walu Bay, near entrance; few feet above sea level. H.S. Ladd.
Do	160A	10	South side of Walu Bay about 200 yards east of bridge (close to sta. 160). R.E. Houtz.
Do	165	10	Right bank of Wailoa River a few yards above sta. 59. H.S. Ladd.
Do	295	10	Tamavua Quarry at head of Walu Bay; 41 ft exposed; base 144 ft above sea level. H.S. Ladd and others.
Do	297	10	Quarry on south side of Walu Bay, near entrance; directly overlies rock of sta. 160. H.S. Ladd.
Do	305	10	About 1¾ miles SSE. of Suva Post Office; old quarry face on left bank of creek which enters sea near tip of Suva Point, 12 ft exposed; base lying 3 ft above high tide level. P. Turner.
Do	320	10	Along trail between Naivotho and Matainanu; 15 ft exposed; altitude 245 ft. H.S. Ladd
Do	MR–20	10	Korotambua Creek. 1,350 ft southwest of end of railroad spur. M.J. Rickard.
Do	FB–20	10	Same as Ladd's sta. 160. W.M. Briggs, Jr.
Do	FB–22	10	Limestone about 28 ft above conglomerate, south side of Walu Bay near entrance. W.M. Briggs, Jr.
Fulanga	L–24	11	Elevated reef at end of northwest horn; altitude 0–10 ft. H.S. Ladd
Do	L–32	11	Summit of Nawiriwiri (Quoin Hill); altitude 260 ft. H.S. Ladd.
Do	L–35	11	Elevated reef on seaward side of Nasuthu; altitude 0–25 ft. H.S. Ladd.
Do	L–45	11	Elevated reef on inner side of northwest horn; altitude 5–15 ft. H.S. Ladd.
Do	L–46	11	Elevated reef on small island northwest of Nasuthu; altitude 0–10 ft. H.S. Ladd.
Do	L–78	11	Southeast slope of Ndelai Korolevu; altitude 10 ft. H.S. Ladd.
Yanuia, Ongea	L–120	12	Elevated reef, southwest coast; altitude 0–8 ft. H.S. Ladd.
Do	L–148	12	Summit of highest hill on northwest coast; altitude 200 ft. H.S. Ladd.
Lakemba	L–304	13	Top of hill at Vatuloa on southwest coast; altitude 84–99 ft. H.S. Ladd.
Do	L–391	13	Outcrop on first point southeast of Tumbou; altitude 0–5 ft. H.S. Ladd.[1]
Do	L–493	13	On west coast about 3 miles northwest of Tumbou; altitude 0–30 ft. H.S. Ladd[1]

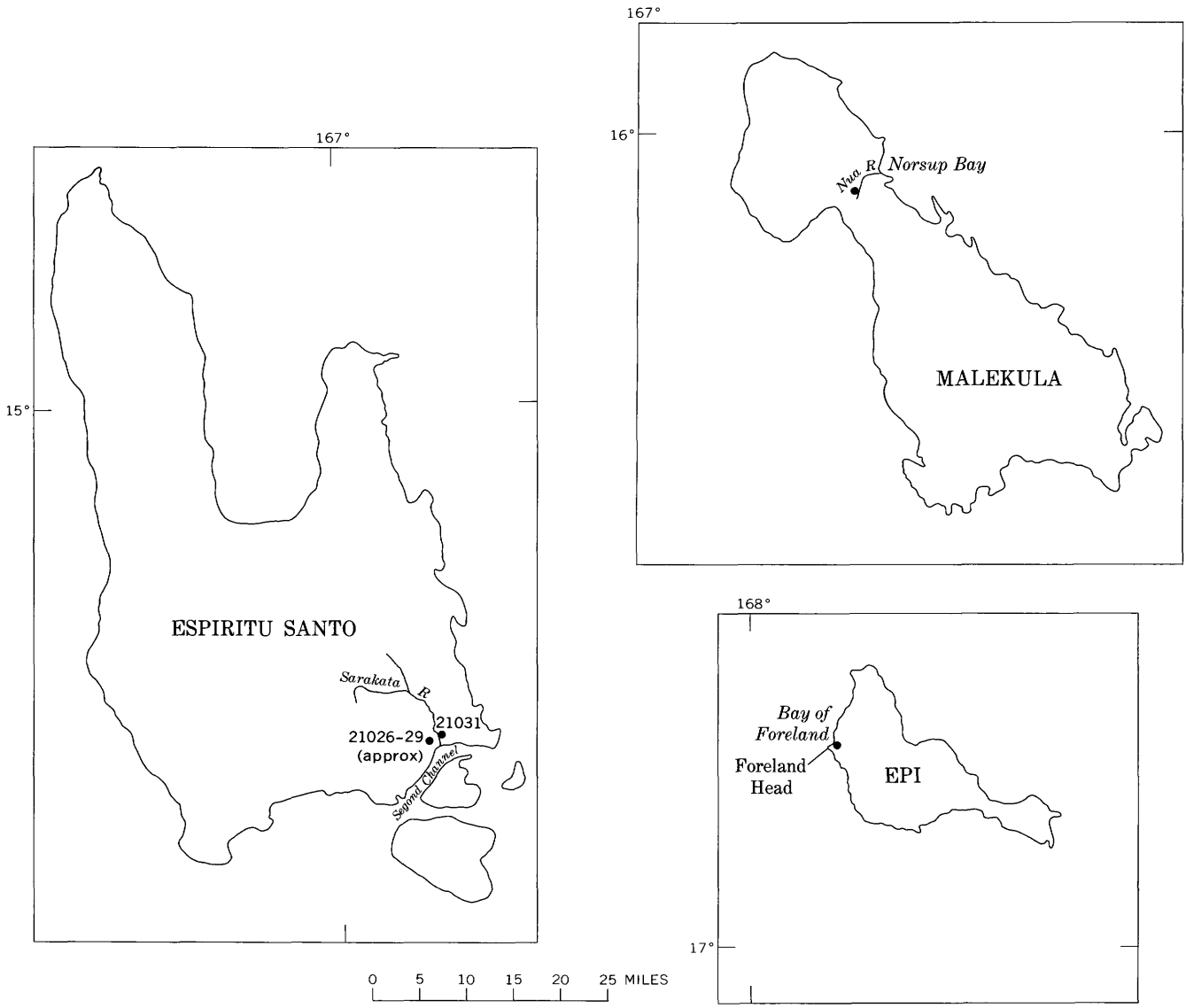


FIGURE 9.—Fossil localities in the New Hebrides.

Fiji—Continued

Island	Station	Locality shown on fig.—	Locality and collector
Vanua Mbalavu	110B		Ndukelulu Point, north of Ndalithoni village; altitude 15 ft. H.S. Ladd and J.E. Hoffmeister.
Do	110C		Tip of Ndukelulu Point, north of Ndalithoni village; altitude 12 ft. H.S. Ladd and J.E. Hoffmeister.
Do			Ngillangilla, northwest extremity of island; altitude 10 ft. E.C. Andrews.
Mango	M2		Southeastern part of island rim; altitude 400 ft. J.E. Hoffmeister.
Tuvutha			Altitude 650 ft. E.C. Andrews.

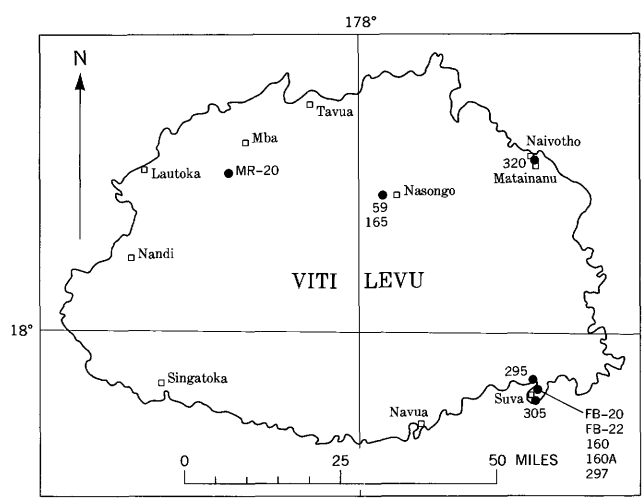


FIGURE 10.—Fossil localities on Viti Levu, Fiji.

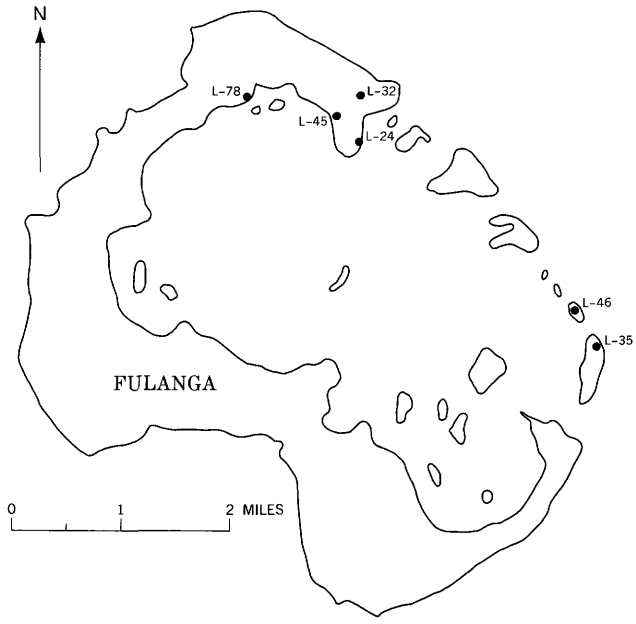
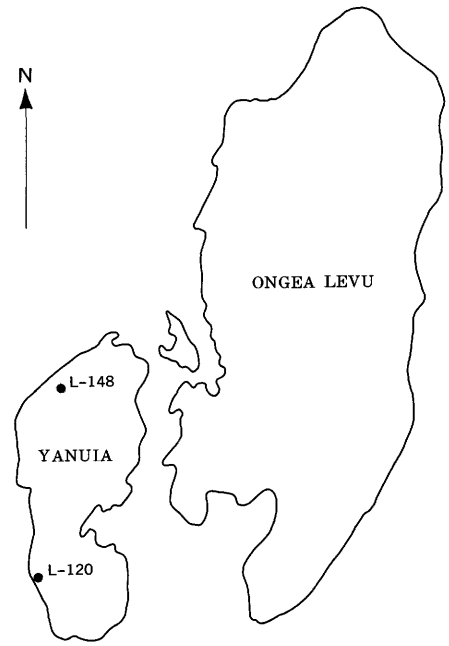


FIGURE 11.—Fossil localities on Fulanga, Lau, Fiji.

Tonga

Island	B.P. Bishop Mus. Cat.	Station (fig. 14)	Locality and collector
Tongatabu	202497	7	Quarry at Nukualofa ¾ mile from sea, alttiude 10 ft. J.E. Hoffmeister and J.M. Ostergaard.
Do	202720	7	See preceding entry.
Do	202879	2	About 1¼ miles south of Houma; altitude 0–40 ft. J.M. Ostergaard, W.A. Setchell and J.E. Hoffmeister.
Do	202950	4	Holoipepe Quarry about 6 miles west of Nukualofa. J.M. Ostergaard and J.E. Hoffmeister.
Do	202967	----------	Shore rocks near Houma. J.M. Ostergaard.
Do	202976	3	About 1 mile southwest of Houma; altitude 35 ft. J.M. Ostergaard.
Do	202980	3	Do.
Do	204926	7	See 202497.
Do	204927	3	See 202976.
Do	204928	3	Do.
Niue	----------	----------	Third terrace at Alofi on western side of island; U.S.F.C. steamer *Albatross*, 1898.



ONGEA ISLANDS

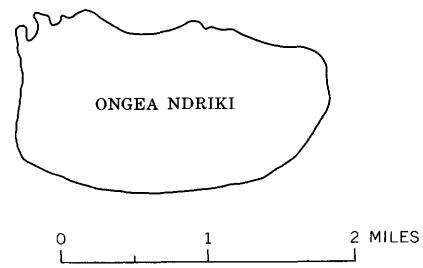


FIGURE 12.—Fossil localities on Ongea, Lau, Fiji.

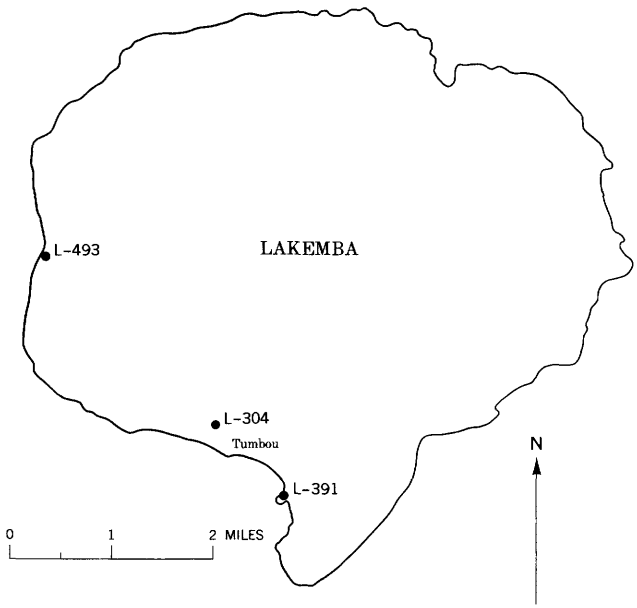


FIGURE 13.—Fossil localities on Lakemba, Lau, Fiji.

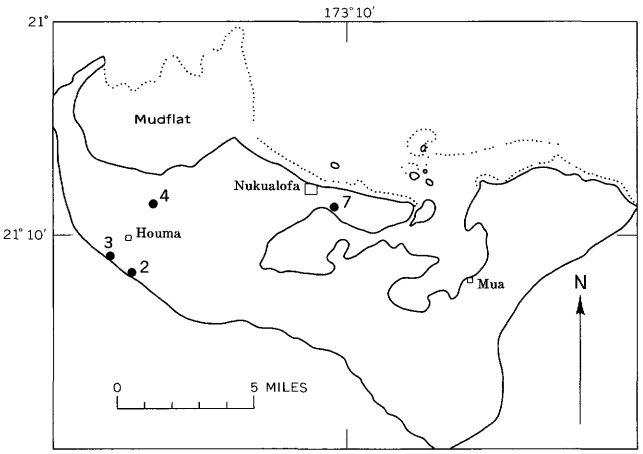


FIGURE 14.—Fossil localities on Tongatabu, Tonga.

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PLATES 1–16

PLATE 1

FIGURES 1–3. *Schizochiton incisus goikulensis* Ladd, n. subsp. (p. 21).
Holotype, a tail valve, length 10.0 mm, × 5. Palau; late Miocene (Tertiary *g*). USNM 648208.

4–9. *Schizochiton marshallensis* Ladd, n. sp. (p. 22).

4–6. Holotype, a tail valve, length 8.2 mm, × 5. . E–1, Eniwetok, 870–880 ft; early Miocene (Tertiary *f*) USNM 648209.

7. Paratype A, a head valve, length 5.5 mm, × 5. F–1, Eniwetok, 740–750 ft; late Miocene (Tertiary *g*). USNM 648210.

8. Paratype B, a second valve, length 7.2 mm, × 5. F–1, Eniwetok, 750–760 ft; late Miocene (Tertiary *g*). USNM 648211.

9. Paratype C, a second valve, length (incomplete) 3.4 mm, × 8. 2A, Bikini, 1,030–1,034 ft; early Miocene (Tertiary *f*). USNM 648212.

10–12. *Loricella* sp. A (p. 22).

10, 11. A head valve, length 1.6 mm, × 8. F–1, Eniwetok, 55–60 ft; Recent. USNM 648215.

