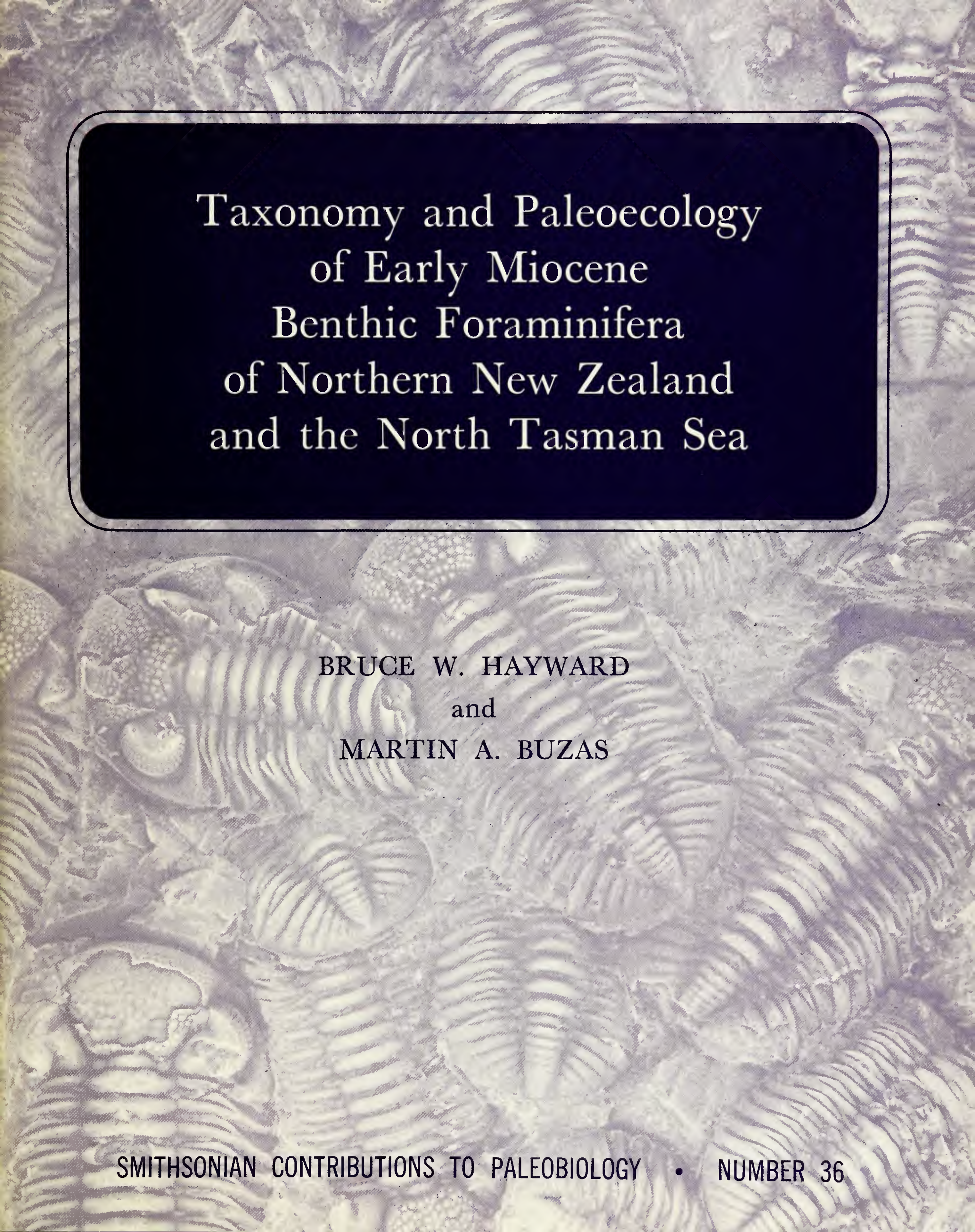

Taxonomy and Paleoecology of Early Miocene Benthic Foraminifera of Northern New Zealand and the North Tasman Sea

BRUCE W. HAYWARD
and
MARTIN A. BUZAS

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Taxonomy and Paleoecology of Early Miocene Benthic Foraminifera of Northern New Zealand and the North Tasman Sea

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ABSTRACT

Hayward, Bruce W., and Martin A. Buzas. Taxonomy and Paleoecology of Early Miocene Benthic Foraminifera of Northern New Zealand and the North Tasman Sea. *Smithsonian Contributions to Paleobiology,* number 36, 154, pages 26 figures, 28 plates, 4 tables, 1979.—Data from 51 samples of early Miocene benthic foraminifera (200–300 individuals per sample) from west Northland, New Zealand (Waitakere and Waitemata Groups), together with those from four samples from the north Tasman sea (Deep Sea Drilling Project 206), are analysed by multidimensional scaling and cluster analysis. The samples are grouped in terms of species abundances into six thanatotopes, which are interpreted as follows: A, dominated by robust *Amphistegina madagascariensis,* 10%–37% planktonics, inner neritic; B, *Cibicides-Cibicidoides* dominant, 10%–55% planktonics, outer neritic; C, *Gyroidina, Euuvigerina, Astrononion, Lenticulina* most abundant, 32%–87% planktonics, upper bathyal; D, *Cassidulina-Bolivina-Cibicides* dominant, 16%–99.5% planktonics, upper and midbathyal; E, *Globocassidulina-Epistominella* dominant, 99.5% planktonics, lower bathyal; F, *Quinqueloculina* dominant, 11%–32% planktonics, inner and midneritic.

Using these thanatotope interpretations in conjunction with their stratigraphic and geographic distributons, a model of the early Mocene paleogeography of west Northland is deduced, refining traditional models for the area. A central midbathyal basin (Waitemata Basin), bounded in the southwest by a pile of volcanic sediments (Waitakere volcanic pile), built up to an island surrounded by neritic and upper bathyal slopes. In the northwest (Kaipara area) volcanics erupted through a neritic shelf. This shelf became shallower and partly terrestrial during latter parts of the early Miocene. Upper bathyal slopes existed around the southern edge of the northwestern shelf. Submarine canyons cut through these slopes channeling shelf sediment into the bathyal basin. Several ungrouped, greatly mixed samples (interbedded with basin sediments) contain individuals from neritic and bathyal thanatotopes and are interpreted as having been mixed during transportation down through the canyons into the basin in the form of subaqueous sediment gravity flows.

No change in depth from the present lower bathyal is inferred to have occurred in the vicinity of DSDP 206 (north Tasman Sea) since the early Miocene.

All 378 identified species are listed together with their synonomies; many are described and 194 species are figured. Besides a number of first records for New Zealand, three new species—*Elphidium gibsoni, Elphidium kanoum,* and *Eoeponidella scotti*—are described.

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Contents

Taxonomy and Paleoecology of Early Miocene Benthic Foraminifera of Northern New Zealand and the North Tasman Sea

Bruce W. Hayward
and Martin A. Buzas

Introduction

Benthic foraminifera are one of the most important marine groups for paleoecologic and paleogeographic studies. In New Zealand, Vella (1962a, b) was among the first to study benthic foraminiferal paleoecology using upper Miocene and Pliocene faunas. Since then, Scott (1970a, 1971a) has delineated thanatotopes of early Miocene foraminiferal faunas. The area of his (1970a) study overlaps with that of the present one, and some of his samples are utilized here.

The purpose of this study is to understand better the changing paleogeography of an early Miocene marine basin. Involved are taxonomic reappraisal of foraminiferal species; grouping of fossil assemblages based on faunal composition, paleoecological interpretation of each grouping; and finally, basin analysis by combining these conclusions with the results of lithostratigraphy and other studies.

Hopefully, this work will provide a basis for future interpretations of this and other early Miocene basins in New Zealand.

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Acknowledgments.—We would like to thank the following for their assistance in this study: Dr. R. Cifelli, Smithsonian Institution, Dr. G. W. Gibson, University of Auckland, and Dr. T. G. Gibson, United States Geological Survey, for their stimulating discussions around the various problems raised in the study; Ms. B. B. Tate, Smithsonian Institution, for assistance with the Cushman Room collections and in curating our specimens; Mr. L. Isham for his expert advice on the figures and illustrations; Dr. L. A. Hayek, Mr. S. Robinson and Mr. D. Piacesi, Smithsonian Institution, for their assistance with the computer programs; Ms. S. Braden, Ms. M. J. Mann and Mr. W. R. Brown, Smithsonian Institution, for the scanning electron photographs; Mr. G. F. Lund for many of the tone illustrations; and Ms. C. McCloy and Ms. C. A. Liebhauser, for assistance in drafting, data assembling, and proof reading.

We thank the Deep Sea Drilling Project (DSDP 206) for supplying Tasman Sea samples through the assistance of the National Science Foundation; and Dr. G. H. Scott, New Zealand Geological Survey, for supplying nine samples from the central Kaipara area for use in this study. Dr. R. K. Smith, University of California at Santa Cruz, and Dr.

N. de B. Hornibrook, New Zealand Geological Survey, read the manuscript and provided helpful suggestions for improving the text.

This project was completed at the Smithsonian Institution while Bruce Hayward held a post-doctoral fellowship there in 1976.

EARLY MIOCENE IN NEW ZEALAND.—By early Miocene times, New Zealand had reached its present-day position with respect to other nearby lands. It consisted then, as it does today, of an elongate slither of continental crust (sial) separated from Australia by the 1500 km wide Tasman Sea (Figure 1). The Tasman Sea is underlain by oceanic crust, formed in the Cretaceous when New Zealand split off from Australia (Hayes and Ringis, 1973). Sedimentation in the Tasman Sea was mainly of coccolith oozes, as it is today.

Geologic evidence indicates that the convergent boundary between the Indian and Pacific Plates passed through New Zealand in the early Miocene, very much as it does today (Ballance, 1976). The land areas, however, were vastly different from the present. One long, narrow island possibly stretched the length of the New Zealand continental crust (Fleming, 1975), with areas of shelf and basinal sedimentation on either side. These uplifted early Miocene marine sediments crop out today over large portions of both islands. One area of extensive outcrop occurs in the north of the North Island of New Zealand and it is on this "basin" that our study is focussed.

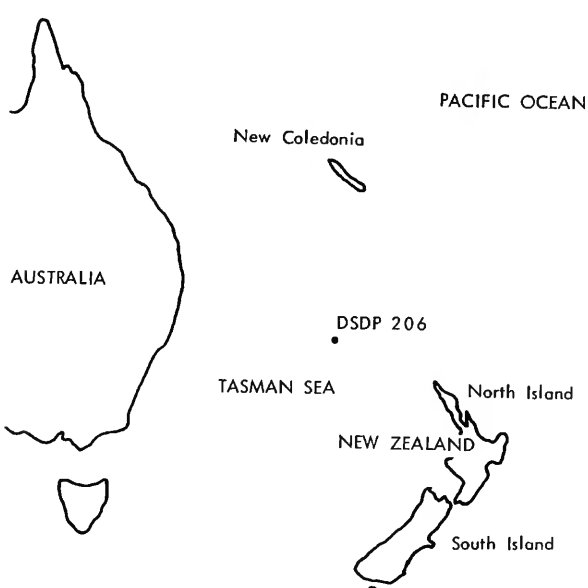

FIGURE 1.—Locality map of the southwest Pacific Ocean. (DSDP 206 = Deep Sea Drilling Program site 206, in the north Tasman Sea.)

NORTHERN NEW ZEALAND IN THE EARLY MIOCENE.—Recent paleogeographic interpretations (Carter, 1974; Hayward, 1975a; Ballance, 1976) of northern New Zealand in the early Miocene have relocated present-day Northland and East Cape regions side by side (Figure 2). Since then, dextral transform diplacement along the Alpine Fault (part of the Plate boundary), together with crustal bending of Northland (Ballance, 1976), has moved the two areas apart.

Present geological knowledge suggests that in the early Miocene a trench marked the plate boundary east of the East Cape block and was paralleled by a volcanic arc (Waitakere Arc) along the west side of Northland (Figure 2). The two were separated by a 350–450 km wide arc-trench gap that can be divided into several physiographic parts (Figure 2):

Eastern Shelf and Slope: Marine sediments accumulated on a wide eastern shelf and slope (neritic–bathyal) that covered most of the easterly-titled East Cape half of the northern New Zealand sialic block and passed eastwards into the trench.

Central Basement High: The central part of the sialic block was uplifted forming an elongate terrestrial high of Permian-Jurassic metagreywackes, metaargillites, and cherts. Minor andesite eruptions occurred along this high in the latter half of the early Miocene (Hayward, 1975a).

Elongate Basin (Waitemata Basin): An elongate marine basin existed between the Waitakere Arc and basement high (Ballance, 1965; 1974). This basin can be divided into a central, deeper portion with dominantly flysch sedimentation, margined to the north and south by two areas of marine shelf (Ballance, 1974). The eastern margin of the basin was formed by a rocky greywacke coastline that fluctuated in position in the vicinity of the present Hauraki Gulf (Searle, 1964; Mayer, 1965).

Northern Landmass: An area of land composed predominantly of unstable Cretaceous and early Tertiary sediments is thought to have had variable form over much of northern Northland. For a time the sea transgressed over portions of this land in at least two places—Hokianga and North Cape (Harrington, 1944; Leitch, 1970). The exact extent of these two basically neritic basins is unknown.

Waitakere Arc: Igneous rocks and coarse volcanic sediments produced by the early to mid-Miocene activity of the Waitakere Arc (Hayward, 1974) crop out in three areas of Northland today—Waipoua, Kaipara, and the Waitakere Hills (Figure 3). Each area is associated with a large positive magnetic anomaly beneath the adjacent west Northland continental shelf (Davey, 1974), which suggests that these were the sites of three major volcanic piles along the Arc (Figure 2). Products from the Waipoua centre occur in the Hokianga basin and over western parts of the northern land mass (Hayward, 1975a). The Kaipara and especially the Waitakere Hills centers built large submarine volcanic piles that formed the western margin of the north and central parts of the Waitemata Basin. It is along this western margin that our foraminiferal studies are centered.

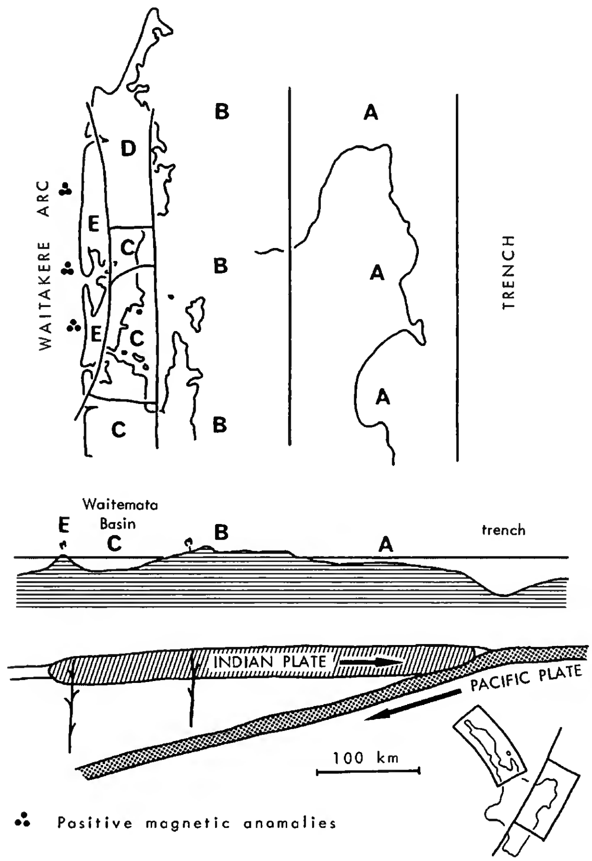

FIGURE 2.—*Upper:* Map showing the inferred reconstruction of northern New Zealand in the early Miocene and the principal geographic features of that time. The arc-trench gap consists of an eastern marine shelf and slope (A), a central basement high (B), an elongate basin (C), a northern landmass (D), and the Waitakere Arc (E). *Middle:* Cross-section through northern New Zealand to illustrate the early Miocene paleogeography of the above map (vertical scale exaggerated). *Lower:* Cross-section (to scale) through northern New Zealand in the early Miocene showing the oceanic crust of the Pacific Plate descending down a low-angle Benioff zone, beneath the New Zealand sialic crust, which lies along the eastern margin of the Indian Plate. *Inset map:* Map of present-day North Island showing position of the two halves of northern New Zealand's early Miocene sialic block.

LITHOSTRATIGRAPHY OF THE WAITAKERE ARC AND WESTERN WAITEMATA BASIN.—Sediments that accumulated in the Waitemata Basin belong to the Waitemata Group. Igneous rocks and associated volcaniclastic sediments of the Waitakere Arc belong to the Waitakere Group (Ballance et al., 1977).

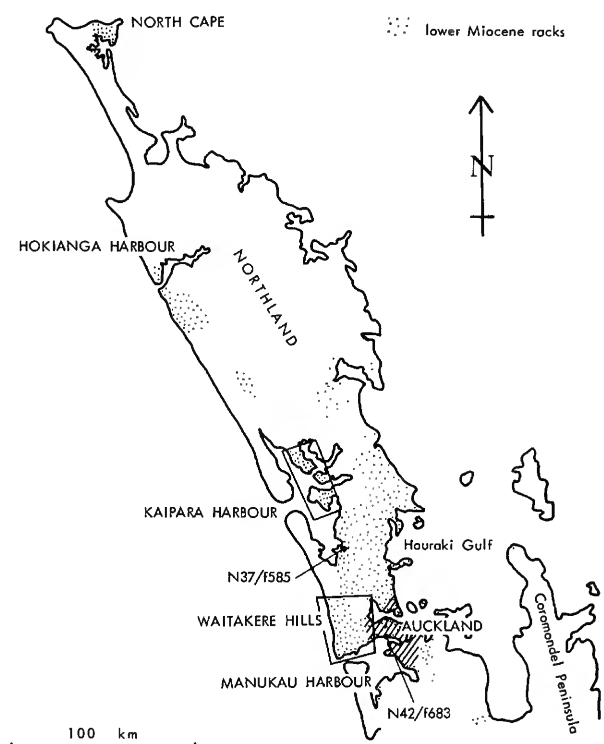

FIGURE 3.—Northern part of the North Island of New Zealand showing present outcrop distribution of lower Miocene rocks, location of South Kaipara (N37/f585) and North Manukau Harbour (N42/f683) samples, and location of maps of central Kaipara and the Waitakere Hills (Figure 4).

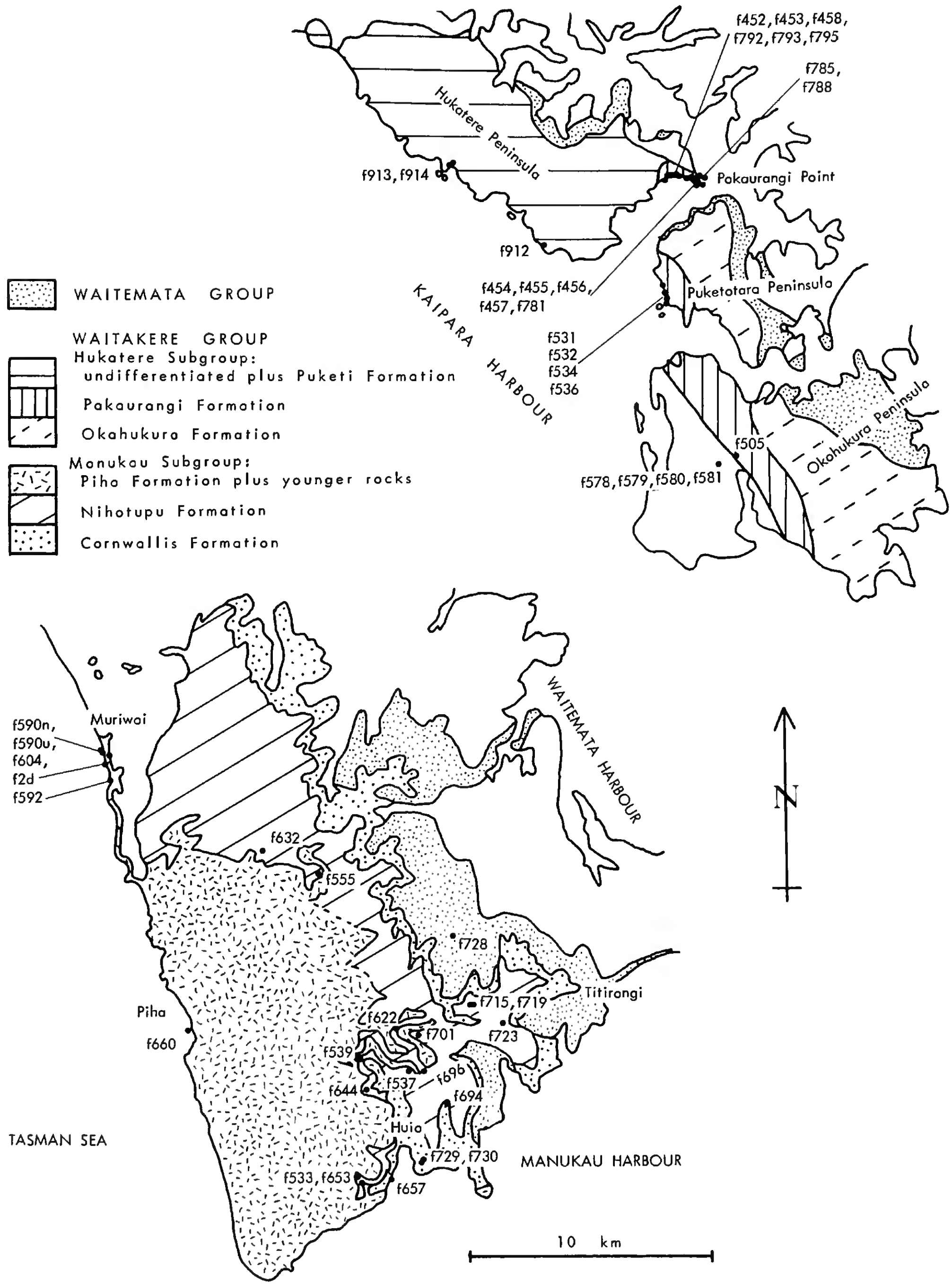

FIGURE 4.—*Upper right:* Map of central Kaipara area (location shown on Figure 3.) *Lower left:* Map of Waitakere Hills (location shown in Figure 3). The outcrop of lower Miocene Waitemata Group, and Waitakere Group Formations are shown, together with the location of samples used in the thanatotope analysis.

