Smaller Foraminifera of Late Eocene Age From Eua, Tonga

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By RUTH TODD

LATE EOCENE FOSSILS FROM EUA, TONGA

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With summary statements on Calcareous nannoplankton, by M. N. Bramlette; Crinoids and echinoids, by Porter M. Kier; Decapod crustaceans, by Henry B. Roberts; Shark teeth, by David H. Dunkle; and Plant microfossils, by Estella B. Leopold

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LATE EOCENE FOSSILS FROM EUA, TONGA—FOREWORD

One of the most widespread units of the Cenozoic section in the islands of the open Pacific is a series of limestones assigned to the upper Eocene (Tertiary *b*). Such limestones, containing diagnostic larger Foraminifera, have been reported in many parts of an area spreading 4,000 miles across the tropical Pacific (fig. 1), from Palau and the Mariana Islands on the northwest through the Marshall Islands (Eniwetok) to Fiji and Tonga on the southeast (Whipple, in Hoffmeister, 1932, p. 79–86; Asano, 1939; Cole, 1950, 1957a, 1957b, 1960). In almost all the islands the limestones are dense and crystalline. Foraminifera and algae are abundant locally, but in most places fossils cannot be extracted and must therefore be studied in random thin sections. On the little island of Eua, Tonga, a locality was recently found where the Eocene limestone is tuffaceous, considerably weathered, and richly fossiliferous. Abundant fossils that represent a dozen organic groups were found. Such abundance and diversity signaled the find as a remarkable one that would add greatly to our knowledge of life in the western Pacific during the Eocene.

The island of Eua measures only 12 by 5 miles but it rises 1,000 feet above sea level. It occupies an interesting position tectonically, as its steep eastern side faces the Tonga Trench. In addition, Eua is the oldest island in the Tonga group that has a plutonic core (Guest, 1959) and a series of associated volcanic rocks, which are partly blanketed by thick limestones of late Eocene age. Younger volcanic rocks and sediments of late Tertiary age are also present (Hoffmeister, 1932).

This series of reports is concerned with one facies of the upper Eocene limestone. After the limestone series was deposited, Eua was uplifted periodically and a sequence of six terraces was cut in the limestones on the windward (eastern) side. Hoffmeister was the first to recognize the Eocene age of the main limestone of the terraces, three of which have veneers of Pliocene reef corals. He made a planetable map of the terraced eastern ridge and recorded the average altitudes of the terraces as 100, 200, 340, 400, 550, and 760 feet. The east-facing "rocky backbone" of Eua thus looks in profile like a giant staircase facing the Tonga Trench. The Eocene limestone may once have covered all of Eua but is now largely limited to the eastern ridge (Hoffmeister, 1932; the Eocene Foraminifera were described by Whipple in this same report, p. 79–86).

The fossils described in this series of reports were obtained from an outcrop on the 400-foot terrace about a quarter of a mile north of Vaingana (fig. 2). At this locality, the limestone lies close to the underlying volcanic rock and is tuffaceous and partly weathered; almost everywhere else on Eua the limestone is pure, hard, and crystalline.

In 1943, Harold T. Stearns, then of the U.S. Geological Survey, also served as a consultant to the Armed Forces at Pacific bases and made a brief visit to Eua. He collected a sample that contained half a dozen fossil brachiopods from the 400-foot terrace on the eastern side of the island. Stearns recorded the locality as: "Tele-a-hiva at elevation of 400 feet about ½ mile north of army lookout tower, at the second stream north of Vaigana [sic]." The brachiopods were examined by G. A. Cooper of the U.S. National Museum. Some years later when I was studying other island fossils collected by Stearns, Cooper showed me the brachiopods and expressed a desire for additional specimens so that he could continue his study of their internal structures.

In 1966, I learned that Yoshio Kondo of the Bernice P. Bishop Museum in Honolulu intended to visit Eua in connection with his studies of living Pacific island land snails (under National Science Foundation grant GB–3974). I sent Stearns' locality data and marked copy of Hoffmeister's Eua map to Kondo, and I informed Stearns of the plan to collect additional material.

Late in August 1967, Kondo reached Eua and, aided by a Tongan guide, Tomiki, and an interpreter, Mosese Vea, spent 2 days searching for the fossil locality. The lookout tower mentioned by Stearns no longer exists and Kondo found that Tele-a-hiva translates to "Nine Gulches." Traveling northward from "Vaigana" (Otu Vaingana) through heavy brush on exceedingly rugged karst topography for about 1,000 feet, he reached the first of the gulches. There he found a soft fossiliferous layer between two harder limestones and collected a

40-pound sample of the material. This gulch locality is probably not the exact spot visited by Stearns. The two collections have minor differences in nature of preservation, but they obviously came from the same formation.

The exact extent of the richly fossiliferous bed is not known but it is probably limited both horizontally and vertically. In 1926, when Hoffmeister made his map of the terraces, he did not come upon this facies, and in 1928 when I spent 2 weeks on Eua with Hoffmeister, reviewing his mapping, no exposures of this zone were seen although we visited Vaingana. Addi-

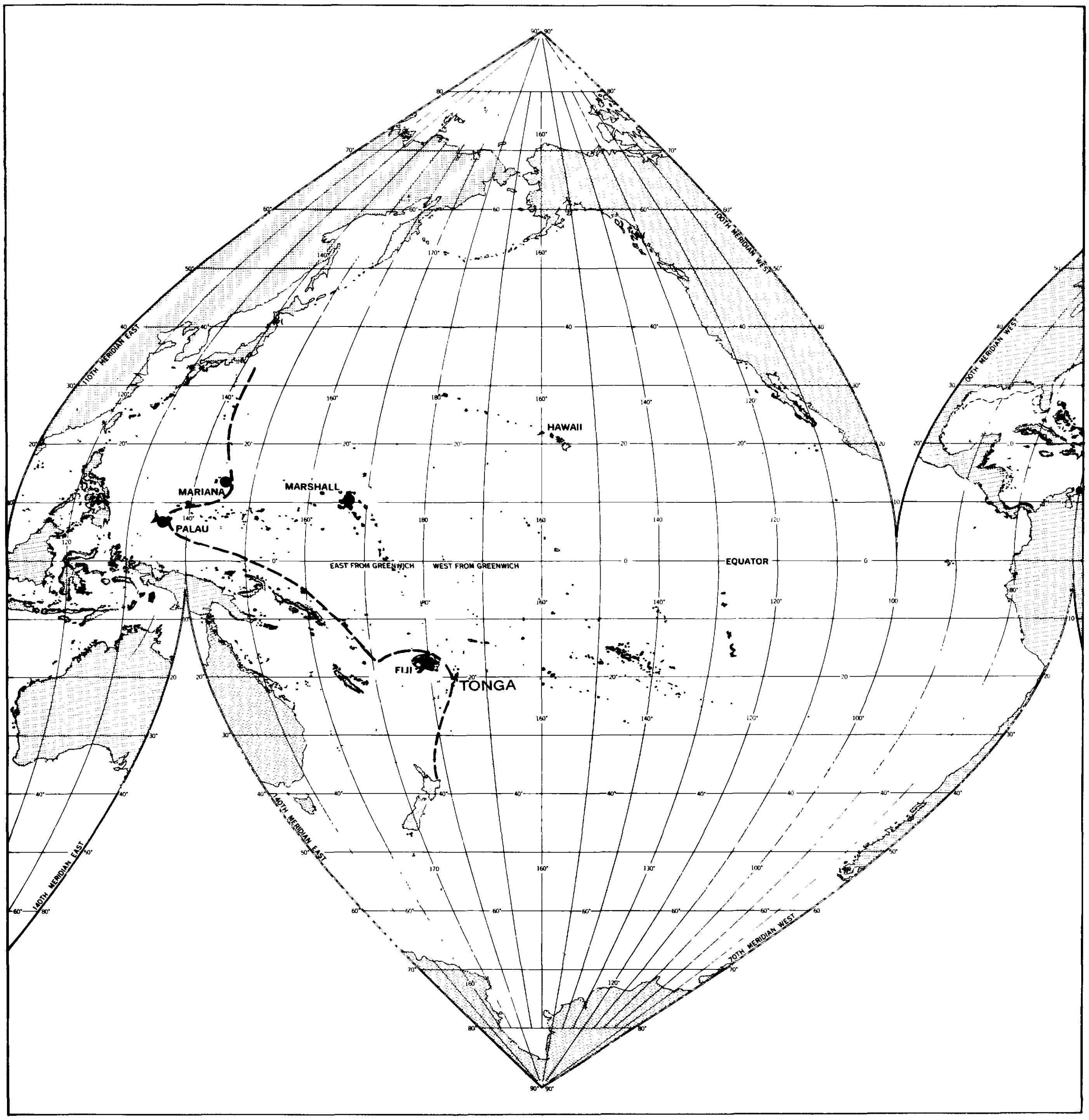

FIGURE 1.—Location of Tonga and other island groups in the southwest Pacific where upper Eocene limestone has been identified. Dashed line marks structural boundary of the Pacific Basin (andesite line).

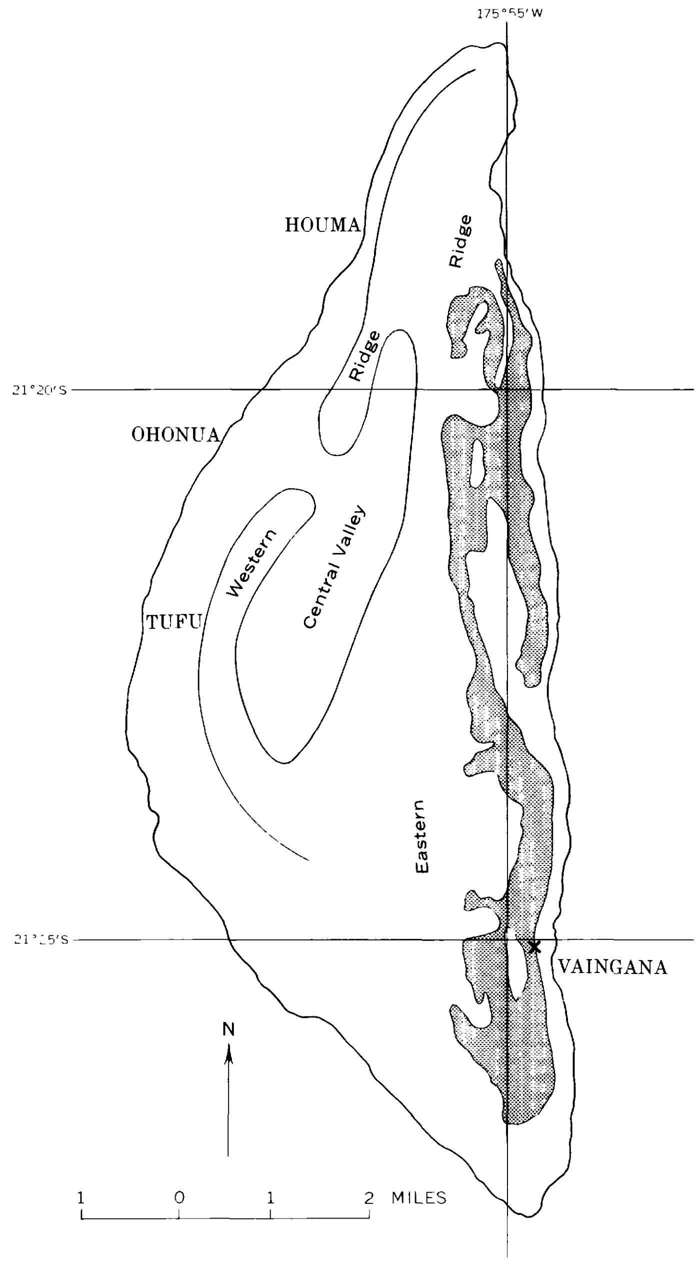

FIGURE 2.—Map of Eua, Tonga, showing the location of the recently discovered fossil outcrop (X) and the main mass of Eocene limestone (patterned area) on the east side of the island, as mapped by Hoffmeister (1932).

tional fieldwork in the area of the rugged "Nine Gulches" would be worthwhile.

William Melson of the Smithsonian Institution examined hand specimens and thin sections of the tuffaceous limestone and noted that the volcanic constituents are highly altered, making it difficult to determine their original nature. The rock is composed of 50 percent or more of volcanoclastic debris, much of which has been replaced by calcite. The predominant volcanic fragments are of porphyritic pumiceous glassy material; most of the phenocrysts are plagioclase, now largely replaced by calcite. The original groundmass of pumiceous glass is now devitrified and dark brown. Fragments of tuff are rare. There appears to be a large and varied assemblage of secondary minerals. The volcanic fragments are mainly porphyritic andesitic rocks, or possibly plagioclase-bearing dacites. The presence of abundant fossils suggests that the volcanic material has been reworked.

The soft tuffaceous limestone collected by Kondo was treated with a wetting agent and penetrant in the laboratory. The material broke down easily, revealing a variety of fossil remains: Foraminifera, discoasters, corals, hydrozoans, brachiopods, bryozoans, annelids, crinoids, echinoids, ostracodes, barnacles, decapod crustaceans, mollusks, shark teeth, otoliths, and spores and other plant microfossils.

W. Storrs Cole has described the larger Foraminifera; these fossils suggest to him a depth of deposition of about 200 feet, but other groups—notably the smaller Foraminifera, the corals, brachiopods, bryozoans, mollusks, ostracodes, and barnacles—point to a considerably greater depth of deposition.

Material representing a total of 17 organic groups was distributed to paleontologists for study and report. Seven of these collections were small or were made up of incomplete specimens leading only to summary reports, but the others, except for the larger Foraminifera, contained much new material. The brachiopod, bryozoan, ostracode, barnacle, and mollusk collections contained the first identifiable Eocene species from the islands of the open Pacific, an area extending 4,000 miles from Palau to Tonga.

HARRY S. LADD

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SMALLER FORAMINIFERA OF LATE EOCENE AGE FROM EUA, TONGA

By Ruth Todd

ABSTRACT

A predominantly planktonic fauna of smaller Foraminifera contains 16 planktonic species and 65 benthonic ones. One planktonic and nine benthonic species are described as new. Age of the deposit is late Eocene, probably in the lower part of the *Globigerina gortanii* Zone of the uppermost Eocene. Depth of deposition seems to have been more than 200 meters.

INTRODUCTION

An exceptionally rich fossil sample from station 24686, Eua, Tonga, has yielded a diverse fauna of beautifully preserved smaller Foraminifera.

The sample location (fig. 2) is as follows: outcrop about a quarter of a mile north of Vaingana, Eua, Tonga; at altitude 400 feet (USGS Foraminifera locality f26192).

The planktonic part (16 species) forms an estimated 95 percent of the total smaller Foraminifera population and the benthonic part (65 species), about 5 percent. Six species of *Lenticulina* dominate the benthonic part. The remaining 59 benthonic species together make up probably less than 2 percent of the total number of specimens.

Fifty-nine of the total 81 species have been identified with already described species; 10 are described as new, and 12 remain indeterminate. The fauna recorded in this study is not complete, as over 20 additional species are represented by too few or too poorly preserved specimens to be included in the present report.

A previous report (Whipple, 1932) of late Eocene (Tertiary *b*) Foraminifera from Eua included twelve species of larger Foraminifera but no smaller Foraminifera.

Acknowledgments.—I am grateful to Harry S. Ladd from whom I received the material for study and to Frances L. Parker, Walter Blow, and James P. Kennett for critical review of the manuscript. Responsibility for conclusions and for the classification used is my own. The photographs were retouched by Doris Low, to whom I am also indebted for other assistance in completing the report. I wish to thank Richard Margerum for preparing the two thin sections of *Amphistegina euaensis* n. sp. and K. Norman Sachs, Jr., for photographing them.

AGE OF THE FAUNA

The age of the fauna is determinable from the planktonic species, six of which appear to have narrow or narrowly overlapping stratigraphic ranges. They are *Globigerina ampliapertura* Bolli, *G. gortanii* (Borsetti), *G.* aff. *G. pseudoampliapertura* Blow and Banner, *Pseudohastigerina barbadoensis* Blow, *Globorotalia cerroazulensis* (Cole), and *Hantkenina bermudezi* Thalmann. The first four species are common or abundant, thus greater weight may be given to them than to the last two species, which are rare.