12. An intermediate valve, length (minus insertion plates) 2.0 mm, × 8. E–1, Eniwetok, 35–40 ft; Recent. USNM 648216.

13–15. *Lucilina russelli* Ladd, n. sp. (p. 23).
Holotype, a tail valve, length 4.1 mm, × 8. K–1B, Eniwetok, 537–548 ft; probably Pliocene (Tertiary *h*). USNM 648217.

16. *Lucilina* sp. A (p. 23).
A tail valve, length (insertion plates missing) 2.1 mm, × 8. Palau; late Miocene (Tertiary *g*). USNM 648219.

17. *Lucilina* sp. B (p. 23).
A tail valve, length 6.5 mm, × 4. Fiji; probably Pliocene (Tertiary *h*). USNM 648218.

18, 19. *Lucilina* sp. (p. 24).
An intermediate valve, length 0.9 mm, × 15. Funafuti, 70 ft; Recent. MCZ 28020.

20, 21. *Acanthochitona* sp. (p. 24).
An intermediate valve, length 1.1 mm, × 15. E–1, Eniwetok, 770–780 ft; late Miocene (Tertiary **g**). USNM 648220.

22. *Cryptoplax* cf. *C. menkrawitensis* Beets (p. 24).
An intermediate valve, length (incomplete) 1.7 mm, × 15. Fiji (sta. 160); Miocene. USNM 648221.

23–27. *Cryptoplax* sp. A (p. 24).

23, 24. Head valve, length 1.4 mm, × 20. E–1, Eniwetok, 750–760 ft; early Miocene (Tertiary *f*). USNM 648222.

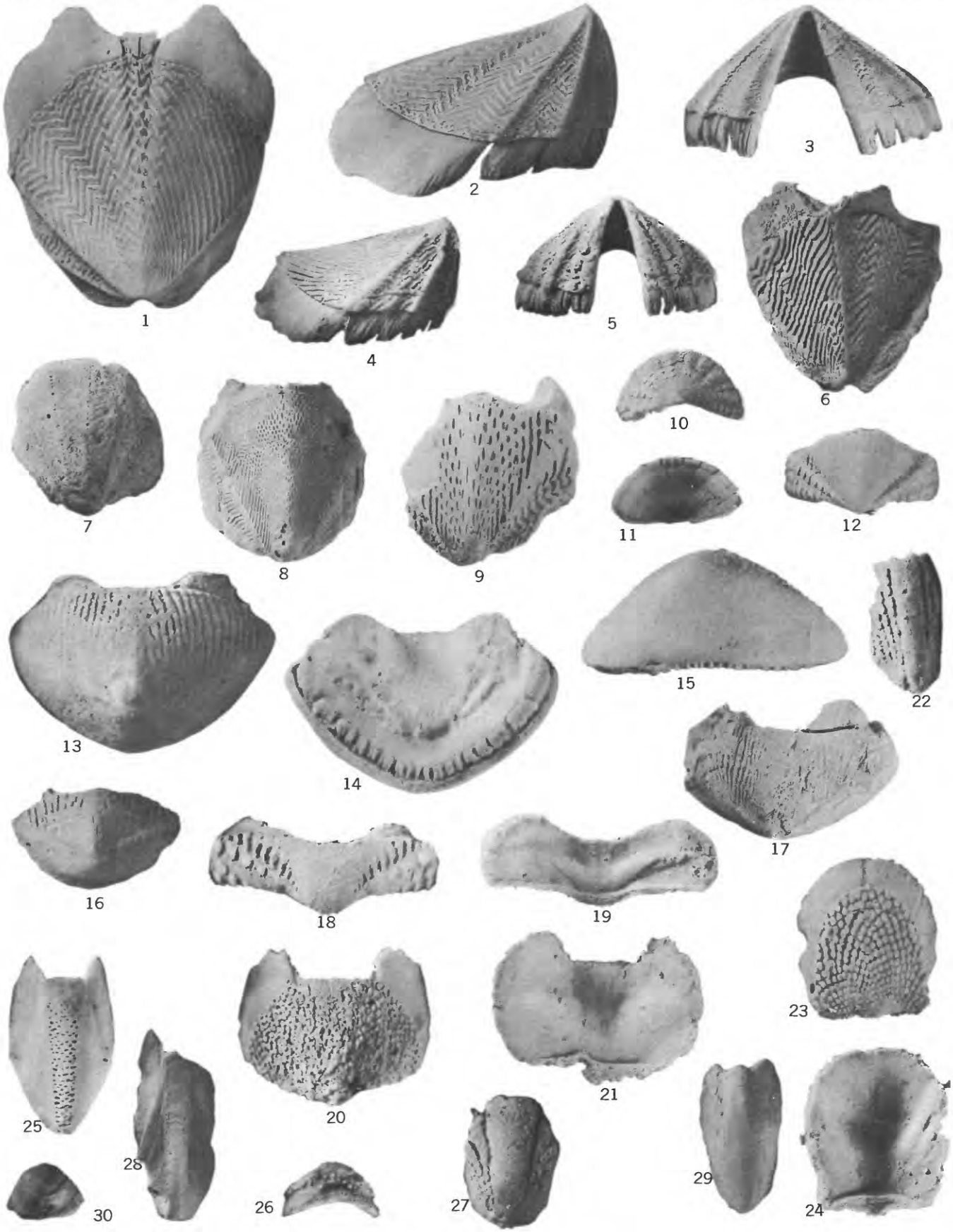
25. Intermediate valve, length 2.1 mm, × 15. 2B, Bikini, 1,891–1,902 ft; early Miocene (Tertiary *e*). USNM 648223.

26, 27. Tail valve, length 1.1 mm, × 20. 2B, Bikini, 1,870–1881 ft); early Miocene (Tertiary *e*). USNM 648224.

28–30. *Cryptoplax* sp. B (p. 25).

28. Intermediate valve, length 7.3 mm, × 5. F–1, Eniwetok, 800–810 ft; late Miocene (Tertiary *g*). USNM 648225.

29, 30. Tail valve, length 5.5 mm, × 5. F–1, Eniwetok, 720–730 ft; late Miocene (Tertiary *g*). USNM 648226.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CHITONS

PLATE 2

FIGURES 1, 2. *Haliotis (Padollus) ovina* Gmelin (p. 25).
Guam specimen, length 58.2 mm, × 1. USGS 20489, Reef facies, Mariana Limestone; Pliocene and Pleistocene. USNM 648227.

3–5. *Haliotis (Padollus)* cf. *H. clathrata* Reeve (p. 26).

3, 4. Guam specimen, length 24.8 mm, × 1. USGS 20994, detrital facies, Mariana Limestone; Pliocene and Pleistocene. USNM 648228.

5. Tinian specimen, length 15.9 mm, × 2. USGS 21611, limestone terrace probably equivalent to Mariana Limestone of Guam; Pliocene and Pleistocene. USNM 648229.

6. *Scissurella (Scissurella) declinans* Watson (p. 26).
Height 0.7 mm, × 20. Drill hole 2B, Bikini Atoll, depth 884–894 ft; late Miocene (Tertiary *g*). USNM 648230.

7, 8. *Scissurella (Scissurella) coronata* Watson (p. 27).
Height 1.3 mm, × 15. Drill hole E–1, Eniwetok Atoll, depth 30–35 ft; Recent. USNM 648329.

9, 10. *Scissurella (Anatoma) equatoria* Hedley (p. 27).
Height 0.6 mm, × 20. Drill hole on Funafuti Atoll, depth 65 ft; Recent. MCZ 28021.

11, 12. *Emarginula (Emarginula) bicancellata* Montrouzier (p. 27).
Height 2.5 mm, × 10. Drill hole on Funafuti Atoll, depth 65–74 ft; Recent. British Mus. 1964, 23.

13, 14. *Emarginula (Emarginula)* cf. *E. peasei* (Thiele) (p. 28).
Length 3.3 mm, × 10. Drill hole E–1, Eniwetok Atoll, depth 90–110 ft; Recent. USNM 648231.

15, 16. *Emarginula (Emarginula)* aff. *E. clypeus* A. Adams (p. 28).
Length 4.3 mm, × 10. Drill hole F–1, Eniwetok Atoll, depth 60–70 ft; Recent. USNM 648232.

17, 18. *Emarginula (Subzeidora) souverbiana* Pilsbry (p. 28).
Length 3.0 mm, × 10. Drill hole E–1, Eniwetok Atoll, depth 10–20 ft; Recent. USNM 648233.

19, 20. *Emarginula (Subzeidora)* sp. A (p. 28).
Length 2.1 mm, × 15. Drill hole 2B, Bikini Atoll, depth 1,807–1,819 ft; early Miocene (Tertiary *e*). USNM 648234.

21, 22. *Emarginula (Subzeidora)* sp. B (p. 29).
Length 2.2 mm, × 15. Drill hole F–1, Eniwetok Atoll, depth 20–45 ft; Recent. USNM 648235.

23. *Hemitoma (Hemitoma)* sp. (p. 29).
Length 28.8 mm, × 1. Sta. 110B, Vanua Mbalavu, Fiji; Ndalithoni limestone; probably Pliocene (Tertiary *h*). USNM 648449.

24, 25. *Hemitoma (Montfortia) bikiniensis* Ladd, n. sp. (p. 29).
Holotype, length 4.8 mm, × 6. Drill hole 2, Bikini Atoll, depth 105 ft; Recent. USNM 648236.

26, 27. *Hemitoma (Montfortia)* sp. A (p. 29).
Length 3.0 mm, × 10. Drill hole E–1, Eniwetok Atoll, depth 35–40 ft; Recent. USNM 648237.

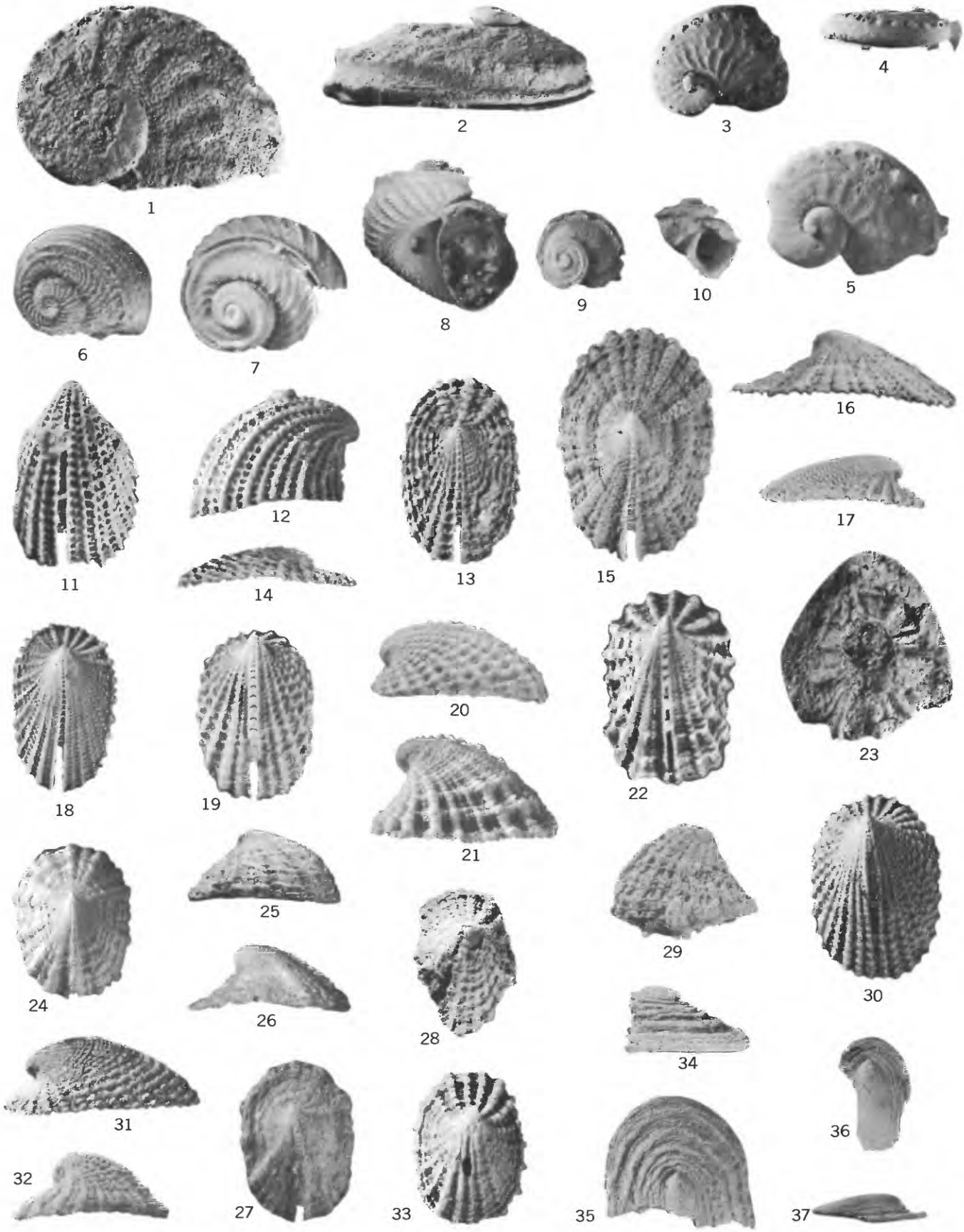
28, 29. *Hemitoma (Montfortista) excentrica* (Iredale) (p. 30).
Length (incomplete) 9.2 mm, × 3. From coral pit (USGS 21029) on Espiritu Santo, New Hebrides; Pleistocene or Recent. USNM 648238.

30, 31. *Rimula exquisita* A. Adams (p. 30).
Length 4.4 mm, × 8. Drill hole 2A, Bikini Atoll, depth 447–453 ft; probably Pliocene. USNM 648239.

32, 33. *Rimula* sp. (p. 30).
Length 1.9 mm, × 15. Drill hole E–1, Eniwetok Atoll, depth 10–20 ft; Recent. USNM 648240.

34, 35. *Scutus (Nannoscutum)* sp. A (p. 31).
Width 7.1 mm, × 4. Drill hole F–1, Eniwetok Atoll, depth 720–730 ft; late Miocene (Tertiary *g*). USNM 648241.

36, 37. *Scutus (Nannoscutum)* sp. B (p. 31).
Length (incomplete) 5.3 mm, × 4. Drill hole K–1B, Eniwetok Atoll, depth 768–779 ft; late Miocene (Tertiary *g*). USNM 648242.



GASTROPODS: HALIOTIDAE, SCISSURELLIDAE, AND FISSURELLIDAE

PLATE 3

FIGURES 1, 2. *Diodora (Elegidion) marshallensis* Ladd, n. sp. (p. 31).
Holotype, length 3.4 mm, × 15. E–1, Eniwetok, 700–710 ft; late Miocene (Tertiary *g*). USNM 648243.

3, 4. *Diodora (Elegidion)* aff. *D. granifera* (Pease) (p. 31).
Length (incomplete) 3.0 mm, × 15. Mu–4, Eniwetok, 8 ft; Recent. USNM 648244.

5, 6. *Diodora (Elegidion)* sp. A (p. 32).
Length 14.8 mm, × 3. Palau; late Miocene (Tertiary *g*). USNM 648245.

7. *Patella (Scutellastra) stellaeformis* Reeve (p. 32).
Length 9.1 mm, × 5. F–23–C, Eniwetok, 85–88 ft; probably Recent. USNM 648246.

8. *Cellana sp.* A (p. 32).
Length 28.2 mm, × 1. USGS 17891, Saipan; probably Recent. USNM 648247.

9, 10. *Euchelus (Euchelus)* cf. *E. quadricarinatus* (Dillwyn) (p. 33).
Height 3.7 mm, × 8. K–1B, Eniwetok, 663–674 ft; late Miocene (Tertiary *g*). USNM 648253.