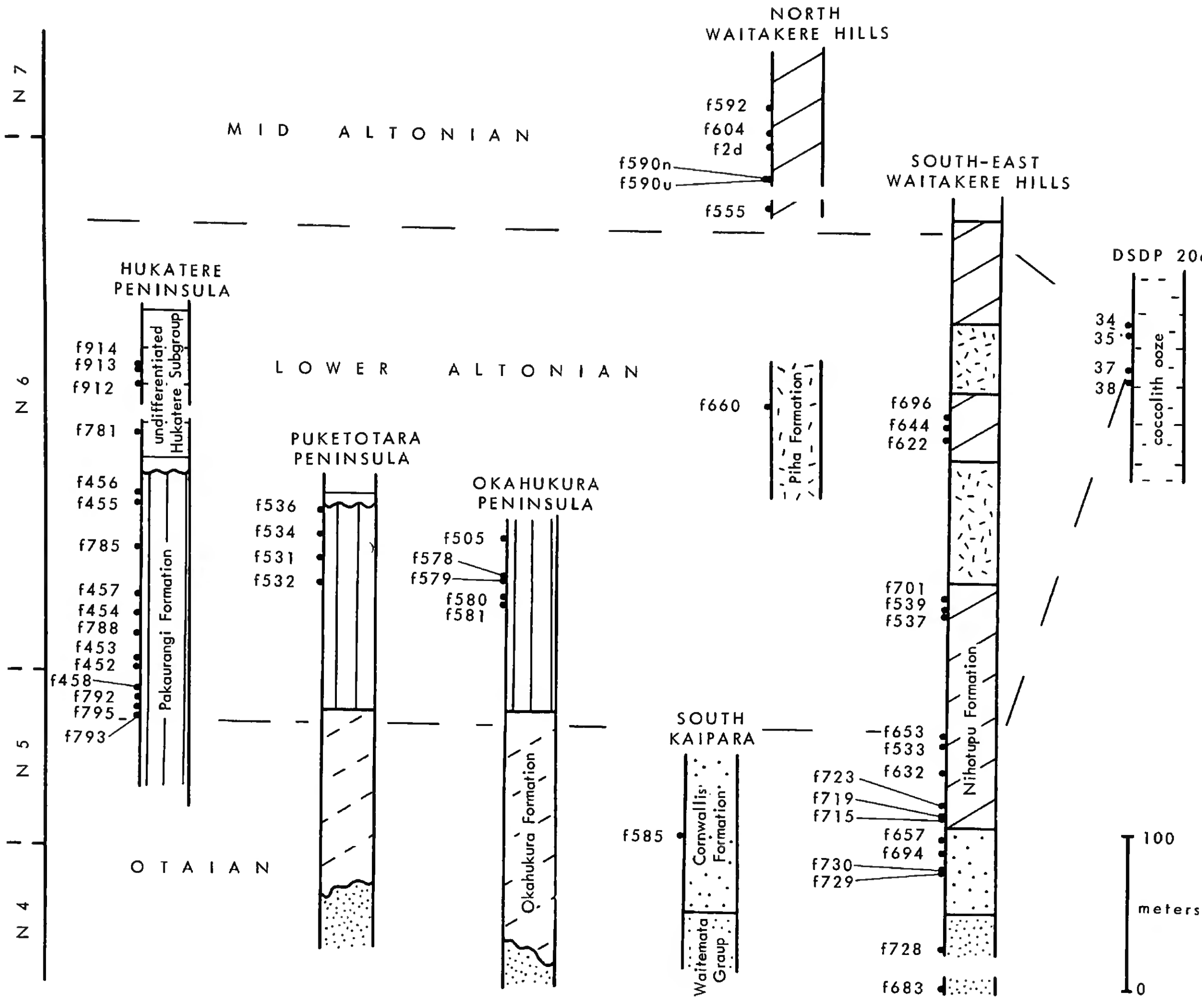

FIGURE 5.—Simplified lithostratigraphic columns of lower Miocene rocks from the west side of the Waitemata Basin and the Waitakere Arc, plus DSDP 206 from the north Tasman Sea. Location of samples used in the thanatotope analysis are shown, together with their approximate age correlation. Blow's (1969) planktonic foraminiferal zones (N4–N7) are indicated on the left.

These rocks are tilted to the west in western Northland. The dividing line between the two Groups is a gradational vertical zone, but for practical mapping purposes an arbitrary horizontal stratum has been selected, below which and cropping out to the east is Waitemata Group, and above which and to the west is Waitakere Group.

The Waitakere Group is divided into the following three subgroups centered on the three volcanic piles (Hayward, 1977b).

1. Waipoua Subgroup in the north is predominantly terrestrial (Hayward 1972, 1973, 1975b) and is not dealt with further in this study.

2. Hukatere Subgroup in the Kaipara area mostly crops out on three peninsulas—Hukatere, Puketotara, and Okahukura (Figure 4). Here the thinly-bedded, Waitemata Group sandstones and siltstones (Timber Bay Formation—Carter, 1971) are unconformably overlain by Hukatere Subgroup. The basal Hukatere Subgroup rocks are diorite-andesite conglomerates and coarse volcanic sandstones (Okahukura Formation—Ballance and McCarthy, 1975) that fill submarine canyons and channels cut in the Waitemata Group. The Okahukura Formation is overlain by macrofossiliferous sandstones with minor pillow lavas and hyaloclastites (Pakaurangi Formation, Figures 4, 5; Jones, 1969; Carter, 1971; Ballance and McCarthy, 1975). The youngest rocks of Hukatere Subgroup crop out on Hukatere Peninsula and consist of volcanic sandstones, lapillistones, tuffaceous breccias, foraminiferal limestones, pillow lava piles and lignites (Puketi Formation—Jones, 1969; undifferentiated Hukatere Subgroup—Brothers, 1954a; Arlidge, 1955).

3. Manukau Subgroup crops out from the Waitakere Hills to south Kaipara Harbour. The oldest rocks are thick, graded, volcanic sandstones and grits (Cornwallis Formation—Jones and Martin, 1965; Hayward, 1977b) that conformably overlie the Waitemata Group flysch (Figure 5). Fine volcaniclastic sediments (sandstones, siltstones, minor pillow lavas, and conglomerates = Nihotupu Formation, Tirikohua Formation—Hayward, 1976a, 1977a, 1977b) lie conformably upon Cornwallis Formation and crop out around the northern and eastern margins of the Waitakere Hills (Figure 4). These fine volcaniclastic sediments interfinger with and laterally grade southwestwards into coarse volcaniclastic sediments (andesite breccio-conglomerates, slump deposits, lava flows, hyaloclastites, and minor sandstones = Piha Formation—Hayward, 1977b) that form the bulk of this fossil submarine volcanic pile and now outcrop throughout most of the Waitakere Hills (Figure 4).

Field Localities

The samples used in this study (Apendix I) are from the Waitemata and Waitakere groups and were collected from several areas along the west coast of Northland, New Zealand.

The sample numbers are those of the New Zealand Fossil Record File. The prefix (e.g., N28) is the sheet number of the New Zealand Lands and Survey Department 1: 63 360 topographic map series (NZMS 1). The standard notation of the Fossil Record File uses prefixes in the form "N28/f" (f = fossil site), but this is often abbreviated to "f" when there is no confusion as to which sheet number is being referred to. Unabbreviated sample numbers together with sample locations are given in Appendix I. The faunal slides are housed in the Geology Department, University of Auckland.

Waitakere Hills (N41 and N42 samples, Appendix I, Figure 4).—Several hundred lithified sediment samples were collected from finer grained lithologies in the Waitakere Hills during geologic mapping from 1972 to 1974 (Hayward, 1975a). The samples used for this faunal analysis were those containing at least 50 individuals in about 10 trays of washed sediment. Altogether, 24 samples met this criterion and were separated into two groups (Table 1) based on field observations.

The 17 Group 1 samples were collected from well-bedded, thinly laminated volcanic sandstones and siltstones that occasionally contain bathyal macrofaunas (Hayward, 1976a, b).

The seven Group 2 samples were collected from thick, graded or massive beds of pebbly grits and coarse, volcanic sandstones that commonly contain broken shell material and sometimes neritic or mixed netritic-bathyal macrofaunas (Hayward, 1976b).

North Manukau Harbour (N42/f683, Figure 3).—A single siltstone sample from the Waitemata Group, three km northwest of Onehunga was included.

South Kaipara (N37/f585, Figure 3).—A single sandstone sample from the Cornwallis Formation, seven km northwest of Kaukapakapa was included.

Central Kaipara (N28 and N33 samples, Appendix I, Figure 4).—Eight processed samples from Pakaurangi Point and five from Okahukura Peninsula, from the collections of the Geology Department, University of Auckland, were selected for use in this study because of their abundant foraminifera, as were a further nine processed sediment samples from Pakaurangi Point and Puketotara Peninsula, from the collections of the New Zealand

TABLE 1.—Samples from the Waitakere Hills containing at least 50 individuals (samples were grouped from field observations)

Group 1 Well-bedded sandstones and siltstones	Group 2 Massive grits and coarse sandstones
N41/f2d	N41/f533
N41/f590n	N41/f537
N41/f590u	N41/f539
N41/f592	N41/f555
N41/f604	N41/f632
N41/f622	N41/f657
N41/f644	N42/f694
N41/f653	
N41/f660	
N42/f696	
N42/f701	
N42/f715	
N42/f719	
N42/f723	
N42/f728	
N42/f729	
N42/f730	

Geological Survey, Lower Hutt (collected by Scott, 1970a). These samples were supplemented by three volcanic sandstones collected from the west coast of Hukatere Peninsula in August 1974. In all, a total of 25 samples were used from the Central Kaipara Area.

NORTH TASMAN SEA (DSDP samples, Figure 1).—Sixteen samples were obtained from the Deep Sea Drilling Project collection to provide an idea of the lower bathyal foraminifera of this region in the early Miocene. Four of these samples (Appendix I) judged to be of equivalent age and containing sufficient benthic foraminifera were selected for use in this study. All samples were from Leg 21, Site 206, between cores 206-32 and 206C-8. The samples were sublithified nannofossil oozes. Site 206 was drilled in the New Caledonia Basin at a present water depth of 3200 m (Burn et al., 1973).

Age and Planktonic Foraminiferal Biostratigraphy

The samples used in this study are of early Miocene age and can be assigned to the local New Zealand stages of Otaian, Po (= Aquitanian), and Altonian, Pl (= upper Aquitanian, Burdigalian). These stage determinations have been made using the planktonic foraminiferal stratigraphic framework established by Jenkins (1967, 1971, 1973) and Scott (1971b, 1972).

Detailed planktonic foraminiferal studies have previously assigned the Pakaurangi Point samples to the lower part of the Altonian (Scott, 1969, 1972), and the Waitakere Hills samples to the upper Otaian to middle Altonian (Scott, 1970b; Hayward, 1975a).

The samples here have been assigned to three stages or substages based on the planktonic foraminifera: Otaian, lower Altonian, and middle Altonian (Figure 6).

OTAIAN.—The oldest samples contain typical Otaian faunas (Jenkins, 1971) with abundant large *Globoquadrina dehiscens* (Plate 1: figure 6), *Globigerina bulloides, Globigerina woodi woodi,* and *Globigerina woodi connecta.* The boundary between the Otaian and Altonian stages is formally defined using a lineage within populations of the benthic foraminiferid *Haeuslerella* (Scott, 1965, 1972). In the absence of *Haeuslerella,* a number of planktonic events have been used to indicate proximity to the boundary. The upper limits of *Catapsydrax dissimilis* and *Globorotalia kugleri* (Plate 1: figure 5) in New Zealand are close to this boundary (Jenkins, 1971, 1973). Scott's (1969, 1972) *Globigerinoides trilobus trilobus* datum level, based upon height:width measurements of the primary aperture in populations of *Globigerinoides trilobus,* is just

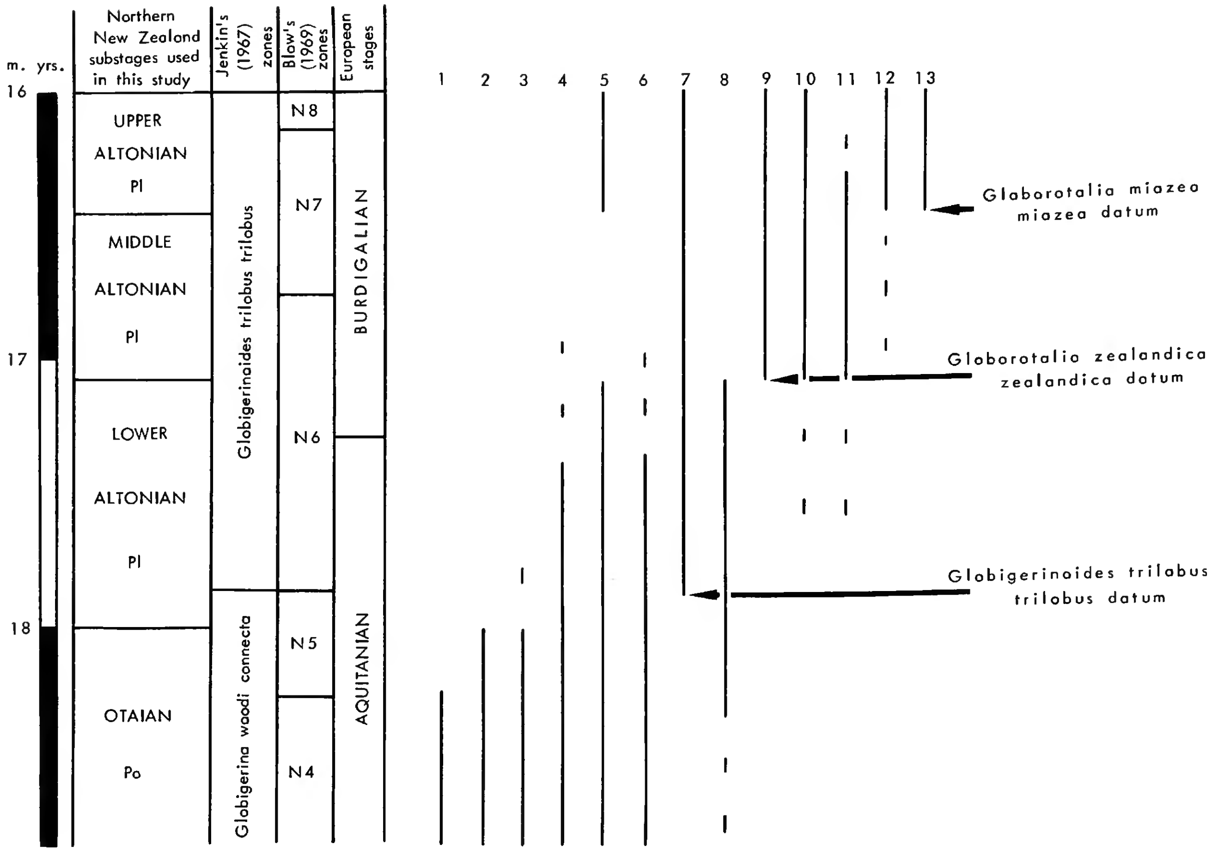

FIGURE 6.—Stratigraphic ranges of key planktonic foraminifera in northern New Zealand, showing important datum levels, appearances and extinctions used in defining the local substages (Otaian, lower Altonian, middle Altonian) applied in this study. The approximate equivalent absolute ages, planktonic zones of Jenkins (1967) and Blow (1969), and European stages are shown. The planktonic foraminifera are: 1, *Globorotalia kugleri* Bolli; 2, *Catapsydrax dissimilis* (Cushman and Bermudez); 3, *Globigerina ciperoensis ciperoensis* Bolli; 4, *Globigerina woodi connecta* Jenkins; 5, *Globoquadrina dehiscens* (Chapman, Parr and Collins); 6, *Globigerinoides trilobus altiaperturus* Bolli; 7, *Globigerinoides trilobus trilobus* (Reuss); 8, *Globorotalia zealandica incognita* Walters; 9, *Globorotalia zealandica zealandica* Hornibrook; 10, *Globorotalia bella* Jenkins; 11, *Globorotalia praescitula* Blow; 12, *Sphaeroidinellopsis disjuncta* (Finlay); 13, *Globorotalia miozea miozea* Finlay.

above the Otaian-Altonian boundary (Figure 6; Scott, 1969, 1972; Jenkins, 1973; Hayward, 1975a).

LOWER ALTONIAN.—Lower Altonian faunas are dominated by more diverse faunas than the Otaian, with common *Globoquadrina dehiscens, Globigerina bulloides, G. woodi woodi, G. woodi connecta, Globigerinoides tribolus tribolus, Globorotalia zealandica incognita,* and *Globigerinoides tribolus altiapertus.* The boundary between the lower Altonian and middle Altonian as used in this study, is based predominantly on the *Globorotalia zealandica zealandica* datum in northern New Zealand (Hayward, 1975). Walters (1965) described the apparent lineage in the East Cape area from *G. zealandica incognita* (Plate 1: figures 1, 2), which evolved with increasing ventral inflation and development of a more angular profile (in axial view) into *G. zealandica zealandica* (Plate 1: figure 3, 4). The *G. zealandica zealandica* datum (Figure 6; Walters, 1965; Scott, 1972; Jenkins, 1973) is taken to be the level where individuals having considerable ventral inflation and subangular profile (Walters, 1965, fig. 6K-Z; pl. 1: fig. 3, 4) comprise fifty percent or more of the *G. zealandica* population.

The lower Altonian-middle Altonian boundary is close to the level at which *Globorotalia praescitula* first appears in northern New Zealand (Hayward, 1975a) and at which *Globoquadrina dehiscens* temporarily disappears (Walters 1965; Hayward, 1975a).

MIDDLE ALTONIAN.—The youngest faunas are dominated by *Globigerina bulloides, G. woodi woodi* and *Globigerinoides tribolus tribolus,* and characterized by the presence of *Globorotalia zealandica zealandica, G. praescitula,* and rare *Sphaeroidinellopsis disjuncta* and by the absence of *Globoquadrina dehiscens* and the upper Altonian form *Globorotalia miozea miozea* and *Globigerinoides tribolus bisphericus* (Figure 6; Jenkins, 1973).

The substages assigned to the various samples on their planktonic content are shown on the lithostratigraphic columns in Figure 5 and listed in Appendix I.

The Waitemata Group, Cornwallis Formation, Okahukura Formation and lower part of the Nihotupu Formation are Otaian. The Pakaurangi Formation, Puketi Formation, Piha Formation, undifferentiated Hukatere Subgroup, and middle part of the Nihotupu Formations are lower Altonian. The upper part of the Nihotupu Formation, cropping out in the northern Waitakere Hills, is middle Altonian.

These local northern New Zealand substages can only be applied with difficulty to the deep-water faunas of the northern Tasman Sea (DSDP 206). The four samples used (DSDP 34, 35, 37, 38) are all early Miocene, being below the *Orbulina* datum and above *Globigerinoides* datum (Burns et al., 1973). Strongly inflated, keeled *Globorotalia* appear above DSDP 34 suggesting that these four samples are age equivalents of the Otaian and lower Altonian.

Methods

LABORATORY.—The 55 samples chosen for this study were crushed and broken down using a combination of hydrogen peroxide, boiling water and an ultrasonic bath. They were then washed over a sieve with a nominal opening of 0.075 mm. Benthic foraminifera were picked directly from the sediment residue, as infilling of their shells prevented the use of the flotation techniques to concentrate them. For picking, the sediment was spread evenly over a metal tray with a grid. Each tray of sediment was a microsplit of the entire processed sample and in all cases a complete trayfull or a number of complete traysfull was scanned to obtain individuals. About 200 to 300 individuals were obtained for most samples, but several yielded fewer than this number. A count of the planktonic foraminifera and ostracods was kept during picking.

The picked benthic formaminifera were mounted on slides, identified and counted.

COMPUTER.—The data consist of counts of the number of individuals belonging to 364 species in 55 samples. Because the number of individuals picked was standardized, in so far as possible, at about 200 to 300, the data are more analogous to species proportions than species densities. Initially the data matrix was standardized by sample, $|\frac{\chi - \mu}{\sigma}|$, and the Euclidian distance was calculated between all possible sample pairs resulting in a distance matrix of size 55 $\times$ 55.

One of the techniques used to identify thanatotopes was nonmetric multidimensional scaling (Kruskal, 1964). This technique presents a configuration of the n=55 sample points in a k-dimensional space (two in the present instance). The interpoint distances in the k space are related monotonically to the original Euclidian distances. The advantage of viewing a configuration in k=2 dimensional rather than k=55 dimensional space is obvious. While other techniques, such as principal component analysis, also present a succinct summarization in a reduced number of dimensions, multidimensional scaling is conceptually and computationally quite distinct.

Initially a random configuration of points is generated from which the distance between all possible pairs are computed. These, in turn, are plotted against the Euclidian distances computed from the standardized data matrix and fitted with a monotonic function. Next a goodness of fit statistic called "stress" (St) is computed by

$$St = \left(\frac{\Sigma(d_{ij}-\hat{d}_{ij})^2}{\Sigma d_{ij}^2}\right)^{1/2}$$

wherein d_{ij} is the original Euclidian distance and d_{ij} is a number computed to minimize the stress. The configuration is then changed slightly so as to improve the stress. Successive iterations are performed until a minimum stress is achieved.

A second technique utilized to identify thanatotopes was weighted pair group cluster analysis using arithmetic averages of the Euclidian distance matrix. Discussions of this commonly used technique are given by Sokal and Sneath (1963), Kaesler (1966), and Mello and Buzas (1968). The above techniques were computed using the "NT-SYS" statistical package of Rohlf, Kishpaugh, and Kirk of the State University of New York, Stony Brook, New York.

Three measures of species diversity S, H, and E were utilized. The first, S, is simply the number of species observed in the sample. The second is the Shannon-Wiener information function

$$H = -\Sigma p_i \ln p_i$$

wherein p_i is the proportion of the ith species (MacArthur and MacArthur, 1961; Pielou, 1966; and Gibson and Buzas, 1973). Unlike S, the information function places little weight on the rarer species encountered in the samples. The evenness with which the species proportions are distributed, however, can alter the value of H considerably. For example, five species each with a species proportion of 0.20 would have a value of H=1.60, while five species with proportions 0.90, 0.04, 0.03, 0.02, and 0.01 would have a value of H=0.45. A value of H=1.60 could also be obtained from a sample containg more than five species, but with less evenness in the distribution of species proportions. Consequently, in addition to S and H some measures of evenness is required. Now the maximum value of H for a given S occurs when all species are equally distributed. In this case H=ln S, and from the definition of logarithms of $e^H=S$, and $e^H/S=1$. Departure from complete evenness results in values of less than 1. Buzas and Gibson (1969) suggested this ratio be used as a measure of evenness and Sheldon (1969) called it E. For reasons given by Hill (1973) the measure

$$E = \frac{e^H}{S}$$

is more appropriate than some others suggested (see Pielou, 1966) and is used here.