Figure 3 charts the ranges, as recorded by Blow and Banner (1962, text fig. 20), for the five of these species that are identified without question. In addition, the ranges of *Globigerina pseudoampliapertura* and *Globorotalia centralis* are also included. As the Tonga specimens represent a form transitional between these two species, I interpret the age of this transitional form to be near the top of the range of the older species and near the bottom of the range of the younger species.

Taking into consideration the relative abundance in the fauna of the five critical species shown in the range chart and the fact that transitional specimens instead of typical ones are representative of the two other species, I estimate the age of the Tonga deposit to be in the lower part of the *Globigerina gortanii* Zone of the uppermost Eocene.

PALEOECOLOGY

Interpretation of depth of deposition is based on two factors: predominance of planktonic specimens and generic composition of the benthonic part of the population. The great predominance of planktonic specimens over benthonic specimens in the Tonga sample, as much as 20 to 1, implies deposition at probably not

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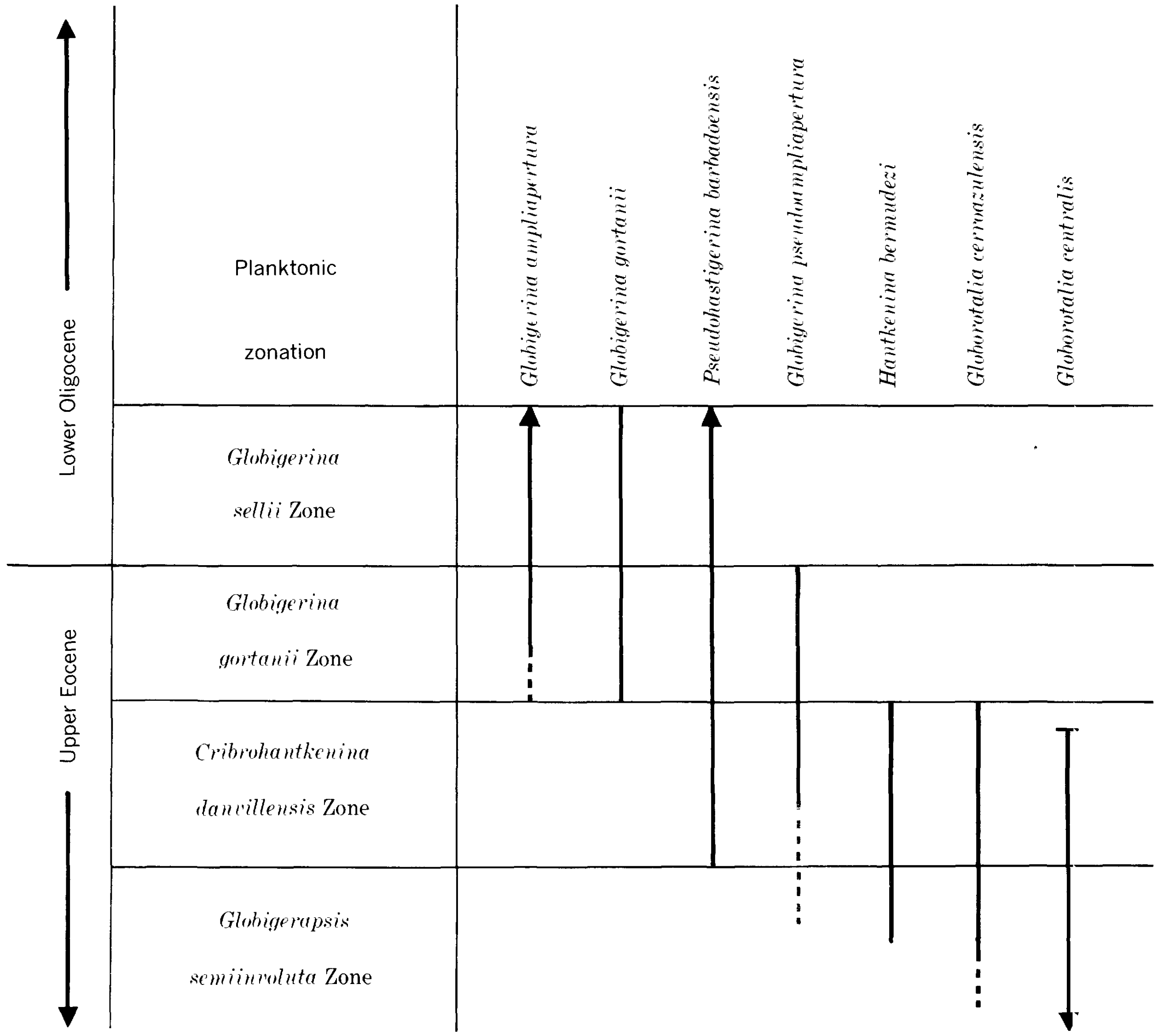

FIGURE 3.—Range chart of seven planktonic Foraminifera species that have narrow or overlapping stratigraphic ranges (modified from Blow and Banner, 1962, text fig. 20).

less than 200 meters and in an area fairly distant from land.

The benthonic population, small in itself, is dominated by mostly large and robust specimens of *Lenticulina*. Around Pacific islands this genus, formerly known as *Cristellaria* and *Robulus*, is almost exclusively found on outer slopes. Off Bikini, *Lenticulina* was found at 114 fathoms (209 meters) and deeper (Cushman and others, 1954, table 2). Off Guam, it was found between 570 and 1,170 feet (174 and 357 meters) (Todd, 1966, table 4). Analyses from the literature (Cushman, 1921, p. 220–254) of the abundant occurrences of *Cristellaria* in the Philippines shows that, with two exceptions at 37 fathoms (68 meters), the genus occurs most abundantly between 106 and 560 fathoms (194 and 1,024 meters). Based on these records, the abundance of *Lenticulina* in the Eocene fauna indicates a depth of deposition no shallower than about 200 meters.

Of the remaining benthonic species, none belong in genera that are restricted to shallow water. Moreover, several of the species have Holocene equivalents that are found at depths greater than about 200 meters. For example, *Lingulina grandis* Cushman (1921, p. 215, pl. 43, fig. 1), a species very similar to *L. wilcoxensis* Cushman and Ponton, is found between 78 and 260 fathoms (143 and 476 meters) in the Philippines.

Several genera (*Vulvulina, Marginulina, Dentalina, Angulogerina, Stilostomella, Siphonodosaria, Gyroidina, Osangularia, Nonion, Cassidulina,* and *Pullenia*) and the family Pleurostomellidae are all found exclusively at depths greater than 200 meters in the vicinity of the Marshall Islands (Cushman and others, 1954, tables 2–4).

Taken together, the above indications suggest deposition of the Tonga material at a depth not less than about 200 meters.

LIST OF SPECIES

Benthonic population:
- Family Ammodiscidae
  - *Ammolagena clavata* (Jones and Parker)
- Family Textulariidae
  - *Textularia eocaena* (Gümbel)
    - aff. *T. subhauerii* Cushman
  - *Vulvulina advena* Cushman
- Family Verneuilinidae
  - *Gaudryina* aff. *G. triangularis* Cushman
    - (*Siphogaudryina*) *rugulosa* Cushman
- Family Valvulinidae
  - *Clavulina parisiensis* d'Orbigny
- Family Miliolidae
  - *Triloculina globosa* (Hanna and Hanna)
    - *tricarinata* d'Orbigny
- Family Nodosariidae
  - *Lenticulina dumblei* (Weinzierl and Applin)
    - *inornata* (d'Orbigny)
    - aff. *L. nuttalli* (Cushman and Renz)
    - *texana* (Cushman and Applin)
    - *mosesei* n. sp.
    - *tomikii* n. sp.
  - *Marginulina* aff. *M. nuttalli* Todd and Kniker
    - *subbullata* Hantken
  - *Lingulina wilcoxensis* Cushman and Ponton
  - *Pseudonodosaria irregularis* n. sp.
    - sp.
  - *Dentalina consobrina* d'Orbigny
    - *cooperensis* Cushman
    - *nummulina* Gümbel
  - *Chrysalogonium lanceolum* Cushman and Jarvis
- Family Polymorphinidae
  - *Polymorphina tongaensis* n. sp.
  - *Sigmomorphina*? sp.
  - *Ramulina globulifera* Brady
- Family Buliminidae
  - *Bulimina* sp.
  - *Buliminella septata* Keyzer
    - *sculpturata* Keyzer
  - *Rectobulimina*? sp.
  - *Bolivina* cf. *B. jacksonensis* Cushman and Applin
  - *Angulogerina cooperensis* Cushman
  - *Fissurina* sp.
  - *Siphonodosaria modesta* (Bermudez)
    - *spinea* (Cushman)
  - *Stilostomella advena* (Cushman and Laiming)
    - sp.
- Family Pleurostomellidae
  - *Pleurostomella brevis* Schwager
  - *Ellipsoglandulina exponens* (Brady)
- Family Patellinidae
  - *Patellina gigantea* n. sp.
- Family Discorbidae
  - *Gyroidina girardana* (Reuss)
  - *Eponides repandus* (Fichtel and Moll)
    - sp.
  - *Oridorsalis umbonatus* (Reuss)
  - *Stomatorbina concentrica* (Parker and Jones)
  - *Osangularia bengalensis* (Schwager)
  - *Heronallenia* sp.
  - *Nuttallides rudis* n. sp.
- Family Amphisteginidae
  - *Asterigerina subacuta* Cushman
  - *Amphistegina euaensis* n. sp.
    - *vulgaris* d'Orbigny
- Family Anomalinidae
  - *Cibicides macrocephalus* (Gümbel)
    - *grumus* n. sp.
  - *Anomalina* cf. *A. polymorpha* Costa
  - *Hanzawaia* sp.
- Family Planorbulinidae
  - *Planorbulinella larvata* (Parker and Jones)
  - *Gypsina globula* (Reuss)
- Family Homotrematidae
  - *Maslinella carolinensis* (Cushman)
  - *Victoriella*? sp.
- Family Rupertiidae
  - *Rupertia incrassata* Uhlig
- Family Nonionidae
  - *Nonion maoricum* (Stache)
  - *Pullenia eocenica* Cushman and Siegfus
- Family Cassidulinidae
  - *Cassidulina* aff. *C. laevigata* d'Orbigny
    - *mene* n. sp.

Planktonic population:
- Family Globigerinidae
  - *Globigerina ampliapertura* Bolli
    - *conglomerata* Schwager
    - *eocenica* Terquem
    - *gortanii* (Borsetti)
    - *hexagona* Natland
    - *officinalis* Subbotina
    - aff. *G. pseudoampliapertura* Blow and Banner
    - *yeguaensis* Weinzierl and Applin
    - *kondoi* n. sp.
- Family Globorotaliidae
  - *Globorotalia cerroazulensis* (Cole)
    - aff. *G. cocoaensis* Cushman
    - sp. A
    - sp. B
- Family Hantkeninidae
  - *Hantkenina* (*Cribrohantkenina*) *bermudezi* Thalmann
  - *Pseudohastigerina barbadoensis* Blow
- Family Heterohelicidae
  - *Chiloguembelina cubensis* (Palmer)

SYSTEMATIC DESCRIPTIONS

Family AMMODISCIDAE
Genus AMMOLAGENA Eimer and Fickert, 1899

Ammolagena clavata (Jones and Parker)

Ammolagena clavata (Parker and Jones). Cushman and Renz, 1948, Cushman Lab. Foram. Research Spec. Pub. 24, p. 7, pl. 2, fig. 2.

A single specimen of this cosmopolitan and long-ranging species was found attached to a fragment in the Tonga material.

Family TEXTULARIIDAE
Genus TEXTULARIA Defrance, 1824

Textularia eocaena (Gümbel)

Plate 1, figure 6

Plecanium eocaenum Gümbel, 1870, Bayerische Akad. Wiss. Abh., Math.-Phys. Abt., Kl. 2, v. 10, p. 603, pl. 1, fig. 3.

Textularia eocaena (Gümbel). Hagn, 1954, Neues Jahrb. Geologie u. Paläontologie Abh., v. 98, no. 3, p. 419 (list), pl. 26, fig. 2.

Described from the Eocene of Bavaria and reported from the Netherlands and Mexico, this species occurs rarely at Tonga. It is distinctive in having chambers which become progressively higher and more inflated toward the apertural end.

Textularia aff. T. subhauerii Cushman

Plate 1, figure 2

A few robust specimens somewhat resemble this species that was described from the Oligocene of Mississippi (Cushman, 1922, p. 89, pl. 14, fig. 2). These specimens are fairly large, as much as 2 mm in length, slightly tapering from the initial end. The sutures are horizontal, the chambers are not inflated, and the periphery is slightly angled to rounded.

Genus VULVULINA d'Orbigny, 1826

Vulvulina advena Cushman

Plate 1, figure 3

Vulvulina advena Cushman, 1926, Cushman Lab. Foram. Research Contr., v. 2, p. 32, pl. 4, fig. 9.

This species—described from the upper Eocene of Alabama and reported from the Eocene of Mississippi, Mexico, Cuba, Dominican Republic, Atlantic cores, and France—is well represented in the Tonga material. Sutures of the biserial part are limbate and raised, and the periphery tends to be serrate.

Family VERNEUILINIDAE
Genus GAUDRYINA d'Orbigny, 1839

Gaudryina aff. G. triangularis Cushman

Plate 1, figure 4

Several specimens, which have a somewhat prominent triangular triserial stage, seem related to the Holocene species *Gaudryina triangularis* Cushman (1937, p. 66, pl. 9, fig. 16). The specimens show considerable variation in roughness of the wall, inflation of chambers, sharpness of angles, and relative size of the triserial stage.

Subgenus SIPHOGAUDRYINA Cushman, 1935

Gaudryina (Siphogaudryina) rugulosa Cushman

Plate 1, figure 5

Gaudryina (Siphogaudryina) rugulosa Cushman. Todd and Low, 1960, U.S. Geol. Survey Prof. Paper 260-X, p. 818, pl. 255, fig. 2; pl. 263, fig. 3.

Although this species was described from the Holocene and is widely recorded in Holocene sediment, it has also been reported in typical form from the Eocene of Saipan and in the Eocene cores from Eniwetok. A single specimen was found in the Tonga material.

Family VALVULINIDAE
Genus CLAVULINA d'Orbigny, 1826

Clavulina parisiensis d'Orbigny

Plate 1, figure 1

Clavulina parisiensis d'Orbigny, 1826, Annals des Sci. Naturelles, v. 7, p. 268, no. 3; Modèles, no. 66.
Cushman, 1937, Cushman Lab. Foram. Research Spec. Pub. 8, p. 18, pl. 2, figs 22–26.

Two specimens of this widely recorded Eocene species were found in the Tonga material. The early stage is triangular and the later stage is circular in section.

Family MILIOLIDAE
Genus TRILOCULINA d'Orbigny, 1826

Triloculina globosa (Hanna and Hanna)

Plate 1, figure 7

Quinqueloculina globosa Hanna and Hanna, 1924, Washington Univ. [Seattle], Geology, Pubs., v. 1, no. 4, p. 58, pl. 13, figs. 1, 2.

Triloculina globosa (Hanna and Hanna). Beck, 1943, Jour. Paleontology, v. 17, p. 594, pl. 100, figs. 3, 4.

This species, described from the Eocene of Washington State and reported from the Eocene of Chile and Japan, occurs in typical form at Tonga. The test is rounded, almost globular, and the aperture is a low-arched opening, not projecting from the circular outline of the test.

Triloculina tricarinata d'Orbigny

Plate 1, figure 8

Triloculina tricarinata d'Orbigny. Cushman, Todd, and Post, 1954, U.S. Geol. Survey Prof. Paper 260–H, p. 340, pl. 85, figs. 15, 16.

Described from the Holocene and widely reported from Eocene to Holocene beds, this sharply angled species occurs in typical form in the Tonga material.

Family NODOSARIIDAE
Genus LENTICULINA Lamarck, 1804

Lenticulina is commonly represented at Tonga by robust specimens of moderate or large size for the genus. As presently understood, this genus includes forms previously known as *Robulus* and separated on the basis of the radiate aperture having unequal slits. This variable now seems of insufficient importance on which to base generic distinctions.