11–13. *Euchelus (Herpetopoma) instrictus* (Gould) (p. 33).
Eniwetok specimen, height 4.1 mm, × 8. E–1, 30–40 ft; Recent. USNM 648254.

14–16. *Euchelus (Herpetopoma) instrictus suvaensis* Ladd, n. subsp. (p. 33).
Holotype, height 3.6 mm, × 8. Viti Levu, Fiji (sta. 160); early Miocene (Tertiary *f*). USNM 648255.

17–19. *Euchelus (Vaceuchelus) angulatus* Pease (p. 34).
Eniwetok specimen height 3.0 mm, × 8. E–1, 40–50 ft; Recent. USNM 648256.

20–22. *Euchelus (Vaceuchelus)* sp. A (p. 34).
Eniwetok specimen, height 2.8 mm, × 8. E–1, 30–40 ft; Recent. USNM 648257.

23, 24. *Hybochelus cancellatus orientalis* Pilsbry (p. 34).
Eniwetok specimen, height (incomplete) 3.6 mm, × 8. E–1, 50–60 ft; Recent. USNM 648258.

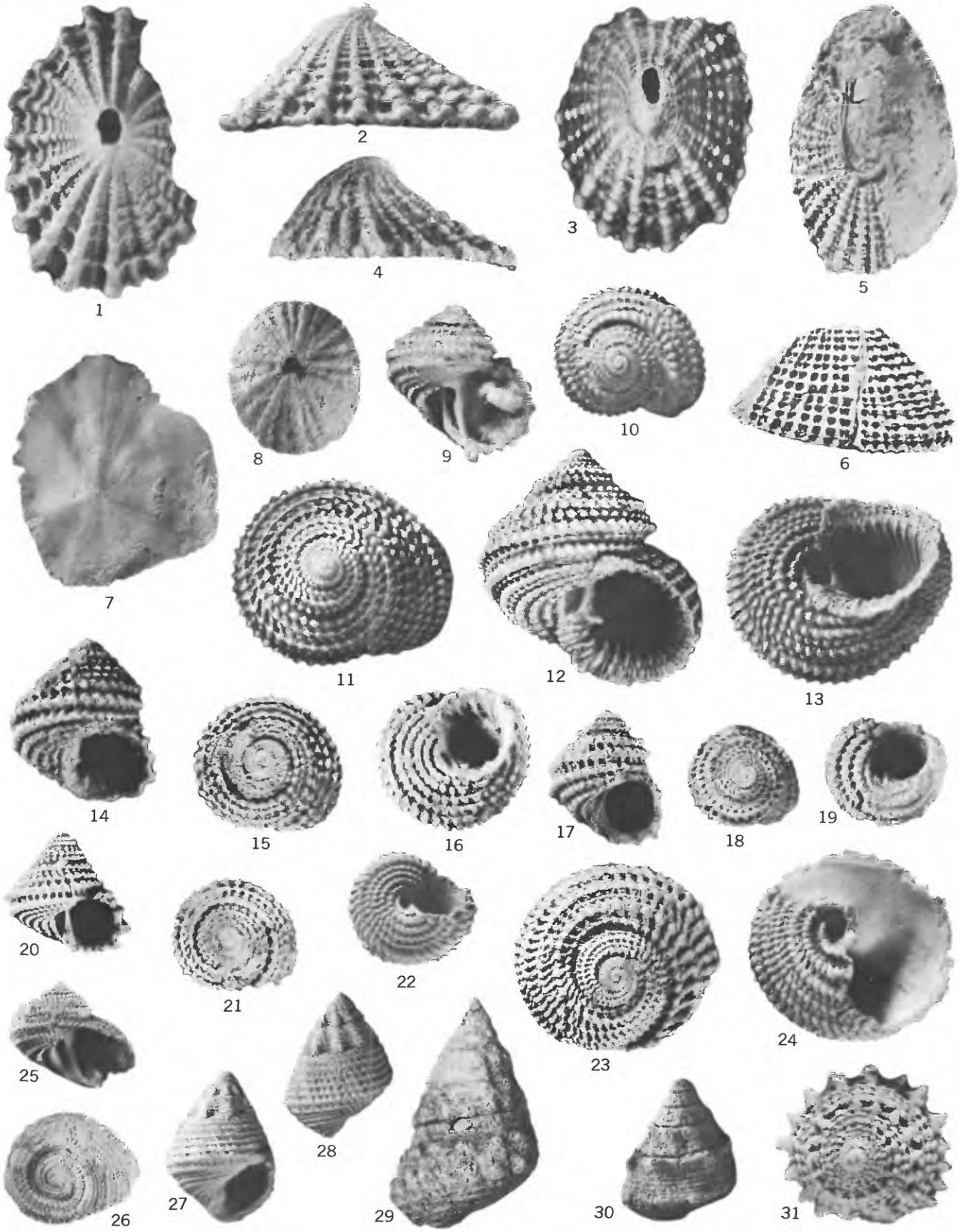
25, 26. *Hybochelus kavoricus* Ladd (p. 35).
Holotype, height 10.2 mm. Diameter (incomplete) 12.2 mm, × 2. Ndalithoni Limestone, sta. 110B, Vanua Mbalavu, Fiji; probably Pliocene (Tertiary *h*). Rochester Univ. Mus. Nat. History 13045.

27, 28. *Thalotia (Thalotia) berauensis* (Beets) (p. 35).
Eniwetok specimen, height 5.2 mm, × 5. K–1B, 1,070–1,081 ft; early Miocene (Tertiary *f*). USNM 648259.

29. *Thalotia (Thalotia)* aff. *T. elongatus* (Wood) (p. 35).
Guam specimen, height 22.2 mm, × 2. Mariana Limestone; (USGS 20574); probably Pleistocene. USNM 648260.

30. *Thalotia (Beraua)* sp. (p. 35).
Saipan specimen, height 9.7 mm, × 3. Inequigranular facies, Tagpochau Limestone (USGS 17904); Miocene. USNM 648261.

31. *Turcica (Perrinia) morrisoni* Ladd, n. sp. (p. 36).
Holotype, diameter 2.8 mm, × 10. Bikini reef; Recent. USNM 648262.



GASTROPODS: FISSURELLIDAE, PATELLIDAE, AND TROCHIDAE

PLATE 4

FIGURES 1–5. *Turcica (Perrinia) morrisoni* Ladd, n. sp. (p. 36).

1, 2. Holotype, height 3.3 mm, × 10. Bikini reef; Recent. USNM 648262.

3–5. Drill hole 2B, Bikini, 1,461–1,472 ft; early Miocene (Tertiary *f*). USNM 648263, × 10.

6, 7. *Gibbula (Gibbula) engebiensis* Ladd, n. sp. (p. 36).
Holotype, height 2.9 mm, × 10. K–1B, Eniwetok, 926–936 ft; early Miocene (Tertiary *f*). USNM 648264.

8–10. *Fossarina (Minopa) hoffmeisteri* Ladd, n. sp. (p. 37).
Holotype, height 4.1 mm, × 8. Mu–4, Eniwetok, 40 ft; Recent. USNM 648265. Fig. 10 uncoated to show color pattern.

11–13. *Astele (Callistele) engebiensis* Ladd, n. sp. (p. 37).
Holotype, height 2.7 mm, × 10. K–1B, Eniwetok, 968–978 ft; early Miocene (Tertiary *f*). USNM 648266.

14, 15. *Trochus (Trochus) maculatus* Linnaeus (p. 37).
Guam specimen, height 20.2 mm, × 2. USGS 20636; Mariana Limestone; Pliocene and Pleistocene. USNM 648248.

16–18. *Trochus (Trochus) histrio* (Reeve) (p. 37).
Height 11.2 mm, × 2. F–1, Eniwetok, 110–120 ft; probably Recent. USNM 648249.

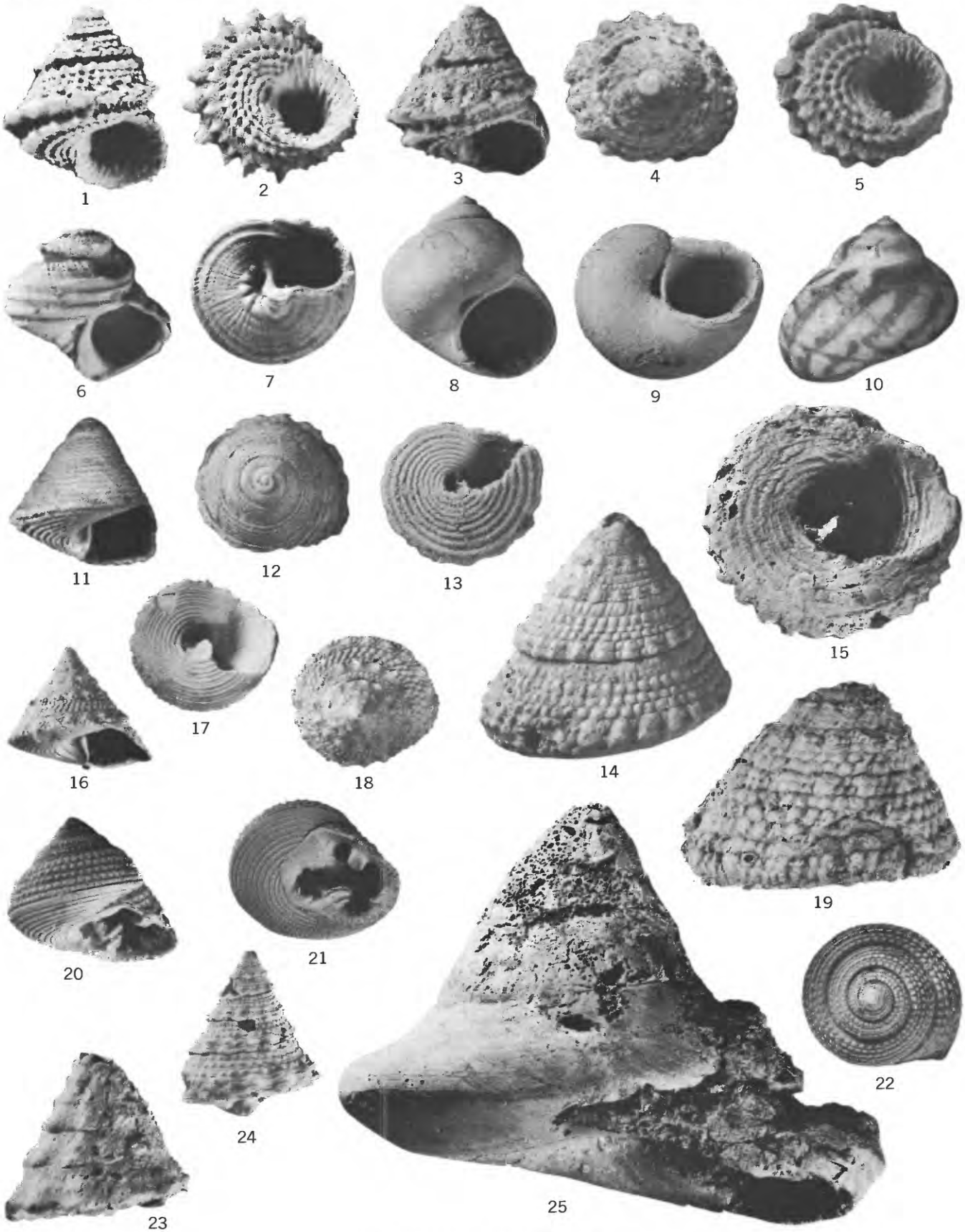
19. *Trochus (Trochus) tubiferus* Kiener (p. 38).
Height (incomplete) 20.8 mm, × 2. Tongatabu, Tonga (sta. 2); probably Pleistocene. B. P. Bishop Mus. geology No. 1339.

20–22. *Clanculus (Clanculus) clanguloides fijiensis* Ladd (p. 38).
Holotype, height 9.6 mm, × 3. Vanua Mbalavu, Fiji (sta. 110B); Ndalithoni Limestone; probably Pliocene (Tertiary *h*), Rochester Univ. Mus. Nat. History 13044.

23. *Tectus (Tectus) mauritianus* (Gmelin) (p. 38).
Height (incomplete) 16.5 mm, × 2. Espiritu Santo, New Hebrides (USGS 21028); probably Pleistocene. USNM 648250.

24. *Tectus (Tectus)* cf. *T. bomasensis* (Martin) (p. 39).
Holotype, height 15.1 mm, × 2. Viti Levu, Fiji (sta. MR–20); probably Pliocene (Tertiary *h*). USNM 648251.

25. *Tectus (Rochia) niloticus* (Linnaeus) (p. 39).
Height (incomplete) 100 mm, × 0.75. Espiritu Santo, New Hebrides (USGS 21029); Pleistocene or Recent. USNM 648252.



GASTROPODS: TROCHIDAE

PLATE 5

FIGURES 1–4. *Isanda (Parminolia) apicina* (Gould) (p. 39).

1, 2. Height 3.9 mm, × 6. Eniwetok speciment, E–1, 60–70 ft; Recent. USNM 648267.

3, 4. Height 4.9 mm, × 6. Gould's type from Australia; Recent. USNM 24159.

5–8. *Monilea (Monilea) mateana* Ladd (p. 40).

5, 6. Holotype, height 7.0 mm, × 4. Viti Levu, Fiji, (sta. 160); Miocene (Tertiary *f*). B. P. Bishop Mus. Geol. 1196.

7, 8. Specimen from type locality, height 6.7 mm, × 4. USNM 648392.

9–12. *Monilea (Monilea) marshallensis* Ladd, n. sp. (p. 40).

9, 10. Holotype, height 3.9 mm, × 6. K–1B, Eniwetok, 1,248–1,259 ft; early Miocene (Tertiary *e*). USNM 648270.

11, 12. Paratype A, height 4.1 mm, × 6. Bikini, core from depth 235 ft; post-Miocene. USNM 648268.

13, 14. *Monilea (Monilea) lifuana* Fischer (p. 40).
Eniwetok specimen, height 5.2 mm, × 4. En–4, 2 ft; Recent. USNM 648269.

15, 16. *Monilea (Monilea) belcheri* (Philippi) (p. 41).
Fiji specimen, height 8.6 mm, × 4. Sta. 320, Viti Levu, Fiji; Miocene. B. P. Bishop Mus., geology No. 1235.

17, 18. *Pseudostomatella (Pseudostomatella) maculata* (Quoy and Gaimard) (p. 41).
Fiji specimen, height 10.5 mm, × 3. Sta. 110B, Vanua Mbalavu; Nadalithoni Limestone; probably Pliocene (Tertiary *h*). USNM 648271.

19. *Stomatia cf. S. phymotis* Helbling (p. 41).
Guam specimen, height 7.3 mm, × 3. USGS 20534; probably Mariana Limestone; Pliocene and Pleistocene. USNM 648272.

20–23. *Synaptocochlea concinna* (Gould) (p. 41).
Eniwetok specimen, height 3.0 mm, × 10. F–1, 60–70 ft; probably Recent. USNM 648273. Figures 21 and 23 are uncoated and show color pattern.

24. *Synaptocochlea rosacea* (Pease) (p. 42).
Eniwetok specimen, length 4.5 mm, × 12. E–1, 30–35 ft; Recent. USNM 648274.

25, 26. *Synaptocochlea lekalekana* (Ladd) (p. 42).
Holotype, diameter 11.5 mm, × 3. Sta. 110C, Vanua Mbalavu, Fiji, Nadalithoni Limestone; probably Pliocene (Tertiary *h*). Rochester Univ. Mus. Nat. History 13051.

27, 28. *Synaptocochlea marshallensis* Ladd, n. sp. (p. 42).
Holotype, height 1.5 mm, × 12. Eniwetok, K–1B, 757–769 ft; late Miocene (Tertiary *g*). USNM 648275.