A computer program that ranks the species by abundance, calculates species proportions and cumulative proportions, S, H, and E was used to evaluate species diversity for each of the 55 samples and the thanatotopes defined by multidimensional scaling and cluster analysis.

Numerical Analyses

The large data matrix (364 × 55) precluded interpretation of the fauna on a sample by sample or species by species basis. Instead two computer techniques, discussed in the previous section, were used to arrange the samples into groups (thanatotopes). We now discuss the results of these analyses.

MULTIDIMENSIONAL SCALING USING EUCLIDIAN DISTANCES.—After 14 iterations a minimum stress of 43% was achieved. According to Kruskal (1964) a stress of 5%–10% can be considered good. The high stress achieved in the present analysis is analogous to a principal component analysis wherein the first two axes account for a relatively small portion of the total variability. Nevertheless, as the two dimensional configuration shown in Figure 7 shows, there are some clear cut clusters.

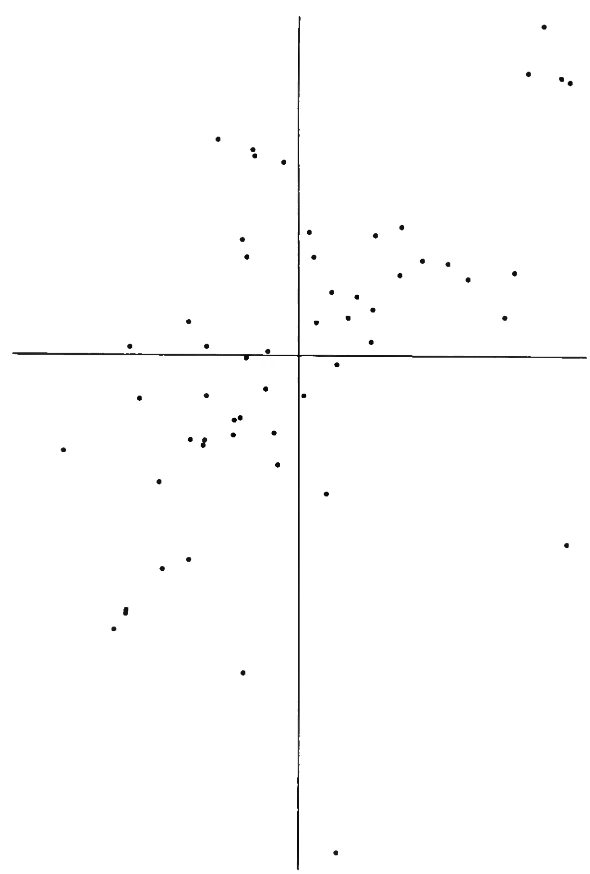

FIGURE 7.—Two-dimensional configuration of samples produced by multidimensional scaling using euclidian distance.

A small cluster (thanatotope) of four samples occurs in the upper right, and a slightly less well-defined thanatotope of five samples occurs in the lower left. Apart from the three scattered samples in the lower right, the remaining samples occur in a diffuse central region. This central configuration represents a natural, gradational change in the fauna, with no rigid boundaries subdividing it into several distinctive thanatotopes. Because of the large faunal change across this central region and the unwieldy number of samples within it, we decided further classification of the samples into thanatotopes was desirable. Consequently, the data were further analyzed through cluster analysis.

CLUSTER ANALYSIS USING EUCLIDIAN DISTANCE.—The dendrogram produced using this technique is shown in Figure 8. The two small distinctive thanatotopes from the multidimensional scaling configuration are the two tightest clusters in the dendrogram (thanatotopes A and E, Figures 8, 9). The central region of Figure 7 is divided into three clusters in the dendrogram (thanatotopes B, C, and D, Figure 8). When placed on the multidimensional scaling configuration, these three thanatotopes form three non-overlapping groupings that divide the central region into smaller, more workable units (Figure 9). Four samples around the fringes of the central region did not cluster with thanatotopes B, C, and D (Figure 9). Two of these (N41/f539, f555) cluster on the dendrogram nearest thanatotope A (Figure 8), but have been left ungrouped here for interpretation purposes. The other two samples (N28/f912, f914) cluster in the dendrogram (Figure 8) with the distant sample, N42/f694 (Figure 9) and are given a loose thanatotope status (thanatotope F) for ease of interpretation.

The remaining distant sample in the lower right quadrant (N33/f579, Figure 9) clusters in the dendrogram nearest thanatotope C but has been left ungrouped, as has the distant sample in the lower left (N41/f632, Figure 9).

Thanatotopes

Faunal composition of thanatotopes A–F is summarized in Figure 10.

THANATOTOPE A (Figure 11).—*Distribution:* Hukatere Peninsula (Puketi Formation: N28/f781: undifferentiated Hukatere Subgroup: N28/f913); Waitakere Hills Group 2 (Cornwallis Formation:

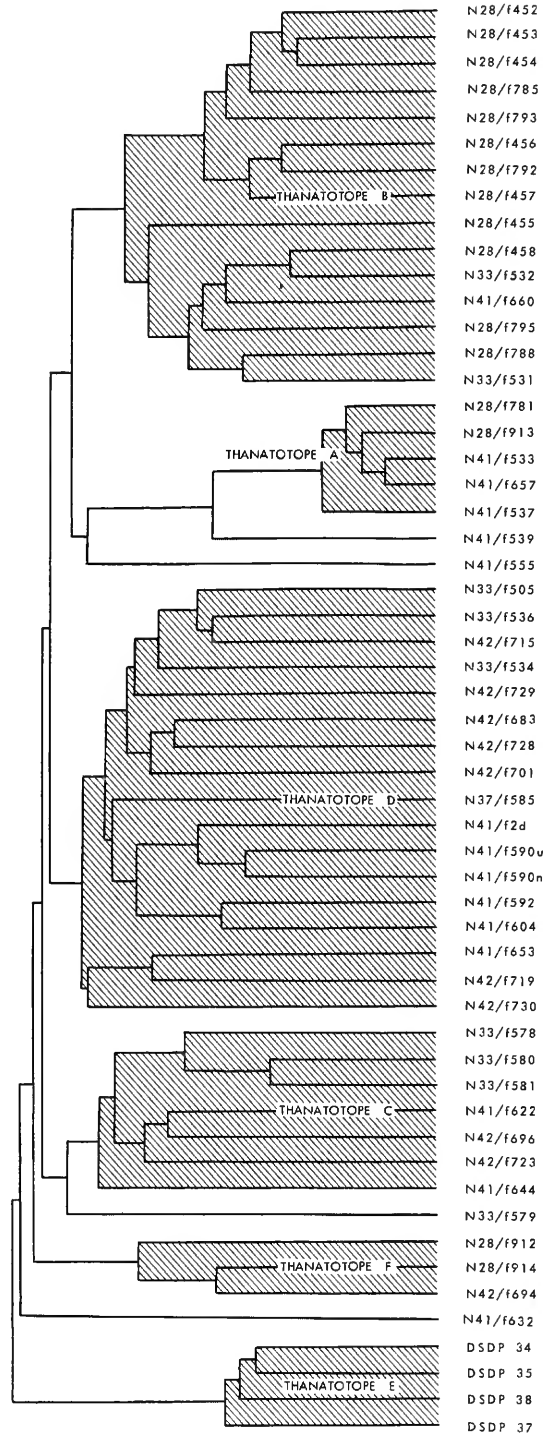

FIGURE 8.—Dendrogram classification of samples produced by cluster analysis using euclidian distance. Thanatotopes A-F were selected by the authors.

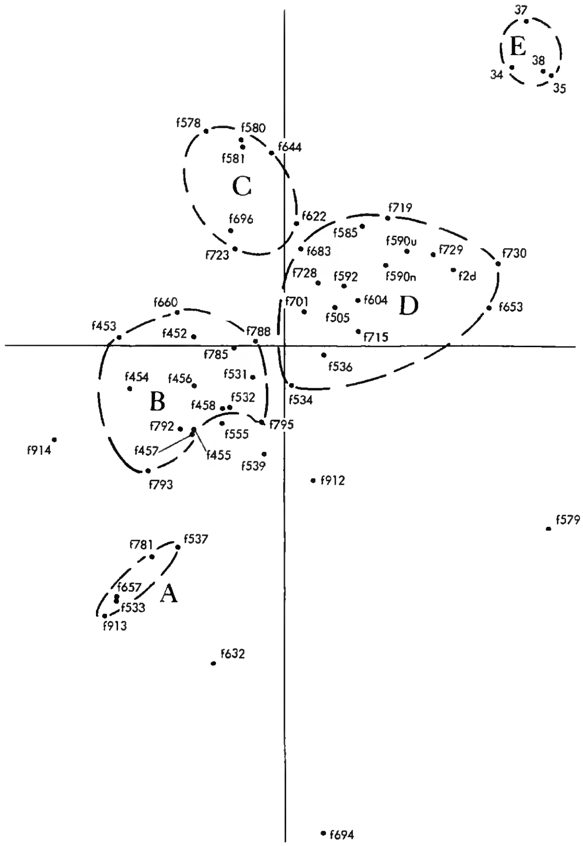

FIGURE 9.—Two-dimensional configuration of samples produced by multidimensional scaling using euclidian distance (as in Figure 7) with thanatotopes A-E (selected from dendrogram, Figure 8) shown. Thanatotope F, consisting of f912, f914 and f694, is not shown because of its very large spread.

N41/f657; Nihotupu Formation: N41/f533, f537).

Fauna: Thanatotope A samples cluster together because of the dominance of a single species, *Amphistegina madagascariensis* (40%–72%). *Miogypsina intermedia* is the second most abundant species with only 5% of the total thanatotope fauna. Five further species (three of *Cibicides,* one *Cibicidoides* and *Victoriella*) each comprise 1.5%–3.0% of the total fauna (Figure 10).

Planktonics: All five samples (Figure 10) have a low percentage of planktonic foraminifera (10%–37%) compared with other thanatotopes.

Species Diversity: These samples (Table 2) have low diversities of benthic species(S=30–51, H=1.46–2.77) and very low evenness of distribution (E=0.14–0.31). This thanatotope has distinctly lower species diversity and evenness than all the other thanatotopes (Figures 12, 13). Only the ungrouped sample N33/f579 has similar low values.

THANATOTOPE B (Figure 14).—*Distribution:* Pakaurangi Point (Pakaurangi Formation: N28/f452, f453, f454, f455, f456, f457, f458, f785, f788, f792, f793, f795); Puketotara Peninsula (Pakaurangi Formation: N33/f531, f532); Waitakere Hills Group 1 (Piha Formation: N41/f660).

Fauna: The most abundant species in all samples is either *Cibicides temperatus* or *C. mediocris* and in one instance *C. vortex.* Small fragile individuals of *Amphistegina madagascariensis* are abundant in many samples. Thantotope B samples cluster together because of the dominance of these four most abundant species (Figures 10, 14). Many different species are common in individual samples but none of these occur frequently in all samples.

Planktonics: Percentage of planktonics (Figure 14) in the foraminiferal population (10%–55%) is mostly slightly higher than in thanatotope A and lower than in thanatotopes C, D, and E.

Species Diversity: Thanatotope B has moderately high species diversity (S=39–78, H=2.63–3.68; N41/f660 cannot be included in these measurements because of the small number of individuals picked). Evenness is moderately low if N41/f660 is not included (E=0.36–0.53). Average species diversity in thanatotope B is similar to that in thanatotopes E and F, higher than A and lower than C and D (Figure 12).

THANATOTOPE C (Figure 15).—*Distribution:* Okahukura Peninsula (Pakaurangi Formation: N33/f578, f580, f581); Waitakere Hills Group 1 (Nihotupu Formation: N41/f622, f644; N42/f696, f723).

Fauna: Thanatotope C is characterized by a group of species that occur in differing combinations as the most abundant constitutents in each sample (Figure 15). These common species are *Gyroidina zelandica, Euuvigerina miozea, Astrononion stelligerum, Lenticulina* cf. *nitida, Anomalinoides macraglabra, Sphaeroidina bulloides, Bolivina punctatostriata,* and *Siphouvigerina proboscidea.* Other species that comprise over 1.5% of the total thanatotope C fauna are shown in Figure 10.

Planktonics: Planktonic percentage (Figure 15) ranges from 32%–87%; higher than thanatotopes A, B, and F, and lower than thanatotopes D and E.

TABLE 2.—Thanatotope designations and summary of observations by sample

Thanatotope	Sample	Lith.	Indivs.	S	H	E	% Plank.	Ostracods
A	N28/f781	c.s.	271	45	2.34	0.23	10	4
A	N28/f913	c.s.	297	35	1.80	0.17	32	1
A	N41/f533	gr.	144	30	1.50	0.15	26	1
A	N41/f537	gr.	194	51	2.77	0.31	37	5
A	N41/f657	gr.	202	30	1.46	0.14	20	-
B	N28/f452	m.s.	292	67	3.47	0.48	55	3
B	N28/f453	c.s.	298	50	2.92	0.37	17	3
B	N28/f454	c.s.	253	45	2.86	0.39	31	5
B	N28/f455	c.s.	266	58	3.35	0.49	19	19
B	N28/f456	m.s.	279	50	2.98	0.39	18	7
B	N28/f457	m.s.	251	50	3.01	0.40	35	8
B	N28/f458	m.s.	237	39	2.63	0.36	11	10
B	N28/f785	m.s.	216	55	3.37	0.53	46	10
B	N28/f788	gr.	290	78	3.68	0.51	55	2
B	N28/f792	gr.	197	42	2.83	0.40	29	7
B	N28/f793	m.s.	269	53	3.08	0.41	40	6
B	N28/f795	m.s.	289	55	3.26	0.47	15	7
B	N33/f531	f.s.	265	64	3.49	0.51	46	4
B	N33/f532	f.s.	295	64	3.19	0.38	22	5
B	N41/f660	m.s.	49	21	2.64	0.66	26	3
C	N33/f578	f.s.	313	58	3.09	0.38	66	-
C	N33/f580	m.s.	294	55	3.20	0.45	43	11
C	N33/f581	f.s.	297	62	3.31	0.44	32	
C	N41/f622	m.s.	214	67	3.81	0.67	78	1
C	N41/f644	zst.	200	56	3.66	0.69	75	1
C	N42/f696	zst.	207	84	4.03	0.67	75	7
C	N42/f723	c.s.	194	67	3.83	0.69	87	5
D	N33/f505	m.s.	300	77	3.70	0.52	46	8
D	N33/f534	f.s.	283	64	3.70	0.63	27	2
D	N33/f536	c.s.	268	70	3.66	0.56	16	7
D	N37/f585	f.s.	301	84	4.02	0.66	95	2
D	N41/f2d	zst.	189	51	3.26	0.51	90	7
D	N41/f590n	m.s.	193	57	3.66	0.68	90	-
D	N41/f590u	m.s.	197	61	3.74	0.69	90	
D	N41/f592	m.s.	168	64	3.74	0.66	87	-
D	N41/f604	c.s.	200	60	3.54	0.58	87	2
D	N41/f653	zst.	202	62	3.66	0.63	94	
D	N42/f683	zst.	290	73	3.75	0.58	96	-
D	N42/f701	m.s.	201	47	3.42	0.65	71	-
D	N42/f715	m.s.	191	49	3.16	0.48	88	2
D	N42/f719	zst.	198	70	3.83	0.66	72	1
D	N42/f728	f.s.	200	55	3.55	0.63	97	-
D	N42/f729	m.s.	188	39	3.23	0.65	95	
D	N42/f730	zst.	193	65	3.52	0.52	99.5	2
E	DSDP 34	n.o.	298	56	3.09	0.39	99.5	
E	DSDP 35	n.o.	296	59	3.25	0.44	99.5	
E	DSDP 37	n.o.	299	55	3.40	0.55	99.5	-
E	DSDP 38	n.o.	330	57	3.26	0.46	99.5	
F	N28/f912	f.s.	223	59	3.52	0.57	11	61
F	N28/f914	c.s.	306	62	3.61	0.60	23	34
F	N42/f694	gr.	96	19	2.38	0.57	32	
ungpd.	N33/f579	f.s.	291	33	2.14	0.26	50	-
ungpd.	N41/f539	gr.	189	70	3.81	0.65	70	17
ungpd.	N41/f555	gr.	188	34	3.06	0.63	47	-
ungpd.	N41/f632	gr.	50	27	3.10	0.82	92	-

ungpd.   ungrouped.
Lithologies: gr.   grit, c.s. = coarse sandstone, m.s.   medium sandstone, f.s. = fine sandstone, zst.   siltstone, n.o. = nannofossil ooze.
Indivs.   number of benthic individuals picked.
S = number of benthic species in pick.
H   information function (see text).
E   evenness (see text).
% Plank.   percentage of total foraminifera that are planktonic.
Ostracods   number of ostracods picked.

FIGURE 10.—Histograms of species of benthic foraminifera summarized from all samples in each of thanatotopes A to F. Only the most common species (abundance ≥ 1.5%) are shown.

Species Diversity: Species diversity and evenness (Table 2) are high (S=55–84, H=3.09–4.03, E=0.38–0.69) and about the same as in thanatotope D (Figures 12, 13).

THANATOTOPE D (Figure 16).—*Distribution:* Puketotara Peninsula (Pakaurangi Formation: N33/f534, f536); Okahukura Peninsula (Pakaurangi Formation: N33/f505); South Kaipara (Cornwallis Formation: N37/f585); Waitakere Hills Group 1 (Waitemata Group: N42/f728, Cornwallis Formation: N42/f729, f730, Nihotupu Formation: N41/f2d, f590n, f590u, f592, f604, f653; N42/f701, f715, f719); North Manukau Harbour (Waitemata Group: N42/f683).

Fauna: Like thanatotope C, there is no single species that dominates or is even common in all samples. Instead thanatotope D samples are dominated by differing combinations of a group of species belonging to the genera *Cassidulina* (*C. laevigata*), *Bolivina* (*B. finlayi*, *B. reticulata*, *B. silvestrina*, *B. plicatella mera*), *Cibicides* (*C. vortex*, *C. mediocris*), *Globocassidulina* (*G. subglobosa*), *Trifarina* (*T. bradyi*), *Gyroidina* (*G. zelandica*), *Astrononion* (*A. stelligerum*), and *Stilostomella* (*S. pomuligera*).

Planktonics: Planktonic percentage ranges from 16%–99.5%, but most samples have over 70% (Figure 5). Only the three northernmost samples have less than 70%.

Species Diversity: Species diversity and evenness

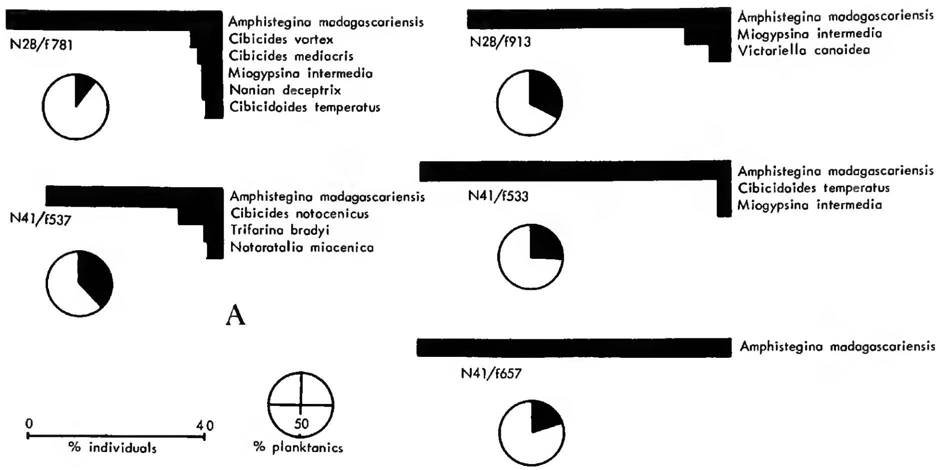

FIGURE 11.—Histograms of common species ($\geq 3\%$) in thanatotope A samples. Percent of foraminifera that are planktonic is shown for each sample.

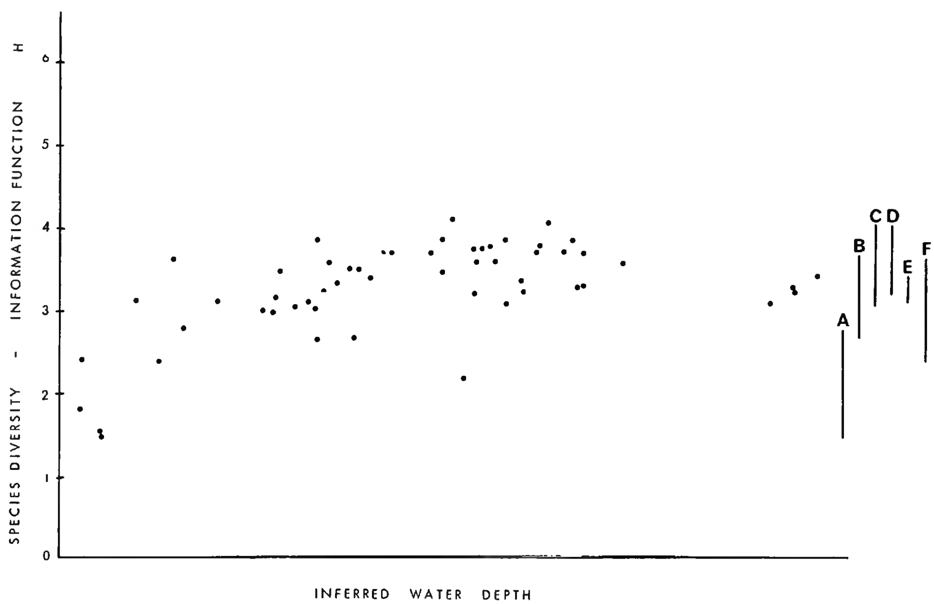

FIGURE 12.—Species diversity (H) plotted against a NE-SW axis placed through the multidimensional scaling configuration (Figure 9). This axis was selected because it is interpreted to represent increasing depth from left to right. The range of values for samples in each thanatotope is shown on right.

are high (S=39–84, H=3.23–4.02, E=0.48–0.69) and about the same as thanatotope C (Figures 12, 13).

THANATOTOPE E (Figure 17).—*Distribution:* North Tasman Sea (DSDP 34, 35, 37, 38).

Fauna: The most abundant species in all four samples is *Globocassidulina subglobosa. Epistominella exigua* is the next most abundant, occurring in numbers greater than 8% in all samples. Other common species are *Bolivina aenariensis, Oridorsalis tenera, Stilostomella pomuligera, Melonis simplex,* and *Bulimina semicostata* (Figure 10).

Planktonics: Benthic foraminifera are sparse in thanatotope E samples. In all four samples 99.5% of the foraminifera are planktonic.