Lenticulina dumblei (Weinzierl and Applin)

Plate 1, figure 15

Robulus dumblei Weinzierl and Applin, 1929, Jour. Paleontology, v. 3, p. 396, pl. 43, fig. 3.

Robulus dumblei was described from the Claiborne Eocene of Texas and has since been recorded from the Jackson Eocene of Mississippi and Alabama and the lower Lutetian of France.

Comparison with the holotype shows that the Tonga specimens are about three times as large but are otherwise quite similar. The Tonga specimens are characterized by a raised central umbo that has limbate and slightly raised curved sutures extending out from it, not tangential to it. Nine or ten chambers, rarely as many as 14, form the adult whorl. The periphery is angled and limbate but not keeled. The wall is smooth except for the raised limbate sutures. The aperture is at the peripheral angle but not much projecting. Diameter ranges between 2 and 3 mm.

Lenticulina inornata (d'Orbigny)

Plate 1, figure 9

Robulina inornata d'Orbigny, 1846, Foraminifères fossiles du bassin tertiaire de Vienne, p. 102, pl. 4, figs. 25, 26.
Hantken, 1881, Kgl. Ungar. Geol. Anstalt Mitt., Jahrb., v. 4, 1875, p. 55, pl. 6, fig. 9.
Robulus inornatus (d'Orbigny). Beck, 1943, Jour. Paleontology, v. 17, p. 595, pl. 104, figs. 1-4, 10, 14.

This species was described from the Miocene of the Vienna Basin and has been reported from Eocene to Holocene beds in many localities around the world. The Tonga specimens seem typical. They have straight sutures tangential to a large prominent umbo. The periphery is angled but not keeled, in some specimens being marked by a limbate cord similar to the nummulitid marginal cord. The chambers are few (seven or eight) and not inflated. The aperture is projecting at the peripheral angle. The Tonga specimens are about 2 mm in diameter; the largest one is 2.9 mm.

Lenticulina aff. L. nuttalli (Cushman and Renz)

Plate 1, figure 10

A few specimens seem to be similar to the species described as *Robulus nuttalli* (Cushman and Renz, 1941, p. 11, pl. 2, fig. 10) from the Agua Salada Formation (specifically from the three lowermost zones which are regarded as being late Oligocene to middle Miocene in age).

In the Tonga material these specimens are distinctive in having only five to seven chambers per whorl and a periphery which is faintly indented at each suture. The sutures are slightly curved and tangential to a raised central umbo. In this respect the specimens are unlike *Robulus nuttalli* in which the central umbonal area is depressed.

Lenticulina texana (Cushman and Applin)

Plate 1, figure 13

Cristellaria articulata Reuss var. *texana* Cushman and Applin, 1926, Am. Assoc. Petroleum Geologists Bull., v. 10, p. 170, pl. 8, figs. 1, 2.
Lenticulina articulata (Reuss) var. *texana* Cushman and Applin. Howe and Ellis, 1932, Louisiana Geol. Bull., no. 2, p. 31, pl. 5, figs. 1, 2.
Robulus texanus (Cushman and Applin). Beck, 1943, Jour. Paleontology, v. 17, p. 595, pl. 103, figs. 1, 2, 4, 5.

This species is widely reported in rocks of Eocene age. It is characterized by its blunt, rounded keel and by the coiling which tends to be slightly evolute so that the central umbo is prominently exposed.

Lenticulina mosesei Todd, n. sp.

Plate 1 figures 11, 14

Test large for the genus, close-coiled, relatively thick, with inconspicuous central umbo, periphery angled but not keeled, peripheral angle limbate in some specimens in others almost rounded over the final chamber; chambers not inflated, as many as 13 per adult whorl, as few as six in immature specimens; sutures flush, not limbate, straight or slightly curved, joining but not tangential to the umbo; wall smooth; aperture radiate, not much projecting at the apertural angle.

Diameter about 2.5 mm (maximum observed 3.2 mm); thickness about 1.25 mm.

Holotype, USNM 687483, from upper Eocene beds about a quarter of a mile north of Vaingana, Eua, Tonga, at altitude 400 feet. USGS Foraminifera locality f23192.

This species is highly variable in size, compression of test, and number of chambers per final whorl. It is common in the Tonga material and is characterized by its thick test and absence of a keel. Having a smooth surface and nothing distinctive about its sutures, *L. mosesei* appears similar to various already described species. Two similar species are *Cristellaria nikobarensis* (Schwager, 1866, p. 243, pl. 6, fig. 87) from the upper Tertiary of Kar Nicobar and *Robulus chehalisensis* (Rau, 1948, p. 162, pl. 29, figs. 14, 15) from the Eocene of Washington State. Both of these differ from *L. mosesei* in being more strongly compressed and in having a slight keel.

This species is named in honor of Mosese Vea, one of the guides who assisted in collecting the material.

Lenticulina tomikii Todd, n. sp.

Plate 1, figure 12

Test robust, of moderate size for the genus, close-coiled, nearly as thick as broad, apertural face low; periphery smooth or slightly lobulated over the final one or two chambers, rounded in edge view; chambers few, indistinct, six or seven forming the adult whorl, not inflated; sutures indistinct, strongly curved, neither raised nor depressed; wall smooth and unornamented; aperture below the peripheral angle, a conspicuous ring of slits that occupies almost the entire height of the apertural face. Diameter about 1.8 mm; thickness about 1.3 mm.

Holotype, USNM 687481, from upper Eocene beds about a quarter of a mile north of Vaingana, Eua, Tonga at altitude 400 feet. USGS Foraminifera locality f26192.

This species is distinctive in its globose shape and its conspicuous aperture that is situated within the apertural face rather than at the peripheral angle. Superficially the species resembles a globular *Cassidulina* until the suture pattern and radiate aperture are seen.

This species is named in honor of Tomiki, one of the guides who assisted in collecting the material.

Genus MARGINULINA d'Orbigny, 1826

Marginulina aff. M. nuttalli Todd and Kniker

Plate 2, figures 3, 4

Several specimens in the Tonga material, although showing considerable variation, appear to be related to this species originally described from the lower Oligocene of Mexico and also known from the Eocene and Oligocene of Cuba and the Eocene of Chile and Saipan.

The Eua specimens are larger than the cotypes from Mexico. They are variable in amount of compression and in straightness or curvature of the test. In most of them the wall is marked by faint costae as dense as, but less well developed than, those on *Dentalina nummulina*. The costae are slightly spiral and best developed over the initial part of the test. The sutures look limbate as seen through the thick, shiny wall of the test. Two specimens are illustrated to show the variability of this suite of specimens.

Marginulina subbullata Hantken

Plate 2, figure 5

Marginulina subbullata Hantken, 1881, Kgl. Ungar. Geol. Anstalt Mitt. Jahrb., v. 4, 1875, p. 46, pl. 4, figs. 9, 10; pl. 5, fig. 5.

A few variable specimens occur at Tonga. The species was described from the Eocene of Hungary and has been reported from widely distributed areas, in beds of Eocene to Holocene age.

M. subbullata has a short compact form and is circular in section and slightly compressed at the initial end; its radiate aperture is at the produced edge of the apertural end.

Genus LINGULINA d'Orbigny 1839

Lingulina wilcoxensis Cushman and Ponton

Plate 2, figures 6–8, 15, 16

Lingulina wilcoxensis Cushman and Ponton, 1932, Cushman Lab. Foram. Research Contr., v. 8, p. 58, pl. 7, fig. 14.
Toulmin, 1941, Jour. Paleontology, v. 15. p. 591, pl. 79, figs. 37, 38.
Todd and Low, 1960, U.S. Geol. Survey Prof. Paper 260–X, p. 828, pl. 255, fig. 13.

This large species is represented in the Tonga material by many specimens. Maximum observed length is 7.7 mm, and the breadth and thickness are around 1.6 and 0.8 mm, respectively. Considerable variation in shape is present within the assemblage; specimens range from elongate parallel-sided to oval specimens, to those tapering from the bluntly pointed initial end (see illustrated specimens). All are compressed but without any keel or limbation around the periphery. The sutures are fairly distinct, and the later sutures are slightly depressed so that the final chambers are slightly inflated. In some specimens the pattern of the later sutures shows that described for *L. wilcoxensis*—that is, a faint backward-extending curve on the central part of each flat side. The aperture is broad but narrowly open, extending about half the breadth of the test. The wall is smooth and unornamented.

The species was described and subsequently reported from several localities in the Wilcox Eocene of Alabama. In addition, a single specimen was found in Eocene core material from Eniwetok atoll. This finding at Tonga—its third recorded occurrence—confirms its presence in the Pacific and further extends its geographic extent.

Genus PSEUDONODOSARIA Boomgaart, 1949

Pseudonodosaria irregularis Todd, n. sp.

Plate 2, figure 10

Test elongate, tapering, irregularly uniserial; chambers irregularly globular, inflated; sutures flush in early stages, depressed or deeply incised later; wall smooth; aperture radiate, protruding. Length 1.6–2.0 mm; diameter 0.65–1.0 mm.

Holotype, USNM 687492, from upper Eocene beds about a quarter of a mile north of Vaingana, Eua, Tonga, at altitude 400 feet. USGS Foraminifera locality f26192.

This species differs from other described species of *Pseudonodosaria* in its irregularity. In some specimens the uniserial axis is bent as much as 90°; in some the globular chambers are flattened as if the test had been crowded during growth; in some the aperture protrudes away from the axis of the test; and in some the sutures are curved and slanting.

This new species is represented by seven adult and two immature individuals.

Pseudonodosaria sp.

Plate 2, figure 14

Three poorly preserved specimens from the Tonga material belong in this genus. The specimens are cylindrical and moderately involute, and the aperture is radiate.

Genus DENTALINA d'Orbigny, 1826

Dentalina consobrina d'Orbigny

Plate 2, figure 11

Dentalina consobrina d'Orbigny, 1846, Foraminifères fossiles du bassin tertiaire de Vienne, p. 46, pl. 2, figs. 1–3.

A few fragmentary specimens from Eua appear to belong in this long-ranging and widely reported species. They are characterized by rather long, slightly inflated chambers separated by horizontal sutures and by a nonarcuate axis.

Dentalina cooperensis Cushman

Plate 2, figures 12, 13

Dentalina cooperensis Cushman, 1933, Cushman Lab. Foram. Research Contr., v. 9, p. 8, pl. 1, fig. 17.

This widely reported late Eocene species occurs in the Tonga material. Specimens are smooth walled and arcuate, and they have a protruding radiate aperture. Sutures are approximately horizontal in some specimens and oblique in others. Chambers are slightly inflated toward the apertural end.

Dentalina nummulina Gümbel

Plate 2, figures 1, 2, 9

Dentalina nummulina Gümbel, 1870, Bayerische Akad. Wiss. Abh., Math.-Phys. Abt., Kl. 2, v. 10, p. 626, pl. 1, fig. 45.

A large robust, densely costate species, originally described from the lower Eocene of Bavaria, is well represented in the Tonga material. The Eua specimens have considerable variation in strength of costae and inflation of chambers. Most specimens are arcuate and only slightly tapering from a blunt or bulbous initial end. In most specimens the horizontal sutures are obscured by the dense costae. The chambers are very little inflated except in a few individuals where the final several chambers are somewhat inflated. The small radiate aperture is at the end of a protruding tube at the inner curve of the arcuate test. The lineation of the costae has a slight tendency to be oblique on some specimens.

D. nummulina may be related to *Marginulina* aff. *M. nuttalli* Todd and Kniker (pl. 2, figs. 3, 4), which is faintly costate particularly over its initial end. The Pliocene to Holocene species *Dentalina spirostriolata* (Cushman) (Cushman, 1921, p. 212, pl. 38, fig. 4) resembles this Eocene species but differs in lacking an apertural neck and in having more strongly spiral costae.

Genus CHRYSALOGONIUM Schubert, 1907

Chrysalogonium lanceolum Cushman and Jarvis

Chrysalogonium lanceolum Cushman and Jarvis, 1934, Cushman Lab. Foram. Research Contr., v. 10, p. 75, pl. 10, fig. 16.

Two fragmentary specimens, both having a cribrate aperture, appear to be identical with this smooth species that was described from the Miocene of Trinidad and has been reported from the Eocene to Miocene of the West Indian region.

Family POLYMORPHINIDAE
Genus POLYMORPHINA d'Orbigny, 1826

Polymorphina tongaensis Todd, n. sp.

Plate 2, figure 18

Test much compressed but bulging in the middle, ovate, equally pointed at both ends; chambers indistinct, not inflated, strongly overlapping so that the last-formed chamber covers more than half the surface of the test; sutures indistinct, not depressed, curved and sinuous; wall smooth; aperture radiate, pointed. Length about 1.00 mm; breadth about 0.80 mm; thickness about 0.45 mm.

Holotype, USNM 687500, from upper Eocene beds about a quarter of a mile north of Vaingana, Eua, Tonga, at altitude 400 feet. USGS Foraminifera locality f26192.

Polymorphina tongaensis differs from *P. frondea* (Cushman) in being bulged in the middle, in being equally pointed on both ends, and in having its periphery angled rather than truncate. Also, the chambers of *P. tongaensis* are more strongly overlapping than those of *P. frondea* so that the final chamber covers much of the surface of the test.

Only five specimens were found in the Tonga material but all are quite similar.

Genus SIGMOMORPHINA? Cushman and Ozawa, 1928

Sigmomorphina? sp.

Plate 2, figure 19

A small polymorphinid with extensive fistulose outgrowths may belong in this genus but cannot be seen clearly enough to insure its correct placement.

Genus RAMULINA Jones 1875

Ramulina globulifera Brady

Ramulina globulifera Brady, 1884, *Challenger* Rept., Zoology, v. 9, p. 587, pl. 76, figs. 22–28.

Two specimens represent this long-ranging and widely reported species. Both consist of central chambers from which project broken-off ends of stolons—six from one and four from the other. Both specimens are spinose.

Family BULIMINIDAE
Genus BULIMINA d'Orbigny 1826

Bulimina sp.

Plate 2, figure 17

A few specimens, too rare and undistinctive to be identified specifically, are rugose over the initial part and smooth and glossy over the final part; they have rather thick and limbate sutures.

Genus BULIMINELLA Cushman 1911

Buliminella septata Keyzer

Plate 2, figure 31

Buliminella septata Keyzer, 1953, Leidse Geol. Meded., pt. 17, p. 276, pl. 1, figs. 26–29.

Todd, 1957, U.S. Geol. Survey Prof. Paper 280-H, p. 298, pl. 73, fig. 3; pl. 75, figs, 27–29.

This species was described from the "Miopliocene" of Buton, Malay Archipelago, and has been reported from the Miocene of Saipan and Guam. At Tonga it is well represented by typical specimens.

In the original description, Keyzer noted its close relationship with the previously described species from the Eocene of Cuba—*Buliminella grata,* particularly its variety *spinosa.* Should they prove to be identical, the earlier name ought to be used. Pending this consideration, I will continue to use *B. septata* and separate it from *B. grata spinosa* on the basis of a stronger development of the scalloped sutures, surface spines, and incised furrows radiating from the aperture. There is no significant difference in size.

Buliminella sculpturata Keyzer

Plate 2, figure 23

Buliminella sculpturata Keyzer, 1953, Leidse Geol. Meded., pt. 17, p. 276, pl. 1, figs. 20–22.

This species was also described from the "Miopliocene" of Buton, Malay Archipelago, where it was reported with *Buliminella septata. B. sculpturata* is distinguished by a reticulate pattern of raised ridges resulting in waffle-like ornamentation over all except the apertural end, which is radially furrowed, and by its size, about half that of *B. septata.*

B. sculpturata and *B. septata* occur together at Tonga, also with the same relative size relationship.

Genus RECTOBULIMINA? Marie, 195?

Rectobulimina? sp.

Plate 2, figure 22

Only two specimens having a central terminal aperture and a coarsely perforate wall with a sugary texture were found in the Tonga material.

They appear to be related to this genus which was described and reported only from the Upper Cretaceous, Maestrichtian, of Belgium. However, *Rectobulimina* is defined as being biserial and then uniserial in its final stages, whereas the Eua specimens are triserial throughout, though with a terminal aperture.