29, 30. *Angaria delphinus* (Linnaeus)? (p. 42).
Guam specimen, height 30.2 mm, × 1. USGS 20720; Alifan Limestone; (Tertiary *g* or *h*). USNM 648276.

31–34. *Angaria delphinus* (Linneaus) (p. 42).
Fijian specimens: 31, height 24.6 mm, × 1.7. 32–34, height 13.9 mm, × 2. Both specimens from sta. 160 on Walu Bay, Viti Levu; Suva Formation; (Tertiary *f*). Fig. 31 is B. P. Bishop Mus., geology No. 1216; figs. 32–34 are USNM 648393.

GASTROPODS: TROCHIDAE, STOMATELLIDAE, AND ANGARIIDAE

PLATE 6

FIGURES 1–5. *Astraea (Astralium) rhodostoma* (Lamarck) (p. 43).

1, 2. Saipan specimen, height 29.1 mm, × 1½. USGS 21407; Tanapag Limestone; probably Pleistocene. USNM 648285.

3–5. New Hebrides specimen, height about 25 mm, × 1½. Unapong, Eromanga; Quaternary.

6. *Astraea (Astralium)* aff. *A. rhodostoma* (Lamarck) (p. 43).
Rubber cast, height 19.7 mm, × 1½. From dolomitic limestone at depth of 1,006 ft, Main boring, Funafuti Atoll; probably Pleistocene. USNM 648286.

7–9. *Astraea (Astralium) eniwetokensis* Ladd, n. sp. (p. 43).
Holotype, height 7.9 mm, × 3. Drill hole F–1, Eniwetok, 790–800 ft; late Miocene (Tertiary *g*). USNM 648290.

10–12. *Astraea (Astralium) waluensis* Ladd, n. sp. (p. 43).
Holotype, height 12.9 mm, × 3. Viti Levu, Fiji (sta. 160); early Miocene (Tertiary *f*) USNM 648291.

13–15. *Astraea (Astralium)* sp. A (p. 44).
Eniwetok specimen, height (incomplete) 11.2 mm, × 3. F–1, 840–850 ft; late Miocene (Tertiary *g*). USNM 648292.

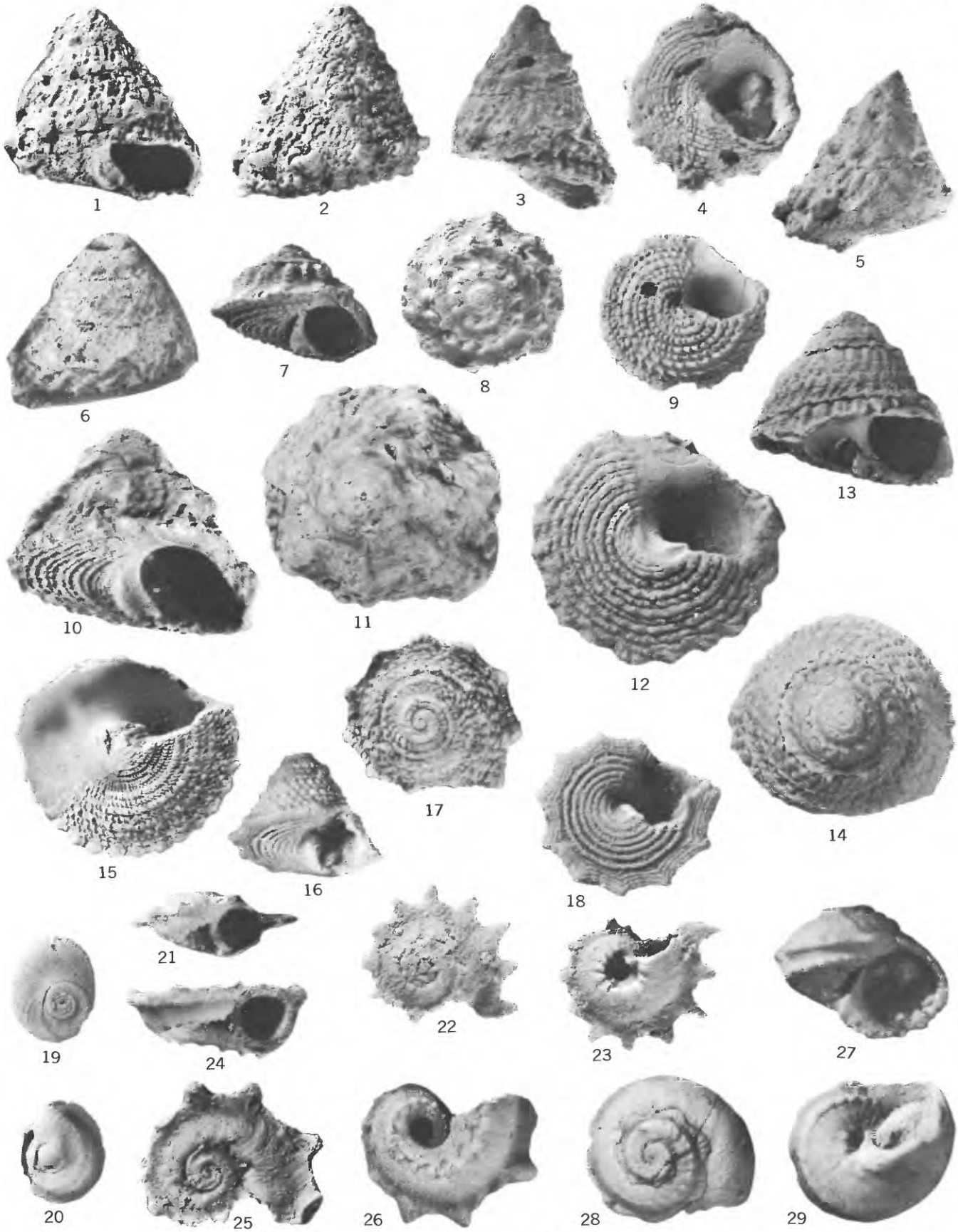
16–18. *Astraea (Astralium)* sp. B (p. 44).
Bikini specimen, height 1.8 mm, × 15. Drill hole 2, from core at 115 ft; Recent. USNM 648293.

19, 20. *Astraea (Astralium)* sp. C (p. 44).
Eniwetok operculum, height 2.8 mm, × 5. K–1B, 937–947 ft; early Miocene (Tertiary *f*). USNM 648294.

21–23. *Astraea (Bellastraea)* sp. D (p. 44).
Holotype, height 1.1 mm, × 10. K–1B, Eniwetok, 841–853 ft; late Miocene (Tertiary *g*). USNM 648295.

24–26. *Astraea (Bellastraea)* sp. E (p. 44).
Eniwetok specimen, height 1.2 mm, × 10. K–1B, 1,196–1,207 ft; early Miocene (Tertiary *e*). USNM 648296.

27–29. *Astraea (Vitiastraea) holmesi* Ladd, n. sp. (p. 45).
Holotype, height 2.4 mm, × 10. Viti Levu, Fiji (sta. 160); early Miocene (Tertiary *f*). USNM 648297.



GASTROPODS: TURBINIDAE

PLATE 7

FIGURES 1–6. *Arene (Arene) metaltilana* Ladd, n. sp. (p. 45).

1–3. Holotype, height 1.2 mm, × 20. 2B, Bikini, 1,702–1,713 ft; early Miocene (Tertiary *e*). USNM 648298.

4–6. Paratype, height 1.2 mm, × 20. 2B, Bikini, 2,297–2,307 ft; early Miocene (Tertiary *e*). USNM 648299.

7, 8. *Arene (Arene)* sp. A (p. 45).
Bikini specimen, height 2.3 mm, × 15. 2A, 742–747 ft; late Miocene (Tertiary *g*). USNM 648300.

9–11. *Liotina (Austroliotia)* cf. *L. botanica* (Hedley) (p. 46).
Holotype, height 1.4 mm, × 10. F–4–A, Elugelab, Eniwetok, 6–12 ft; Recent. USNM 648301.

12–14. *Liotina (Dentarene) loculosa* (Gould) (p. 46).
Eniwetok specimen, height 3.6 mm, × 6. E–1, 110–120 ft; probably Recent. USNM 648302.

15–17. *Liotina (Dentarene)* sp. A (p. 47).
Eniwetok specimen, height (incomplete) 1.9 mm, × 8. E–1, 2,590–2,600 ft; early Miocene, (Tertiary *e*). USNM 648303.

18–20. *Liotina (Dentarene)* sp. B (p. 47).
Bikini specimen, height (incomplete) 1.4 mm, × 8. 2B, 1,629–1,639 ft; early Miocene (Tertiary *f*). USNM 648304.

21, 22. *Turbo (Turbo) petholatus* Linnaeus (p. 47).

21. Guam specimen, height (incomplete) 23.8 mm, × 1½. USGS 20653; Agana Argillaceous Member of Mariana Limestone; Pliocene and Pleistocene. USNM 648277.

22. Guam specimen, height 29.4 mm, × 1½. USGS 20720; Alifan Limestone; (Tertiary *g* or *h*). USNM 648278.

23. *Turbo (Turbo) petholatus thanus* Ladd (p. 47).
Fiji specimen, height 23.2 mm, × 2. Sta. 160, Viti Levu; early Miocene (Tertiary *f*). USNM 648279.

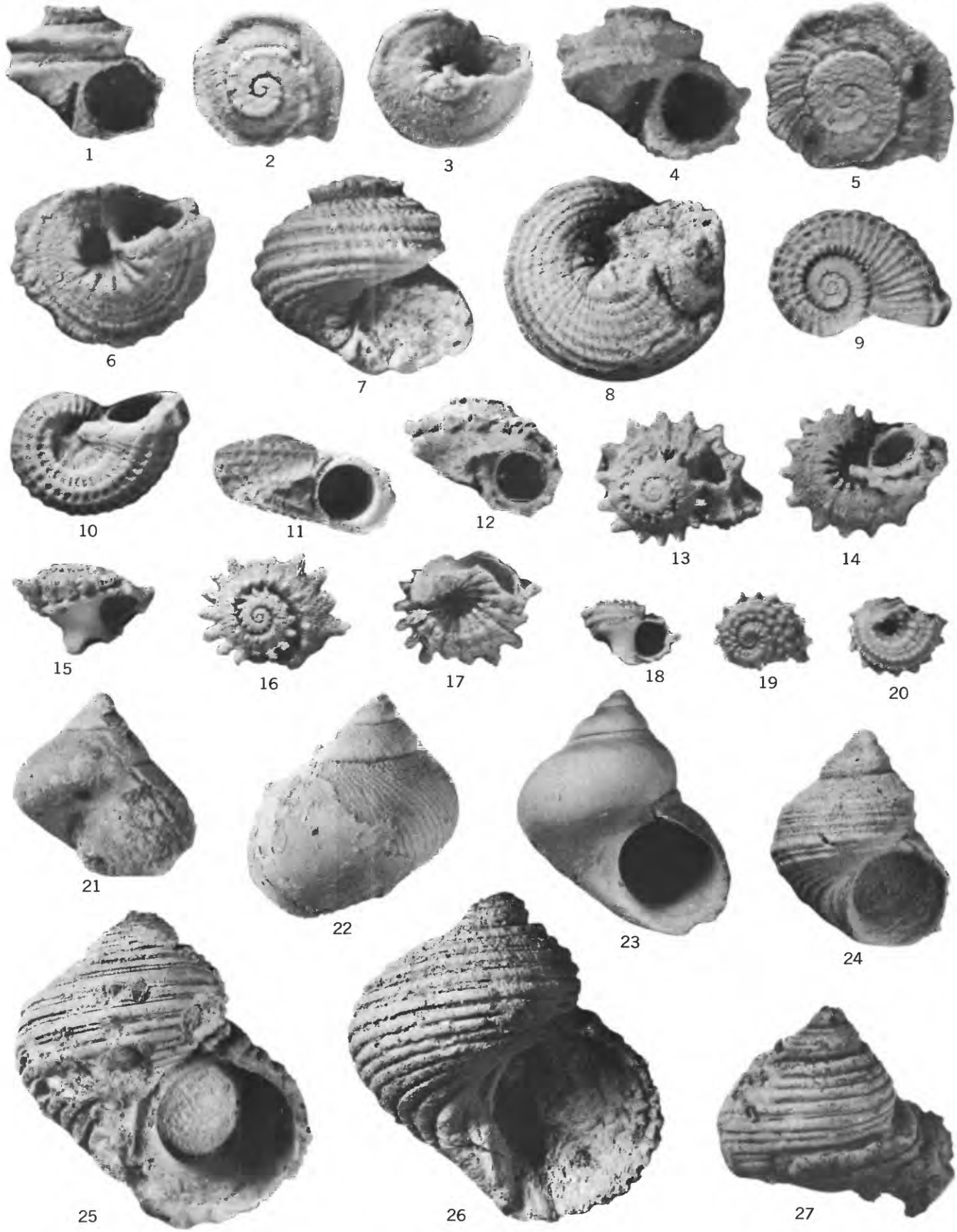
24. *Turbo (Marmarostoma) chrysostomus* Linnaeus (p. 48).
Guam specimen, height 22.0 mm, × 2. USGS 20636, Agana Argillaceous Member of the Mariana Limestone; Pliocene and Pleistocene. USNM 648280.

25, 26. *Turbo (Marmarostoma) argyrostomus* Linnaeus (p. 48).

25. Saipan specimen, height (incomplete) 59.5 mm, × 1. USGS 17387; Tanapag Limestone; Pleistocene. USNM 648281.

26. Guam specimen, height (incomplete) 62.6 mm, × 1. USGS 20679; Agana Argillaceous Member of Mariana Limestone; Pliocene and Pleistocene. USNM 648282.

27. *Turbo (Marmarostoma) setosus* Gmelin? (p. 49).
Rubber cast from Funafuti, height 24 mm, × 1½. Made from core piece 276 from depth of 526–546 ft; post-Miocene. USNM 648283.



GASTROPODS: TURBINIDAE

PLATE 8

FIGURES 1, 2. *Turbo (Marmarostoma) crassus* Wood (p. 49).
Tonga specimen, height 79.3 mm, × 1. Near Houma, Tongatabu; probably Pleistocene.

3, 4. *Turbo (Marmarostoma)* sp. A (p. 49).
Fiji rubber cast and internal mold; height (of internal mold) 25.0 mm, × 1½. Sta. 295, Viti Levu; Suva Formation; early Miocene (Tertiary *f*). B. P. Bishop Mus., geology No. 1228.