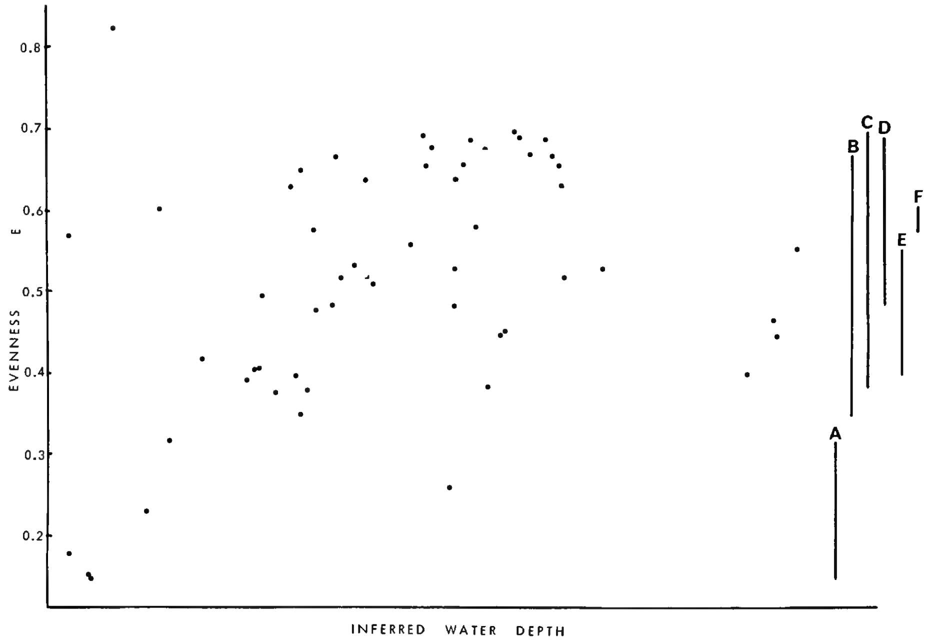

FIGURE 13.—Evenness (E) for species diversity plotted against the same NE-SW axis (in Figure 9) used in Figure 12. Depth increases from left to right. The range of values for samples in each thanatotope is shown on right.

Species Diversity: Species diversity is moderately high (S=55–59, H=3.09–3.40), similar to thanatotopes B and F but generally lower than C and D. Evenness is moderately low (E=0.39–0.55) similar to B, but lower than C, D, and F (Figures 12, 13).

THANATOTOPE F (Figure 18).—*Distribution:* Hukatere Peninsula (Undifferentiated Hukatere Subgroup: N28/f912, f914); Waitakere Hills Group 2 (Cornwallis Formation: N42/f694).

Fauna: All three samples are dominated by miliolids, especially *Quinqueloculina angulostriata, Q. seminula,* and *Q. plana.* Other common species are *Bulimina pupula, Elphidium hornibrooki,* and *E. advenum.*

Planktonics: Planktonic percentage is low (11%–32%) similar to thanatotopes A and B.

Species Diversity: Species diversity is average (S=59–62, H=3.52–3.61) if N42/f694 is not included because of the small number of individuals in this sample. Evenness is moderately high (E=0.59–0.60).

UNGROUPED SAMPLES: (Figure 19).—

N33/f579, Okahukura Peninsula (Pakaurangi Formation)

Fauna: This sample is unusual in the dominance of *Lenticulina* cf. *nitida* (43%) and *Bulmina pupula* (18%).

Planktonics: 50%.

Species Diversity: Species diversity is moderately low (S=33, H=2.14) and evenness is very low (E=0.26).

N41/f539, Waitakere Hills Group 2 (Nihotupu Formation)

Fauna: This sample is dominated by *Amphistegina madagascariensis* (15%) in fewer numbers than in thanatotope A. The other common species—*Cassidulina laevigata, Anomalinoides macraglabra,* and *Bulimina pupula*—are not common in thanatotope A but are in thanatotopes C and D (Figure 9).

Planktonics: 70%.

Species Diversity: Species diversity and evenness are high (S=70, H=3.81, E=0.65).

N41/f555, Waitakere Hills Group 2 (Nihotupu Formation)

Fauna: This sample is dominated by *Cibicides notocenicus,* robust *Amphistegina madagascariensis*

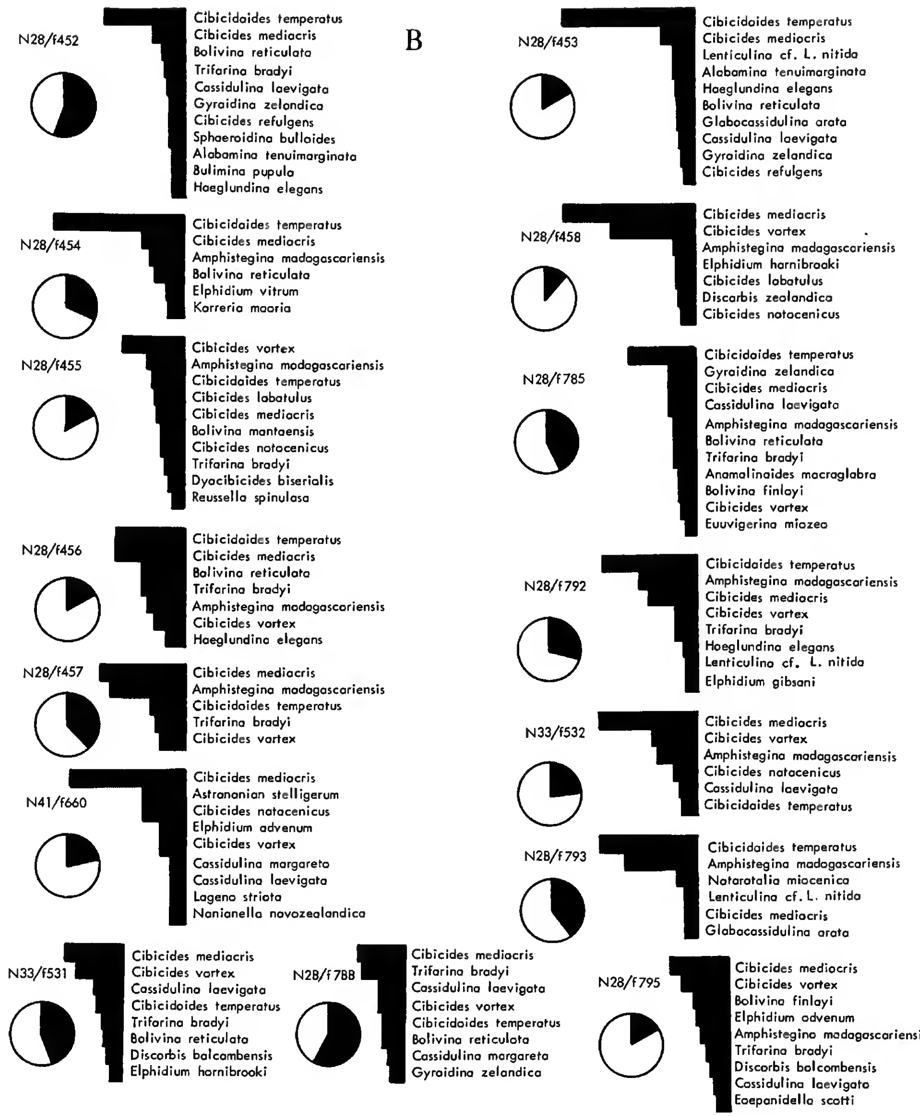

FIGURE 14.—Histograms of common species ($\geq$ 3%) in thanatotope B samples. Percent of foraminifera that are planktonic is shown for each sample.

(both common in thanatotope A), *Cibicides mediocris* (common in thanatotope B), and *Globocassidulina subglobosa* (common in thanatotopes D and E).

Planktonics: 47%.

Species Diversity: Species diversity is average (S=34, H=3.06) and evenness is high (E=0.63).

N41/f632, Waitakere Hills Group 2 (Nihotupu Formation)

Fauna: This sample is dominated by *Siphonina australis* with common *Amphistegina madagascariensis.*

Planktonics: 92%.

Species Diversity: A total of only 50 benthics were obtained from this sample; consequently, S is low (S=27), and H and E are high (H=3.10, E=0.82).

Interpretation of the Benthic Fauna

BENTHIC FORAMINIFERA.—*Thanatotope A:* The dominating form in thanatotope A, *Amphistegina*

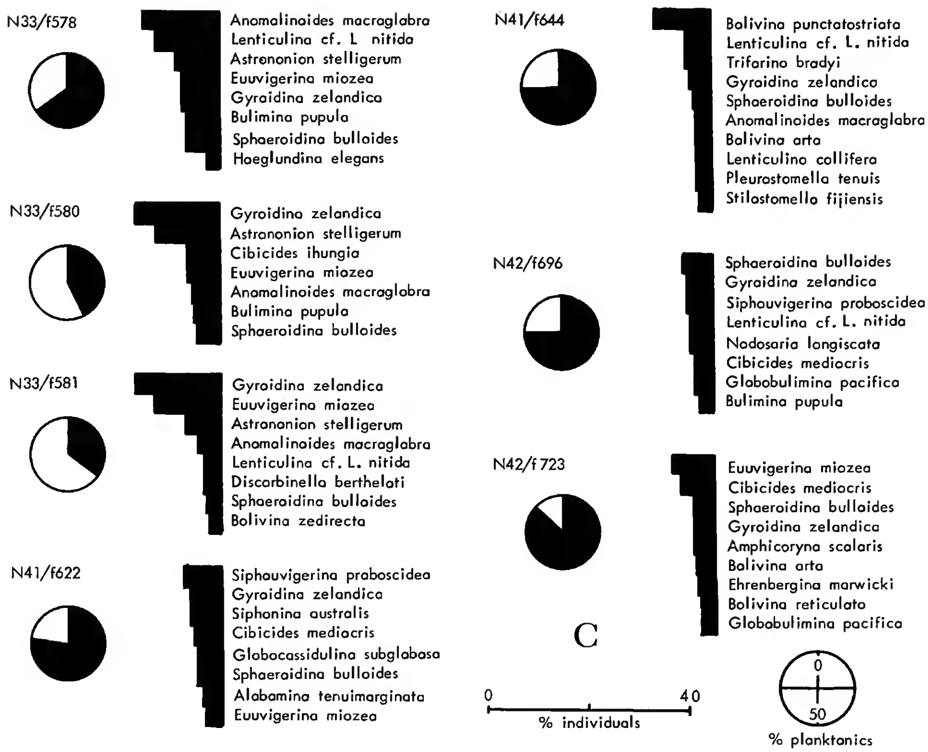

FIGURE 15.—Histograms of common species (≥ 3%) in thanatotope C samples. Percent of foraminifera that are planktonic is shown for each sample.

madagascariensis, today is a common, warm-water Indo-Pacific species. Although the precise distribution of this species is not well-documented, it is generally accepted that *Amphistegina* is a shallow, warm-water genus (Scott, 1970a; Murray, 1973; Boltovskoy and Wright, 1976; Todd, 1976). This genus is particularly prone to post-mortem transportation by surf and currents that obscures its living distribution and has prevented accurate determination of its lower depth limit (Todd, 1976). Todd (1965, 1976) recognized several forms of *Amphistegina madagascariensis.* Thick, robust individuals are characteristic of reef-flats, beach sands and near-shore sediments, and small, flatter and more fragile individuals are characteristic of lagoonal and deeper reef-slope environments. In all these environments *Amphistegina madagascariensis* has commonly been recorded comprising up to 25% of the benthic foraminifera. Thanatotope A samples all have over 40% *Amphistegina* (Figures 11, 20). Such a dominance has rarely been recorded, but Cushman, Todd, and Post (1954) found *A. madagascariensic* comprising up to 80% of the fauna in the lagoons and on the outer reef slopes (about 0–50 m), around the Marshall Islands.

Most *Amphistegina madagascariensis* in thanatotope A are robust individuals supporting in an ferred exposed environment, 5–40 m deep in coarse sands or granular gravels (as indicated by the enclosing sediments.)

Thanatotope A faunas are little mixed as most genera present occur together today in such an environment with frequent *Cibicides, Cibicidoides, Elphidium, Discorbis,* and miliolids (Figures 10, 11, 20). *Cibicides notocenicus* shows its greatest abundance in this shallow thanatotope (Figure 20). A number of extinct, inferred shallow, warm-water, larger foraminifera are common in or restricted to thanatotope A, e.g., *Miogypsina intermedia, Victoriella conoidea, Eulepidina dilatata dilatata, Heterostegina borneensis, Hofkerina semiornata,* and *Sherbornina cuneimarginata.*

Foraminifera reworked from Cretaceous and lower Tertiary strata occur in greatest abundance

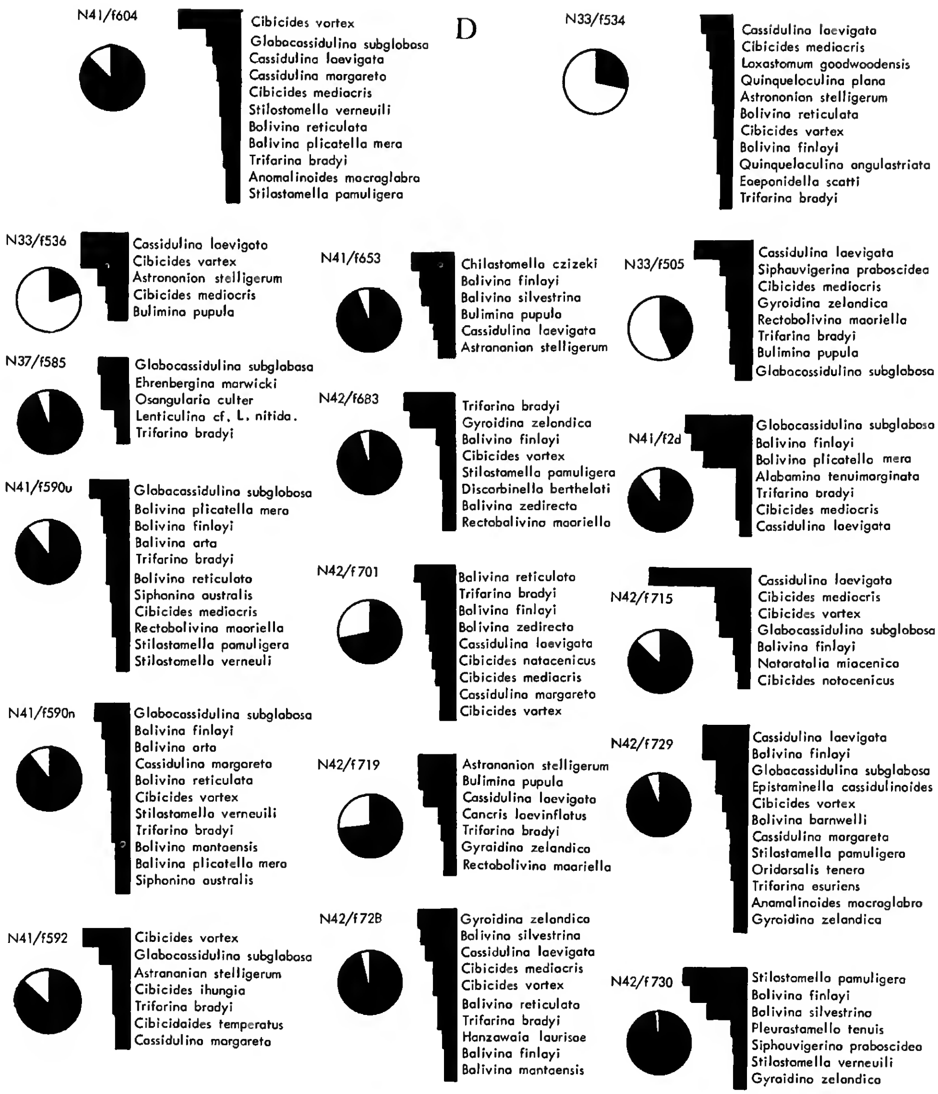

FIGURE 16.—Histogram of common species (≥ 3%) in thanatotope D samples. Percent of foraminifera that are planktonic is shown for each sample.

in this thanatotope (e.g., *Glomospira corona, Pelosina complanata, Rzehakina epigona*). A little mixing of the fauna is indicated by the presence of rare individuals of deep-water restricted genera (e.g., *Osangularia, Stilostomella,* Figure 20).

Thanatotope B: Species of *Cibicides* and *Cibicidoides* (Figure 10, 14, 21) dominate this thanatotope, comprising over 40% of the benthic foraminifera. Such an abundance of these two genera has not often been recorded from modern sediments. Their greatest concentrations, however, are found today in outer shelf depths (50–200 m) where they are two of the most predominant genera (Boltovskoy and Wright, 1976:119). The four most common species of *Cibicides* and *Cibicidoides* in this thanatotope are extinct, but two living species (*Cibicides lobatulus* and *C. refulgens*) are persistently present and have been recorded as reaching their greatest abundance in the Gulf of Gascogne at outer shelf depths (Pujos-Lamy, 1973).

An outer-shelf environment is supported by other faunal comparisons with present-day distribu-

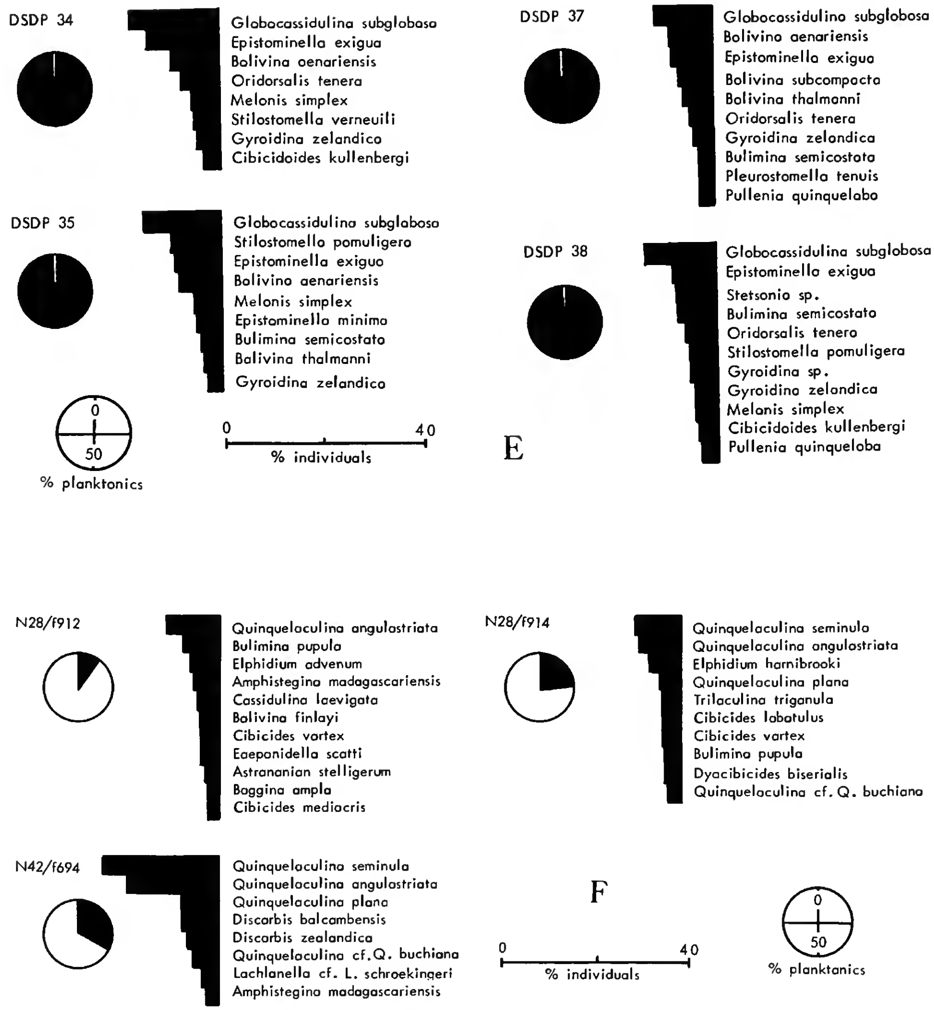

FIGURE 18.—Histogram of common species ($\geq$ 3%) in thanatotope F samples. Percent of foraminifera that are planktonic is shown for each sample.

tions. Thin, fragile individuals of *Amphistegina madagascariensis* are abundant in this thanatotope (Figures 10, 20), and it is this form that Todd (1965, 1976) noted was typical of deeper water situations. She records it in abundance from samples as deep as 300 m.

Thanatotope B faunas are almost entirely autochthonous with few, if any, records of bathyal or deeper water-restricted forms (Figure 21). The samples are almost all sandstones and the dominant faunal elements are typical of modern sandy sediments.

A lower depth limit of approximately 200 m for this thanatotope is indicated by the common occurrence of a number of shelf-restricted genera (e.g., *Bolivinella, Buccella, Discorbis, Elphidium, Glabratella, Notorotalia, Pavonina*).

An upper depth limit to thanatotope B may be gauged by the common presence of *Hoeglundina elegans* (shallowest known modern record: 40 m), *Cassidulina laevigata* (almost entirely deeper than 75 m), *Lenticulina* (mostly deeper than 50 m) and *Euuvigerina* (predominantly deeper than 100 m).

Thanatotope C: Of the nine most abundant genera in this thanatotope (Figure 10), three (*Anomalinoides, Cibicides,* and *Sphaeroidina*) occur commonly in modern outer neritic and bathyal sediments; one (*Astrononion*) is most abundant in

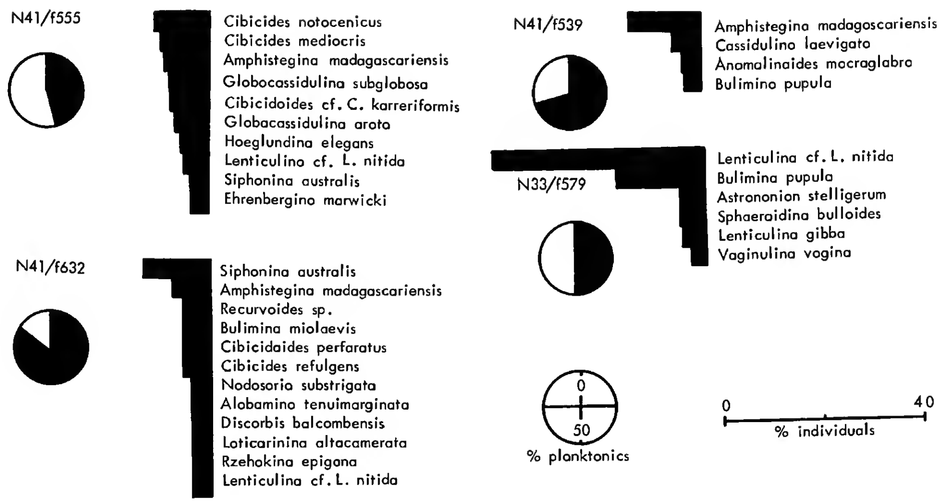

FIGURE 19.—Histogram of common species (≥ 3%) in ungrouped samples. Percent of foraminifera that are planktonic is shown for each sample.

the outer neritic and uppermost bathyal; three are predominant members of modern bathyal faunas *(Bolivina, Bulimina,* and *Gyroidina);* and two are most abundant in the upper bathyal *(Euuvigerina* and *Lenticulina)* (Boltovskoy and Wright, 1976; Vella, 1962a; Murray, 1973). From this we conclude that thanatotope C most likely was located at upper bathyal (200–1000 m) depths.