In the slender shape of the test and in the wall texture, these specimens resemble *Bulimina jarvisi* Cushman and Parker (1936, p. 39, pl. 7, fig. 1) from the Eocene of Trinidad, but in that species the aperture is comma-shaped and typical of *Bulimina,* whereas in the Eua species the aperture is clearly terminal.

Genus BOLIVINA d'Orbigny, 1839

Bolivina cf. B. jacksonensis Cushman and Applin

Plate 2, figure 20

Rare and poorly preserved specimens seem to belong in this late Eocene species that was described from Texas and has since been reported from many localities in the United States, the West Indian region, and South America, as well as Saipan.

Genus ANGULOGERINA Cushman, 1927

Angulogerina cooperensis Cushman

Plate 2, figure 21

Angulogerina cooperensis Cushman, 1935, U.S. Geol. Survey Prof. Paper 181, p. 42, pl. 16, fig. 9.

Typical specimens of this slender carinate species are rare in the Tonga material. The species has been widely recorded from the upper Eocene of the United States. In the Pacific it has been reported from Saipan and Guam.

Genus FISSURINA Reuss, 1850

Fissurina sp.

Plate 2, figure 24

Two specimens—both compressed, one completely surrounded by a flangelike keel and the other bluntly rounded on the periphery—were found in the Tonga material.

Genus SIPHONODOSARIA A. Silvestri, 1924

Siphonodosaria modesta (Bermudez)

Plate 2, figure 25

Ellipsonodosaria modesta Bermudez, 1937, Soc. Cubana Hist. Nat. Mem., v. 11, p. 238, pl. 20, fig. 3.
Cushman and Stainforth, 1945, Cushman Lab. Foram. Research Spec. Pub. 14, p. 57, pl. 10, fig. 2.
Cushman and Renz, 1948, Cushman Lab. Foram. Research Spec. Pub. 24, p. 32, pl. 6, figs. 11, 12.

Typical specimens of this costate species, described from the Eocene of Cuba and recorded from the Eocene and Oligocene of Trinidad, are present in the Tonga material. They have the internal striations of the apertural tube that are characteristic of this genus.

Siphonodosaria spinea (Cushman)

Plate 2, figure 26

Ellipsonodosaria curvatura Cushman var. *spinea* Cushman, 1939, Cushman Lab. Foram. Research Contr., v. 15, p. 71, pl. 12, figs. 7–11.
Stilostomella curvatura (Cushman) var. *spinea* (Cushman). Beckmann, 1954, Eclogae Geol. Helvetiae, v. 46, no. 2, 1953, p. 370, pl. 21, fig. 28.
Siphonodosaria curvatura var. *spinea* (Cushman). Todd, 1957, U. S. Geol. Survey Prof. Paper 280–H, p. 268 (table 1), pl. 67, fig. 5.
Stilostomella spinea (Cushman). Parker, 1964, Jour. Paleontology, v. 38, p. 628, pl. 98, fig. 4.

Four Tonga specimens appear to be identical with this species that was described from Eocene rocks cored off the eastern coast of the United States. The species seems to be a widespread one, having been reported from the Eocene of Trinidad, Ecuador, Austria, and Saipan; from the Oligocene of Barbados; and from the Miocene and Pliocene of the experimental drilling near Guadalupe Island, Mexico.

Genus STILOSTOMELLA Guppy, 1894

Stilostomella advena (Cushman and Laiming)

Plate 2, figure 27

Nodogenerina advena Cushman and Laiming, 1931, Jour. Paleontology, v. 5, p. 106, pl. 11, fig. 19.
Siphonodosaria advena (Cushman and Laiming). White, 1956, Jour. Paleontology, v. 30, p. 260, pl. 32, fig. 11.

This species was first described from the Miocene of California and has been recorded from many localities and from Eocene to Pliocene beds under three generic names—*Nodogenerina*, *Siphonodosaria*, and *Stilostomella*. *Nodogenerina* is regarded as generically indistinguishable from *Stilostomella*, whereas *Siphonodosaria* is distinguished by the internal striations of its aperture.

Stilostomella advena is characterized by a straight, not arcuate, test and a phialine lip indented by a single tooth. The Tonga specimens are faintly hispid.

Stilostomella sp.

Plate 2, figure 28

A costate species, represented by a few specimens at Tonga, appears to be undescribed. It is tapering and arcuate. The initial chambers are not inflated, the final chambers progressively more so, and the last one is smooth. The costae are thick, heavy, and continuous from the initial end. The aperture is at the end of a neck with phialine lip that is indented by a single tooth and is not internally striate.

Family PLEUROSTOMELLIDAE
Genus PLEUROSTOMELLA Reuss, 1860

Pleurostomella brevis Schwager

Plate 2, figure 30

Pleurostomella brevis Schwager, 1866, *Novara* Exped., Geol. Theil, v. 2, p. 239, pl. 6, fig. 81.

Specimens of this long-ranging (Eocene to Holocene) species found at Eua are robust and short and have a blunt initial end.

Genus ELLIPSOGLANDULINA A. Silvestri, 1900

Ellipsoglandulina exponens (Brady)

Plate 2, figure 29

Ellipsoglandulina exponens (Brady). Cushman and Stainforth, 1945, Cushman Lab. Foram. Research Spec. Pub. 14, p. 57, pl. 10, fig. 8.

A single typical specimen, clearly showing the curved aperture, was found in the Tonga material. This species was described from the Tertiary of Trinidad and has been reported from Puerto Rico, the Dominican Republic, Barbados, Guatemala, and several localities in Europe.

Family PATELLINIDAE
Genus PATELLINA Williamson, 1858

Patellina gigantea Todd, n. sp.

Plate 3, figures 1, 4

Test very large for the genus, planoconvex with the basal surface undulating; periphery sharp; dorsal apex high; dorsal surface bears roughly concentric ridges marking the edges of chambers, and both surfaces have radiating lines around the outer circumference; ventral surface divided by an irregular line of junction between the final and the penultimate chamber; chambers half a whorl in length, indistinct, not inflated; sutures indistinct; wall unornamented except by the concentric ridges on the dorsal side; aperture unobserved. Diameter as much as 1.6 mm; height as much as 1.0 mm.

Holotype, USNM 687515, from upper Eocene beds about a quarter of a mile north of Vaingana, Eua, Tonga at altitude 400 feet. USGS Foraminifera locality f26192.

Patellina gigantea n. sp. differs from the other described species of this genus in its size, as much as eight times the size of other species of *Patellina.*

This species is represented by large (1.6 mm±) and small (1.0 mm±) specimens; one of each is illustrated. Very few specimens of an intermediate size were found.

Family DISCORBIDAE
Genus GYROIDINA d'Orbigny, 1826

Gyroidina girardana (Reuss)

Plate 3, figure 2

Gyroidina girardana (Reuss). Cushman and Stainforth, 1945, Cushman Lab. Foram. Research Spec. Pub. 14, p. 60, pl. 10, fig. 18.

A few specimens of *Gyroidina* are characterized by a slightly bulging dorsal surface, an open umbilicus, and a wide apertural face.

Genus EPONIDES Montfort, 1808

Eponides repandus (Fichtel and Moll)

Plate 3, figure 9

Eponides repandus (Fichtel and Moll). Todd, 1965, U.S. Natl. Mus. Bull. 161, pt. 4, p. 20, pl. 7, figs. 3, 4.

Four typical specimens of this cosmopolitan species were found in the Tonga material. They all belong to the compact *"repandus"* form as distinguished from the spreading *"lateralis"* form.

Eponides sp.

Plate 3, figure 5

Three specimens of an ornamented species appear to be new. The test is planoconvex, flat on the dorsal side and has an angled periphery. Chambers are not inflated but are defined only by prominent raised limbate sutures that extend part way out from the umbilical area on both dorsal and ventral surfaces. About 12 chambers make up the final whorl. The wall is ornamented by fine sugary pustules covering the whole test in between the raised limbate sutures and the knobs over the central areas. The aperture is not clear but appears to be a low opening between the periphery and the umbilicus on the convex side, with a loop parallel to the peripheral angle. Diameter, 0.70–1.10 mm; thickness, 0.42–0.52 mm.

Genus ORIDORSALIS Andersen, 1961

Oridorsalis umbonatus (Reuss)

Plate 3, figure 3

Rotalina umbonata Reuss, 1851, Deutsch. Geol. Gesell. Zeitschr., v. 3, p. 75, pl. 5, fig. 35.
Oridorsalis umbonatus (Reuss). Todd, 1965, U.S. Natl. Mus. Bull. 161, pt. 4, p. 23, pl. 6, fig. 2.

This species known from Eocene to Holocene beds and from many localities is represented by five typical specimens in the Tonga material.

Genus STOMATORBINA Dorreen, 1948

Stomatorbina concentrica (Parker and Jones)

Plate 3, figure 7

Pulvinulina concentrica Parker and Jones, *in* Brady, 1864, Linnean Soc. London Trans., v. 24, p. 470, pl. 48, fig. 14.
Stomatorbina concentrica (Parker and Jones). Todd, 1965, U.S. Natl. Mus. Bull. 161, pt. 4, p. 24, pl. 16, figs. 1, 2.

This genus, although originally based on an Eocene species from Cuba and New Zealand, appears to range from Eocene to Holocene. The Holocene specimens have little to distinguish them from the Eocene ones but appear to be smaller, less robust, and flatter. The Tonga specimens show greater similarity with Holocene specimens than with those from the Eocene; hence, the Holocene name is used for them.

Genus OSANGULARIA Brotzen, 1940

Osangularia bengalensis (Schwager)

Plate 3, figure 6

Anomalina bengalensis Schwager, 1866, *Novara* Exped., Geol. Theil, v. 2, p. 259, pl. 7, fig. 111.

Osangularia bengalensis (Schwager). Todd, 1957, U.S. Geol. Survey Prof. Paper 280–H, p. 274 (table 2); p. 278 (table 3), pl. 77, fig. 1.

Truncatulina velascoensis Cushman, 1925, Cushman Lab. Foram. Research Contr., v. 1, p. 20, pl. 3, fig. 2.

Osangularia velascoensis (Cushman). von Hillebrandt, 1962, Bayerische Akad. Wiss. Abh., Math.-Naturw. Kl., n. f., Heft 108, p. 110, pl. 9, figs. 16, 17.

Pulvinulinella culter (Parker and Jones) var. *mexicana* Cole, 1927, Bulls. Am. Paleontology, v. 14, no. 51, p. 31, pl. 1, figs. 15, 16.

Pulvinulinella mexicana Cole. Cushman and Todd, 1945, Cushman Lab. Foram. Research Spec. Pub. 15, p. 61, pl. 10, fig. 7.

Osangularia mexicana (Cole). Todd, 1957, U.S. Geol. Survey Prof. Paper 280–H, p. 268, (table 1), pl. 69, fig. 1.

Reconsideration of the various specimens placed in several species of this genus has led me to conclude that at least those listed above, and possibly others, should be combined into a single species and the earliest name used.

Specimens of this species show considerable variation in number of chambers per whorl, width of keel, and limbation of sutures. The Tonga specimens have about 15 chambers in the final whorl, the keel is thick and very wide, and the dorsal surface is nearly buried under the coalescing of clear shell material that originates from the limbation of the sutures, both spiral and radial.

The species is cosmopolitan and occurs in beds from Paleocene to Holocene in age.

Genus HERONALLENIA Chapman and Parr, 1931

Heronallenia sp.

Plate 3, figure 8

A single specimen, here illustrated, is larger than most species of this genus. It is rather highly arched on the dorsal side.

Genus NUTTALLIDES Finlay, 1939

Nuttallides rudis Todd, n. sp.

Plate 4, figure 1

Test biconvex, close-coiled, consisting of 2½ to 3 whorls; ventral umbilicus closed by a plug of shell material, periphery sharp, not lobulated, not keeled; chambers distinct, numerous, about 12 making up the final whorl, not much increasing in size as added, not inflated; sutures distinct, spiral suture thickened, indistinct in the initial stage, dorsal sutures straight and tangential, ventral sutures straight and radial, slightly indented at their outer ends; wall smooth; aperture extending from the ventral plug almost to the periphery with a deep re-entrant just inward from the periphery. Diameter, 0.65–0.70 mm; thickness, 0.36–0.39 mm.

Holotype, USNM 687524, from upper Eocene beds about a quarter of a mile north of Vaingana, Eua, Tonga, at altitude 400 feet. USGS Foraminifera locality f26192.

This species differs from the well-known and widely reported Eocene species, *N. truempyi* (Nuttall), in having more chambers per whorl and in the ventral sutures being straight rather than sinuous.

Family AMPHISTEGINIDAE
Genus ASTERIGERINA d'Orbigny, 1839

Asterigerina subacuta Cushman

Plate 4, figure 4

Asterigerina subacuta Cushman, 1922, U.S. Geol. Survey Prof. Paper 129–E, p. 100, pl. 24, figs. 1–3.

A few specimens appear to be identical with this species that has so far been reported only from the Oligocene of the southeastern United States.

Genus AMPHISTEGINA d'Orbigny, 1826

Amphistegina euaensis Todd, n. sp.

Plate 4, figure 2; text figure 4

Test of moderate size for the genus, robust, equally biconvex, with thickness almost equaling diameter, periphery flangelike and bluntly angled; chambers indistinct on the surface, 19 or 20 forming a whorl in the adult, four to five whorls forming an adult test; sutures obscured; wall thick and heavy, ornamented by irregular weltlike elongated ridges that radiate out from the smooth umbo to the smooth flangelike periphery; ornamentation equally developed on both sides; aperture not observed. Diameter about 2.5 mm (greatest observed 3 mm); thickness about 2 mm.

Holotype, USNM 687527, from upper Eocene beds about a quarter of a mile north of Vaingana, Eua, Tonga, at altitude 400 feet. USGS Foraminifera locality f26192.

This species is distinctive in its equally biconvex shape and its surface ornamentation.

FIGURE 4.—Thin sections of *Amphistegina euaenis* Todd, n. sp. Upper: Horizontal section, paratype, USNM 687528, × 30. Lower: Vertical section, paratype, USNM 687529, × 30; specimen cracked during sectioning and five air bubbles appear on photograph.

Amphistegina vulgaris d'Orbigny

Plate 4, figure 3

Amphistegina vulgaris d'Orbigny, 1826, Annals des Sci. Naturelles, v. 7, p. 305, no. 8; Modèles no. 40.
Parker, Jones, and Brady, 1865, Annals and Mag. Nat. History, ser. 3, v. 16, p. 25, pl. 3, fig. 91.
Jones, 1897, Foraminifera of the Crag, pt. 4, p. 359, pl. 2, figs. 46–48.

Compared with topotypes from the Miocene, Burdigalian, of Landes, France, the Tonga specimens seem to be indistinguishable. They are compressed and have about 12 chambers per whorl. Specimens are rare at Tonga.

Family ANOMALINIDAE
Genus CIBICIDES Montfort, 1808

Cibicides macrocephalus (Gümbel)

Plate 4, figure 7

Rotalia macrocephala Gümbel, 1870, Bayerische Akad. Wiss. Abh., Math.-Phys. Abt., Kl. 2, v. 10, p. 652, pl. 2, fig. 91.
Cibicides macrocephalus (Gümbel). Todd and Low, 1960, U.S. Geol. Survey Prof. Paper 260–X, p. 852, pl. 258, fig. 4.

Described from the Eocene of Bavaria, this species has also been reported from the Eocene of Eniwetok and Guam. It is a moderately large, coarsely perforate species, planoconvex with a ventral plug of clear shell material. The aperture, on the flattened ventral side, is rimmed by a conspicuous lip.

Cibicides grumus Todd, n. sp.

Plate 4, figure 6

Test close-coiled, planoconvex—dorsal side flat, ventral side conical with a prominent umbilical plug of clear shell material; periphery not lobulated, bluntly angled and limbate but not keeled; chambers distinct, 12 or 13 making up the final whorl, the last two or three chambers very slightly inflated ventrally; sutures distinct, slightly limbate on the dorsal side, slightly incised and curved backwards on the ventral side; wall smooth and finely perforate on the ventral side; irregularly ornamented by limbate sutures and shell material perforated by coarse pores on the dorsal side; aperture is on the periphery and extends over onto the dorsal side, rimmed by a small lip. Diameter 0.48–0.78 mm; height 0.30–0.48 mm.