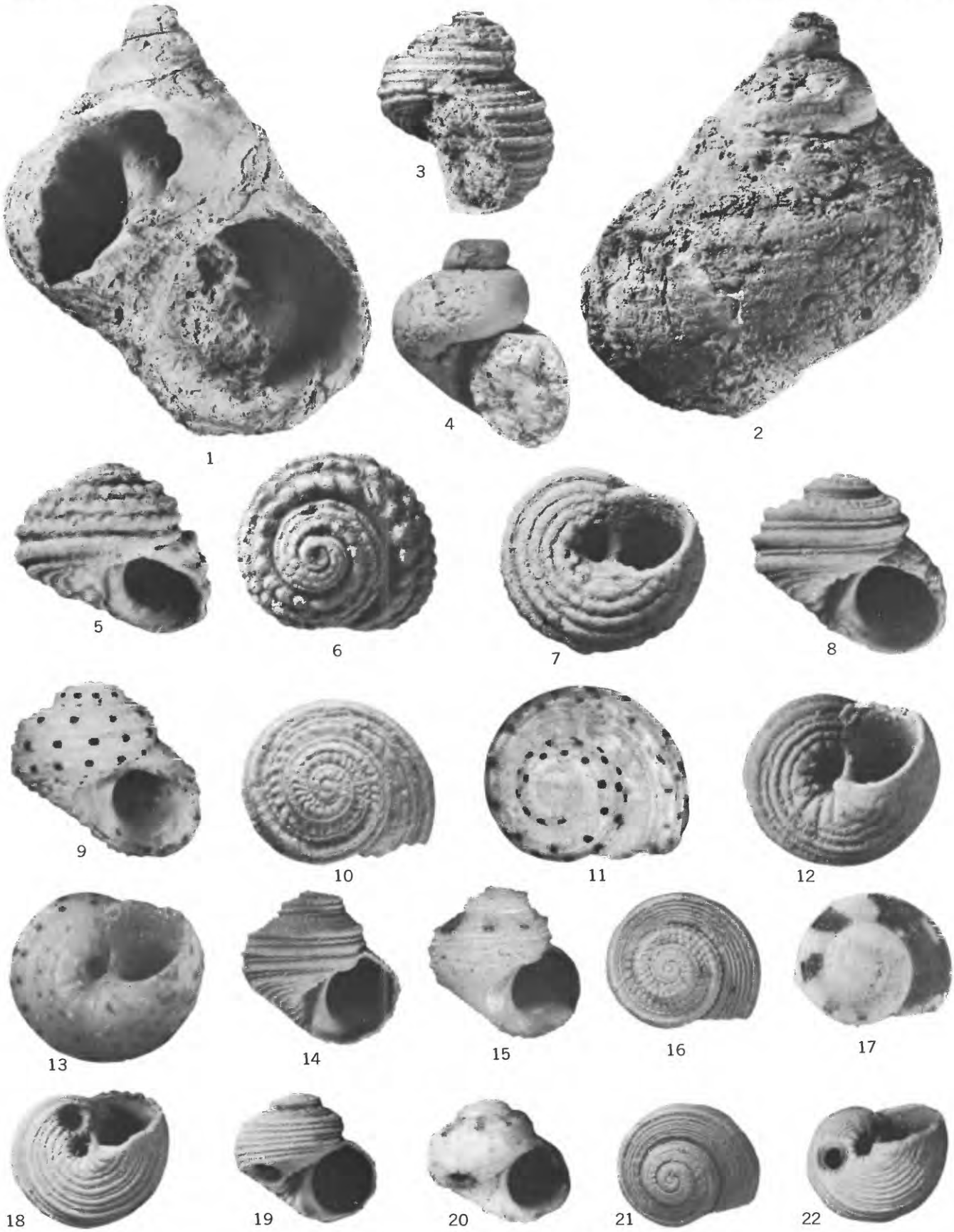
5–7. *Cynisca pacifica* Ladd, n. sp. (p. 49).
Holotype, height 4.1 mm, × 8. E–1, Eniwetok, 1,000–1,010 ft; early Miocene (Tertiary *f*). USNM 648284.

8–13. *Leptothyra maculosa* (Pease) (p. 50).
Eniwetok specimen, height 1.7 mm, × 20. E–1, 40–45 ft; Recent. USNM 648305. Figs. 9, 11, 13 uncoated to show color pattern.

14–22. *Leptothyra inepta* (Gould) (p. 50).

14–18. Eniwetok specimen, height 2.8 mm, × 10. Mu–4, 40 ft, 6 in. to 41 ft; Recent. USNM 648306. Figs. 15 and 17 uncoated to show color pattern.

19–22. Gould's type USNM 1372, height 2.3 mm, × 10. Kagoshima, Japan; Recent. Fig. 20 uncoated to show color pattern.



GASTROPODS: TURBINIDAE

PLATE 9

FIGURES 1–3. *Leptothyra harlani* Ladd, n. sp. (p. 51).
Holotype, height 1.9 mm, × 12. K–1B, Eniwetok, 663–674 ft; late Miocene (Tertiary *g*). USNM 648307.

4–6. *Leptothyra* aff. *L. laeta* Montrouzier (p. 51).
Eniwetok specimen, height 2.9 mm, × 10. K–1B, 957–968 ft; early Miocene (Tertiary *f*). USNM 648312.

7–9. *Leptothyra* aff. *L. candida* (Pease) (p. 51).
Eniwetok specimen, height 1.7 mm, × 15. BO–2–1, depth 7 in.; Recent. USNM 648308.

10–12. *Leptothyra balnearii Pilsbry* (p. 51).
Eniwetok specimen, height 0.7 mm, × 15. F–1, 55–60 ft; Recent. USNM 648309.

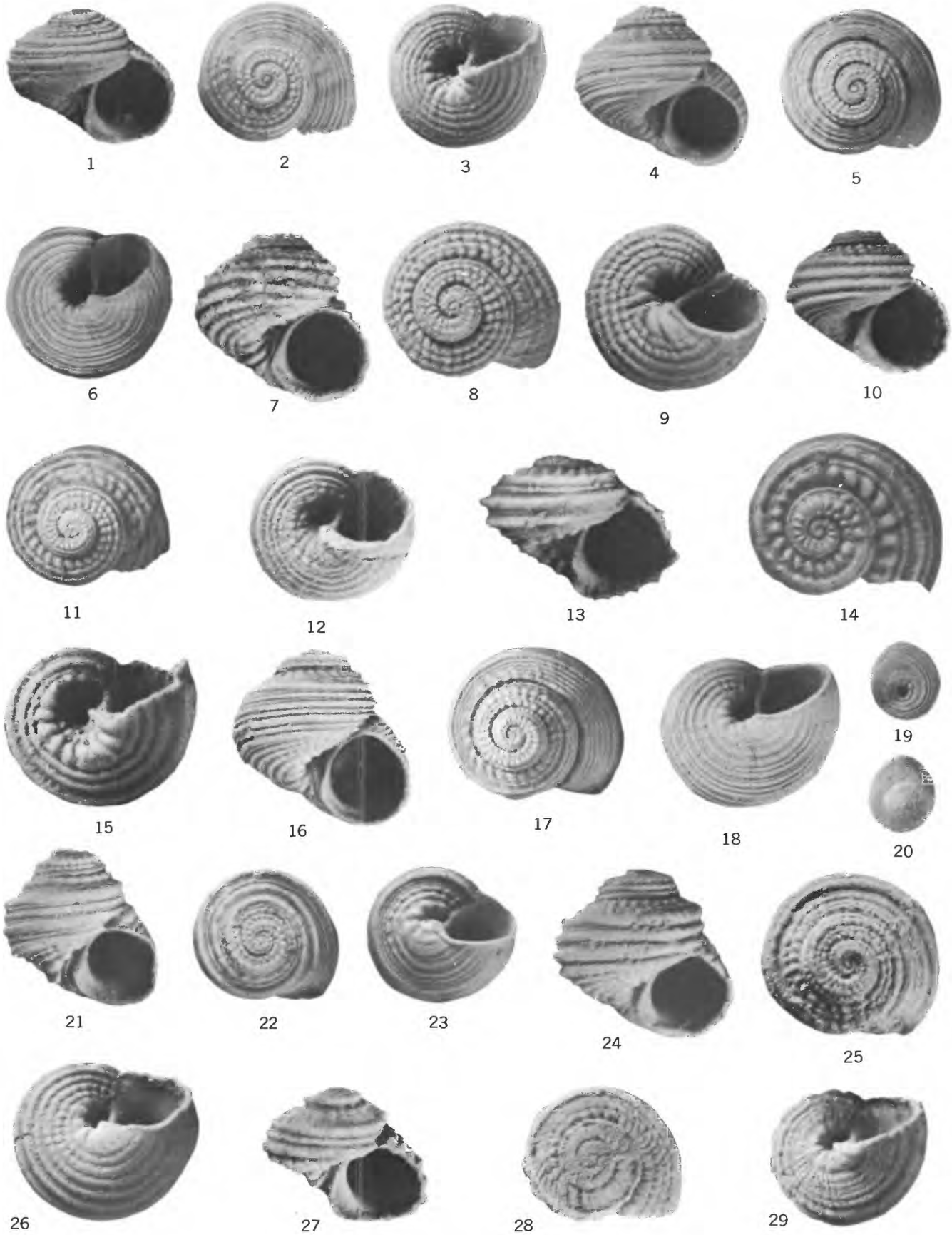
13–15. *Leptothyra wellsi* Ladd, n. sp. (p. 52).
Holotype, height 0.9 mm, × 25. F–1, Eniwetok, 690–700 ft; late Miocene (Tertiary *g*). USNM 648310.

16–20. *Leptothyra glareosa marshallensis* Ladd, n. subsp. (p. 52).
16–18. Holotype, height 2.3 mm, × 12. USNM 648313;
19–20. Operculum from paratype, USNM 648314, maximum diameter 1.1 mm, × 12; both Recent; Bikini lagoon, depth 30 fathoms.

21–23. *Leptothyra picta* (Pease) (p. 53).
Eniwetok specimen, height 2.1 mm, × 12. E–1, Eniwetok, 35–40 ft; Recent. USNM 648315.

24–26. *Leptothyra emenana* Ladd, n. sp. (p. 53).
Holotype, height 2.7 mm, × 12. F–1, Eniwetok, 940–950 ft; early Miocene (Tertiary *f*). USNM 648316.

27–29. *Leptothyra* sp. A (p. 53).
Eniwetok specimen, height 2.0 mm, × 12. K–1B, 642–653 ft; late Miocene (Tertiary *g*). USNM 648318.



GASTROPODS: TURBINIDAE

PLATE 10

FIGURES 1–5. *Gabrielona raunana* Ladd, n. sp. (p. 54).

1, 2. Holotype, height 1.4 mm, × 30. F–1, Eniwetok, 20–45 ft; Recent. Fig. 2 uncoated to show color pattern. USNM 648319.

3. Paratype A, height 2.0 mm, × 15. F–1, Eniwetok, 20–45 ft; Recent. USNM 648320.

4, 5. Operculum, paratype C, maximum diameter 0.8 mm, × 40. F–15–A, Eniwetok, 26–29 ft; Recent. USNM 648322.

6, 7. *Tricolia (Hiloa) variabilis* (Pease) (p. 54).

6. Eniwetok specimen, height 1.4 mm, × 15. E–1, 30–40 ft; Recent. USNM 648323.

7. Eniwetok specimen, height 1.9 mm, × 15. E–1, 40–45 ft; Recent. USNM 648324.

8. *Assiminea nitida eniwetokensis* Ladd, n. subsp. (p. 75).
Holotype, height 1.8 mm, × 15. K–1B, Enwetok, 831–842 ft; early Miocene (Tertiary *f*). USNM 648325.

9. *Tricolia (Hiloa)* sp. A (p. 55).
Fiji specimen, height 0.9 mm, × 30. Viti Levu (sta. 160); early Miocene (Tertiary *f*). USNM 648326.

10, 11. *Phasianella* sp. (p. 53).
Eniwetok specimen, maximum diameter 3.4 mm, × 8. K–1B, 841–853 ft; late Miocene (Tertiary *g*). USNM 648327.

12–14. *Neritopsis (Neritopsis) radula* Linnaeus (p. 55).
Eniwetok specimen, height 2.8 mm. F–1, 960–970 ft; early Miocene (Tertiary *f*). USNM 648238. Figs. 12 and 13 are × 10; fig. 14 is × 15.

15, 16. *Nerita (Amphinerita) insculpta* Recluz (p. 55).
Eniwetok specimen, height 4.6 mm, × 5. F–1, 690–700 ft; late Miocene (Tertiary *g*). USNM 648332.

17, 18. *Nerita (Amphinerita)* aff. *N. polita* Linnaeus (p. 56).
Holotype, height 3.4 mm, × 8. F–1, Eniwetok, 930–940 ft; early Miocene (Tertiary *f*). USNM 648333.

19. *Nerita (Ritena) palauensis* Ladd, n. sp. (p. 56).
Holotype, height (incomplete) 17.3 mm, × 2. Auluptagel, Palau (USGS 23642); base of Palau Limestone; late Miocene. USNM 648330.

20, 21. *Nerita (Theliostyla)* sp. A (p. 56).
Fiji specimen, height 11.3 mm, × 3. Viti Levu (sta. 95); probably Miocene. B. P. Bishop Mus., geology No. 1195.

22. *Nerita (Theliostyla)* sp. B (p. 57).
Fiji specimen, diameter 31.0 mm, × 1. Mango (sta. M2D); probably Miocene. USNM 648331.

23–25. *Neritina (Vitta) oualaniensis* Lesson (p. 57).

23, 24. Guam specimen, height 6.3 mm, × 5. USGS 21377. USNM 648334.

25. Guam specimen, height (incomplete) 5.0 mm, × 5. USGS 20600; both specimens from Mariana Limestone; Pliocene and Pleistocene. USNM 648335.

26, 27. *Neritilia traceyi* Ladd (p. 57).
Holotype, height 1.9 mm. × 12. 2B, Bikini, 2,154–2,165 ft; early Miocene (Tertiary *e*). USNM 648336.

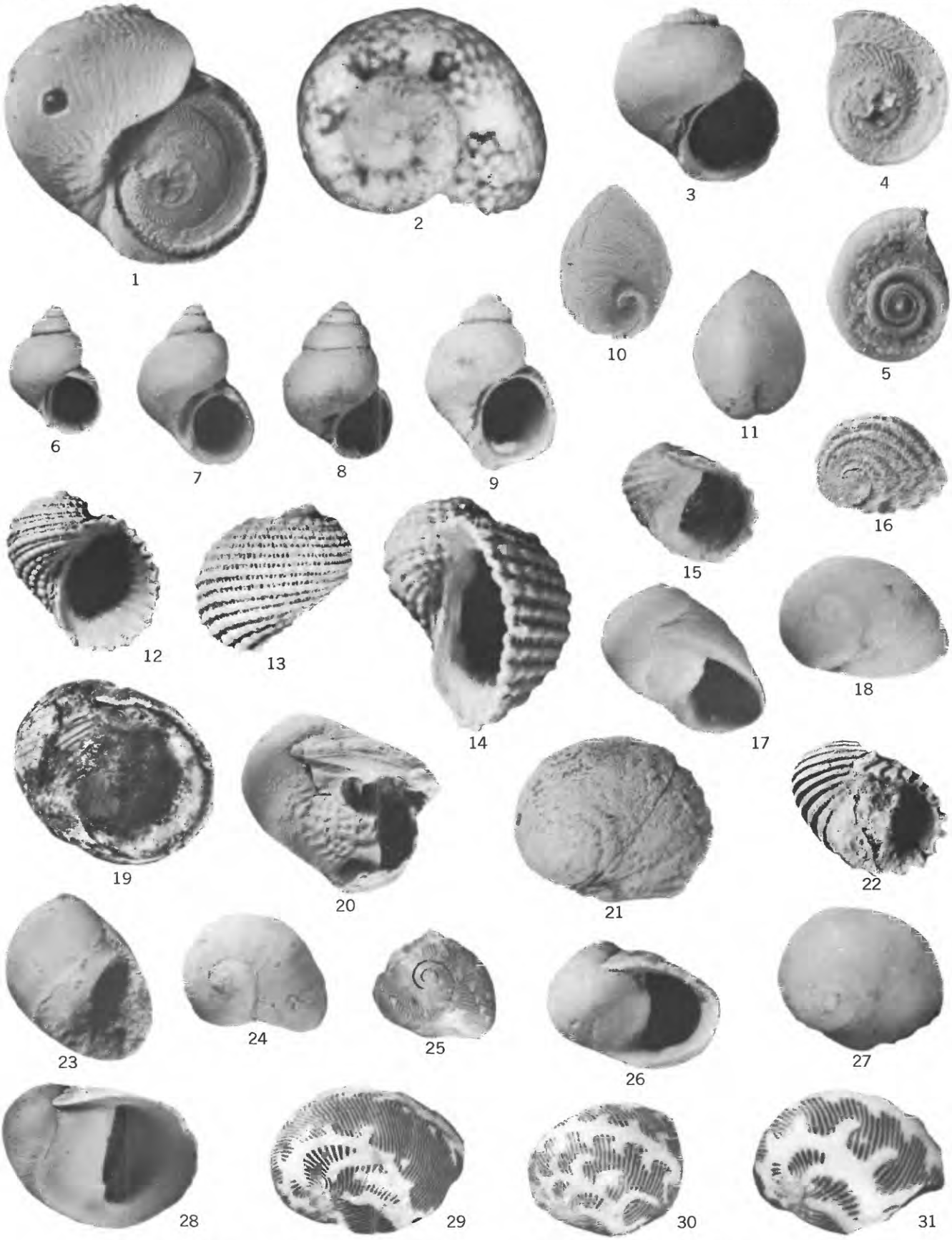
28–31. *Smaragdia (Smaragdia) jogjacartensis* (Martin) (p. 58).