Further support for an upper bathyal environment comes from the most common records in this thanatotope of *Ehrenbergina, Globobulimina, Saracenaria, Siphonina,* and *Siphouvigerina,* all of which are predominantly found today in this zone.

Samples in this thanatotope can probably be divided further into two groups. Those with abundant *Astrononion* and *Lenticulina* (N33/f578, f580, f581; Figure 15) are probably from the uppermost bathyal, as *Astrononion* is not found in abundance at depths greater than 300–400 m (Vella, 1962a; Thompson, 1975) and *Lenticulina* is predominantly found between 200–700 m (Vella, 1962a; Lewis, 1971; Murray, 1973).

The four remaining samples, in the lower right portion of thanatotope C (Figure 9), and lower part of the dendrogram cluster (Figure 8, N41/f622, f644; N42/f696, f723) are probably from the lower upper bathyal. This is suggested by the presence in all four, and not the first three, of two reliable deep-water-restricted taxa: *Osangularia culter* (shallowest known modern record: 700 m; Brady, 1884; Bandy and Chierici, 1966; Frerichs, 1970; Lewis, 1971; Pflum and Frerichs, 1976) and the genus *Pleurostomella* (predominantly deeper than 1000 m; Brady, 1884; Bandy and Rodolfo, 1964; Frerichs, 1970).

All seven samples contain some allochthonous tests, transported in from shallower depths (e.g., *Elphidium, Amphistegina,* Figure 20). The lower four samples appear to be more mixed than the upper three. N41/f644 contains a large number of very battered *Lenticulina* that probably were transported down the slope by currents.

Thanatotope D: Thanatotope D samples are dominated by species of *Cassidulina (C. laevigata, C. margareta), Bolivina (B. finlayi, B. reticulata, B. mantaensis, B. silvestrina, B. plicatella mera,* etc.), *Cibicides (C. vortex, C. mediocris)* and *Globocassidulina (G. subglobosa)* (Figures 10, 16, 20, 21). Assemblages dominated by these genera are typical of outermost neritic and upper half of the bathyal (150–2000 m) in modern sediments (Bandy and Rodolfo, 1964; Betjeman, 1969; Boltovskoy and Wright, 1976; Saidova, 1967). Most of the species are extinct, but the most abundant overall, *Cassidulina laevigata,* is still found commonly (neritic to abyssal) with its greatest abundance in middle latitudes in the upper half of the bathyal (200–1500 m—Brady, 1884; Bandy, 1960). *Globocassidulina subglobosa* is rarely found today above 100 m and is most common in the mid- to

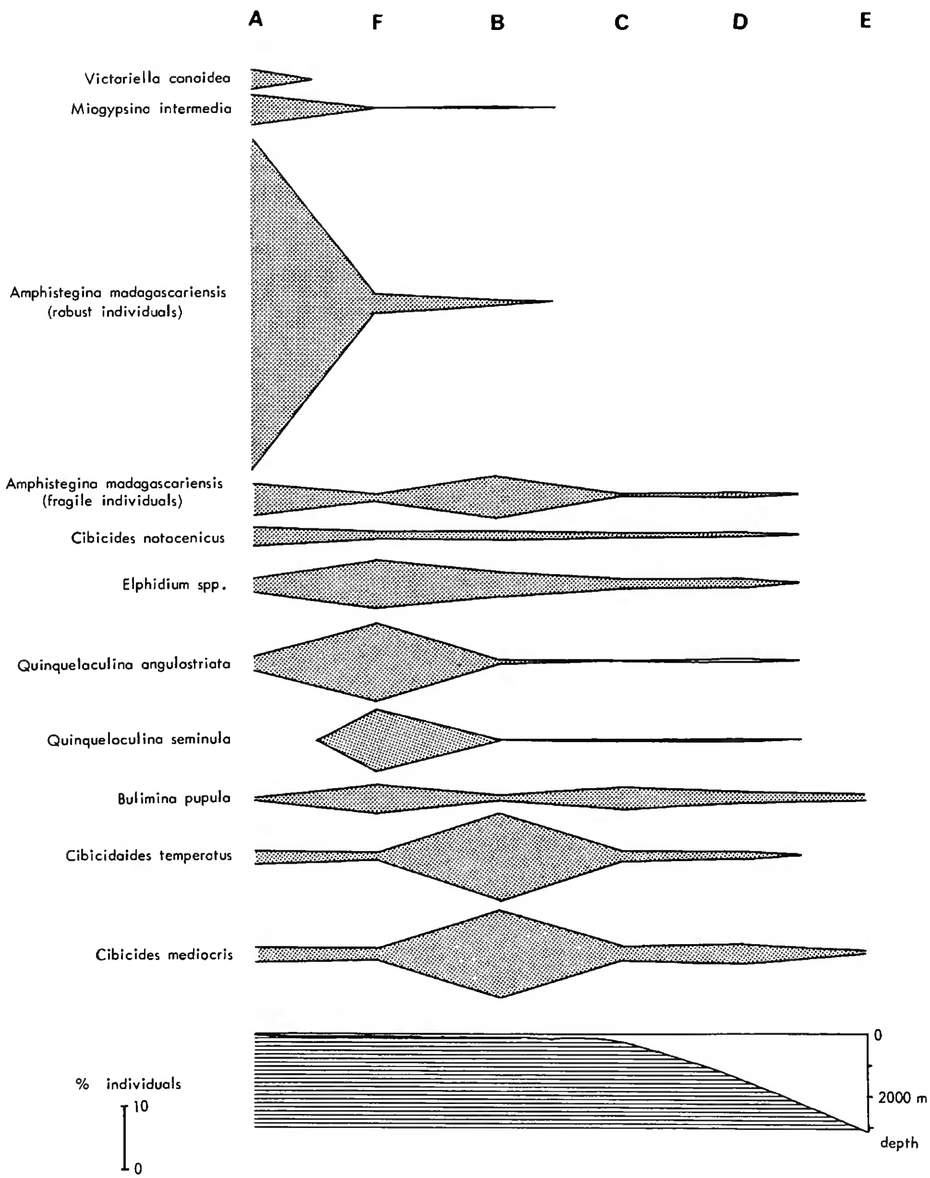

FIGURE 20.—Kite diagrams showing the distribution of common benthic foraminiferal species and genera in thanatotopes A to F. The thanatotopes have been arranged in order of inferred increasing depth as shown by the depth profile at the bottom. The forms in this chart are predominanly neritic species and genera.

lower bathyal (1000–4000 m, Brady 1884; Pflum and Frerichs, 1976).

Other prominent genera in the upper half of the bathyal (200–2000 m) and common in this thanatotope are *Gyroidina, Bulimina, Siphouvigerina, Euuvigerina, Chilostomella, Pleurostomella, Allomorphina, Pullenia,* and *Nonion* (Boltovsky and Wright, 1976:119).

The benthic composition of thanatotope D is intermediate between C and E (Figures 20, 21), with some of the shallower species of C decreasing in abundance (e.g., *Gyroidina zelandica, Euuvigerina*

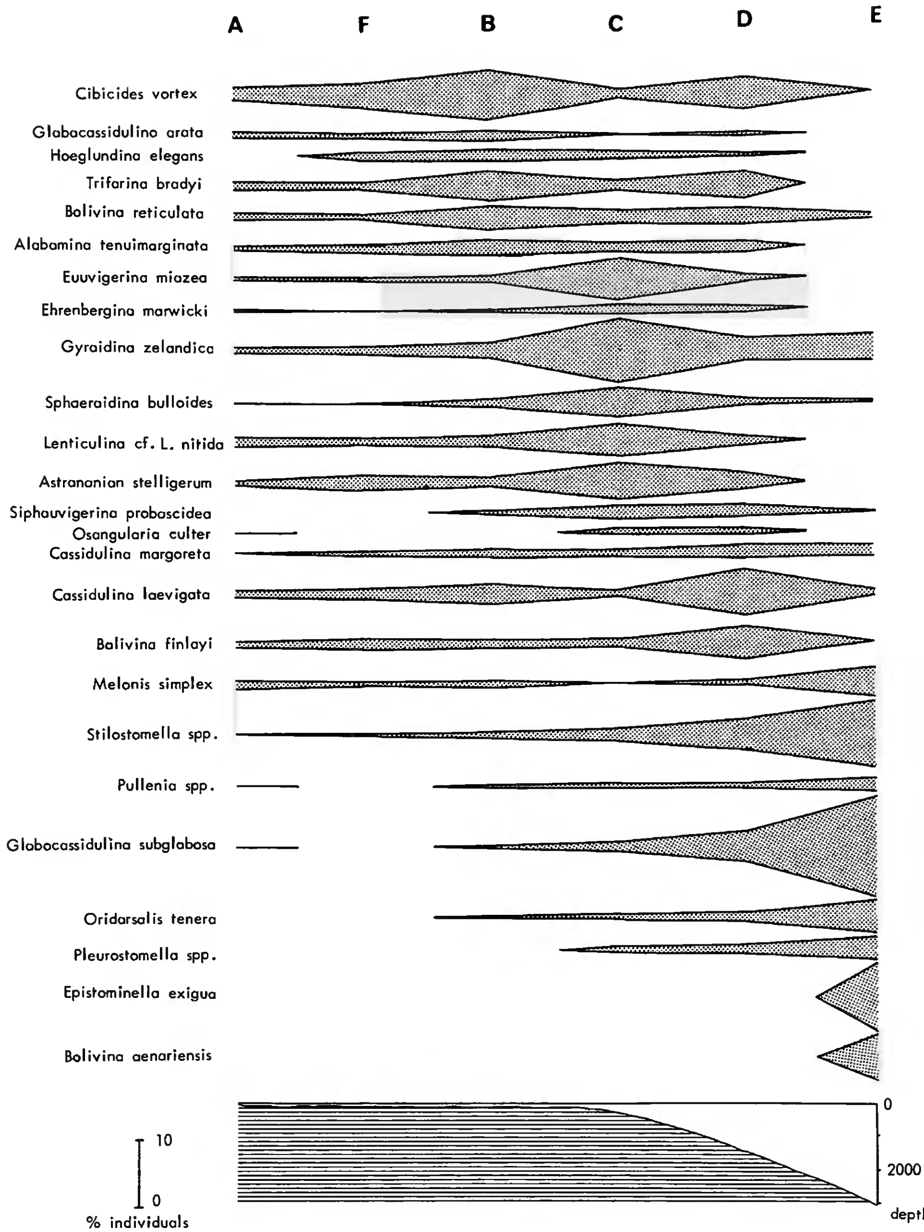

FIGURE 21.—Kite diagrams showing the distribution of common benthic foraminiferal taxa in thanatotopes A to F. The thanatotopes are arranged in order of inferred increasing depth (left to right) as shown by the depth profile at the bottom. The forms in this chart are predominantly outer neritic and bathyal species and genera.

miozea, Astrononion stelligerum, Lenticulina cf. *nitida, Cibicidoides temperatus, Sphaeroidina bulloides)* and many of the deeper forms typical of E, rapidly increasing in abundance (e.g., *Melonis simplex, Oridorsalis umbonatus, Globocassidulina subglobosa, Bulimina truncana, Epistominella* spp., *Pleurostomella* spp., *Stilostomella* spp., *Pullenia* spp.). Several of the dominant species of thanatotope E (e.g., *Epistominella exigua, Bolivina aenariensis)* are not present in D, suggesting that the lower depth limit for this thanatotope is somewhat above the 3000 m level of E.

The upper depth limit is best gauged using several deep-water-restricted genera that commonly occur in D. A combination of *Osangularia culter, Stilostomella* spp., *Pleurostomella* spp., *Oridorsalis umbonatus,* and several others indicates a depth greater than 1000 m (Brady, 1884; Bandy and Chierici, 1966; Bandy and Rodolfo, 1964; Boltovskoy and Wright, 1976; Frerichs, 1970; Lewis, 1971; Pflum and Frerichs, 1976). This is supported by the common presence of globular Pullenias *(P. bulloides),* small costate Buliminas *(Bulimina striata, B. truncana),* small *Eponides (Eponides broeckhianus),* and spinose Uvigerinidae (*Siphouvigerina proboscidea*), which are most abundant in mid–lower bathyal depths (Bandy, 1960).

Some mixing of thanatotope D fauna by downslope displacement is indicated by the rare occurrences of shelf forms (e.g., *Amphistegina, Buccella, Elphidium, Discorbis, Notorotalia, Buliminella elegantissima)* and possibly of some upper bathyal forms (e.g., some *Astrononion, Lenticulina, Saracenaria).*

As in thanatotope C. this thanatotope can be divided into deeper and shallower samples. The bulk of the thanatotope (upper right quadrant in Figure 9) are here considered to be midbathyal (1000–2000 m) assemblages, based on the above data. The two lower left samples N33/f534, 536) do not contain the deep-water-restricted forms mentioned above and have faunas more compatible with an upper bathyal interpretation. They contain abundant shelf and uppermost bathyal (0–500 m) restricted forms (e.g., *Quinqueloculina, Astrononion, Elphidium, Amphistegina, Buliminella elegantissima),* not all of which appear to be displaced.

Thanatotope E: The benthic fauna of thanatotope E is typical of a modern lower bathyal (2000–4000 m) assemblage and is consistent with inferred little change in water depth (3000 m) at DSDP 206 between the early Miocene and now (Burns et al., 1973). The two dominant species *(Globocassidulina subglobosa* and *Epistominella exigua;* Figures 10, 17, 21) are both abundant in modern midbathyal to abyssal sediments (Brady, 1884; Pujos-Lamy, 1973). Other distinctively deep-water-restricted living forms that occur in E include *Bolivina decussata, Cibicidoides kullenbergi, Cibicides wuellerstorfi, Eggerella bradyi, Laticarinina pauperata, Oridorsalis umbonatus, Stilostomella antillea, Pleurostomella* species, and diverse *Fissurina, Lagena, and Parafissurina* species (Ingle, 1973; Boltovskoy and Wright, 1976; Brady, 1884; Phleger, 1960).

The fauna appears to be entirely autochthonous with no shallow-restricted forms present at all (Figures 20, 21).

Thanatotope F: Thanatope F is dominated by miliolids *(Quinqueloculina angulostriata, Q. seminula, Q. plana, Q.* cf. *buchiana, Triloculina trigonula, Lachlanella* cf. *schroekingeri;* Figures 10, 18, 20). Modern miliolid-dominated faunas are confined to warm water lagoons, estuaries, and inner neritic situations (Murray, 1973; Boltovskoy and Wright, 1976). *Quinqueloculina* seldom occurs living in depths greater than 50 m (Bandy, 1960; Murray, 1973). Both fragile and robust *Amphistegina madagascariensis* occur in all three samples, suggesting some mixing of the faunas with a site of accumulation in the deeper part of the inner neritic (20–50 m). Support for an inferred inner neritic environment, especially for N42/f694, comes from the abundance of *Discorbis,* which is also restricted to water depths shallower than 50 m (Murray, 1973). Other elements common in modern inner neritic sediments and present in E are *Elphidium* and *Cibicides.*

The fauna of N28/f912 is significantly different from the other two samples. It is dominated by *Quinqueloculina angulostriata* but also has a strong mid- to outer neritic representation (Figures 18, 20, 21; e.g., *Cassidulina laevigata, Bulimina pupula, Hoeglundina elegans, Cancris, Lenticulina, Astrononion)* that suggest that the fauna is considerably mixed. A midneritic depth of accumulation (50–100 m) with a large allochthonous inner neritic component is most consistent with faunal composition for N28/f912.

Ungrouped Samples: N33/f579. The four most abundant species in this sample (Figure 19) are among the seven most abundant in thanatotope C (Figure 10). The fauna is consistent with an inferred outermost neritic to uppermost bathyal environment (150–400 m) similar to the shallower samples in thanatotopes C and D. In modern sediments, the dominant genera in this sample *(Lenticulina, Astrononion,* and large smooth *Bulimina)* are most abundant in this zone.

N41/f539, N41/f555, N41/f632. These three samples appear to contain greatly mixed faunas derived from several of the thanatotopes (Figures 20, 21): robust *Amphistegina madagascariensis*, *Cibicides motocenicus* (from A), *Elphidium* (from A, B, or F); *Globocassidulina arata*, *Hoeglundina elegans* (from B or C); *Cassidulina laevigata*, *Cibicides mediocris*, *C. refulgens* (from B, C, or D); *Anomalinoides macraglabra*, *Bulimina pupula*, *Lenticulina* cf. *nitida*, *Ehrenbergina marwicki* (from C); and *Globocassidulina subglobosa*, *Osangularia culter* (from D). Since all samples are from massive, coarse-grained beds (Waitakere Hills Group 2) and are interbedded with thanatotope D bearing sediments, it is logical to explain these faunas as of subaqueous mass flow origin. The mass flows originating in the inner neritic (A) and passing over and mixing with outer neritic (B) and upper bathyal (C) sediments before coming to rest in the mid-bathyal (D).

SPECIES DIVERSITY.—The species diversity of shallow water foraminifera (less than 50 or 100 m) is much lower than in deeper waters (Buzas and Gibson, 1969; Gibson and Buzas, 1973; Sen Gupta and Kilbourne, 1974). In deeper water, species diversity either remains constant, increases, or decreases. On others diversity increases to the edge of the shelf, remains constant thereafter or either increases or decreases at lower bathyal and abyssal depths. The reasons why this is so are not clear, but analyses of hundreds of modern samples from the eastern margin of North America document the pattern.

In the present study the inferred depth ranges from thanatotopes A through E increase. Species diversity as measured by the number of species, S, and the information function, H, indicates an increase in diversity from A to B, a slight increase from B to C and D, and a decrease from C and D to E. (Figures 12, 13). Examining the analyses of Gibson and Buzas (1973), one observes a similar pattern for the modern total population in the northeastern Gulf of Mexico (Parker, 1954, traverses VI, VIII, XI). To illustrate the similarities we have tabulated S, H, and E (evenness) from the Gulf of Mexico and the thanatotopes described here (Table 3).

The mean number of species in the samples from the Gulf of Mexico and thanatotope A are nearly identical. H is somewhat higher in the Gulf of Mexico because of the relative evenness of species distributions found there. As already pointed out, thanatotope A is dominated by *Amphistegina*, and, consequently, we observe a low value of E (mean 0.20) resulting in a lower H. Table 3 indicates both the Gulf of Mexico and thanatotope A have much lower species diversities than the other tabulated classes.

In the 50–200 m depth range the samples from the Gulf of Mexico and thanatotope B have very similar species diversity for mean as well as observed ranges.

Thanatotopes C and D have inferred overlapping depth ranges and are grouped adjacent to one another by multidimensional scaling (Figure 9). The number of species and the information function for these thanatotopes and their modern counterparts are similar. H is slightly higher in the fossil example because of the higher values of E recorded there. Whether or not fossil populations consistently have higher values of E in this depth range poses an intriguing ecological question. If so, then populations in the past would have had much less dominance than modern populations. The mean values of 0.57 and 0.61 for both thanatotopes represents a very high value of E; a value of 0.63 would be obtained if individuals were distributed according to MacArthur's broken stick model. The high values of E cannot be due to mixing of different populations unless one of the populations being mixed had even a higher value of E (Gibson and Buzas, 1973).

Thanatotope E has an inferred depth of about 3000 m and the samples from the Gulf of Mexico in the range of 2560 to 3251 m have strikingly similar values.

We conclude that the pattern of species diversity observed for the inferred depth ranges of the thanatotopes are entirely in keeping with what one could expect from observations on modern populations.

PLANKTONIC FORAMINIFERA.—The percentage of planktonic foraminifera in a sample has been used by many workers as a crude indicator of depth (Grimsdale and Morkhoven, 1955; Phleger, 1960; Vella, 1962a; Boltovskoy and Wright, 1976). In present day oceanic sediments, planktonic foraminifera increase in abundance with distance from shore, and this usually parallels increasing depth.

Lewis (1971) studied present-day sediments off the east coast of the North Island of New Zealand, south of Hawkes Bay. He found 0%–50% plank-

TABLE 3.—Number of species (S), information function (H), and evenness (E) for thanatotopes A through E, and modern samples from the northeastern Gulf of Mexico (see text for explanation)

	Depth (m)		Thanatotope (inferred depth in m)	
	mean	o.r.	mean	o.r
	0-50		A 0-50	
S	39.89	27 - 58	38.20	30 - 51
H	2.74	2.06 - 3.18	1.97	1.46 - 2.77
E	.40	.29 - .51	.20	.14 - .31
	50-200		B 50-200	
S	66.82	36 - 79	55.00	39 - 78
H	3.41	2.14 - 3.74	3.15	2.63 - 3.68
E	.46	.23 - .56	.44	.35 - .52
	200-1000		C 200-1000	
S	70.82	64 - 87	64.14	55 - 84
H	3.31	2.86 - 3.75	3.56	3.20 - 4.03
E	.39	.26 - .49	.57	.38 - .69
	150-2000		D 150-2000	
S	73.37	64 - 91	61.65	39 - 84
H	3.40	2.86 - 3.93	3.60	3.60 - 4.02
E	.44	.26 - .71	.61	.48 - .69
	2560-3251		E about 3000	
S	51.33	35 - 88	56.75	55 - 59
H	3.10	2.99 - 3.67	3.25	3.09 - 3.40
E	.45	.35 - .52	.46	.39 - .55

tonics in neritic thanatotopes and generally 60%–90% planktonics in bathyal thanatotopes. Thompson (1975) observed a consistent increase in the planktonic percentage in sediments with increasing depth across the continental shelf, east of Northland, New Zealand. Vella (1962a) defined two deep-water biofacies based on their high planktonic content: semipelagic biofacies (600–1200 m), 40%–60% planktonics; eupelagic facies (1200–4000 m), 70%–100% planktonics. Vella noted, however, that high percentages of planktonics sometimes occur in shallow water and may be due to lengthy periods of onshore winds, such as occur on the west coast of New Zealand. Pflum and Frerichs (1976) summarize data from the Gulf of Mexico that show fewer than 50% planktonics in the neritic, 50% to 90% in the upper bathyal (200–1000 m) and more than 90% in the mid and lower bathyal (1000–4000 m).