Holotype, USNM 687531, from upper Eocene beds about a quarter of a mile north of Vaingana, Eua, Tonga, altitude 400 feet. USGS Foraminifera locality f26192.

This species seems to be distinct in its high, planoconvex test and the large umbilical plug. *C. grumus* is somewhat reminiscent of *Cibicides dickersoni* Bermudez (1937, p. 244, pl. 21, figs. 8, 9) from the Eocene of Cuba, but *C. grumus* is more highly conical and the umbilical plug occupies a larger proportion of the ventral side. In addition, the dorsal ornamentation is not beaded in the Eua species, as it is in *C. dickersoni*, but is irregularly limbate.

Genus ANOMALINA d'Orbigny, 1826

Anomalina cf. A. polymorpha Costa

A single specimen seems probably identical with this species that was described from the Pliocene of Italy (Costa, 1856, p. 252, pl. 21, figs. 7–9). The test is flattened and concave on one side, where it was attached, and irregularly conical and coarsely perforate on the other side. On the conical side the three last chambers extend into blunt-spined protuberances around the umbilical depression.

Previous records of *Anomalina polymorpha* are from Miocene to Holocene beds.

Genus HANZAWAIA Asano, 1944

Hanzawaia sp.

Plate 5, figure 1

Only three specimens were found. All are plano-convex, steepsided, about 0.75 mm in diameter, and 0.38 mm thick. The flattened side is slightly concave and shows one or two umbilical flaps. On the opposite side the coiling is not completely involute, and the area of the early coil is slightly depressed in the middle. Eight chambers make up the final whorl. The sutures are rather thickened and limbate, especially on the concave side, and the periphery is marked by a limbate rim. The wall is rather coarsely perforate.

Family PLANORBULINIDAE
Genus PLANORBULINELLA Cushman, 1927

Planorbulinella larvata (Parker and Jones)

Plate 4, figure 5

Planorbulina larvata Parker and Jones. Brady, 1884, *Challenger* Rept., Zoology, v. 9, p. 658, pl. 92, figs. 5, 6.

A few typical specimens of this cosmopolitan species, that has been recorded from Eocene to Holocene beds, are present in the Tonga material.

Genus GYPSINA Carter, 1877

Gypsina globula (Reuss)

Gypsina globula (Reuss). Cushman, 1935, U.S. Geol. Survey Prof. Paper 181, p. 54, pl. 23, figs. 4, 5.

A few typical specimens of this widely reported Eocene to Holocene species were found in the Tonga material.

Family HOMOTREMATIDAE
Genus MASLINELLA Glaessner and Wade, 1959

Maslinella carolinensis (Cushman)

Plate 5, figure 2

Eponides carolinensis Cushman, 1935, U.S. Geol. Survey Prof. Paper 181, p. 46, pl. 17, fig. 7.

Comparison of the type species of the genus (paratypes of *Maslinella chapmani* deposited in the U.S. National Museum) with the types of *Eponides carolinensis* leads me to conclude that the latter should be transferred to *Maslinella*. Typical specimens occur in the Tonga material. They have heavy limbation of dorsal sutures and periphery and a coarsely perforate wall. They have the umbilical knobs of shell material that are present on both *Maslinella chapmani* and "*Eponides carolinensis*." *M. carolinensis* differs from *M. chapmani* in being more compactly coiled (less flaring).

The genus *Maslinella* was described from the upper Eocene of Australia. "*Eponides carolinensis*" was described and known only from the upper Eocene of North Carolina. Judging only from the literature it seems that several records under the name of *Eponides* cf. *E. carolinensis* and two varieties of *E. carolinensis* may prove to belong in *Maslinella*. They are: a record (Colom, 1945, p. 43, pl. 1, figs. 13, 16, 17, 23, 24) from the Eocene and Oligocene of Navarra, Spain, a record (de Witt Puyt, 1941, p. 66, pl. 1, figs. 52, 57; pl. 2, fig. 2) from the Eocene of Hercegovina; and a record (de Gaona and Colom, 1950, p. 377, text fig. 14, figs. 5, 10) from the Eocene of the southern Pyrenees.

Genus VICTORIELLA? Chapman and Crespin, 1930

Victoriella? sp.

Plate 5, figure 3

A single specimen, here illustrated, may belong in this genus. The robust test consists of a low trochospiral coil of three whorls. The wall is thick, rough surfaced, and coarsely perforate. The specimen appears to have been attached at the umbilical area. Matrix obscures the apertural opening.

The genus is known from upper Eocene to Miocene beds in Australia, New Zealand, New Guinea, Saipan, and Europe.

Family RUPERTIIDAE
Genus RUPERTIA Wallich, 1877

Rupertia incrassata Uhlig

Plate 5, figure 7

Rupertia incrassata Uhlig, 1886, K.k. Geol. Reichsanstalt Jahrb., v. 36, no. 1, p. 185, pl. 4, figs. 3–9.

This species, described from the "Alttertiar" of the West Galician Carpathians, is present at Tonga. The wall is characteristically coarsely perforate and in some specimens is covered by wartlike protuberances.

Family NONIONIDAE
Genus NONION Montfort, 1808

Nonion maoricum (Stache)

Plate 5, figure 4

Rosalina maorica Stache, 1864, *Novara* Exped., Geol. Theil, v. 1, sec. 2, p. 282, pl. 24, fig. 32.

Nonion maoricum (Stache). Dorreen, 1948, Jour. Paleontology, v. 22, p. 289, pl. 37, fig. 9.
Todd, 1966, U.S. Geol. Survey Prof. Paper 403-I, p. 29, pl. 6, fig. 8.

This species, described from the Eocene of New Zealand and also recorded from the Eocene and Oligocene of Guam, occurs at Tonga. These specimens have slightly fewer chambers than the New Zealand types.

Genus PULLENIA Parker and Jones, 1862

Pullenia eocenica Cushman and Siegfus

Plate 5, figure 5

Pullenia eocenica Cushman and Siegfus, 1939, Cushman Lab. Foram. Research Contr., v. 15, p. 31, pl. 7, fig. 1.

A single typical specimen was found at Tonga. This species was described from the Eocene of California and has also been reported from the Eocene of Maryland, Chile, Poland, and Japan.

Family CASSIDULINIDAE

Genus CASSIDULINA d'Orbigny, 1826

Cassidulina aff. C. laevigata d'Orbigny

Only two specimens were found of a species having an angled but not keeled periphery. About four pairs of chambers make up the final whorl.

Cassidulina mene Todd, n. sp.

Plate 5, figure 6

Test compact, smoothly globular, apertural face low and concave or slightly flattened; chambers numerous, indistinct, narrow, elongate, not inflated; sutures indistinct, slightly irregular; wall smooth; aperture rather large for the genus, a straight loop-shaped opening extending up at a slight angle to the suture at the base of the apertural face. Diameter 0.42–0.48 mm.

Holotype, USNM 687539, from upper Eocene beds about a quarter of a mile north of Vaingana, Eua, Tonga, at altitude 400 feet. USGS Foraminifera locality f26192.

This species seems related to *Cassidulina pacifica* Cushman from the Holocene and upper Tertiary but differs in having narrower and more numerous chambers so that eight or nine alternating ones are visible on the dorsal curved surface.

Family GLOBIGERINIDAE

The classification of the family Globigerinidae is still a speculative matter. When the families Globigerinidae and Globorotaliidae were originally established (Cushman, 1927, p. 87, 91), the major means by which the two families were separated was shape of chambers in the adult test—more or less globular in the Globigerinidae and compressed and keeled, or at least angular on the periphery, in the Globorotaliidae. Bolli, Loeblich, and Tappan (1957, p. 31, 39) used position of the aperture—whether it is umbilical or extends beyond the umbilicus—as the determining characteristic whereby genera of the Globigerinidae were separated from those of the Globorotaliidae. Parker (1962, p. 220–221) used spinose walls (or hispid walls in fossil forms) as opposed to nonspinose, smooth or pitted walls as the determining characteristic in separating genera of the Globigerinidae from those of the Globorotaliidae.

Each of these systems of classification, if strictly followed, results in combinations or separations of genera that to me seem unnatural. I doubt that a simple twofold system of classification can be set up that will result in strict conformity of all morphological elements in all the genera concerned. Hence, for the present, I will use *Globigerina* for those species that have generally globular chambers and either hispid or pitted walls, and either an umbilical or extraumbilical-umbilical aperture. I will use *Globorotalia* for species that have a more or less angular or keeled periphery.

Genus GLOBIGERINA d'Orbigny, 1826

Globigerina ampliapertura Bolli

Plate 6, figure 1

Globigerina ampliapertura Bolli, 1957, U.S. Natl. Mus. Bull. 215, p. 108, pl. 22, figs. 4–7; p. 164, pl. 36, fig. 8.

This species occurs in uppermost Eocene and Oligocene beds and is found in the equatorial belt around the world. It is characterized by a compact low spire, a broad and widely open umbilical aperture, and a cancellate wall. Specimens are common in the Tonga material.

Globigerina conglomerata Schwager

Plate 6, figures 2–5

Globigerina conglomerata Schwager. Todd, 1964, U.S. Geol. Survey Prof. Paper 260-CC, p. 1080, pl. 291, figs. 8, 9.

The above reference includes a partial synonymy of the species as well as a discussion of its variability. The species seems to range from at least upper Eocene to Holocene, as typical specimens have been reported from the upper Eocene of Guam (Todd, 1966, pl. 2, fig. 5). The similar early Tertiary species, *Globigerina tripartita*, may prove to belong with *G. conglomerata* as a synonym.

Globigerina conglomerata is abundant in the Tonga material. Four specimens, showing its variable form, are illustrated. The largest has a heavy, closely compact form and three chambers in the final whorl; two are medium-sized specimens—one has three chambers per final whorl plus a smooth bulla partly covering the umbilicus, and the other has a more loosely coiled form and four chambers in the final whorl; and the smallest specimen is a probably juvenile form that has four chambers in the final whorl around a fairly open umbilical depression. In none of these is the aperture more than a low opening under the inner edge of the chamber.

The late Eocene species, *Globigerina turgida* Finlay (Bolli, 1957a, pl. 15, figs. 3–5), bears a close resemblance to this species. Comparison with a topotype from New Zealand indicates a closely similar morphology, in particular with the two more loosely coiled four-chambered forms that have an umbilicus (this paper, pl. 6, figs. 2, 4). However, the close relationships between the four described variants lead me to regard them all as a single species, *G. conglomerata*, possibly with *G. turgida* as a synonym.

Globigerina eocenica Terquem

Plate 7, figure 4

Globigerina eocenica Terquem, 1882, Soc. Géol. France Mém., ser. 3, v. 2, p. 86, pl. 9 (17), fig. 4.

This species, described from the Eocene of the Paris Basin and reported from many Eocene localities in Europe and America as well as at Eniwetok, occurs rarely at Tonga. It is a tightly coiled form that has three chambers in the final whorl, and the aperture is merely a low slit beneath the edge of the chamber.

Globigerina gortanii (Borsetti)

Plate 7, figure 8

Catapsydrax gortanii Borsetti, 1959, Gior. Geologia, ser. 2, v. 27, 1956–57, p. 205, pl. 1, fig. 1.

Globigerina gortanii (Borsetti). Blow and Banner, 1962, *in* Eames, Banner, Blow, and Clarke, Fundamentals of mid-Tertiary stratigraphical correlation, Cambridge Univ. Press, p. 146 (postscript).

Todd, 1966, U.S. Geol. Survey Prof. Paper 403–I, p. 33, pl. 2, fig. 3; pl. 10, figs. 6–8.

Globigerina turritilina Blow and Banner, 1962, *in* Eames, Banner, Blow, and Clarke, Fundamentals of mid-Tertiary stratigraphical correlation, Cambridge Univ. Press, p. 98, pl. 13, figs. D–G.

Described from the Oligocene of Italy, this species has been reported from the uppermost Eocene and Oligocene of East Africa and Guam. Typical specimens are rare in the Tonga material. They are among the largest of the Tonga planktonic species. The species is a high-spired form that has a low and inconspicuous umbilical aperture and a cancellate wall. Four distinctly separated chambers form the final whorl.

Globigerina hexagona Natland

Plate 7, figure 6

Globigerina (*Globorotaloides*) *hexagona* Natland. Todd, 1964, U.S. Geol. Survey Prof. Paper 260–CC, p. 1080, pl. 292, fig. 3.

The reference above gives my reasons for combining a series of described species as a single species having a range from middle Eocene to Holocene, and having an evolutionary development from few chambers (four) to more chambers (six) and from a thicker and more compact test to a flatter and more attenuated one. The most characteristic feature of this species is its coarsely cancellate wall.

The specimens from Tonga have four chambers per final whorl (rarely five in juvenile specimens) and are thick and compactly coiled.

Globigerina officinalis Subbotina

Plate 7, figure 1

Globigerina officinalis Subbotina. Blow and Banner, 1962 *in* Eames, Banner, Blow, and Clarke, Fundamentals of mid-Tertiary stratigraphical correlation, Cambridge Univ. Press, p. 88, pl. 9, figs. A–C; text figs. 16 (i–v).

This minute (0.19–0.23 mm) species was described from the upper Eocene and lower Oligocene of the Caucasus and also recorded from East Africa. Under other names (see synonymy given in above reference), it has been recorded from France, Germany, and Trinidad. Typical specimens, characterized by a low-spired four-chambered whorl and a low aperture, are present in the Tonga material.

Globigerina aff. G. pseudoampliapertura Blow and Banner

Plate 8, figure 1

Specimens transitional between *Globorotalia centralis* and *Globigerina ampliapertura*, described and illustrated from the uppermost Eocene of Trinidad (Bolli, 1957b, p. 164, pl. 36, figs. 9, 10), were interpreted as possibly representing a gerontic stage of the *Globorotalia centralis-G. cocoaensis* strain, in the process of reverting to a globigerinid form before it became extinct.

These transitional specimens were subsequently included in the synonymy of *Globigerina pseudoampliapertura* (Blow and Banner, 1962, p.77, 95, pl. 12, figs. A–C; pl. 17, figs. A, E; text fig. 12c) and that species said to be typical of and abundant in the *Cribrohantkenina danvillensis* and *Globigerina gortanii* Zones of the upper Eocene of East Africa (Blow and Banner, 1962, p. 68).

Specimens that appear very similar, although not identical, to *G. pseudoampliapertura* are fairly common in the Tonga material. They differ from typical specimens in that the aperture is not umbilical but rather extends from the umbilicus to the periphery. They differ from *Globorotalia centralis* in that the chambers are somewhat inflated individually so that the dorsal surface is bulging rather than flat, and the periphery is lobulated rather than entire.

Globigerina yeguaensis Weinzierl and Applin

Plate 7, figure 7

Globigerina yeguaensis Weinzierl and Applin, 1929, Jour. Paleontology, v. 3, p. 408, pl. 43, fig. 1.
Bolli, 1957, U.S. Natl. Mus. Bull. 215, p. 163, pl. 35, figs. 14, 15.

This late Eocene and Oligocene species is widely known. It occurs rarely in typical form in the Tonga material. *G. yeguaensis* is characterized by loose coiling and the flange that protects the apertural opening in the deep umbilicus. About 3½ chambers form the final whorl, and the periphery is deeply indented. The wall is cancellate.

Globigerina kondoi Todd, n. sp.

Plate 7, figure 2

Test small for the genus, compactly coiled, not compressed; periphery indented; chambers few, early ones indistinct, 3½ to 4 making up the adult whorl, moderately inflated; sutures indistinct on the dorsal side, straight and incised on the ventral side; wall finely cancellate; aperture large, high-arched, extending from the umbilicus toward the periphery, protected by a narrow rim. Length 0.30–0.40 mm; breadth 0.25–0.32 mm; thickness 0.20–0.30 mm.

Holotype, USNM 687550, from upper Eocene beds about a quarter of a mile north of Vaingana, Eua, Tonga at altitude 400 feet. USGS Foraminifera locality f26192.