28, 29. Eniwetok specimen, height 5.2 mm, × 6. F–1, 830–840 ft; late Miocene (Tertiary *g*). USNM 648337.

30, 31. Two specimens from hole K–1B on Eniwetok to show variation in color pattern.

30. From a depth of 841–853 ft; late Miocene (Tertiary *g*). USNM 648401, × 10.

31. From a depth of 873–884 ft; early Miocene (Tertiary *f*). USNM 648402, × 10.



GASTROPODS: PHASIANELLIDAE, NERITOPSIDAE, NERITIDAE, AND ASSIMINEIDAE

PLATE 11

FIGURES 1, 2. *Smaragdia (Smaragdia) jogjacartensis* (Martin) (p. 58).
Palau specimen, height 2.6 mm, × 10. Goikul Peninsula, Babelthuap (USGS 21308); late Miocene (Tertiary *g*). USNM 648403.

3, 4. *Smaragdia (Smaragdia)* aff. *S. rangiana* (Récluz) (p. 58).
Palau specimen, height (incomplete) 3.2 mm, × 10. Goikul Peninsula, Babelthuap (USGS 21308); late Miocene (Tertiary *g*). USNM 648338.

5–7. *Smaragdia (Smaragdia) colei* Ladd, n. sp. (p. 58).

5, 6. Holotype, height 5.6 mm, × 6. F–1, Eniwetok, depth 880–890 ft; early Miocene (Tertiary *f*). USNM 648339.

7. Paratype, height 3.8 mm, × 8. F–1, Eniwetok, depth 830–840 ft; late Miocene (Tertiary *g*). USNM 648405.

8, 9. *Smaragdia (Smaragdia)* sp. A (p. 59).
Eniwetok specimen, height 1.4 mm, × 20. K–1B, 715–727 ft; late Miocene (Tertiary *g*). USNM 648340.

10. *Pisulina subpacifica* Ladd, n. sp. (p. 59).
Holotype, height 1.2 mm, × 20. 2B, Bikini, 789–799 ft; late Miocene (Tertiary *g*). USNM 648341.

11–13. *Tectarius (Subditotectarius) rehderi* Ladd, n. sp. (p. 59).
Holotype, height 2.8 mm, X 12. 2A, Bikini, 1,051–1,057 ft; early Miocene (Tertiary *f*). USNM 648342.

14, 15. *Iravadia gardnerae* Ladd, n. sp. (p. 60).
Holotype, height 3.3 mm, × 10. K–1B, Eniwetok, 831–842 ft; late Miocene (Tertiary *g*). USNM 648343.

16, 17. *Putilla (Pseudosetia) morana* Ladd, n. sp. (p. 60).
Holotype, height 1.1 mm, × 25. E–1, Eniwetok, 1,805–1,835 ft; early Miocene (Tertiary *e*). USNM 648344.

18–20. *Putilla (Parvisetia) goikulensis* Ladd, n. sp. (p. 60).
18, 19. Holotype, height 1.1 mm, × 30. USNM 648345.
20. Paratype, height 0.9 mm, × 30. Both specimens Goikul Peninsula, Babelthuap, Palau (USGS 21308); late Miocene (Tertiary *g*). USNM 648346.

21, 22. *Putilla (Parvisetia) suvaensis,* Ladd, n. sp. (p. 61).
Holotype, height 0.9 mm, × 30. Suva formation (sta. FB–20). Viti Levu, Fiji; early Miocene (Tertiary *f*). USNM 648347.

23, 24. *Cingula (Peringiella) parryensis* Ladd, n. sp. (p. 61).
Holotype, height 1.7 mm, × 20. E–1, Eniwetok, 700–710 ft; late Miocene (Tertiary *g*). USNM 648348.

25, 26. *Cingula (Peringiella)* cf. *C. roseocincta* (Suter) (p. 61).
Palau specimen, height 1.0 mm, × 30. Goikul Peninsula, Babelthuap (USGS 21304); late Miocene (Tertiary *g*). USNM 648349.

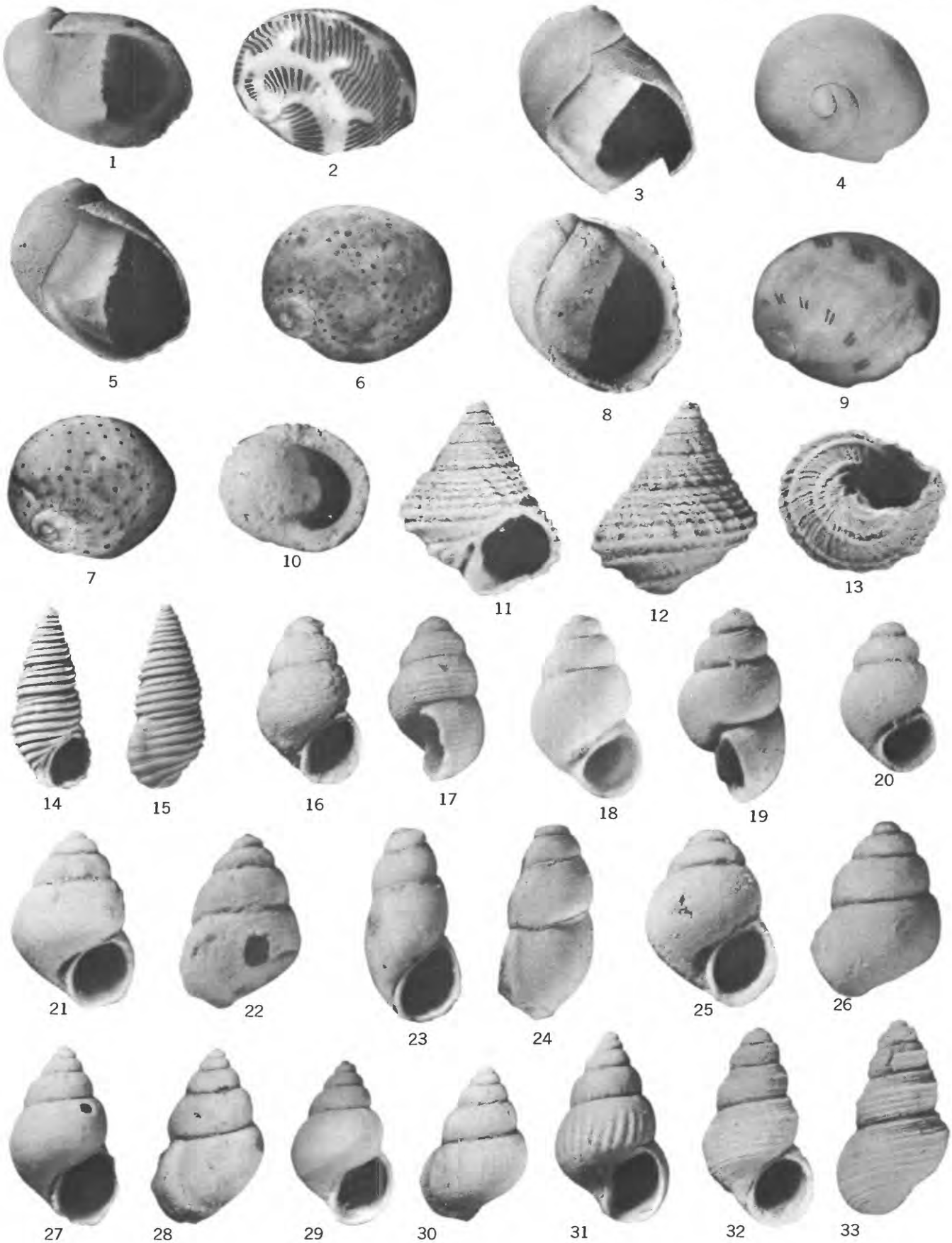
27–31. *Amphithalmus (Cerostraca) jeffcoati* Ladd, n. sp. (p. 62).

27, 28. Holotype, a smooth shell, height 1.9 mm, × 15. E–1, Eniwetok, 840–850 ft; late Miocene (Tertiary *g*). USNM 648350.

29, 30. Paratype A, a weakly ribbed shell, height 1.9 mm, × 15. K–1B, Eniwetok, 968–978 ft; early Miocene (Tertiary *f*). USNM 648351.

31. Paratype B, a strongly ribbed shell, height 2.3 mm, × 15. E–1, Eniwetok, 1,010–1,020 ft; early Miocene (Tertiary *f*). USNM 648352.

32, 33. *Amphithalmus (Cerostraca?) myersi* Ladd, n. sp. (p. 62).
Holotype, height 1.5 mm, × 20. E–1, Eniwetok, 770–780 ft; late Miocene (Tertiary *g*). USNM 648353.



GASTROPODS: NERITIDAE, LITTORINIDAE, IRAVADIIDAE, AND RISSOIDAE

PLATE 12

FIGURES

1. *Amphithalmus (Pisinna) bikiniensis* Ladd, n. sp. (p. 62).
   Holotype, height 1.7 mm, × 20. 2B, Bikini, 1,839–1,850 ft; early Miocene (Tertiary *e*). USNM 648354.
2. *Alvania (Taramellia) corayi* Ladd, n. sp. (p. 63).
   Holotype, height 1.6 mm, × 20. Mu–4, Eniwetok, 35–36 ft; Recent. USNM 648355.
3. *Alvania (Taramellia) kenneyi* Ladd, n. sp. (p. 63).
   Holotype, height 0.8 mm, × 30. E–1, Eniwetok, 1,746–1,777 ft; early Miocene (Tertiary *e*). USNM 648356.

4, 5. *Merelina (Merelina) pisinna* (Melvill and Standen) (p. 63).
   Eniwetok specimen, height 1.9 mm, × 15. E–1, 850–860 ft; late Miocene (Tertiary *g*). USNM 648357.

6, 7. *Merelina (Linemera) telkibana* Ladd, n. sp. (p. 64).
   Holotype, height 1.9 mm, × 15. USGS 21301, Goikul Peninsula, Babelthuap, Palau; late Miocene (Tertiary *g*). USNM 648358.

8, 9. *Parashiela beetsi* Ladd, n. sp. (p. 64).
   Holotype, height 1.4 mm, × 20. F–8–C, Eniwetok, 19–22 ft; Recent. USNM 648368.

10. *Zebina (Cibdezebina) metaltilana* Ladd, n. sp. (p. 64).
    Holotype, height 3.5 mm, × 10. 2B, Bikini, 1,860–1,870 ft; early Miocene (Tertiary *e*). USNM 648359.

11, 12. *Zebina (Morchiella)* cf. *Z. cooperi* (Oliver) (p. 65).
    Eniwetok specimen, height 5.7 mm. E–1, 110–120 ft; Recent. USNM 648361. Fig. 11, × 6; fig. 12, × 12.

13, 14. *Zebina (Morchiella) killeblebana* Ladd, n. sp. (p. 65).
    13. Holotype, height 5.6 mm, × 6. E–1, Eniwetok, 960–970 ft; early Miocene (Tertiary *f*). USNM 648363.
    14. Paratype, height 3.2 mm, × 8. F–1, Eniwetok, 930–940 ft; early Miocene (Tertiary *f*). USNM 648364.

15–18. *Zebina (Ailinzebina) abrardi* Ladd, n. sp. (p. 65).
    15, 16. Holotype, height 3.9 mm, × 8. Bikini lagoon at depth of 20 fathoms; Recent. USNM 648365.
    17. Paratype A, height 2.9 mm, × 10. En–4, Eniwetok, 11 ft; Recent. USNM 648366.
    18. Paratype B, height (incomplete) 2.3 mm, × 10. 2B, Bikini, 1,450–1,461 ft; early Miocene (Tertiary *e*). USNM 648367.

19. *Zebina*? sp. A (p. 66).
    Bikini specimen, height 2.7 mm, × 12. 2B, depth 2,112–2,128 ft; early Miocene (Tertiary *e*). USNM 648370.

20. *Rissoina (Schwartziella) gracilis* (Pease) (p. 66).
    Tongan specimen, height 3.0 mm, × 10. Tongatabu at altitude of 35 ft (B. P. Bishop Mus., geology No. 1340); probably Pleistocene.

21, 22. *Rissoina (Schwartziella)* aff. *R. flexuosa* Gould (p. 66).
    Eniwetok specimen, height 4.0 mm, × 8. E–1, 40–45 ft; Recent. USNM 648382.

23, 24. *Rissoina (Schwartziella)* aff. *R. indrai* Beets (p. 66).
    Eniwetok specimen, height 7.7 mm, × 5. F–1, depth 930–940 ft; early Miocene (Tertiary *f*). USNM 648383.

25, 26. *Rissoina (Schwartziella) mejilana* Ladd, n. sp. (p. 67).
    Holotype, height 2.8 mm, × 12. K–1B, Eniwetok, 831–842 ft; early Miocene (Tertiary *f*). USNM 648384.

27, 28. *Rissoina (Schwartziella) jirikana* Ladd, n. sp. (p. 67).
    Holotype, height 2.3 mm, × 15. 2B, Bikini, 1,440–1,451 ft; early Miocene (Tertiary *e*). USNM 648385.

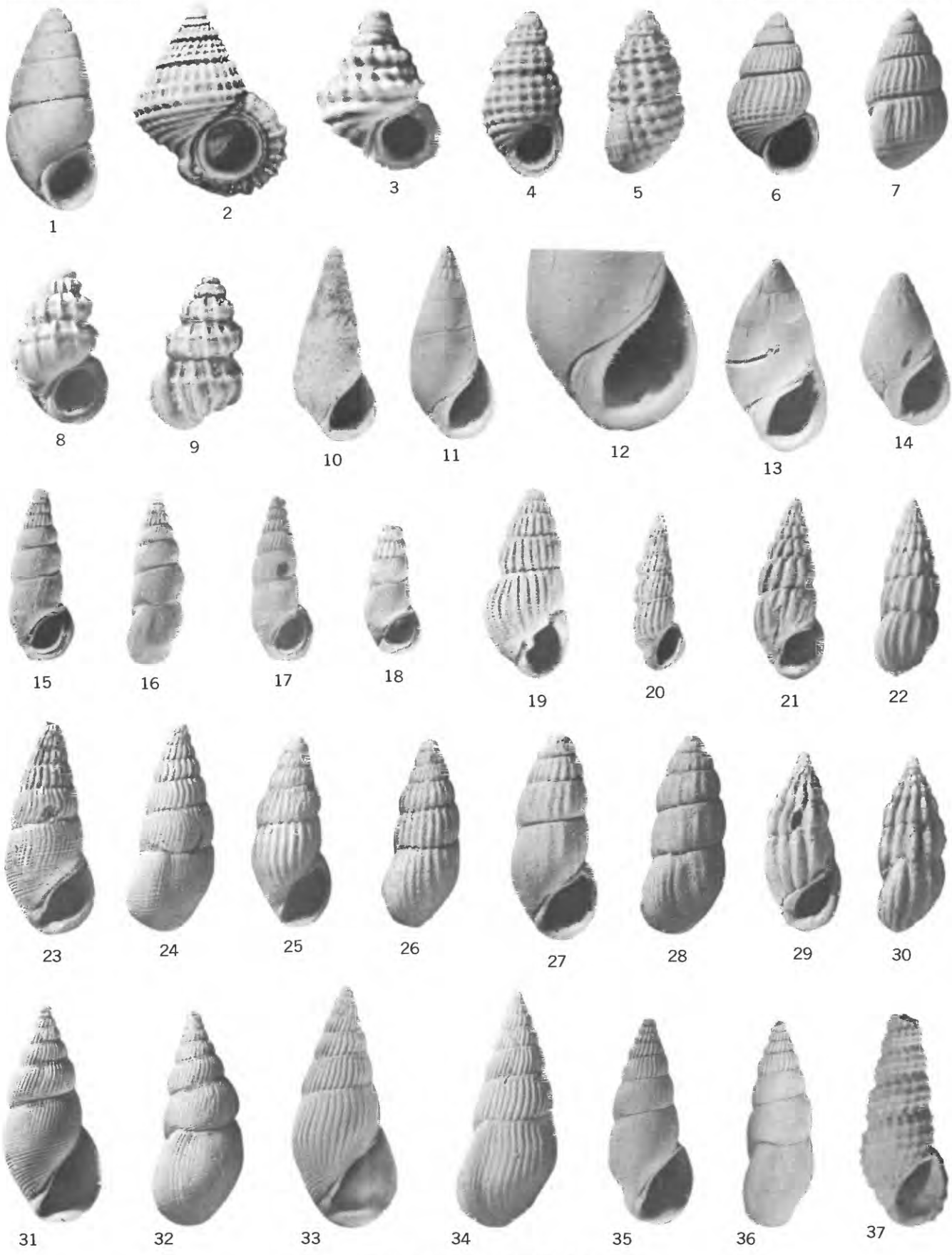
29, 30. *Rissoina (Schwartziella) rilebana* Ladd, n. sp. (p. 67).
    Holotype, height 3.1 mm, × 10. 2B, Bikini, 778–789 ft; late Miocene (Tertiary *g*). USNM 648386.