In this study, thanatotope A has the fewest planktonic foraminifera and E the most. If the planktonic percentage of each sample is plotted on the multidimensional scaling configuration (Figure 22), there is a definite overall increase in plank-

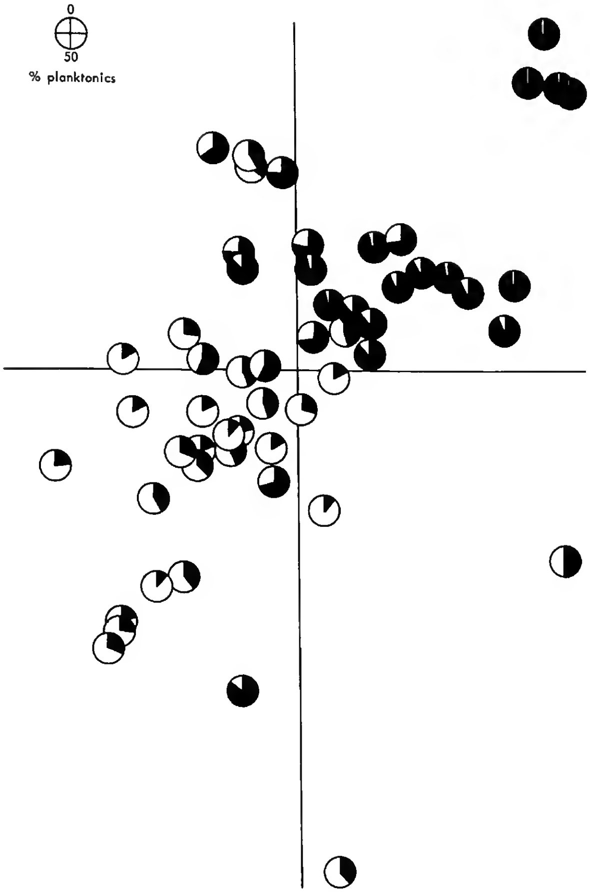

FIGURE 22.—Planktonic percentage of total foraminiferal fauna for each sample plotted on the multidimensional scaling configuration (Figures 7, 9). The inferred shallow water samples in the bottom left quadrant have smaller planktonic percentages than the inferred deepest (lower bathyal) samples in the upper right.

tonics from bottom left to upper right. This "SW-NE" axis is interpreted as one of increasing depth. Thanatotope A is the shallowest thanatotope followed by B and F, then with steadily increasing depth C, D, and lastly E. The average planktonic percentage of samples in A, B, and F is less than 40%. Using the data of Vella (1962a), Lewis (1971), and Thompson (1975), we conclude that these three thanatotopes are neritic. The planktonic percentages of samples in C and the lower left (shallower) samples of D are mostly 40%–75%, not inconsistent with a depth interpretation of upper bathyal (200–1000 m). The upper right (deeper) samples in D are mostly 85%–99% planktonics and are possibly midbathyal (1000–2000 m). The consistent 99.5% planktonics in E is consistent with a depth similar to that at their present position in the New Caledonia basin (3000 m, lower bathyal).

MACROFAUNA.—Rich macrofaunas are absent from all thanatotope A, C, E, and F samples, as well as ungrouped samples N33/f579 and N41/f632.

Thanatotope B samples from Pakaurangi Point (Pakaurangi Formation–Figure 5) come from richly macrofossiliferous beds, from which Jones (1970) concluded an environment of warm (23°–27° C) marine waters at depths varying from 20 to 250 m (mostly midneritic). These depths are compatible with those we inferred from the foraminifera (50–200 m, Table 4).

Most thanatotope D faunas are from non-macrofossiliferous sediments, but four of the samples from the north Waitakere Hills (N41/f2d, f590u, f590n, and f592) come from sediments containing sparse macrofaunas (Hayward, 1976b). These faunas are typical deepwater assemblages and contain several bathyal-restricted genera of gastropod, bivalve, and ahermatypic coral (Hayward, 1976b) and have been interpreted on the basis of these, together with the more definitive benthic foraminifera, as midbathyal (Hayward, 1976a, 1976b).

The two ungrouped samples, N41/f539 and f555, have rich macrofaunas (Hayward, 1976b, 1977c, 1977d). Like the microfaunas, these macrofaunas are greatly mixed and derived from the same wide range of thanatotopes, with members from inner neritic hermatypic coral banks and gravels, midneritic sands, and bathyal sands and silts (Hayward, 1976b). These mixed macrofaunas lend support to the subaqueous mass flow origin already proposed for Waitakere Hills Group 2 samples.

PREVIOUS DEPTH INTERPRETATIONS.—Depth interpretations for thanatotopes based upon their benthic foraminifera and supported by their benthic species diversities and planktonic content are summarised in Table 4 and shown as a general deepening trend towards the upper right on the multidimensional scaling configuration (Figure 23).

Traditional models of the Waitemata Basin (thanatotope D) envisaged it as a shallow basin or lagoon (Bartrum, 1929; Brothers, 1954; Searle, 1964). A limited study of the benthic foraminifera in three samples from Muriwai, north Waitakere Hills (Bandy, et al., 1970), indicated that basin

TABLE 4.—Inferred depth zones for thanatotopes A through F and ungrouped samples

Thanatotope	Depth zones	Depth range
A	inner neritic	0 - 50 m
B	outer neritic	50 - 200 m
C	upper bathyal	200 - 1000 m
1. shallow samples (f578, f580, f581)	uppermost bathyal	200 - 400 m
2. deeper samples (f622,f644,f696,f723)	lower upper bathyal	800 - 1000 m
D	upper-mid bathyal	200 - 2000 m
1. shallow samples (f534, f536)	uppermost bathyal	200 - 500 m
2. deeper samples (remainder)	mid-bathyal	1000 - 2000 m
E	lower bathyal	3000 m
F	inner-mid neritic	20 - 100 m
1. shallower samples (f694, f914)	inner neritic	20 - 50 m
2. deeper sample (f912)	mid neritic	50 - 100 m
Ungrouped		
1. f579	uppermost bathyal	150 - 400 m
2. f539, f555, f632	inner neritic - mid bathyal	greatly mixed

depths could have been far greater than originally thought. Bandy, et al., concluded depths of greater than 2000 m for one sample and 200–500 m for the other two. Considering their small faunas, these depths are not substantially different from our 1000–2000 m interpretation for the same sequence (N41/f590n, f590u, f604—thanatotope D). The basin depths of 700–2000 m, deduced from turbidity current models (Ballance, 1974), are extremely close to ours.

Although nine of our samples were splits of Scott's (1970a) processed samples, percentage histograms of the common species differ greatly between the two studies. Undoubtedly this difference can be explained in that Scott's counts are of large individuals ($\geq$0.152 mm) and our counts include individuals down to half this size ($\geq$0.075 mm). Despite these differences and different methods used in analysis, the two studies concur on a threefold division of the samples (although Scott's study divided one of these three groupings into four smaller clusters). These divisions are as follows.

1. N28/f781 cluster with our thanatotope A (inner neritic) and Scott's A5 ("near-shoal"). Both interpretations agree upon a coarse sediment, shallow environment.

2. N33/f534 and f536 clustered with our thanatotope D (shallow samples, uppermost bathyal) and Scott's A4 ("back-shoal"). Environmental interpretation of these two samples differs greatly. We consider that a "back-shoal" lagoonal-type of environment is highly unlikely because of their planktonic content, their similarity to our deeper-water thanatotope D samples, and the rarity of the most abundant species (*Cassidulina laevigata*) in such shallow environments today.

3. Six samples (N28/f785, f788, f792, f793; N33/f531, f532) clustered in our thanatotope B (outer neritic) but occur scattered through Scott's A1, A2, A3, and ungrouped ("fore-shoal" and "outer shelf"). Scott's interpretation of these thanatotopes as downslope away from his "shoal," and possibly laterally contiguous, is compatible with our broader outer neritic interpretation.

Paleogeography

The spatial distribution of thanatotopes (Figure 24) suggests the former presence (during late Otaian–mid-Altonian) of two areas of shelf separated and bounded to the east by a bathyal basin. Both neritic shelf areas (thanatotopes A, B, and

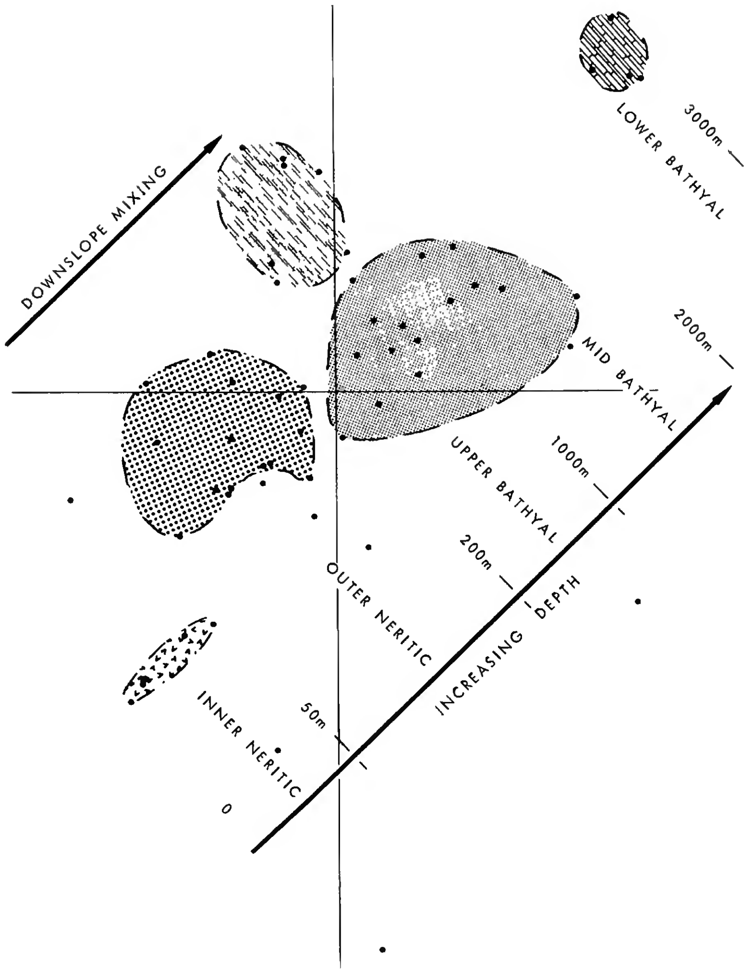

FIGURE 23.—Two-dimensional configuration of samples produced by multidimensional scaling using euclidian distance with thanatotopes A-E shown (as in Figure 9). Paleodepth interpretations based upon the foraminifera are plotted and indicate a general trend of increasing depth towards the upper right. Downslope mixing of the faunas is most noticeable in the outer neritic and upper bathyal zones.

F) are separated from the midbathyal basin (thanatotope D) by an upper bathyal zone (thanatotope C). This distribution pattern is compatible with the traditional paleogeographic model of a flysch basin bounded to the north and west by the Waitakere arc (Searle, 1964; Ballance, 1965, 1974).

Using the depth interpretations of the benthic foraminiferal thanatotopes, together with stratigraphic, lithologic, paleocurrent, and macrofaunal data, a more precise picture of the paleogeography along the western side of the Waitemata Basin can be obtained.

The elongate Waitemata flysch basin was 50–80 km wide and 100–150 km long, bounded to the east by the central basement high (Figures 2, 25) and to the west by the Waitakere volcanic pile. In the north the basin lapped onto the southern end of the northern landmass (Figure 2), forming a marine shelf through which the Kaipara center of the Waitakere Volcanic Arc was erupting (Figure 25). Sediment derived from the basement high and northwestern shelf flowed southeast into the basin via submarine canyons and channels (Ballance, 1974; Hayward, 1975a). This sediment was mostly transported as turbidites, which accumulated in the basin at midbathyal depths of 1000–2000 m (as

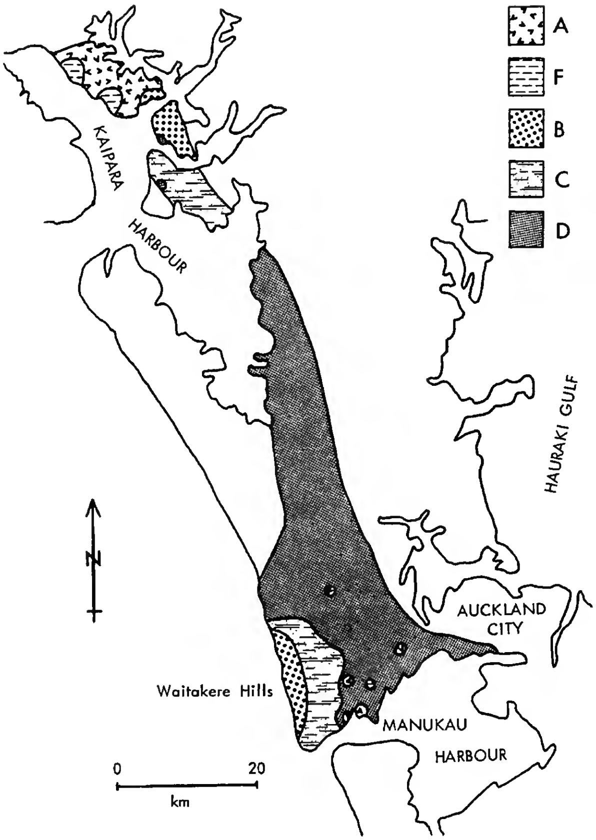

FIGURE 24.—Generalized distribution of thanatotopes in southern Northland based upon the sample studies.

indicated by thanatotope D faunas in the interturbudite sediments, e.g., N42/f683), having travelled up to 100 km down an average submarine slope of 0.6°–1.2°. A fan built up around the base of the canyons that arose on the northwestern shelf, and conglomerates (Albany and Helensville Conglomerates) accumulated in the lower canyons and channels of the upper fan.

Coarse subaqueous sediment gravity flow deposits occur sporadically within the basin flysch sequence, especially in the west and northwest. From the lithologies of the larger clasts it can be deduced that some flowed down the canyons from the northwestern shelf, whereas other (containing solely andesitic material) came down the slopes of the Waitakere volcanic pile. All the Waitakere Hills Group 2 samples have shallow or mixed benthic foraminiferal faunas and were probably displaced downslope in sediment gravity flows. Samples derived from the northwestern shelf include N42/f694 (thanatotope F) N41/f533, f537, f657 (thanatotope A) and N41/f539, f632 (ungrouped, mixed neritic-bathyal). N41/f555 (ungrouped, mixed neritic-bathyal) probably came from the Waitakere volcanic pile, as it contains andesite boulders up to 2 m across and no Cretaceous or early Tertiary sedimentary clasts typical of the northwestern shelf.

The Waitemata Basin was bordered to the southwest by the submarine pile of the Waitakere volcanic centre. This was composed of coarse volcaniclastic sediments and pillow lavas (Piha Formation) margined by finer grained volcanic sediments (Nihotupu Formation) that graded eastwards into the basin flysch. The presence of aerially erupted tephra and inner neritic hermatypic corals in sediment gravity flows on the pile's flanks (e.g., N41/f555, f567; Hayward, 1977a, 1977c, 1977e) indicate that shallow water and volcanic islands were present (Figure 25). Only a single microfossiliferous sample (N41/f660, thanatotope B) was obtained from the Piha Formation and this is consistent with inferred neritic to upper bathyal (0–800 m) depths of deposition for the pile slopes. Samples from the finer grained sediments of the Nihotupu Formation (Waitakere Hills Group 1) all cluster in the deeper halves of thanatotopes C and D (Table 4) and are interpreted as lowermost upper bathyal–midbathyal (800–2000 m). Stratigraphically, a slight shallowing on the eastern flanks of the pile could be inferred to have occurred in early Altonian times, on the basis of the three youngest samples all belonging to thanatotope C (Figure 26). On the northern slopes, however, no shallowing is indicated until later mid-Altonian times, when fault movement, submarine channel erosion and eruption of nearby subaerial vents occurred (Hayward, 1977a). This mid-Altonian shallowing was general over the whole Waitakere Hills area, as the volcanic pile's marine sediments are conformably overlain in many places by terrestrial andesite flows and pyroclastics (Hayward, 1977e).

In the late Otaian–early Altonian times, a northwestern neritic shelf existed in the area of present-day central Kaipara. This shelf was underlain by uplifted Cretaceous–lower Tertiary sediments and some bathyal lower Miocene sediments (Waitemata Group, Puriri and Timber Bay Formations). Samples from the lowest shelf sediments (Okahukura and Pakaurangi Formations) in the outcrop area

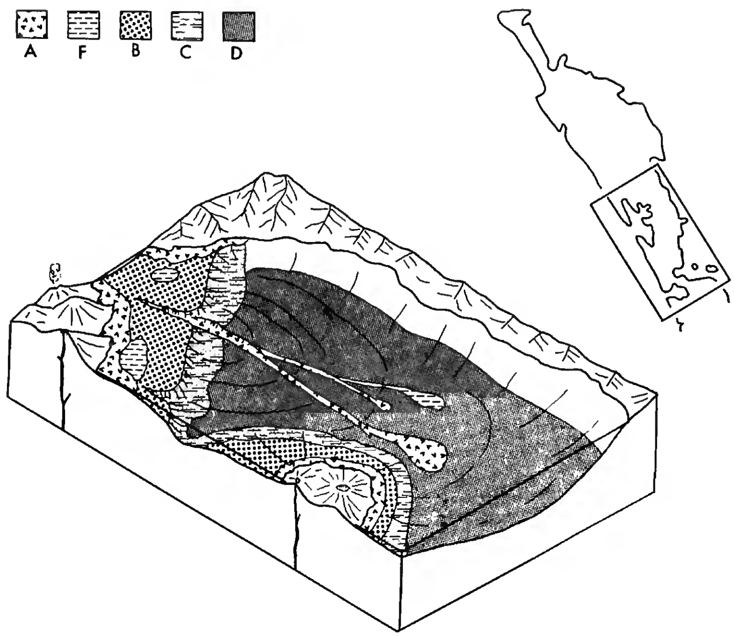

FIGURE 25.—Interpretation of the paleogeography of southern Northland in the late Otaian–early Altonian showing thanatotope distribution. The elongate, bathyal (thanatotope D), Waitemata Basin covered the central area, bounded to the east by a basement high landmass. The basin was bounded in the southwest by the Waitakere volcanic pile (thanatotopes A, B, C) and in the northwest by a neritic shelf (thanatotopes A, B, F) with associated Kaipara volcanic centre. Submarine canyons channelled subaqueous sediment gravity flows (containing thanatotopes A and F) from the north-western shelf down into the Waitemata Basin.

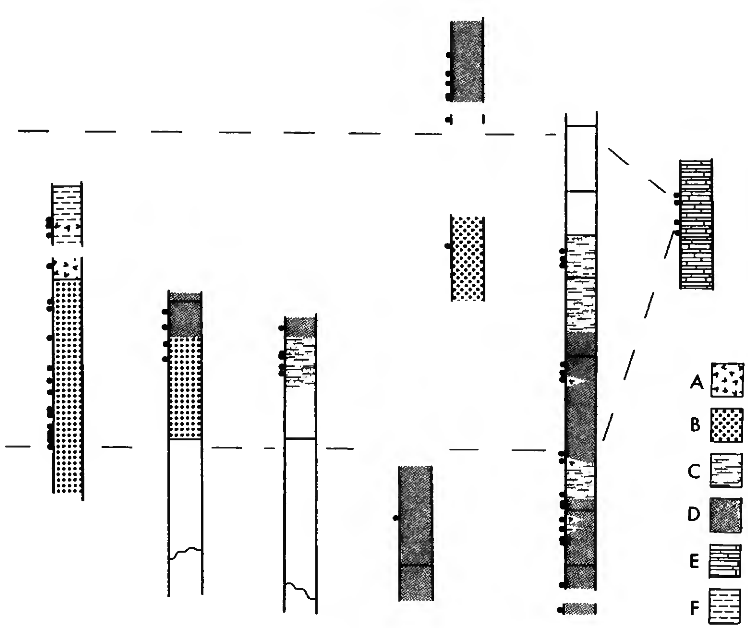

FIGURE 26.—Lithostratigraphic columns (Figure 5), showing distribution of thanatotopes, both spatially and temporally.

cluster in thanatotopes B, C, and D, indicating uppermost bathyal–outer neritic depths (50–500 m, Table 4). The deeper samples (shallow parts of thanatotopes C and D, and ungrouped N33/f579, uppermost bathyal) occur in the southern two peninsulas (Figure 26), with a shallowing towards the north where all the outer neritic thanatotope B samples occur. This shelf was not stable, as indicated by numerous sediment wedges, unconformities, and by the changing foraminiferal thanatotopes.

Activity of the Kaipara centre of the Waitakere Volcanic Arc advanced eastwards into the outcrop area in late early Altonian period (Figure 25) and may have been associated with the general shallowing indicated by the thanatotopes and lithologies of the youngest (lower Altonian) sediments of the Waitakere Group in this area (Puketi Formation, undifferentiated Hukatere Subgroup, Figure 26). The sediments are mostly inner neritic (0–50 m, thanatotopes A and F), with some midneritic (50–100 m, thanatotope F) and some terrestrial deposits.

Systematics

This section catalogues all the benthic foraminiferal taxa identified during the faunal analysis of the 55 samples, together with a few extra species identified from less fossiliferous samples from the Waitakere Hills. The location of these additional samples is given in Appendix B.

The holotypes and some paratypes of the three new species described are deposited in the New Zealand Geological Survey, Lower Hutt (TF numbers); paratypes of these three new species are also deposited in the Geology Department, University of Auckland (F numbers), and the National Museum of Natural History, Smithsonian Institution, Washington, D. C. (USNM number = catalog numbers using the abbreviation for the former United States National Museum). All other figured specimens are deposited in the National Museum of Natural History (USNM numbers).

In this section the genera are listed alphabetically under the three suborder headings Textulariina, Miliolina, and Rotaliina.

Taxonomic work on the benthic foraminifera from the Waitemata and Waitakere Groups was initiated by Karrer (1864) using the fauna in a single sample from the central part of the Waitemata Basin at Orakei Bay, Auckland. Hornibrook (1971) recently revised Karrer's work and reduced the number of recognized species with Orakei Bay type localities to 17. Finlay (1939b, c, 1940) and Hornibrook (1958) described five new species with type-localities at Pakaurangi Point, Pakaurangi Formation (*Bolivina lapsus* Finlay, *Cancris brevior* Finlay, *Cerobertina bartrumi* Finlay, *Discorbis galerus* Finlay, *Loxostomum pakaurangiensis* Hornibrook), and one new species with a type-locality in the Waitemata Group, Waiheke Island (*Notorotalia powelli* Finlay).