The high-arched aperture, at least as high as wide, is the distinguishing characteristic of this species. It is a smaller species than *Globigerina ampliapertura*, and its large aperture is high and narrow as compared with the broad aperture of that species. *Globigerina druryi* Akers (1955, p. 654, pl. 65, fig. 1) is somewhat similar but is a more tightly coiled form and the aperture is much lower. A species called "*Globorotalia*" *acrostoma* Wezel (1966, p. 1298, pl. 101, figs. 1–12; text fig. 1) from the upper Oligocene and lower Miocene of southern Italy resembles this new species in the size and shape of its aperture, but "*G.*" *acrostoma* differs in the peripheral position of the aperture, the compression of the whole test, and the greater number of chambers per whorl. This species is named in honor of Yoshio Kondo, the collector of the material, of the Bernice P. Bishop Museum in Honolulu.

Family GLOBOROTALIIDAE
Genus GLOBOROTALIA Cushman, 1927

Globorotalia cerroazulensis (Cole)

Plate 8, figure 3

Globigerina cerro-azulensis Cole, 1928, Bulls. Am. Paleontology, v. 14, no. 53, p. 217, pl. 1, figs. 11–13.
Globorotalia cerro-azulensis (Cole). Todd, 1957, U.S. Geol. Survey Prof. Paper 280–H, p. 268 (table 1), pl. 71, fig. 4.
Globorotalia (*Turborotalia*) *cerro-azulensis* (Cole). Blow and Banner, 1962, *in* Eames, Banner, Blow, and Clarke, Fundamentals of mid-Tertiary stratigraphical correlation, Cambridge Univ. Press, p. 118, pl. 12, figs. D–F; pl. 16, fig. M; text figs. 12 d, e.

Only four specimens were found in the Tonga material. They are typical of this species described from the Eocene of Mexico and widely reported around the world in the equatorial belt.

The dorsal surface is flat, and the peripheral outline is only slightly indented. Four compactly coiled chambers make up the final whorl, and each chamber is distinctly thicker than the previous one, so that the test is tapering in thickness.

Globorotalia aff. G. cocoaensis Cushman

Plate 8, figure 4

A single specimen seems similar to *G. cocoaensis* Cushman (1928, p. 75, pl. 10, fig. 3) described from the Eocene of Alabama. The Tonga specimen differs from *G. cerroazulensis* in being flatter throughout. It is more compressed than the holotype of *G. cocoaensis* but seems related to it.

Globorotalia sp. A

Plate 8, figure 2

Only two minute specimens (0.18 mm in diameter), one dextral and one sinistral, were found in the Tonga material.

The test is composed of nine chambers, 4½ making up the final whorl. The chambers are moderately inflated, and the periphery is rounded and slightly indented. The wall is finely spinose. The aperture is obscured.

Globorotalia sp. B

Plate 8, figure 5

A few specimens represent another species of *Globorotalia* that seems to be undescribed. The dorsal surface is slightly bulging, the ventral surface is conical and has an open umbilicus, and the apertural face has a high sloping surface. The periphery is entire, angled, and limbate. The chambers rapidly increase in size as added, and five or six make up the final whorl. The aperture is low, under the edge of the final chamber. The wall appears to be smooth and unornamented, except for the limbate dorsal sutures and peripheral border.

Family HANTKENINIDAE
Genus HANTKENINA Cushman, 1924
Subgenus CRIBROHANTKENINA Thalmann, 1942

Hantkenina (Cribrohantkenina) bermudezi Thalmann

Plate 8, figure 6

Hantkenina (*Cribrohantkenina*) *bermudezi* Thalmann, 1942, Am. Jour. Sci., v. 240, p. 814, pl. 1, figs. 5, 6.
Bronnimann, 1950, Jour. Paleontology, v. 24, p. 417, pl. 56, figs. 6-9, 24, 25.
Hantkenina bermudezi Thalmann. Todd, 1957, U.S. Geol. Survey Prof. Paper 280-H, p. 304, pl. 70, fig. 13.
Hantkenina brevispina Cushman of Bermudez [not Cushman], 1937, Soc. Cubana Hist. Nat. Mem., v. 11, no. 3, p. 151, pl. 19, figs. 7-10.
Cribrohantkenina danvillensis (Howe and Wallace). Blow and Banner, 1962, *in* Eames, Banner, Blow, and Clarke, Fundamentals of mid-Tertiary stratigraphical correlation, Cambridge Univ. Press, p. 128, pl. 16, figs. G, H; text figs. 19(i-vii).
Hantkenina inflata Howe. Todd, 1966, U.S. Geol. Survey Prof. Paper 403-I, p. 34, pl. 1, fig. 2, pl. 8, fig. 6.

This late Eocene species has a worldwide distribution, having been reported from the Gulf of Mexico coast, Cuba, Trinidad, Saipan, Guam, Italy, Armenia, and East Africa.

Only two specimens were found in the Tonga material. Each subsequent chamber is larger and broader than the previous one, and one specimen shows the cribrate aperture typical of the subgenus *Cribrohantkenina*.

The name of this species is open to question. Eventually, the four inflated species—*H. inflata*, *H. mccordi*, *H. danvillensis*, and *H. bermudezi*—may probably prove to be conspecific, in which case the earliest name should be used.

A zone erected in the middle part of the upper Eocene in East Africa takes its name from this species (Blow and Banner, 1962, p. 68). In Trinidad this species is characteristic of the *Globorotalia cocoaensis* Zone (Bolli, 1957b, p. 160), which is regarded as equivalent to the lower half of the above-mentioned *Cribrohantkenina danvillensis* Zone of East Africa (Blow and Banner, 1962, text fig. 8).

The *Cribrohantkenina* "*danvillensis*" Zone has also been recognized in Alabama (Deboo, 1965, p. 11, 12, text fig. 3), where it is considered a subzone in the Shubuta Member of the Yazoo Clay and placed in the uppermost Eocene. In Alabama, this zone includes four other species that are typical of or comparable with species in the Tonga material. They are *Globigerina gortanii*, *G. pseudoampliapertura*, *Globorotalia cerroazulensis*, and *Globorotalia cocoaensis*. *Globigerina ampliapertura* is present in the overlying Red Bluff Clay in Alabama, but this species does not occur with *Cribrohantkenina* in Alabama, as it does at Tonga. This relation suggests that the Tonga material is younger than the Alabama material from the Shubuta Member of the Yazoo Clay.

Genus PSEUDOHASTIGERINA Banner and Blow, 1959

Pseudohastigerina barbadoensis Blow

Plate 7, figure 3

Pseudohastigerina barbadoensis Blow, 1969, Geneva Planktonic Conf., 1st, Geneva, 1967, Proc., p. 409, pl. 53, figs. 7-9; pl. 54, figs. 1-3.

Test minute for the genus, compressed, planispiral, close-coiled; periphery rounded, slightly lobulate around the last several chambers; chambers indistinct in the initial part, about seven in the final whorl, slightly inflated, gradually increasing in size and inflation as added; sutures indistinct, straight or slightly curved; wall smooth; aperture under a slightly projecting lip of the final chamber. Diameter 0.18 mm; thickness 0.07 mm.

This minute and strongly compressed species was described from the lower Oligocene (zone P. 19) in Trinidad and has been reported to be restricted to beds of late Eocene and early Oligocene age (zones P. 16 to P. 19) (Blow, 1969, p. 410). It is much smaller and more strongly compressed than the other described species of this genus (Berggren and others, 1967). In addition its chambers are less inflated, and the periphery consequently less lobulated.

Family HETEROHELICIDAE
Genus CHILOGUEMBELINA Loeblich and Tappan, 1956

Chiloguembelina cubensis (Palmer)

Plate 7, figure 5

Gümbelina cubensis Palmer, 1934, Soc. Cubana Hist. Nat. Mem., v. 8, no. 2, p. 74, text figs. 1-6.
Chiloguembelina cubensis (Palmer). Beckmann, 1957, U.S. Natl. Mus. Bull. 215, p. 89, pl. 21, fig. 21; text figs. 14 (5-8).
Todd, 1966, U.S. Geol. Survey Prof. Paper 403-I, p. 33, pl. 8, figs. 1, 4.

This late Eocene and early Oligocene species is represented by very rare specimens at Tonga. It was described from Cuba and has been recorded from Trinidad, Venezuela, the Dominican Republic, the southeastern United States, and Guam.

CALCAREOUS NANNOPLANKTON

By M. N. Bramlette

A total of 21 specimens of calcareous nannoplankton were identified from the tuffaceous limestone of station 24686 on Eua, Tonga:

Apertapetra umbilica (Levin)
Braarudosphaera bigelowi (Gran and Braarud)
    discula Bramlette and Riedel
Bramletteius serraculoides Gartner
Coccolithus bisectus (Hay, Mohler, and Wade)
    eopelagicus (Bramlette and Riedel)
    scissurus (Hay, Mohler, and Wade)
Cyclococcolithus lusitanicus (Black)
    neogrammation Bramlette and Wilcoxon
Discoaster tani Bramlette and Riedel
    deflandrei Bramlette and Riedel
Helicosphaera compacta Bramlette and Wilcoxon
    intermedia Martini
    aff. *H. reticulata* Bramlette and Wilcoxon
Micrantholithus sp.
Peretrachelina joidesa Bukry and Bramlette
Sphenolithus moriformis (Stradner)
    predistentus Bramlette and Wilcoxon
    pseudoradians Bramlette and Wilcoxon
Thoracosphaera sp.
Zygrhablithus bijugatus Deflandre

All but one of the specimens listed are known from upper Eocene and lowermost Oligocene strata in the southeastern United States and elsewhere. An age of earliest Oligocene is also suggested by the complete absence of such common Eocene discoasters as *Discoaster barbadiensis* Tan Sin Hok, emend. Bramlette and Riedel, and *D. saipanensis* Bramlette and Riedel, as well as *Isthmolithus recurvus* Deflandre and *Cyclococcolithus reticulatus* Gartner and Smith. However, a single specimen of a distinctive (undescribed) *Thoracosphaera* is present. This is a species that is common elsewhere in the middle Eocene and previously unknown in younger strata.

CRINOIDS AND ECHINOIDS

By Porter M. Kier

The echinoderms are represented by crinoid and echinoid fragments and one very small test of a regular noncidarid echinoid too small for more detailed identification. The spines are from cidarid, spatangoid, and possibly cassiduloid echinoids, and one fragment is from an echinometrid echinoid, perhaps *Heterocentrotus*. The cidarid spines are slender indicating that they probably came from echinoids living in water deeper than 100 meters. *Heterocentrotus* is presently confined to shallow water where its heavy distinctive spines serve as protection from heavy waves. However, this fragment is abraded suggesting that it has been transported.

The crinoid fragments consist of a few isolated calyx plates and stem columnals. Most of the stem columnals are from pentacrinoids which in present seas occur in water deeper than 80 meters.

The echinoderm fragments indicate that the echinoderms lived in water deeper than 80 meters.

DECAPOD CRUSTACEANS

By Henry B. Roberts

Fifty-seven fragments of fingers and palms of fossil decapod crustaceans, the first recorded from the Tonga Islands, are included among the fossil invertebrates collected from the tuffaceous limestone of Eocene (Tertiary *b*) age on the island of Eua. These fragments, which range from 2 to 8 mm in length, and from which the original surface ornamentation as well as all sharp edges have been effaced, are enumerated below:

	Number of specimens
Infraorder Brachyura:	
Family Xanthidae	46
Family undetermined	6
Infraorder Anomura:	
Family Porcellanidae	1
Family Callianassidae	1
Family Paguridae	1

In the absence of generic and specific identifications, which cannot be made, at least not by the writer, these Eua decapods are of small value in determining the conditions under which the sediments containing them were deposited. It may be suggested, however, that the present specimens were deposited initially in either the littoral or the sublittoral zone, or in both of these zones, because their Holocene counterparts—namely, the Xanthidae, the Porcellanidae, the Callianassidae, and certain of the Paguridae—are typical of sublittoral and littoral marine environments.

SHARK TEETH

By David H. Dunkle

The sample of Eocene tuffaceous limestone from station 24686 on Eua, Tonga, contained seven incomplete shark teeth that are tentatively assigned to three families: Lamnidae, Carchariidae, and Carcharhinidae. The lamnid is the porbeagle shark (*Lamna*) represented by one tooth having part of a principle cusp with lateral accessory denticle. The carchariid is the sand shark, represented by a single acutely conical cusp. Five crowns of teeth appear to represent one of the requiem sharks of the Carcharhinidae; both upper teeth with serrated borders and lower teeth with smooth borders are present.

The occurrences are not stratigraphically significant. The lamnids and carchariids are known from Early Cretaceous and younger strata. The carcharhinids appeared in the Eocene and are today the largest and most numerous family of sharks. The association, however, is an interesting one. *Lamna* normally is an inhabitant of Boreal and Temperate continental waters. The sand shark is a coastwise form in tropical and warm Temperate waters and the requiem sharks are found almost everywhere in tropical and warm Temperate zones. All the fossil teeth from Eua are small and resistant to erosion. There is no way of telling how far they may have been transported prior to burial in the tuffaceous limy sediment.

PLANT MICROFOSSILS

By Estella B. Leopold

A sample of the Eocene tuffaceous limestone from station 24686 on Eua, Tonga (USGS Paleobotany locality D4297), was divided into four fractions. Two were sized samples, 115–200 mesh and 25–115 mesh, which had been macerated in a wetting agent and penetrant, and two were whole-rock samples, one of which was macerated in a wetting agent and penetrant and the other was macerated in 10 percent HCl. All fractions were decalcified with HCl; the two whole-rock fractions were partly desilicified with HF, and the organic remains were floated off with heavy liquid.

All sample fractions contain abundant smooth-walled cysts 20–40 microns in diameter, some of which have double walls, and all of which are probably resting cysts of marine algae. Occasional oval and rounded triangular cells, about 60 microns in diameter, with smooth walls, appear to be unilocular sporangia, for they each contain a large number of simple smaller cells, which are probably swarmer or reproductive cells. Simple reproductive structures of this pattern are seen in many filamentous algae.

A very few simple trilete spores which are attributable to lower vascular plants (land plants) were seen, but no pollen of higher plants could be found.

Pollen and spores from land-based plants are typically concentrated in shelf sediments within a few miles of shore, and are known to be a rare but consistent minor element in samples even from abyssal depths. Considering the probable distance from Eocene land plants and the water depth (more than 80 meters) at the site as inferred from other fossil evidence, an abundance of pollen and spores in these sediments would not be expected.

REFERENCES CITED

Akers, W. H., 1955, Some planktonic Foraminifera of the American Gulf Coast and suggested correlations with the Caribbean Tertiary: Jour. Paleontology, v. 29, p. 647–664, pl. 65, figs. 1–3.

Asano, Kiyoshi, 1939, Limestones of the South Sea Islands under the Japanese Mandate (Jubilee publication in commemoration of Prof. Hisakatsu Yabe's 60th birthday): v. 1, p. 537–550.

Berggren, W. A., Olsson, R. K., and Reyment, R. A, 1967, Origin and development of the foraminiferal genus *Pseudohastigerina* Banner and Blow, 1959: Micropaleontology, v. 13, p. 265–288, pl. 1, figs. 1–12.

Bermúdez, P. J., 1937, Nuevas especies de Foraminíferos del Eoceno de las cercanías de Guanajay, Provincia Pinar del Río, Cuba: Soc. Cubana Hist. Nat. Mem., v. 11, no. 4, p. 237–247, pls. 20, 21.

Blow, W. H., 1969, Late middle Eocene to Recent planktonic foraminiferal biostratigraphy: Geneva Planktonic Conf., 1st, Geneva, 1967, Proc. [Leiden, E. J. Brill and Co.], p. 199–422, pls. 1–54.

Blow, W. H., and Banner, F. T., 1962, The mid-Tertiary (upper Eocene to Aquitanian) Globigerinaceae, *in* Eames, F. E., Banner, F. T., Blow, W. H., and Clarke, W. J., Fundamentals of mid-Tertiary stratigraphical correlation: New York, Cambridge Univ. Press, p. 61–163, pls. 7–17, figs. 6–20.

Bolli, H. M., 1957a, The genera *Globigerina* and *Globorotalia* in the Paleocene-lower Eocene Lizard Springs formation of Trinidad, B. W. I.: U. S. Natl. Mus. Bull. 215, p. 61–81, pls. 15–20, figs. 11–13.

——— 1957b, Planktonic Foraminifera from the Eocene Navet and San Fernando formations of Trinidad, B. W. I.: U.S. Natl. Mus. Bull. 215, p. 155–172, pls. 35–39, figs. 25, 26.