31, 32. *Rissoina (Zebinella) emnanana* Ladd, n. sp. (p. 67).
    Holotype, height 4.8 mm, × 8. E–1, Eniwetok, 1,010–1,020 ft; early Miocene (Tertiary *f*). USNM 648387.

33, 34. *Rissoina (Zebinella) tenuistriata* Pease (p. 68).
    Eniwetok specimen, height 5.5 mm, × 8. En–4, 5½ ft; Recent. USNM 648388.

35, 36. *Rissoina (Zebinella)* aff. *R. supracostata* Garrett (p. 68).
    Eniwetok specimen, height (incomplete) 12.4 mm, × 5. E–1, depth 890–900 ft; early Miocene (Tertiary *f*). USNM 648389.

37. *Rissoina (Phosinella) clathrata* A. Adams (p. 68).
    New Hebredu specimen, described by Abrard, height (incomplete) 8.7 mm, × 4.6. Island of Malekula; Pliocene.



GASTROPODS: RISSOIDAE

PLATE 13

FIGURES 1, 2. *Rissoina (Phosinella) clathrata* A. Adams (p. 68).
Fijian specimen, height 7.2 mm, × 5. Suva Formation, Viti Levu, (sta. 160); early Miocene (Tertiary *f*). USNM 648391.

3, 4. *Rissoina (Phosinella) briggsi* Ladd, n. sp. (p. 68).
Holotype, height 4.3 mm, × 8. Goikul Peninsula, Babelthuap, Palau (USGS 21301; late Miocene (Tertiary *g*). USNM 648390.

5–8. *Rissoina (Phosinella) balteata* Pease (p. 69).
5, 6. Bikini specimen, height 3.7 mm, × 8. 2A, depth 38–40 ft; Recent. USNM 648394.
7, 8. Eniwetok specimen, height 3.7 mm, × 8. E–1, depth 880–890 ft; early Miocene (Tertiary *f*). USNM 648395.

9, 10, 17, 18. *Rissoina (Phosinella) bikiniensis* Ladd, n. sp. (p. 69).
9, 10. Holotype, height 4.9 mm, × 8. 2A, Bikini, 1,056–1,063 ft; early Miocene (Tertiary *f*). USNM 648396.
17, 18. Paratype, height 3.6 mm, × 6. E–1, Eniwetok, 1,746–1,777 ft; early Miocene (Tertiary *e*). USNM 648400.

11, 12. *Rissoina (Phosinella) transenna* Watson (p. 69).
Eniwetok specimen, height 3.6 mm, × 10. Mu–4, 40 ft; Recent. USNM 648397.

13–16. *Rissoina (Phosinella) alexisi* Ladd, n. sp. (p. 70).
13, 14. Holotype, height 2.7 mm, × 12. F–1, Eniwetok, 1,110–1,120 ft; early Miocene (Tertiary *e*). USNM 648398.
15, 16. Paratype, height 2.5 mm, × 12. F–1, Eniwetok, 1,100–1,110 ft; early Miocene (Tertiary *e*). USNM 648399.

19–21. *Rissoina (Rissoina) abbotti* Ladd, n. sp. (p. 70).
19. Holotype, height (incomplete) 4.9 mm, × 6. 2A, Bikini, 1,061–1,067 ft; early Miocene (Tertiary *f*). USNM 648371.
20. 21. Paratype, height (incomplete) 8.1 mm, × 4. Goikul Peninsula, Babelthuap, Palau (USGS 21301); late Miocene (Tertiary *g*). USNM 648372.

22–25. *Rissoina (Rissoina) mijana* Ladd, n. sp. (p. 70).
22, 23. Slender specimen, height 3.3 mm, × 10. K–1B, Eniwetok, 968–978 ft; early Miocene. (Tertiary *f*). USNM 648373.
24, 25. Holotype, height (incomplete) 4.3 mm, × 8. E–1, Eniwetok, 880–890 ft; early Miocene (Tertiary *f*). USNM 648374.

26. *Rissoina (Rissoina) ailinana* Ladd, n. sp. (p. 70).
Holotype, height 3.0 mm, × 10. E–1, Eniwetok, 1,925–1,955 ft; early Miocene (Tertiary *e*). USNM 648375.

27, 28. *Rissoina (Rissoina) lomaolana* Ladd, n. sp. (p. 71).
Holotype, height 4.1 mm, × 8. K–1B, Eniwetok, 842–852 ft; late Miocene (Tertiary *g*). USNM 648376.

29. *Rissoina (Rissoina) goikulensis* Ladd, n. sp. (p. 71).
Holotype, height 3.7 mm, × 8. Goikul Peninsula, Babelthuap, Palau (USGS 21304); late Miocene (Tertiary *g*). USNM 648377.

30. *Rissoina (Rissoina) waluensis* Ladd, n. sp. (p. 71).
Holotype, height 3.8 mm, × 8. Walu Bay, Viti Levu, Fiji (sta. 160); Suva Formation, early Miocene (Tertiary *f*). USNM 648378.

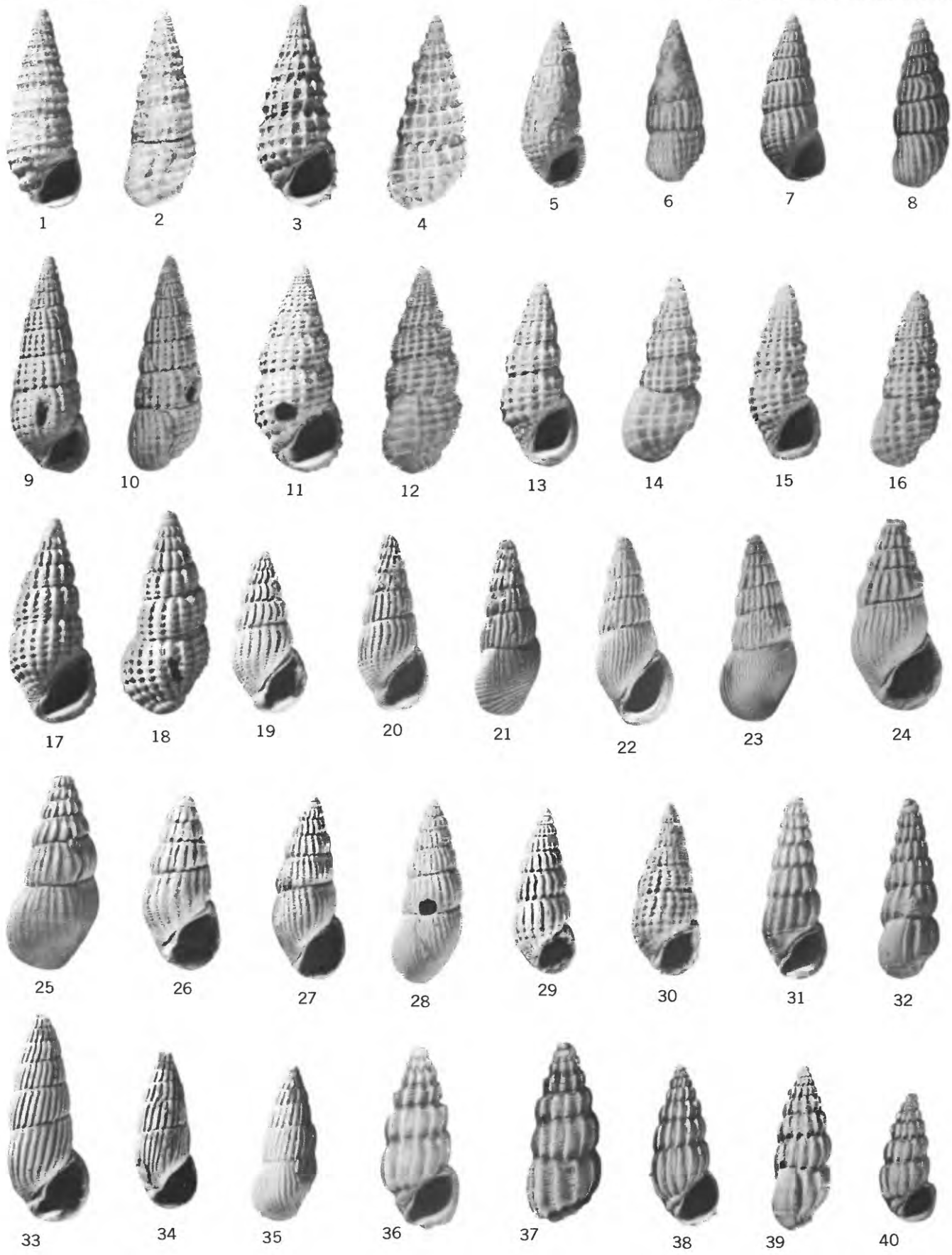
31, 32. *Rissoina (Rissoina) ekkanana* Ladd, n. sp. (p. 71).
Holotype, height 3.2 mm, × 10. Mu–4, Eniwetok, 35 ft; Recent. USNM 648379.

33. *Rissoina (Rissoina) concinna* A. Adams (p. 72).
Eniwetok specimen, height (incomplete) 6.4 mm, × 6. E–1, 970–980 ft; early Miocene (Tertiary *f*). USNM 648380.

34, 35. *Rissoina (Rissoina)* sp. A (p. 72).
Fiji specimen, height (incomplete) 4.8 mm, × 6. Walu Bay, Viti Levu (sta. 160); Suva Formation, early Miocene (Tertiary *f*). USNM 648381.

36, 37. *Rissoina (Rissolina) turricula* Pease (p. 72).
Eniwetok specimen, height 2.7 mm, × 12. F–1, 20–45 ft; Recent. USNM 648407.

38–40. *Rissoina (Rissolina) marshallensis* Ladd, n. sp. (p. 73).
38, 39. Holotype, height 5.0 mm, × 6. K–1B, Eniwetok, 894–905 ft; early Miocene (Tertiary *f*). USNM 648408.
40. Paratype A, height (incomplete) 3.8 mm, × 6. E–1, Eniwetok, 850–860 ft; late Miocene (Tertiary *g*). USNM 648409.



GASTROPODS: RISSOIDAE

PLATE 14

FIGURES 1–4. *Rissoina (Rissolina) marshallensis* Ladd, n. sp. (p. 73).

1. Paratype B, height 7.4 mm, × 6. K–1B, Eniwetok, 1,049–1,060 ft; early Miocene (Tertiary *f*). USNM 648410.
2. Paratype C, height 4.2 mm, × 6. K–1B, Eniwetok, 842–852 ft; late Miocene (Tertiary *g*). USNM 648411.
3. Paratype D, height 3.8 mm, × 6. K–1B, Eniwetok, 936–947 ft; early Miocene (Tertiary *f*). USNM 648412.
4. Paratype E, height 5.2 mm, × 6. 2B, Bikini, 1,020–1,100 ft; early Miocene (Tertiary *f*). USNM 648413.

5–8. *Rissoina (Rissolina) ephamilla* Watson (p. 73).

5,6. Eniwetok specimen, height 3.0 mm, × 10. E–1, 850–860 ft; late Miocene (Tertiary *g*). USNM 648414.

7,8. Bikini specimen, height 2.9 mm, × 10. 2A, 447–453 ft; Pliocene (Tertiary *h*) or Pleistocene. USNM 648415.

11,12. Slender Eniwetok specimen, height 3.0 mm, × 10. E–1, Eniwetok, 530–540 ft; probably Pliocene (Tertiary *h*). USNM 648417.

9, 10. *Rissoina (Rissolina) kickarayana* Ladd, n. sp. (p. 74).
Holotype, height 4.1 mm, × 10. Goikul Peninsula, Babelthuap, Palau (USGS 21301); late Miocene (Tertiary *g*). USNM 648416.

13, 14. *Rissoina (Rissolina) herringi* Ladd, n. sp. (p. 74).
Holotype, height 4.8 mm, × 8. F–1, Eniwetok, 710–720 ft; late Miocene (Tertiary *g*). USNM 648418.

15, 16. *Rissoina (Rissolina) harti* Ladd, n. sp. (p. 74).
Holotype, height 3.2 mm, × 10. 2B, Bikini, 1,555–1,566 ft; early Miocene (Tertiary *e*). USNM 648419.

17, 18. *Rissoina (Rissolina) bourneae* Ladd, n. sp. (p. 74).
Holotype, hegiht 3.2 mm, × 10. Suva Formation, Viti Levu, Fiji (sta. FB–20); early Miocene (Tertiary *f*). USNM 648420.

19, 20. *Rissoina (Rissolina)* sp. B (p. 75).
Fiji specimen, height (incomplete) 3.9 mm, × 8. Viti Levu (sta. 165); probably Miocene. USNM 648421.

21, 22. *Rissoina (Rissolina) plicata* A. Adams (p. 74).
Eniwetok specimen, height (incomplete) 6.9 mm, × 6. F–1, 870–880 ft; early Miocene (Tertiary *f*). USNM 648422.

23, 24. *Rissoina (Rissoina) ambigua* (Gould) (p. 71).
Eniwetok speciment, height 6.4 mm, × 6. Rujiyoru Island, Eniwetok; Recent. USNM 648423.

25, 26. *Rissoina (Rissoina) ambigua parryensis* Ladd, n. subsp. (p. 72).
Holotype, height (incomplete) 6.8 mm, × 6. E–1, Eniwetok, 620–630 ft; late Miocene (Tertiary *g*). USNM 648425.