Faunas from these two groups have been listed by several workers: Chapman (1926) from Orakei Bay and Titirangi (Waitemata Group) and Pakaurangi Point (Pakaurangi Formation); Finlay (in Searle, 1944) from the north side of Manukau Harbour (Waitemata Group); Hornibrook and Schofield (1963) from the southern part of Waitemata Basin, south of Auckland; Jones (1970) from Pakaurangi Point (Pakaurangi and Puketi Formations).

Order FORAMINIFERIDA Eichwald, 1830

Suborder TEXTULARIINA Delage and Hérouard, 1896

Ammodiscus archimedis (Stache)

Cornuspira archimedis Stache, 1864;180, pl. 22: figs. 1a,b.
Ammodiscus archimedis (Stache).—Hornibrook, 1971:30, pl. 5: figs. 72–74.

Distribution.—One specimen in N41/f612. Cornwallis Formation.

Ammodiscus finlayi Parr

Plate 1: figure 7

Ammodiscus finlayi Parr, 1935:80, pl. 19: figs. 5, 6.

Distribution.—Four specimens in N41/f612. Cornwallis Formation.

Arenodosaria antipoda (Stache)

Clavulina antipodum Stache, 1864:161, pl 21: figs. 3–8.
Arenodosaria antipoda (Stache).—Hornibrook, 1971:32, pl. 5: figs. 77, 78.

DISTRIBUTION.—One specimen in N41/f555. Nihotupu Formation.

Bathysiphon species

PLATE 1: FIGURE 8

DISTRIBUTION.—Rare in thanatotope D. Nihotupu Formation.

Bolivinopsis compta Finlay

Bolivinopsis compta Finlay, 1947:262, pl. 1: fig. 8–12.—Hornibrook, 1968:48, fig. 6.

DISTRIBUTION.—Rare in thanatotopes B, D, and E. Nihotupu Formation, Pakaurangi Formation, Waitemata Group, DSDP.

Bolivinopsis cubensis (Cushman and Bermudez)

Spiroplectoides cubensis Cushman and Bermudez, 1937:13, pl. 1: figs. 44, 45.
Bolivinopsis cubensis (Cushman and Bermudez).—Hornibrook, 1961:15, pl. 1: fig. 1.

DISTRIBUTION.—Rare in thanatotopes A, B, and F. Cornwallis Formation, Pakaurangi Formation.

Bolivinopsis species

PLATE 1: FIGURE 12

DESCRIPTION.—Early portion planispiral, later uncoiled and biserial; sutures with raised, strong ribs; spiral sutural rib with radial sutural rib branches, continuing as medial rib with alternate sutural ribs in biserial portion; early portion of coil occurs in a wide depression surounded by spiral rib.

DISCUSSION.—This form differs from all described species in its distinctive sutural ribs. It is represented by four juvenile or broken specimens, insufficient material for a new species.

DISTRIBUTION.—Extremely rare in thanatotope E. DSDP.

Cyclammina incisa (Stache)

Haplophragmium incisum Stache, 1864:165, pl. 21: fig. 1.
Cyclammina incisa (Stache).—Hornibrook, 1971:34, pl. 6: figs. 88–91.—Quilty, 1974:33, pl. 1: figs. 1–3.

DISTRIBUTION.—One specimen in N41/f555. Nihotupu Formation.

Dorothia minima (Karrer)

Textularia minima Karrer, 1864:79, pl. 16: fig. 9.
Dorothia minima (Karrer).—Hornibrook, 1961:28, pl. 2: fig. 27; 1971:16, pl. 1: figs. 16–20.

DISTRIBUTION.—Extremely rare in thanatotope B. Pakaurangi Formation.

Eggerella bradyi (Cushman)

Verneuilina pygmaea (Egger).—Brady, 1884:385, pl. 47: figs. 4–7.
Verneuilina bradyi Cushman, 1911:54.
Eggerella bradyi (Cushman).—Gibson, 1967:11, pl. 2: fig. 21.

DISTRIBUTION.—Extremely rare in thanatotope E. DSDP.

Eggerella ihungia Finlay

Eggerella ihungia Finlay, 1940:450, pl. 62: figs. 11–13.

DISTRIBUTION.—Extremely rare in thanatotope C. Nihotupu Formation.

Gaudryina convexa (Karrer)

Textularia convexa Karrer, 1864:78, pl. 16: fig. 8.
Gaudryina convexa (Karrer).—Hornibrook, 1971:16, pl. 1: figs. 8–15.—Quilty, 1974: pl. 1, figs. 14, 15.

DISTRIBUTION.—Extremely rare in thanatotope B. Pakaurangi Formation.

Gaudryina healyi Finlay

Gaudryina healyi Finlay, 1939c:311, pl. 25: figs. 34, 35.

DISTRIBUTION.—One specimen in N41/f645, Nihotupu Formation. Possibly reworked from Cretaceous strata.

Gaudryina quadrazea Hornibrook

Gaudryina quadrazea Hornibrook, 1961:25, pl. 2: figs. 22, 28.

DISTRIBUTION.—Extremely rare in thanatotope D. Nihotupu Formation.

Gaudryina whangaia Finlay

Gaudryina whangaia Finlay, 1939:311, pl. 25: figs. 29–31.

DISTRIBUTION.—Extremely rare in thanatotope D. Nihotupu Formation. Possibly reworked from Cretaceous strata.

Glomospira corona Cushman and Jarvis

Glomospira charoides var. *corona* Cushman and Jarvis, 1928: 89, pl. 12: figs. 9–11.
Glomospira corona Cushman and Jarvis.—Hornibrook, 1968: 42, fig. 4.

DISTRIBUTION.—Rare in thanatotopes A and F. Cornwallis Formation. Nihotupu Formation. Probably reworked from Cretaceous and lower Tertiary strata.

Haeuslerella decepta Hornibrook

Haeuslerella decepta Hornibrook, 1961:21, pl. 2: fig. 30.

DISTRIBUTION.—Extremely rare in thanatotope C. Nihotupu Formation.

Haeuslerella hectori Finlay

Haeuslerella hectori Finlay, 1939c:310, pl. 24: fig. 11, 12, 20. —Hornibrook, 1961:20, pl. 2: fig. 31; 1968:94, fig. 18.

DISTRIBUTION.—Extremely rare in thanatotope D. Cornwallis Formation.

Haeuslerella pukeuriensis Parr

Haeuslerella pukeuriensis Parr, 1935:83, pl. 19: figs. 7a, b.—Hornibrook, 1961:21, pl. 2: figs. 32, 33; 1968:94, fig. 18.

DISTRIBUTION.—Rare in thanatotopes B, C, and D. Pakaurangi Formation.

Karreriella bradyi (Cushman)

Guadryina pupoides d'Orbigny.—Brady, 1884:373, pl. 46: figs. 1–4.
Gaudryina bradyi Cushman, 1911:67, text fig. 107.
Karreriella bradyi (Cushman).—Hornibrook, 1961:28.

DISTRIBUTION.—Extremely rare in thanatotope E. DSDP.

Martinotiella communis (d'Orbigny)

PLATE 1: FIGURE 9, 10

Clavulina communis d'Orbigny, 1846:196, pl. 12: figs. 1–2.
Martinotiella communis (d'Orbigny).—Hornibrook, 1961:29, pl. 27: fig. 536.

DISTRIBUTION.—Rare in thanatotopes B, C, and D. Cornwallis Formation, Pakaurangi Formation.

Martinotiella species

PLATE 1: FIGURE 11

DESCRIPTION.—Test coarsely agglutinated with additional irregularly arranged spicules.

DISTRIBUTION.—Extremely rare in thanatotope E. DSDP.

Pelosina complanata Franke

PLATE 2: FIGURE 13

Pelosina complanata Franke, 1912:107, pl. 3: fig. 1.

DISTRIBUTION.—Extremely rare in thanatotope A. Cornwallis Formation, Nihotupu Formation. Probably reworked from Cretaceous or lower Tertiary strata.

Recurvoides species

PLATE 2: FIGURE 14

DESCRIPTION.—Subglobular test, smoothly arenaceous; streptospiral, with 6–7 chambers per whorl; sutures distinct; flush; small, indistinct areal aperture with lip.

DISTRIBUTION.—Extremely rare. Three specimens in N41/f632, Nihotupu Formation.

Rzehakina epigona (Rzehak)

Silicina epigona Rzehak, 1895:214, pl. 6: fig. 1.
Rzehakina epigona (Rzehak).—Scott, 1961:21: figs. 10–23.—Hornibrook, 1968:42, fig. 4.

DISTRIBUTION.—Rare in thanatotopes A, B, D, and F. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation, Waitemata Group. Probably reworked from Cretaceous and lower Tertiary strata.

Semivulvulina capitata (Stache)

PLATE 2: FIGURES 15, 16

Textilaria capitata Stache, 1864:270, pl. 24: figs. 19a–c.
Vulvulina (Semivulvulina) capitata (Stache).—Hornibrook, 1971:31, pl. 5: fig. 76.
Semivulvulina capitata (Stache).—Quilty, 1974:37, pl. 1: fig. 11.

DISTRIBUTION.—Frequent in thanatotope C, extremely rare in thanatotope D. Nihotupu Formation, Pakaurangi Formation.

Siphotextularia awamoana Finlay

Siphotextularia awamoana Finlay, 1939b:91, pl. 14: figs. 89, 90. —Hornibrook, 1961:22, pl. 1: figs. 11, 12; 1968:68, fig. 12.—Gibson, 1967:9, pl. 1: figs. 14–16.

DISTRIBUTION.—Extremely rare in thanatotopes C and F. Nihotupu Formation, undifferentiated Hukatere Subgroup.

Textularia awamoana Hornibrook

Textularia awamoana Hornibrook, 1961:18, pl. 1. figs. 8, 9.

DISTRIBUTION.—Rare in thanatotopes B, C, D, and E. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation, DSDP.

Textularia hayi Karrer

Textilaria hayi Karrer, 1864:78, pl. 16: fig. 7.
Textularia hayi Karrer.—Hornibrook, 1971:15, pl. 1: figs. 1–7.

DISTRIBUTION.—Rare in thanatotopes C and D. Nihotupu Formation, Pakaurangi Formation, Waitemata Group.

Textularia miozea Finlay

Textularia miozea Finlay, 1939a:509; 1947:266, pl. 2: figs. 18–20.—Hornibrook, 1961:17, pl. 1: fig. 15; 1968:72, fig. 13. —Gibson, 1967:8, pl. 1: figs. 3, 4.

DISTRIBUTION.—Extremely rare in thanatotopes C and D. Nihotupu Formation, Waitemata Group.

Textularia ototara Hornibrook

Textularia ototara Hornibrook, 1961:17, pl. 1: figs. 6, 10.

DISTRIBUTION.—Extremely rare in thanatotope B. Pakaurangi Formation.

Textularia saggitula Defrance

Textularia saggitula Defrance, 1824:177.—Brady, 1884:361, pl. 17: figs. 17, 18.

DISTRIBUTION.—Extremely rare in thanatotope E. DSDP.

Triplasia marwicki Loeblich and Tappan

PLATE 2: FIGURE 17

Triplasia marwicki Loeblich and Tappan, 1952:46, pl. 8: figs. 2–4.

DISTRIBUTION.—Extremely rare in thanatotope C. Nihotupu Formation.

Tritaxilina languida Finlay

Tritaxilina languida Finlay, 1939b:98, pl. 37: figs. 37–39.

DISTRIBUTION.—One specimen in N42/f733. Cornwallis Formation. Possibly reworked from lower Tertiary strata.

Trochammina species

DESCRIPTION.—Test trochospiral, finely agglutinated; 12–13 chambers per whorl; sutures curved, slightly depressed; interiomarginal aperture.

DISTRIBUTION.—Extremely rare in thanatotope B. Pakaurangi Formation.

Vulvulina pennatula (Batsch)

Nautilus (Orthoceras) pennatula Batsch, 1791:3, 5, pl. 4, figs. 13a–e.
Bigenerina pennatula (Batsch).—Brady, 1884:373, pl. 45, figs. 5–8.
Vulvulina pennatula (Batsch).—Hornibrook, 1961:24.

DISTRIBUTION.—Extremely rare in thanatotope E. DSDP.

Suborder MILIOLINA Delage and Hérouard, 1896

Articulina parri Cushman

PLATE 2: FIGURES 18–21

Articulina parri Cushman, 1944:10, pl. 3: figs. 7–10.

DESCRIPTION.—Early portion quinqueloculine, adult with one and rarely two rectilinear chambers; quinqueloculine chambers slightly elongate with broadly rounded periphery; rectilinear chambers oval in section, compressed towards aperture; ornament of longitudinal costae; aperture terminal, elongate elliptical, with distinct, slightly flaring lip.

DISCUSSION.—This is the first New Zealand record of *Articulina parri* Cushman; previously known only from the Miocene of Australia. The species is distinguished by its elongate aperture, strong costae and broadly rounded early chambers. Unbroken adult specimens are rare; most individuals lack the rectilinear chambers or consist of broken portions.

DISTRIBUTION.—Extremely rare in thanatotopes B, C, D, and F. Nīhotupu Formation, Pakaurangi Formation, undifferentiated Hukatere Subgroup.

Lachlanella cf. *L. schroekingeri* (Karrer)

PLATE 2: FIGURES 22, 23

DISCUSSION.—Specimens in this study are similar to those figured as *Quinqueloculina schroekingerii* Karrer (1868:149, pl. 2: fig. 12) and as *Lachlanella schroekingeri* (Karrer) by Luczkowska (1974:94, pl. 10: figs. 4a-c).

DISTRIBUTION.—Frequent in thanatotope F, rare in thanatotopes A, B, D, and E. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation, undifferentiated Hukatere Subgroup, Waitemata Group, DSDP.

Pyrgo anomala (Schlumberger)

PLATE 2: FIGURE 24

Biloculina anomala Schlumberger, 1891:182, pl. 11: figs. 84–86.—Vella, 1957:29, pl. 7: figs. 135, 136.—Gibson, 1967:18.

DISTRIBUTION.—Frequent in thanatotope F, rare in thanatotopes B and D. Nihotupu Formation, Pakaurangi Formation, undifferentiated Hukatere Subgroup.

Pyrgo depressa (d'Orbigny)

PLATE 2: FIGURE 25

Biloculina depressa d'Orbigny, 1826:298, no. 7, "Modèle, No." 91.

Pyrgo depressa (d'Orbigny).—Vella, 1957:29, pl. 7: figs. 137, 140.

DISTRIBUTION.—Extremely rare in thanatotopes B and D. Pakaurangi Formation.

Pyrgo cf. *P. lucernula* (Schwager)

PLATE 3: FIGURE 26

DISCUSSION.—Several specimens of *Pyrgo* are most similar to *Pyrgo lucernula* (Schwager) (as *Biloculina lucernula,* 1866:202, pl. 4: fig. 17a, b; and as *Pyrgo lucernula* (Schwager), Barker, 1960, pl. 3: figs. 6, 14).

DISTRIBUTION.—Extremely rare in thanatotope F. Undifferentiated Hukatere Subgroup.

Quinqueloculina angulostriata Cushman and Valentine

PLATE 3: FIGURES 27, 28

Quinqueloculina angulostriata Cushman and Valentine, 1930: 12, pl. 2: figs. 5a–c.—Quilty, 1974:49, pl. 2: figs. 41, 42.

DISTRIBUTION.—Abundant in thanatotope F, frequent in thanatotopes A, B and D. Cornwallis Formation, Nihotupu Formation, Pakaurangi Forma tion, undifferentiated Hukatere Subgroup.

Quinqueloculina cf. *Q. buchiana* d'Orbigny

PLATES 3: FIGURES 29–31

DISCUSSION.—Many *Quinqueloculina* specimens are most similar to *Quinqueloculina buchiana* d'Orbigny (1846:289, pl. 18: figs. 10–12).

DISTRIBUTION.—Frequent in thanatotope F, rare in thanatotopes A, B, D, and E. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation, undifferentiated Hukatere Subgroup, DSDP.

Quinqueloculina plana d'Orbigny

PLATE 3: FIGURES 32, 33

Quinqueloculina plana d'Orbigny, 1850:409.—Fornasini, 1905: 64, pl. 2: fig. 11.

DISTRIBUTION.—Common in thanatotope F, frequent in thanatotope D, rare in thanatotopes A and B. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation, undifferentiated Hukatere Subgroup.

Quinqueloculina seminula (Linnaeus)

PLATE 3: FIGURE 34

Serpula seminulum Linnaeus, 1758:786, pl. 2: figs. 1a–c.

Miliolina seminulum (Linnaeus).—Brady, 1884, pl. 5: fig. 6.

Quinqueloculina seminulum (Linnaeus).—Quilty, 1974:52, pl. 2: figs. 52, 53.

DISTRIBUTION.—Abundant in thanatotope F, frequent in thanatotope D, rare in thanatotopes B, C, and E. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation, undifferentiated Hukatere Subgroup, Waitemata Group, DSDP.

Quinqueloculina singletoni Crespin

PLATE 3: FIGURES 35, 36

Quinqueloculina singletoni Crespin, 1950:72, pl. 10: fig. 6.

DESCRIPTION.—Test slender, fusiform, about three times longer than broad; periphery rounded; chambers elongate, semicircular in section, covered with strong costae running entire length; aperture circular, terminal on neck.

DISCUSSION.—This is the first New Zealand record of *Quinqueloculina singletoni* Crespin, previously known only from the Eocene of Australia.

Sigmoilina victoriensis Cushman

PLATE 3: FIGURE 37

Sigmoilina sigmoidea (Brady) var. *compressa* Cushman, 1946a: 32, pl. 5: figs. 10–12.
Sigmoilina victoriensis Cushman, 1946b:103.—Quilty, 1974:55, pl. 2: figs. 65, 66.
Sigmoilina cushmani Finlay, 1947:271.

DISTRIBUTION.—Extremely rare in thanatotope B. Pakaurangi Formation.

Sigmoilopsis schlumbergeri (Silvestri)

Sigmoilina schlumbergeri Silvestri, 1904:267.
Sigmoilopsis schlumbergeri (Silvestri).—Gibson, 1967:15, pl. 2: figs. 30, 37.—Hornibrook, 1968:69, fig. 12.

DISTRIBUTION.—Extremely rare in thanatotopes D and E . Nihotupu Formation, DSDP.

Spiroloculina disparilis Terquem

Spiroloculina disparilis Terquem, 1878:85, pl. 5: fig. 12.—Vella, 1957:27, pl. 6: figs. 122, 123.—Hornibrook, 1961:34, pl. 3: fig. 41.

DISTRIBUTION.—Extremely rare in thanatotope F. Undifferentiated Hukatere Subgroup.

Spiroloculina excavata d'Orbigny

PLATE 3: FIGURE 38

Spiroloculina excavata d'Orbigny, 1846:271, pl. 16: figs. 19–21.

DISTRIBUTION.—Extremely rare in thanatotope E. DSDP.

Spiroloculina torquayensis Chapman

Spiroloculina torquayensis Chapman, 1921:320, pl. 51: figs. 1, 2.

DISTRIBUTION.—Extremely rare in thanatotope E. DSDP.

Triloculina oculina d'Orbigny

Triloculina oculina d'Orbigny, 1846:277, pl. 17: figs. 7–9.

DISTRIBUTION.—Extremely rare in thanatotopes B and F. Pakaurangi Formation, undifferentiated Hukatere Subgroup.

Triloculina tricarnata d'Orbigny

Triloculina tricarinata d'Orbigny, 1826:299, no. 7, "Modèle No." 94.—Barker, 1960, pl. 3: fig. 17.—Gibson, 1967:18.

DISTRIBUTION.—Rare in thanatotope F, extremely rare in thanatotopes C and E. Cornwallis Formation, Nihotupu Formation, undifferentiated Hukatere Subgroup, DSDP.

Triloculina trigonula (Lamarck)

PLATE 3: FIGURE 39

Miliolites trigonula Lamarck, 1804:351, No. 3.
Triloculina trigonula (Lamarck).—Barker, 1960, pl. 3: figs. 15, 16.—Hornibrook, 1961, table 6.—Quilty, 1974:59, pl. 2: figs. 80, 81.

DISTRIBUTION.—Frequent in thanatotope F, rare in thanatotope B, extremely rare in thanatotope D. Cornwallis Formation, Pakaurangi Formation, undifferentiated Hukatere Subgroup.

Wiesnerella species

PLATE 3: FIGURE 40

DISTRIBUTION.—Extremely rare in thanatotope B. Pakaurangi Formation.

Suborder ROTALIINA Delage and Hérouard, 1896

Alabamina tenuimarginata (Chapman, Parr and Collins)

PLATE 4: FIGURE 41

Pulvinulinella tenuimarginata Chapman, Parr, and Collins, 1934:565, pl. 9: fig. 19.
Alabamina tenuimarginata (Chapman, Parr, and Collins, Hornibrook, 1961:123, pl. 17: figs. 365, 366.—Scott, 1970a: fig. 5, no. 4.

DISTRIBUTION.—Common in thanatotopes B and D, frequent in thanatotopes A, C, and F. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation, Puketi Formation, undifferentiated Hukatere Subgroup, Waitemata Group.

Allomorphina cubensis Palmer and Bermudez

PLATE 4: FIGURE 42

Allomorphina cubensis Palmer and Bermudez, 1936:308, pl. 14: figs. 10, 11.—Cushman and Todd, 1949:67, pl. 11: figs. 19, 20.

DESCRIPTION.—Test subglobular to ovoid; three strongly embracing chambers exposed, only small portion of earliest chamber visible; aperture slit with flaring lip.

DISCUSSION.—This is the first New Zealand record of *Allomorphina cubensis* Palmer and Bermudez, previously recorded from the Oligocene of Cuba. This species is very similar to *Chilostomella globata* Gallway and Heminway, from which it differs by its asymmetry and visibility of three instead of two chambers.

DISTRIBUTION.—Extremely rare in thanatotopes A, C, and D. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation.

Allomorphina pacifica Cushman and Todd

PLATE 4: FIGURE 43–45

Allomorphina pacifica Cushman and Todd, 1949:68, pl. 12: figs. 6–9.

DESCRIPTION.—Test subtriangular, about two thirds as broad as high; three slightly inflated chambers exposed ventrally; early whorls all visible on flattened dorsal side; walls smooth; aperture a slit beneath a flap that extends backwards from last chamber towards middle of test on ventral side.

DISCUSSION.—This is the first New Zealand fossil record of *Allomorphina pacifica* Cushman and Todd, previously recorded from the Miocene to Recent of the Indo-Pacific region.