Bolli, H. M., Loeblich, A. R., Jr., and Tappan, Helen, 1957, Planktonic foraminiferal families Hantkeninidae, Orbulinidae, Globorotaliidae, and Globotruncanidae: U.S. Natl. Mus. Bull. 215, p. 3–50, pls. 1–11, figs. 1–9.

Cole, W. S., 1950, Larger Foraminifera from the Palau Islands: U.S. Geol. Survey Prof. Paper 221–B, p. 21–31.

——— 1957a, Larger Foraminifera [of Saipan, Mariana Islands]: U.S. Geol. Survey Prof. Paper 280–I, p. 321–360.

——— 1957b, Larger Foraminifera from Eniwetok Atoll drill holes: U.S. Geol. Survey Prof. Paper 260–V, p. 743–784 [1958].

——— 1960, Upper Eocene and Oligocene larger Foraminifera from Viti Levu, Fiji: U.S. Geol. Survey Prof. Paper 374–A, p. A1–A7 [1961].

Colom, Guillermo, 1945, Estudio preliminar de las microfaunas de Foraminíferos de las margas eocenas y oligocenas de Navarra: Inst. Inv. Geol. "Lucas Mallada," Estudios Geol., no.2, p. 35–84, pls. 1–7.

Costa, O.G., 1856, Paleontologia del Regno di Napoli. Part 2: Accad. Pontaniana Atti, v. 7, pt. 2, p. 1–378, pls. 1–28.

Cushman, J. A., 1921, Foraminifera of the Philippine and adjacent seas: U.S. Natl. Mus. Bull. 100, v. 4, 608 p., 100 pls., 52 figs.

——— 1922, The Foraminifera of the Byram calcareous marl at Byram, Mississippi: U.S. Geol. Survey Prof. Paper 129–E, p. 87–122, pls. 14–28.

——— 1927, An outline of a re-classification of the Foraminifera: Cushman Lab. Foram Research Contr., v. 3, p. 1–105, pls. 1–21.

——— 1937, A monograph of the foraminiferal family Verneuilinidae: Cushman Lab. Foram. Research Spec. Pub. 7, 157 p., 20 pls.

Cushman, J. A., and Parker, F. L., 1936, Some American Eocene Buliminas: Cushman Lab. Foram. Research Contr., v. 12, p. 39–45, pls. 7, 8.

Cushman, J. A., and Renz, H. H., 1941, New Oligocene-Miocene Foraminifera from Venezuela: Cushman Lab. Foram. Research Contr., v. 17, p. 1–27, pls. 1–4.

Cushman, J. A., Todd, Ruth, and Post, R. J., 1954, Recent Foraminifera of the Marshall Islands: U.S. Geol. Survey Prof. Paper 260–H, p. 319–384, pls. 82–93, figs. 116–118.

Deboo, P. B., 1965, Biostratigraphic correlation of the type Shubuta Member of the Yazoo Clay and Red Bluff Clay with their equivalents in southwestern Alabama: Alabama Geol. Survey Bull. 80, 84 p., 28 pls.

Gaona, M. R. de, and Colom, Guillermo, 1950, Estudios sobre las Sinecias de los Foraminiferos Eocenicos de la Vertiente. Meridional del Pirineo (Cataluña-Vizcaya): Inst. Inv. Geol. "Lucas Mallada," Estudios Geol. no. 12, p. 293–434, pls. 53, 54, text figs. 1–19.

Guest, N. J., 1959, in Fiji Geological Survey Dept. Ann. Rept. for 1958, Council Paper 17, p. 3.

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

Parker, F. L., 1962, Planktonic foraminiferal species in Pacific sediments: Micropaleontology, v. 8, p. 219–254, pls. 1–10.

Rau, W. W., 1948, Foraminifera from the Porter shale (Lincoln formation), Grays Harbor County, Washington: Jour. Paleontology, v. 22, p. 152–174, pls. 27–31.

Schwager, Conrad, 1866, Fossile Foraminiferen von Kar Nikobar: *Novara*-Exped., Geol. Theil, v. 2, p. 187–268, pls. 4–7.

Todd, Ruth, 1966, Smaller Foraminifera from Guam: U.S. Geol. Survey Prof. Paper 403–I, 41 p., 19 pls. 2 figs., 4 tables.

Wezel, F. C., 1966, "*Globorotalia*" *acrostoma*, nuova specie dell 'Oligomiocene italiano: Riv. Italiana Paleontologia e Stratigrafia, v. 72, no. 4, p. 1297–1312, pl. 101.

Whipple, G. L., 1932, Eocene Foraminifera, *in* Hoffmeister, J. E., Geology of Eua, Tonga: Bernice P. Bishop Mus. Bull. 96, p. 79–86, pls. 20–22, text-fig. 6, tables 5, 6.

Witt Puyt, J. F. C. de, 1941, Geologische und Paläontologische Beschreibung der Umgebung von Ljubuški, Hercegovina: Utrecht, N. V. Drukkerij V/H L. E. Bosch Zoon, 99 p., 5 pls.

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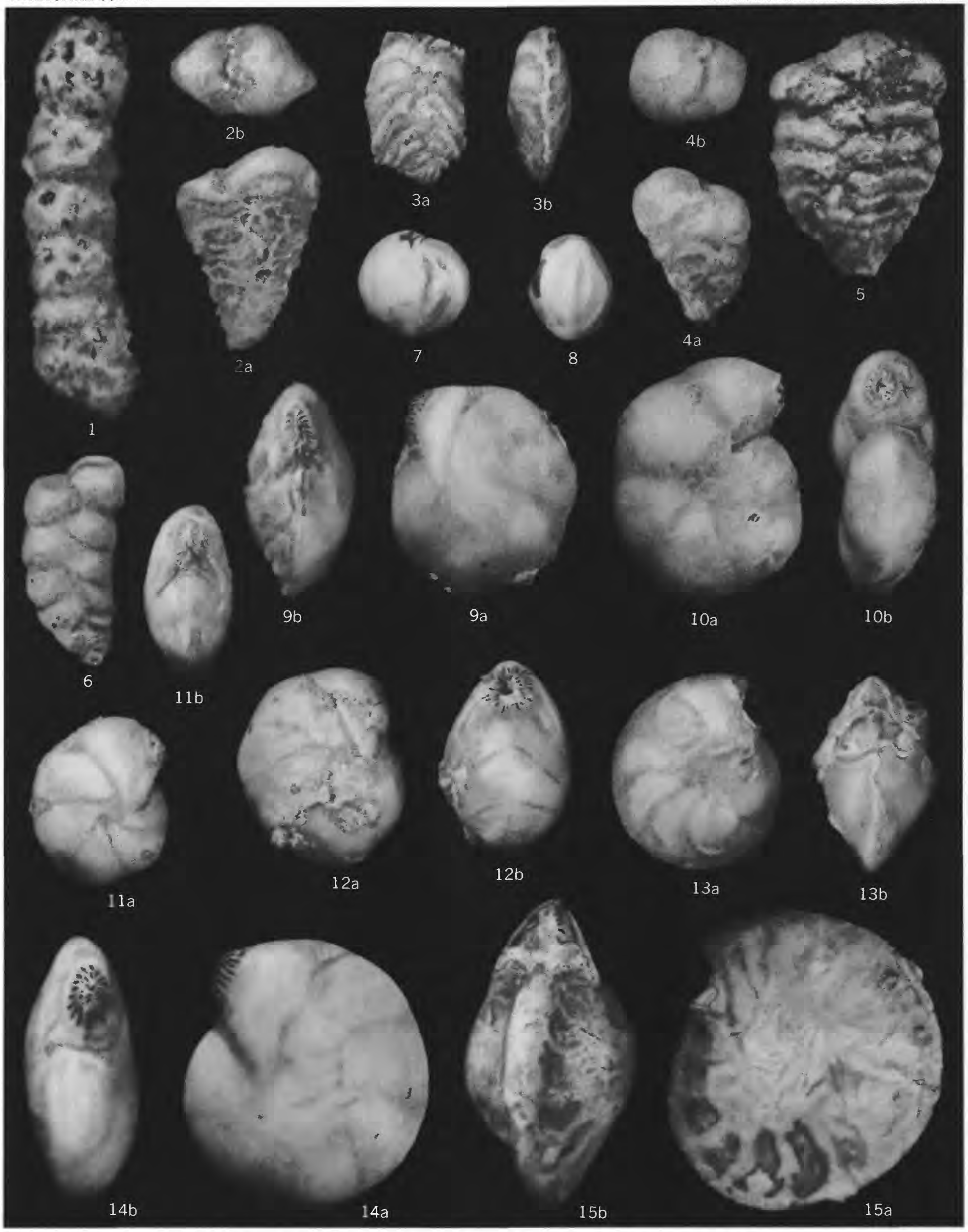

EOCENE BENTHONIC FORAMINIFERA FROM EUA, TONGA

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EOCENE BENTHONIC FORAMINIFERA FROM EUA, TONGA

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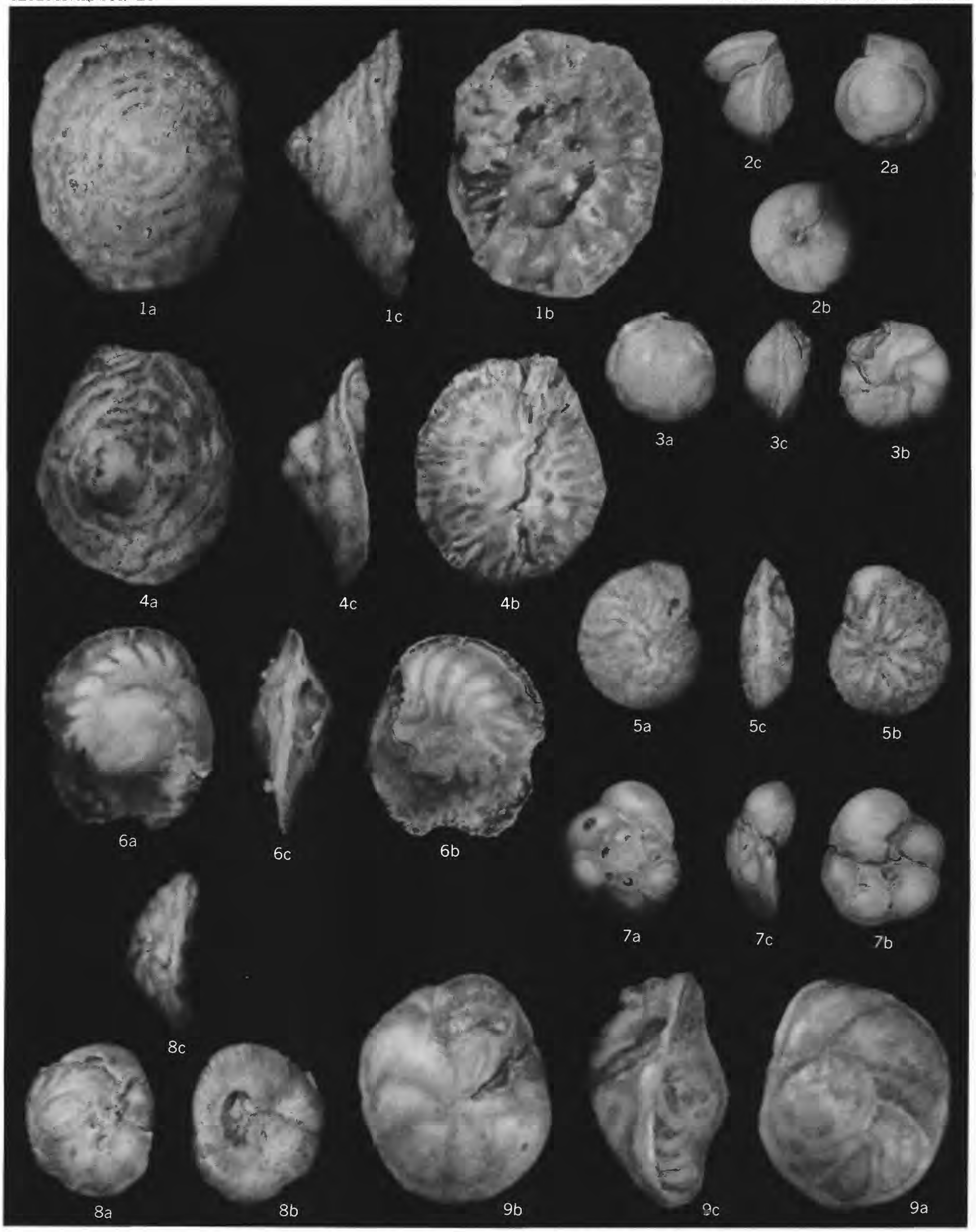

EOCENE BENTHONIC FORAMINIFERA FROM EUA, TONGA

PLATE 4

[*a*, Dorsal view; *b*, ventral; view *c*, peripheral view, except as indicated]

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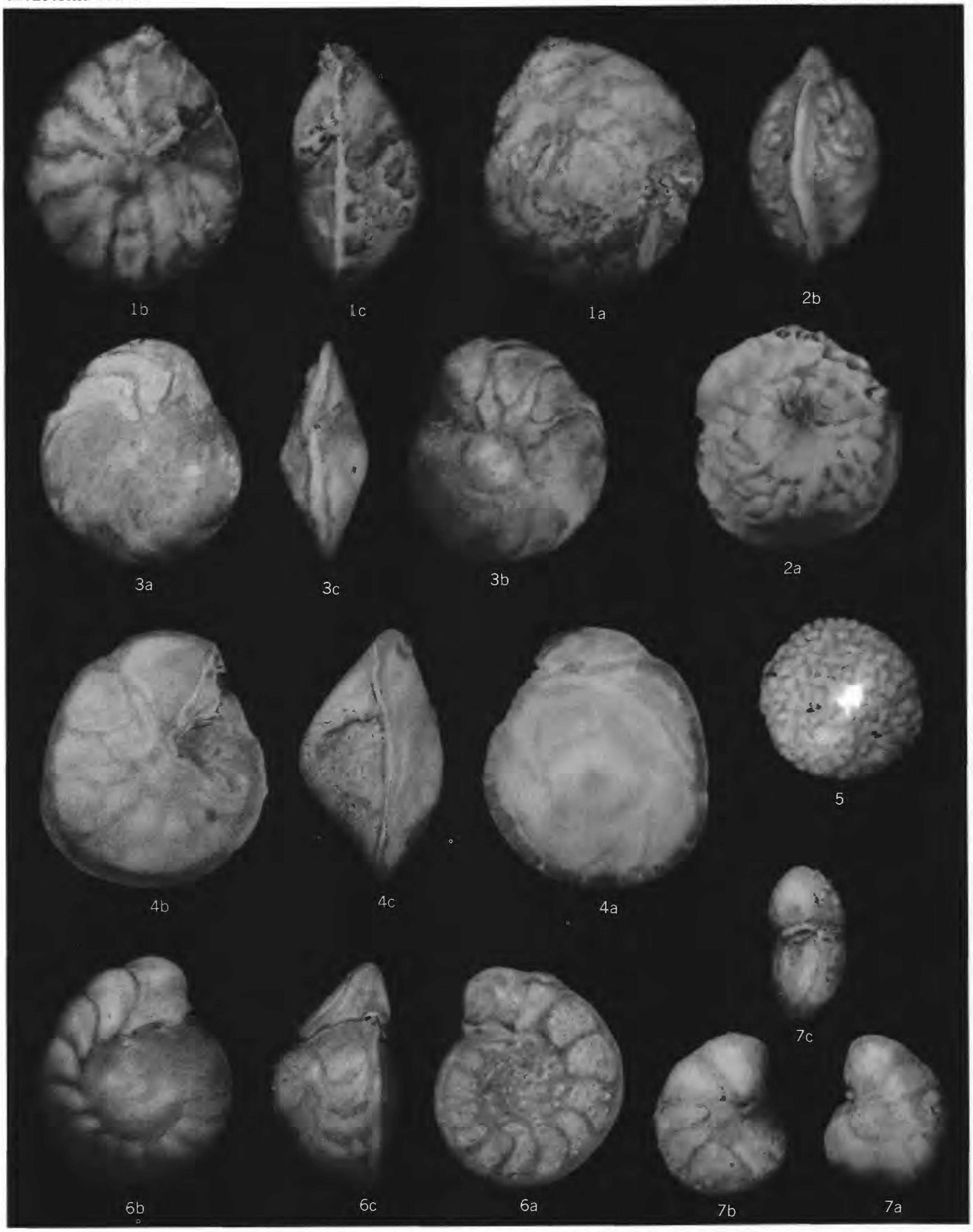