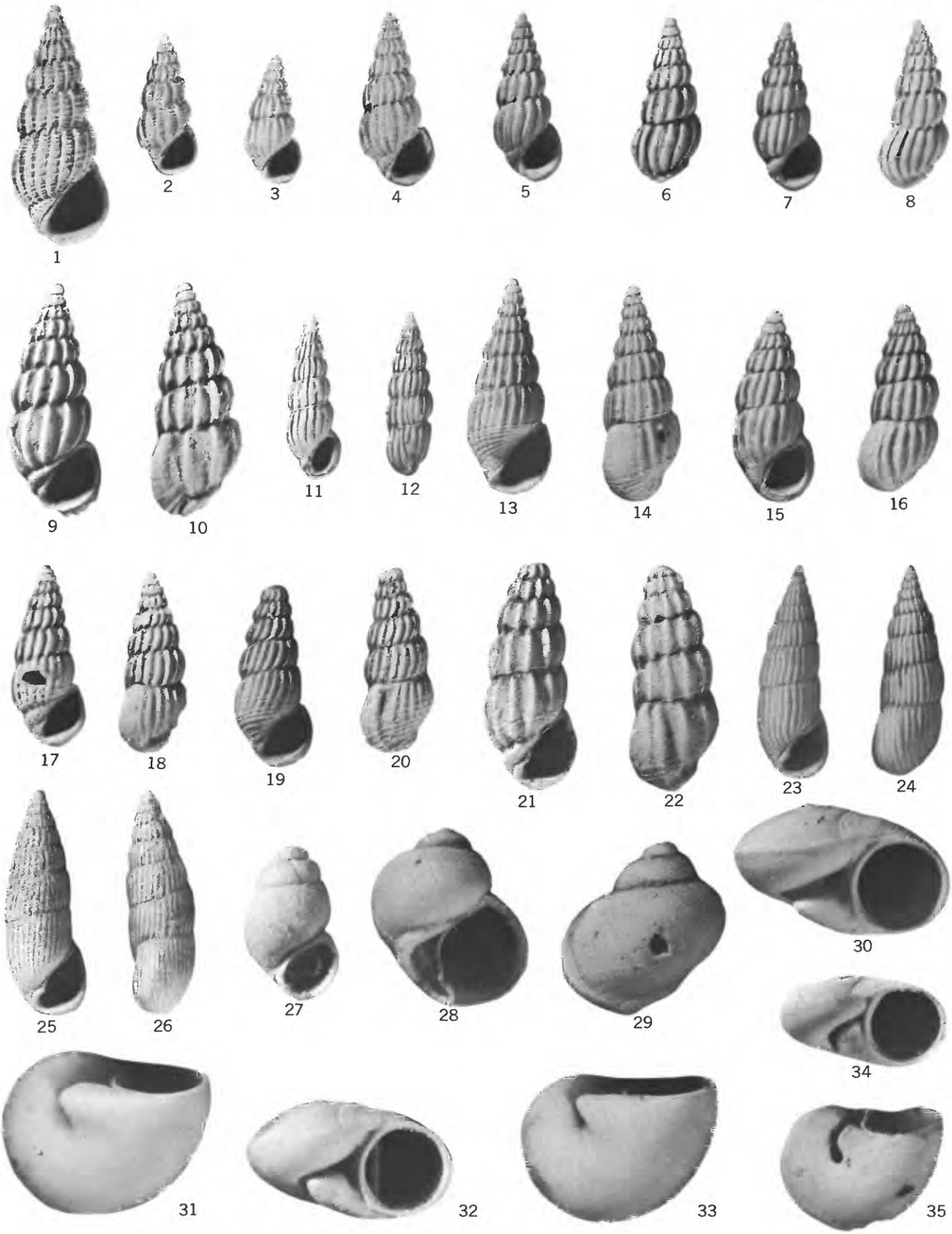
27. *Barleeia (Barleeia) meiauhana* Ladd, n. sp. (p. 75).
Holotype, height 0.9 mm, × 30. Goikul Peninsula, Babelthuap, Palau (USGS 21301); late Miocene (Tertiary *g*). USNM 648426.

28, 29. *Haplocochlias* sp. A (p. 76).
Eniwetok specimen, height 1.2 mm, × 25. K–1B, 831–842 ft; late Miocene (Tertiary *g*). USNM 648427.

30, 31. *Leucorhynchia caledonica* Crosse (p. 76).
Eniwetok specimen, height 1.4 mm, × 15. Eb–2, 21–21½ ft; Recent. USNM 648428.

32, 33. *Leucorhynchia crossei* Tryon (p. 76).
Eniwetok specimen, height 1.2 mm, × 15. E–1, 35–40 ft; Recent. USNM 648429.

34, 35. *Leucorhynchia? stephensoni* Ladd, n. sp. (p. 76).
Holotype, height 1.0 mm, × 15. K–1B, Eniwetok, 1,249–1,259 ft; early Miocene (Tertiary *e*). USNM 648430.



GASTROPODS: RISSOIDAE AND ADEORBIDAE

PLATE 15

FIGURES 1, 2. *Leucorhynchia? lilli* Ladd, n. sp. (p. 77).
Holotype, height 1.6 mm, × 15. Drill hole 1, Bikini, 40 ft; Recent. USNM 648432.

3–5. *Lophocochlias minutissimus* (Pilsbry) (p. 77).
Eniwetok specimen, height 0.5 mm, × 30. E–1, 710–720 ft; late Miocene (Tertiary *g*). USNM 648433.

6–8. *Lophocochlias paucicarinatus* Ladd, n. sp. (p. 77).
Holotype, height 1.0 mm, × 30. E–1, Eniwetok, 2,040–2,050 ft; early Miocene (Tertiary *e*). USNM 648434.

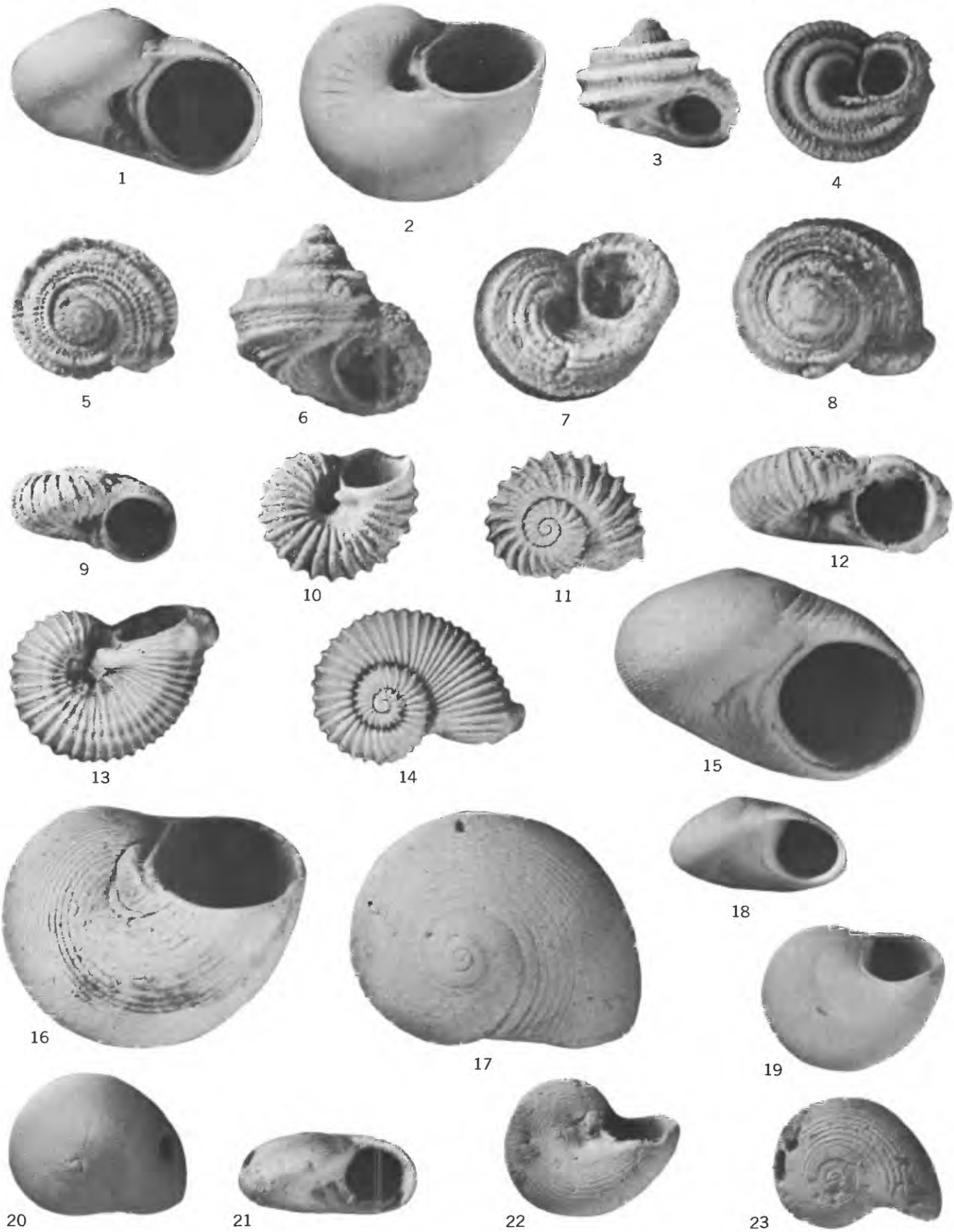
9–11. *Munditiella qualum* (Hedley) (p. 77).
Eniwetok specimen, height 1.0 mm, × 15. F–1, 280–290 ft; probably Pleistocene. USNM 648435.

12–14. *Munditiella parryensis* Ladd, n. sp. (p. 78).
Holotype, height 1.1 mm, × 15. E–1, Eniwetok, 35–40 ft; Recent. USNM 648436.

15–17. *Teinostoma (Esmeralda) engebiense* Ladd, n. sp. (p. 78).
Holotype, height 2.4 mm, × 15. En–4, Eniwetok, 1 ft; Recent. USNM 648437.

18–20. *Teinostoma (Esmeralda) marshallense* Ladd, n. sp. (p. 78).
Holotype, height 1.1 mm, × 15. K–1B, Eniwetok, 863–873 ft; early Miocene (Tertiary *f*). USNM 648438.

21–23. *Teinostoma (Esmeralda)* sp. A (p. 78).
Fiji specimen, height 0.7 mm, × 20. Suva Formation, Viti Levu (sta. 160); early Miocene (Tertiary *f*). USNM 648439.



GASTROPODS: ADEORBIDAE

PLATE 16

FIGURES 1–3. *Solariorbis tricarinata* (Melvill and Standen) (p. 79).
Eniwetok specimen, height 1.6 mm, × 15. E–1, 990–1,000 ft; early Miocene (Tertiary *f*). USNM 648440.

4, 5. *Solariorbis*? sp. (p. 79).
Fiji specimen, height 1.3 mm, × 15. Suva Formation, Viti Levu (sta. 160); early Miocene (Tertiary *f*). B. P. Bishop Mus. Geol. 1236.

6–8. *Lydiphnis eniwetokense* Ladd, n. sp. (p. 79).
Holotype, height 1.8 mm, × 15. K–1B, Eniwetok, 936–946 ft; early Miocene (Tertiary *f*). USNM 648441.

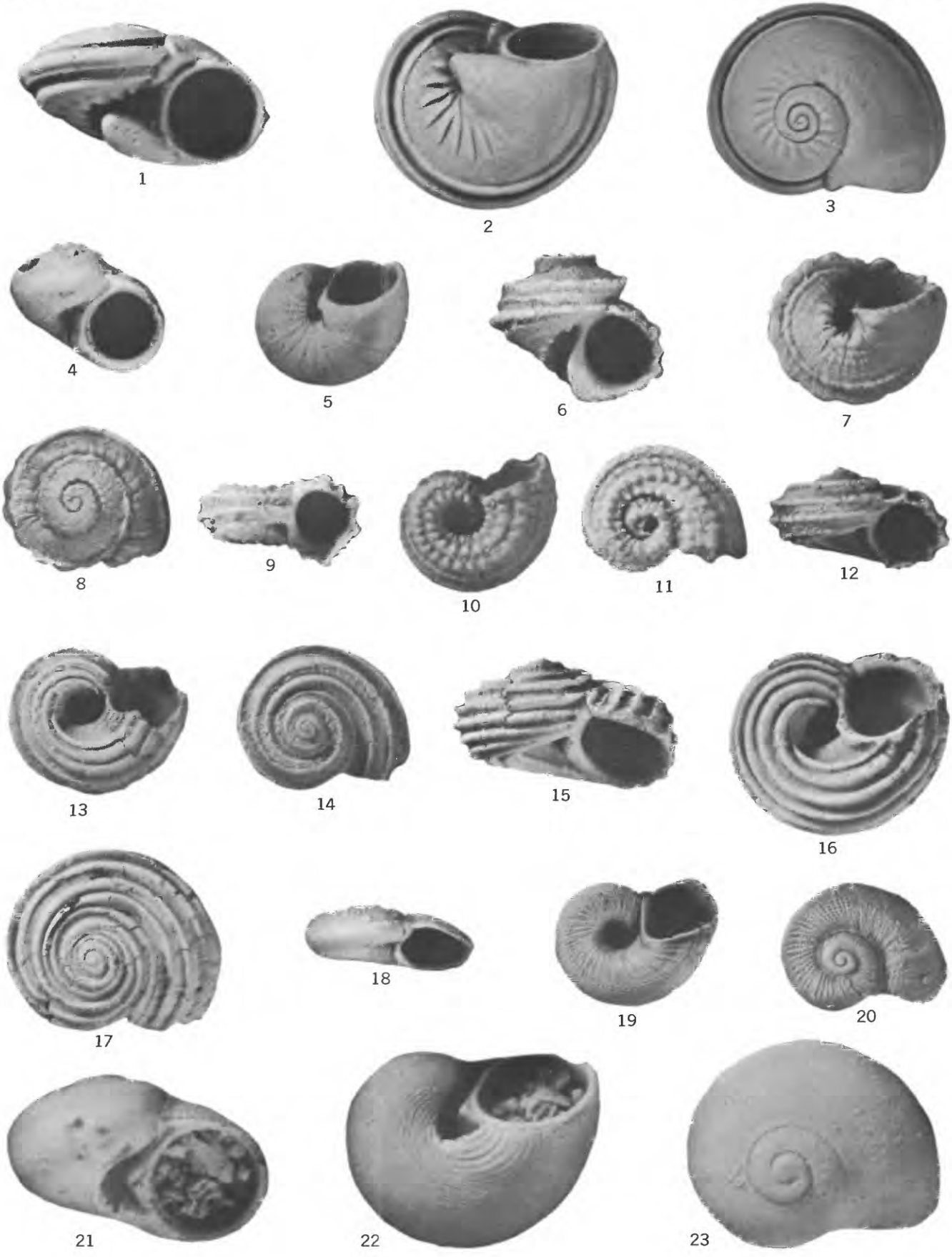
9–11. *Cyclostremiscus emeryi* Ladd, n. sp. (p. 80).
Holotype, height 0.4 mm, × 30. E–1, Eniwetok, 780–790 ft; late Miocene (Tertiary *g*). USNM 648444.

12–14. *Cyclostremiscus (Ponocyclus) novemcarinatus* Melvill (p. 80).
Eniwetok specimen, height 1.0 mm, × 15. K–1B, 873–884 ft; early Miocene (Tertiary *f*). USNM 648442.

15–17. *Cyclostremiscus (Ponocyclus) cingulifera* (A. Adams) (p. 80).
Palau specimen, height 2.4 mm, × 10. Goikul Peninsula, Babelthuap (USGS 21304); late Miocene (Tertiary *g*). USNM 648443.

18–20. *Cochliolepis diangalana* Ladd, n. sp. (p. 81).
Holotype, height 0.8 mm, × 15. Goikul Peninsula, Babelthuap, Palau (USGS 21301); late Miocene (Tertiary *g*). USNM 648445.

21–23. *Vitrinella* sp. A (p. 81).
Bikini specimen, height 0.9 mm, × 30. 2B, 1,723–1,734 ft; early Miocene (Tertiary *e*). USNM 648446.



GASTROPODS: ADEORBIDAE