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PLATE 5

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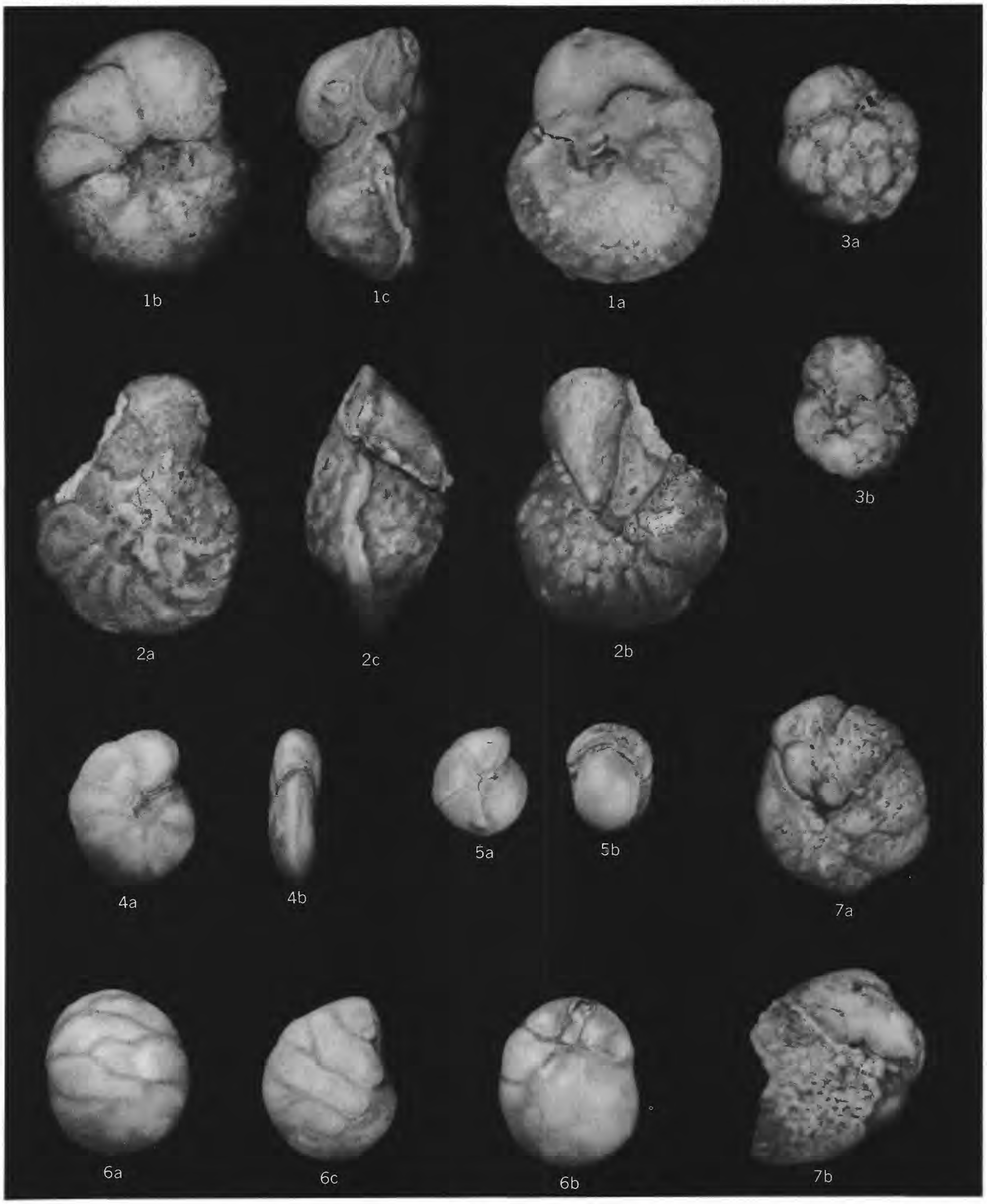

EOCENE BENTHONIC FORAMINIFERA FROM EUA, TONGA

PLATE 6

[*a*, Dorsal view; *b*, ventral view; *c*, peripheral view]

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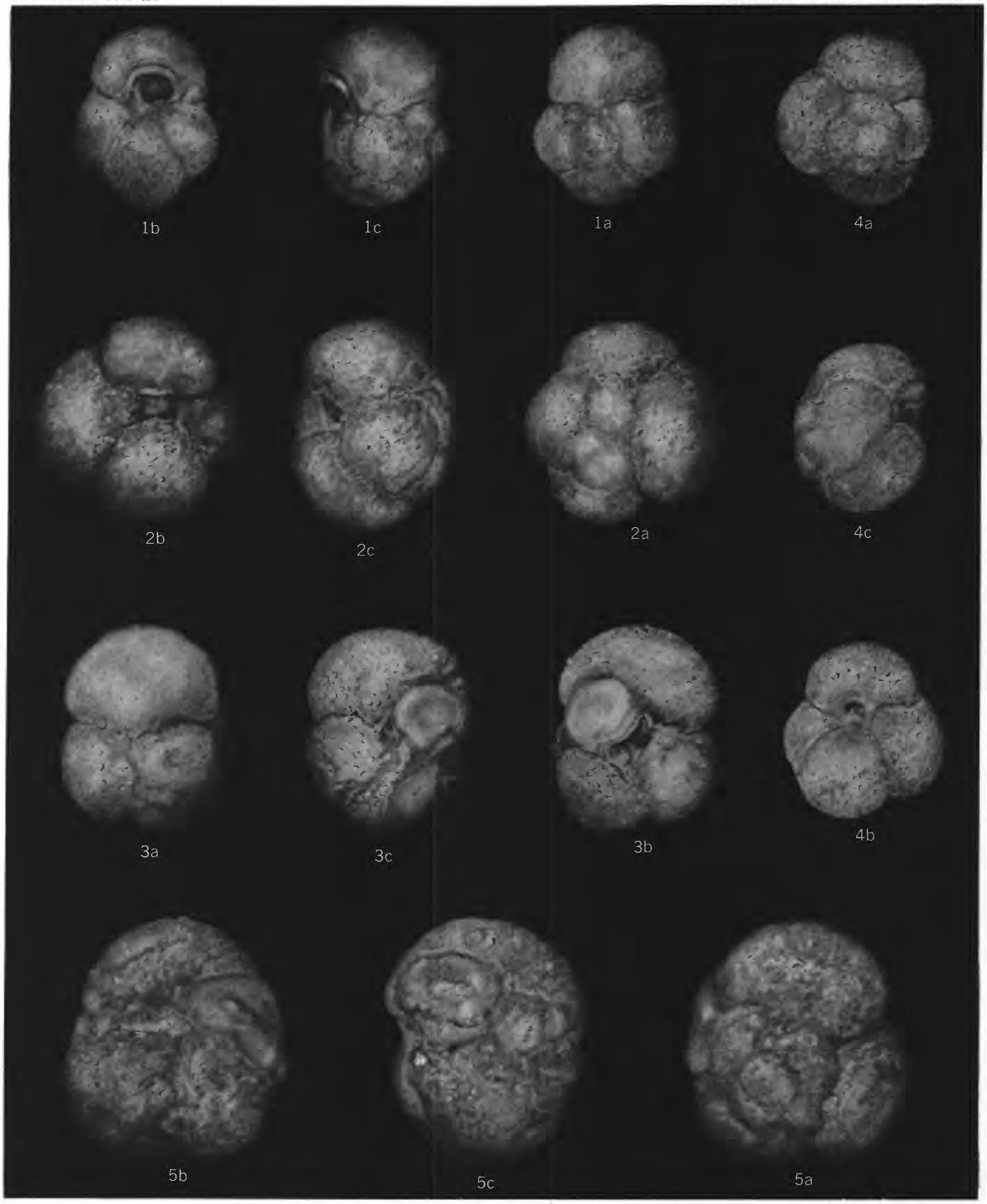
2. USNM 687543, × 90.
3. USNM 687542, × 90.
4. USNM 687544, × 90.
5. USNM 687541, × 70.



EOCENE PLANKTONIC FORAMINIFERA FROM EUA, TONGA

PLATE 7

[*a*, Dorsal view; *b*, ventral view; *c*, peripheral view, except as indicated]

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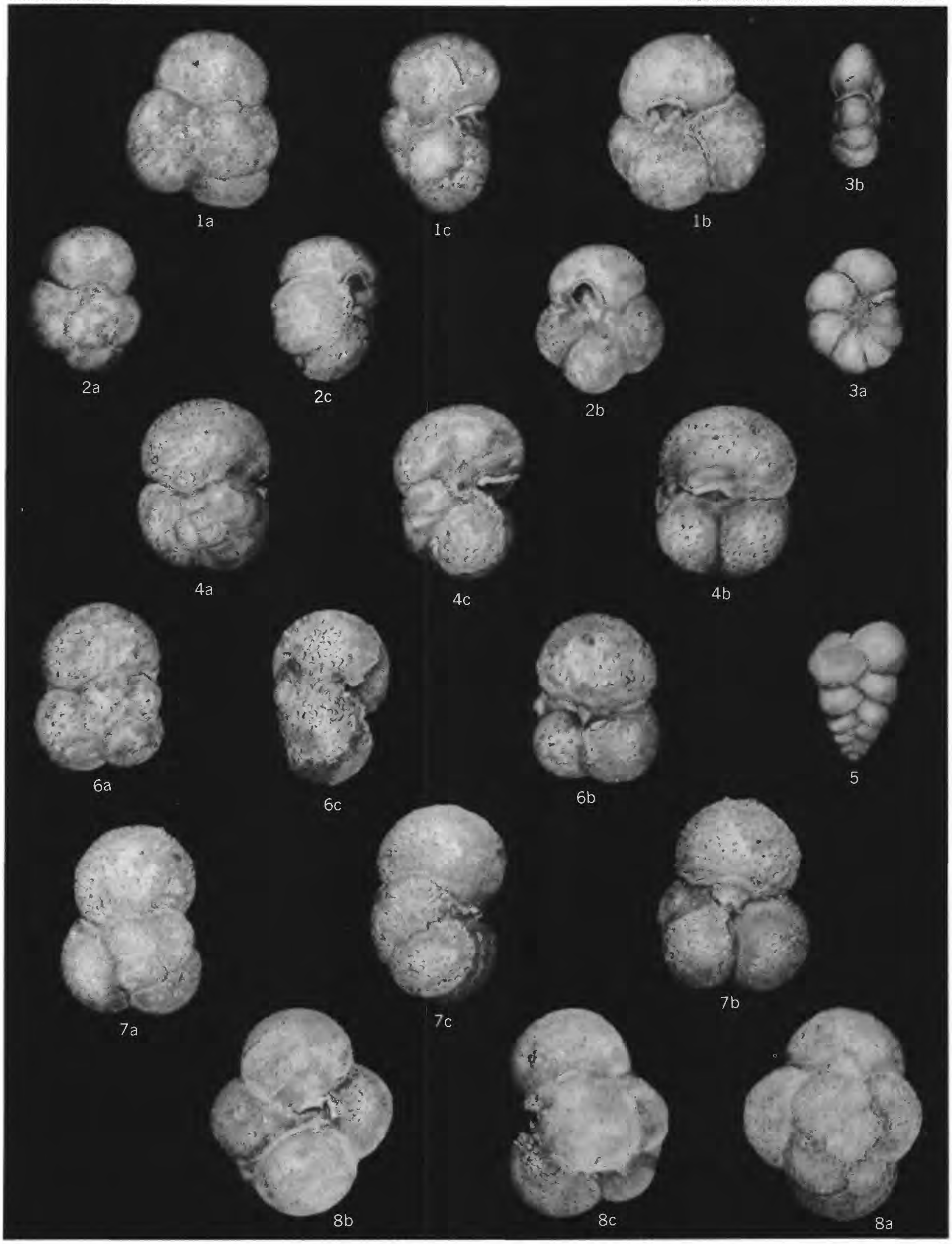

EOCENE PLANKTONIC FORAMINIFERA FROM EUA, TONGA

PLATE 8

[*a*, Dorsal view; *b*, ventral view; *c*, peripheral view, except as indicated]

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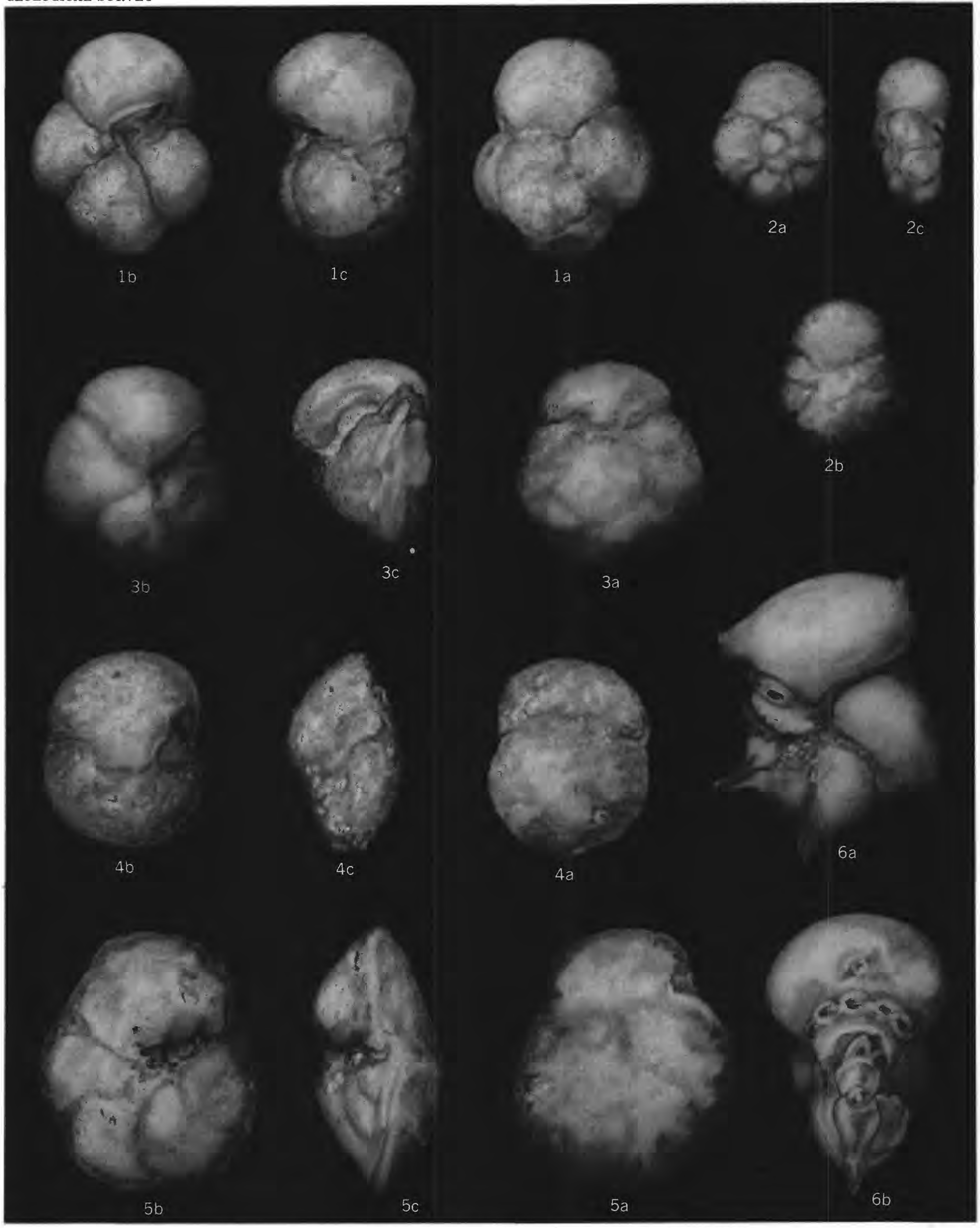

EOCENE PLANKTONIC FORAMINIFERA FROM EUA, TONGA