DISTRIBUTION.—Extremely rare in thanatotopes D and E. Nihotupu Formation, DSDP.

Amphicoryna hirsuta (d'Orbigny)

Nodosaria (Nodosaire) hirsuta d'Orbigny, 1826:252.
Nodosaria hirsuta d'Orbigny.—Brady, 1884:507, pl. 63: fig. 16 [in part.].
Lagenonodosaria hirsuta (d'Orbigny).—Hornibrook, 1961:48, pl. 6: fig. 100.

DISTRIBUTION.—Extremely rare in thanatotopes C and D. Cornwallis Formation and Nihotupu Formation.

Amphicoryna nebulosa (Ishizaki)

PLATE 4: FIGURE 46

Lagenonodosaria nebulosa Ishizaki, 1943:219, pl. 10: figs. 5, 7, 8.

DESCRIPTION.—Test with two to four spherical to slightly elongate chambers; sutures depressed; surface smooth; small lipped aperture on long slender neck.

DISTRIBUTION.—One specimen in N41/f539. Nihotupu Formation.

Amphicoryna scalaris (Batsch)

Nautilus (Orthoceras) scalaris Batsch, 1791:4, pl. 2: fig. 4.
Nodosaria scalaris (Batsch).—Brady, 1884:510, pl. 63: figs. 28–31.
Lagenonodosaria scalaris (Batsch).—Hornibrook, 1961:48, pl. 6: fig. 101.

DISTRIBUTION.—Frequent in thanatotope C, rare in thanatotopes A, B, and D. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation, Puketi Formation, Waitemata Group.

Amphicoryna scalaris seminuda (Chapman)

PLATE 4: FIGURE 47

Lagenonodosaria scalaris var. *seminuda* Chapman, 1941:161, pl. 9: fig. 2.

DISCUSSION.—This subspecies differs from typical *Amphicoryna scalaris* in having areas of smooth chamber surface and less distinct costae.

DISTRIBUTION.—Extremely rare in thanatotopes A and D. Nihotupu Formation, Puketi Formation.

Amphimorphina gagei Hornibrook

Amphimorphina gagei Hornibrook, 1961:83, pl. 12: fig. 249.

DISTRIBUTION.—Extremely rare in thanatotopes C and D. Nihotupu Formation.

Amphistegina madagascariensis d'Orbigny

PLATE 4: FIGURES 48, 49

Amphistegina madagascariensis d'Orbigny, 1826:304.—Fornasini, 1904:143, pl. 2: fig. 5.—Todd, 1965:34, pl. 11: fig. 3; pl. 12: figs. 1, 2.—Todd, 1976:387.
Amphistegina aucklandica Karrer, 1864:85, pl. 16: fig. 19.—Hornibrook, 1971:22, pl. 4: figs. 61–63.
Amphistegina campbelli Karrer, 1864, pl. 16: fig. 18.—Hornibrook, 1971:22, pl. 4: figs. 57–60.

DESCRIPTION.—Test involute, compressed to inflated lenticular; raised transparent umbos on both sides; profile symmetric to assymmetric; periphery acutely rounded to slightly keeled; small individuals fragile, commonly with 8–12 chambers per whorl; large individuals robust, commonly with 15–24 chambers per whorl; irregular, radial, limbate lines on both sides; dorsal sutures very strongly recurved; ventral sutures digitate; ventral supplementary chambers slender, curved backward at their outer ends which fail to reach periphery.

DISCUSSION.—*Amphistegina madagascariensis* is a highly variable species (Todd, 1976) characterized by its digitate ventral sutures; slender, curved supplementary chambers; and irregular limbate lines on both sides. Most descriptions attribute this species with an average of 15 chambers per whorl but a study of recent assemblages held in the National Museum of Natural History shows many adults to have 20 or more. The more robust individuals are typical of near-shore sediments (Todd, 1965) and the more fragile individuals are common in present-day deeper environments (Todd, 1976).

Amphistegina aucklandica Karrer and *A. campbelli* Karrer are identical to large robust present-day individuals of *A. madagascariensis* and probably represent Todd's (1965) beach and lagoonal forms respectively.

DISTRIBUTION.—Large, robust individuals: abundant in thanatotope A, rare in thanatotopes B and F. Small, fragile individuals: common in thanatotope B, frequent in thanatotope F, extremely rare in thanatotopes C and D. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation, Puketi Formation, undifferentiated Hukatere Subgroup, Waitemata Group.

Anomalinoides alazanensis (Nuttall)

Anomalina alazanensis Nuttal, 1932:32, pl. 8: figs. 5–7.
Anomalina vitrinoda Finlay, 1940:458, pl. 65: figs. 120–122.
Anomalinoides vitrinoda (Finlay).—Hornibrook, 1968:70, fig. 12.
Anomalinoides alazanensis (Nuttall).—Douglas, 1973, pl. 19: figs. 6–8; pl. 25: figs. 1, 2.

DISCUSSION.—Examination of the holotype and paratypes of *Anomalina alazanensis* Nuttall (Cushman Collection 16460, 16461) and a paratype of *Anomalina vitrinoda* Finlay (USNM689130) indicates that the two species are conspecific.

DISTRIBUTION.—Extremely rare in thanatotopes C and D. Nihotupu Formation.

Anomalinoides awamoana Hornibrook

Anomalinoides awamoana Hornibrook, 1961:157, pl. 23: figs. 461–463.

DISTRIBUTON.—Rare in thanatotope E, DSDP.

Anomalinoides fasciatus (Stache)

Rosalina fasciata Stache, 1864:281, pl. 24: figs. 31a–c.
Anomalinoides fasciatus (Stache).—Hornibrook, 1961:154, pl. 24: figs. 470–2.—Hornibrook, 1971:50, pl. 11: figs. 194–6.

DISTRIBUTION.—Extremely rare in thanatotopes A and B. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation.

Anomalinoides globulosa (Chapman and Parr)

PLATE 4: FIGURE 50, 51

Anomalina globulosa Chapman and Parr, 1937:117, pl. 9: fig. 27.—Barker, 1960, pl. 94: fig. 4.

DESCRIPTION.—Test evolute dorsally, involute ventrally; 6–8 inflated chambers per whorl; sutures deeply impressed, curved; periphery rounded; ventral side strongly convex; dorsal side flattened; surface deeply pitted on both sides; aperture interiomarginal slit.

DISCUSSION.—This is the first New Zealand fossil record of *Anomalinoides globulosa* (Chapman and Parr); previously known from Miocene to Recent sediments from various other parts of the world.

DISTRIBUTION.—Extremely rare in thanatotope C. Nihotupu Formation.

Anomalinoides macraglabra (Finlay)

PLATE 5: FIGURE 52, 53

Anomalina macraglabra Finlay, 1940:460, pl. 65: figs. 141–3.
Anamolinoides macraglabra (Finlay).—Hornibrook, 1961:155, pl. 24: figs. 473–5.

DISTRIBUTION.—Common in thanatotopes C and D, frequent in thanatotopes B and E, extremely rare in thanatotopes A and F. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation, Piha Formation, undifferentiated Hukatere Subgroup, Waitemata Group, DSDP.

Anomalinoides parvumbilia (Finlay)

Anomalina parvumbilia Finlay, 1940:461, pl. 65: figs. 157–9.
Anomalinoides parvumbilia (Finlay).—Hornibrook, 1961:156, pl. 23: figs. 458–60.

DISTRIBUTION.—Extremely rare in thanatotopes A, B, and D. Cornwallis Formation, Pakaurangi Formation.

Anomalinoides semicribrata (Beckmann)

PLATE 5: FIGURES 54, 55

Anomalina pompilioides var. *semicribrata* Beckmann, 1953:400 pl. 27: fig. 3.
Anomalinoides semicribrata (Beckmann).—Douglas, 1973, pl. 14: figs. 1, 2.

DESCRIPTION.—Test involute ventrally, partly evolute dorsally; 5–7 inflated chambers per whorl; sutures slightly depressed, almost radial; periphery broadly rounded; surface smooth on dorsal side, coarsely punctuate on ventral; aperture interiomarginal slit.

DISCUSSION.—This is the first New Zealand fossil record of *Anomalinoides semicribrata* (Beckmann).

DISTRIBUTION.—Extremely rare in thanatotopes D and E. Cornwallis Formation, Nihotupu Formation, DSDP.

Anomalinoides species

PLATE 5: FIGURE 56

Anomalinoides sp. 1 Douglas, 1973, pl. 19: figs. 4, 5; pl. 24: figs. 15, 16.

DESCRIPTION.—Test involute ventrally, partly evolute dorsally; 6–8 chambers per whorl sutures slightly depressed, curved; periphery rounded; ventral side greatly inflated, dorsal side flat to concave; early whorls on dorsal side with bead-like pustules; aperture interiomarginal slit with lip on dorsal side.

DISTRIBUTION.—Rare in thanatotope E. DSDP.

Astacolus compressus (Stache)

Hemirobulina compressa Stache, 1864:229, pl. 23: figs 8a, b.
Astacolus compressus (Stache).—Hornibrook, 1971:41, pl. 8: figs. 132–4.

DISTRIBUTION.—Extremely rare in thanatotopes A, B, and C. Nihotupu Formation, Pakaurangi Formation, Puketi Formation, undifferentiated Hukatere Subgroup.

Astacolus insolitus (Schwager)

PLATE 5: FIGURES 58–60

Cristellaria insolita Schwager, 1866:242, pl. 6: fig. 85.

DESCRIPTION.—Test elongate, smooth, consisting of an initial half coil followed by a series of uncoiled, steeply sloping, curved chambers; apertural face about half as high as test; periphery and margins of apertural face acutely rounded; aperture terminal, radiate.

DISCUSSION.—This is the first New Zealand record of *Astacolus insolitus* (Schwager). It differs from other New Zealand species in its more elongate, inflated test.

DISTRIBUTION.—Extremely rare in thanatotopes B, C, D, and F. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation, undifferentiated Hukatere Subgroup.

Astacolus cf. *A. judyae* Hornibrook

DISCUSSION.—One individual of *Astacolus* is most similar to *Astacolus judyae* Hornibrook (1961:39, pl. 4: figs. 59, 60).

DISTRIBUTION.—Extremely rare in thanatotope A. Undifferentiated Hukatere Subgroup.

Astacolus neolatus Vella

Astacolus neolatus Vella, 1957:30, pl. 7: figs. 143, 146–8.—Hornibrook, 1961:39, pl. 4: fig. 61.

DISTRIBUTION.—Extremely rare in thanatotopes B, D, and F. Nihotupu Formation, Pakaurangi Formation, undifferentiated Hukatere Subgroup.

Astrononion fijiensis Cushman and Edwards

Astrononion fijiensis Cushman and Edwards, 1937:35, pl. 3: figs. 15, 16.

Astrononion (Fijinonion) fijiensis Cushman and Edwards,—Hornibrook, 1964:338, pl. 1: figs. 1–3.

DISTRIBUTION.—Extremely rare in thanatotopes B and D. Nihotupu Formation, Pakaurangi Formation.

Astrononion impressum Hornibrook

Astrononion impressum Hornibrook, 1961: 96, pl. 12: figs. 228, 235.

DISTRIBUTION.—Rare in thanatotopes C and D. Cornwallis Formation, Pakaurangi Formation, Nihotupu Formation, Waitemata Group.

Astrononion parki Hornibrook

Astrononion parki Hornibrook, 1961:95, pl. 12: figs. 230, 237.

DISTRIBUTION.—Extremely rare in thanatotopes C and D. Cornwallis Formation, Nihotupu Formation.

Astrononion pusillum Hornibrook

Astrononion pusillum Hornibrook, 1961:96, pl. 12: figs. 229, 236; 1964:335, pl. 1: fig. 24.

DISTRIBUTION.—Extremely rare in thanatotope D. Nihotupu Formation.

Astrononion stelligerum (d'Orbigny)

PLATE 5: FIGURE 57

Nonionina stelligera d' Orbigny, 1839c:128, pl. 3: figs. 1, 2.

Astrononion australe Cushman and Edwards, 1937:33, pl. 3: figs. 13, 14.

Astrononion stelligerum (d'Orbigny).—Cushman and Edwards, 1937:31, pl. 3: fig. 7.—Hornibrook, 1964:334, pl. 1: figs. 5–9, 14–19.—Le Calvez, 1974:37, pl. 9: figs. 1–4.

DESCRIPTION.—Test somewhat compressed, planispiral; periphery broadly rounded, slightly lobulate in adult; 8–10 chambers per whorl; umbilicus distinct, sometimes with slight rim; sutures gently curved, distinctly incised, especially in adult; external tubes, distinct and narrow in early whorls, extending one third of the way along sutures; tubes becoming increasingly plate-like and lance-shaped in adult whorls; tubes having oblique, oval-shaped openings at outer ends, these openings developing into elongate slits along posterior side of plates of adult whorls; primary aperture low arched slit at base of apertural face.

DISCUSSION.—Like most *Astrononion* species, *A. stelligerum* is highly variable in the degree of chamber inflation, test compression, umbilical opening and tube and plate development. Juveniles and adults of this species look distinctly different. In describing *Astrononion australe,* Cushman and Edwards distinguished this species from *A. stelligerum* on the basis of a completely filled umbilical region. Examination of the holotype and paratypes of *A. australe* (Cushman Collection 6653, 23640, 23641) shows the presence of a distinct, depressed umbilicus, and they appear to be identical to Hornibrook's (1964) neotypes of *A. stelligerum* and also to the invalid neotypes of *A. stelligerum* selected by Le Calvez (1974).

This is the first New Zealand Miocene record of *Astrononion stelligerum* (d'Orbigny), it has previously been recorded from Miocene to Recent sediments from many parts of the world.

DISTRIBUTION.—Abundant in thanatotope C, common in thanatotope D, frequent in thanatotope B and F, extremely rare in thanatotope A. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation, Piha Formation, Puketi Formation, undifferentiated Hukatere Subgroup, Waitemata Group.

Astrononion tumidum Cushman and Edwards

Astrononion tumidum Cushman and Edwards, 1937:33, pl. 3: fig. 17.
Astrononion (Laminonion) tumidum (Cushman and Edwards). —Hornibrook, 1964:335, pl. 1: figs. 10–13.

DISTRIBUTION.—Extremely rare in thanatotope D. Cornwallis Formation.

Bolivina acerosa Cushman

PLATE 6: FIGURE 63

Bolivina acerosa Cushman, 1936a:54, pl. 8: fig, 1: 1937:94, pl. 12: figs. 11–13.
Bolivina cf. *acerosa* Cushman.—Hornibrook, 1961:73, pl. 9: fig. 174.

DISTRIBUTION.—Frequent in thanatotope D, rare in thanatotopes B, C, and E, extremely rare in thanatotope A. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation, Puketi Formation, Waitemata Group, DSDP.

Bolivina aenariensis (Costa)

PLATE 6: FIGURES 64, 65

Brizalina aenariensis Costa, 1856:297, pl. 15: figs. 1A, B.
Bolivina aenariensis (Costa).—Cushman, 1937:105, pl. 12: figs. 21–26.

DISTRIBUTION.—Abundant in thanatotope E. DSDP.

Bolivina arta Macfadyen

Bolivina arta Macfadyen, 1931:58, pl. 4: fig. 21.—Cushman, 1937:79, pl. 9: figs. 23–26.
Bolivina lapsus Finlay, 1939b:98, pl. 11: fig. 9.—Hornibrook, 1961:73, pl. 10: fig. 184.—Gibson, 1967:34, pl. 8: fig. 130.

DISCUSSION.—Examination of topotypes of *Bolivina arta* Macfadyen (Miocene, Egypt; Cushman Collection 17237, 21792) and a paratype and topotypes of *Bolivina lapsus* Finlay (Miocene, Pakaurangi Point, New Zealand, USNM 689195) indicates that they are conspecific.

DISTRIBUTION.—Frequent in thanatotopes B, C, and D, extremely rare in thanatotope F. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation, undifferentiated Hukatere Subgroup.

Bolivina barnwelli Finlay

Bolivina barnwelli Finlay, 1947:280, pl. 5: figs. 73, 75.—Gibson, 1967:33, pl. 8: figs. 128, 129, 132, 133, 138.
Bolivina lutosa Finlay, 1947:280, pl. 5: figs. 76–79.

DISTRIBUTION.—Rare in thanatotope D, extremely rare in thanatotopes B, C, and E. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation.

Bolivina beyrichi Reuss

PLATE 6: FIGURE 66

Bolivina beyrichi Reuss, 1851:83, pl. 6: fig. 51.—Cushman, 1937:74, pl. 9: figs. 3–6.—Hornibrook, 1961:72.

DISTRIBUTION.—Extremely rare in thanatotope D. Cornwallis Formation, Nihotupu Formation.

Bolivina aff. *B. compacta* Sidebottom

DISCUSSION.—A number of specimens of *Bolivina* are most similar to *Bolivina robusta* var. *compacta* Sidebottom (1905:15, pl. 3: fig. 7) and *Bolivina compacta* Sidebottom (Cushman, 1937:135, pl. 17: figs. 22–23).

DISTRIBUTION.—Frequent in thanatoptoe E. DSDP.

Bolivina decussata Brady

Bolivina decussata Brady, 1881:58.—1884:423, pl. 53: figs. 12, 13.—Cushman, 1937:125, pl. 16: figs. 7–9.

DISTRIBUTION.—Extremely rare in thanatotope E. DSDP.

Bolivina finlayi Hornibrook

PLATE 6: FIGURE 67

Bolivina finlayi Hornibrook, 1961:75, pl. 9: figs. 169–171.

DISTRIBUTION.—Abundant in thanatotope D, common in thanatotopes B and C, frequent in thanatotope F, extremely rare in thanatotopes A and E. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation, Puketi Formation, undifferentiated Hukatere Subgroup, Waitemata Group, DSDP.

Bolivina mantaensis Cushman

PLATE 6: FIGURES 69, 70

Bolivina mantaensis Cushman, 1929b:92, pl. 13: fig. 27; 1937: 91, pl. 11: figs. 25, 26.

DESCRIPTION.—Test elongate, somewhat compressed, gently tapered; periphery acutely rounded; sutures strongly oblique, very gently curved, slightly depressed to flush; lower half to two-thirds of test ornamented with distinct longitudinal striae.

DISCUSSION.—This species differs from *Bolivina finlayi* Hornibrook in its almost straight sutures. In form it resembles *Bolivina zedirecta* Finlay, differing by the presence of striae.

DISTRIBUTION.—Frequent in thanatotopes B, C, and D, rare in thanatotope A, extremely rare in thanatotope F. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation, Puketi Formation, undifferentiated Hukatere Subgroup, Waitemara Group.

Bolivina aff. *B. mississippiensis* Cushman

DISCUSSION.—Several specimens of *Bolivina* are most similar to *Bolivina mississippiensis* Cushman (1922a:92, pl. 15: fig. 5; 1937:69, pl. 8, fig. 16).

DISTRIBUTION.—Extremely rare in thanatotope E. DSDP.

Bolivina mitcheli Gibson

PLATE 6: FIGURE 68

Bolivina mitcheli Gibson, 1967:34, pl. 8: figs. 136, 137, 139.

DISTRIBUTION.—Rare in N41/f609, N42/f722, N42/f725. Waitemata Group.

Bolivina plicatella mera Cushman and Ponton

PLATE 5: FIGURES 61, 62

Bolivina plicatella var. *mera* Cushman and Ponton, 1932:82, pl. 12: fig. 4.—Cushman, 1937:90, pl. 11: figs. 5–8.

DESCRIPTION.—Test small, short, broad, compressed; periphery rounded; sutures sinuate between adult chambers, somewhat obscured by coarse ornamentation; coarsely perforate.

DISCUSSION.—This is the first New Zealand record of *Bolivina plicatella mera* Cushman and Ponton; it has previously been recorded from the Oligocene and Miocene of the Americas, Europe, North Africa and Guam.

DISTRIBUTION.—Frequent in thanatotope D, extremely rare in thanatotopes B and C. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation.

Bolivina pukeuriensis Hornibrook

Bolivina pukeuriensis Hornibrook, 1961:76, pl. 9: figs. 172, 173.

DISTRIBUTION.—Extremely rare in thanatotope B. Pakaurangi Formation.

Bolivina punctatostriata Kreuzberg

PLATE 6: FIGURE 71

Bolivina punctatostriata Kreuzberg, 1930:278, pl. 20: figs. 5a–c.—Hornibrook, 1968:68, fig. 12.

DISTRIBUTION.—Frequent in thanatotope C, rare in thanatotope D. Nihotupu Formation.

Bolivina reticulata Hantken

PLATE 6: FIGURE 72

Bolivina reticulata Hantken, 1875:56, pl. 15: fig. 6.—Cushman, 1937:50, pl. 6: figs. 24–27.

Bolivina anastomosa Finlay, 1939c:320, pl. 27: figs. 75–77, 103, 111.—Hornibrook, 1961:72, pl. 10: fig. 188; 1968:63, fig. 10.

Bolivina anastomosa Finlay, smooth var.—Hornibrook, 1961: 72.

Bolivina (Latibolivina) reticulata reticulata Hantken.—Hofmann, 1971:304, fig. 13: nos. 1, 3, 8, 9, 11.

DISCUSSION.—Included here are the typical reticulately ribbed individuals, together with Hornibrook's (1961) smooth variety, which is identical in all respects except for its very reduced ribbing.

DISTRIBUTION.—Common in thanatotopes B, C, and D, extremely rare in thanatotopes A, E, and F. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation, Puketi Formation, undifferentiated Hukatere Subgroup, Waitemata Group, DSDP.

Bolivina silvestrina Cushman

PLATE 6: FIGURES 73, 74

Bolivina silvestrina Cushman, 1936a:56, pl. 8: figs. 5a, b.—1937:109, pl. 13: figs. 14–16.

DESCRIPTION.—Test elongate, slender, slightly twisted, gently compressed; periphery broadly rounded; chambers inflated, about as broad as high and of uniform shape throughout; sutures depressed, straight or slightly curved, forming an angle of about 25° with horizontal; surface coarsely perforate.

DISCUSSION.—This is the first New Zealand fossil record of *B. silvestrina* Cushman, previously recorded from the Miocene to Pleistocene of parts of Europe and the Pacific.

DISTRIBUTION.—Frequent in thanatotope D, extremely rare in thanatotopes B and E. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation, Waitemata Group, DSDP.

Bolivina subcompacta Finlay

PLATE 6: FIGURE 75

Bolivina subcompacta Finlay, 1947:278, pl. 5: figs. 64–69.—Hornibrook, 1961:73, pl. 9: fig. 177.

DISTRIBUTION.—Common in thanatotope E, rare in thanatotope D, extremely rare in thanatotopes A, B, and C. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation, Puketi Formation, DSDP.

Bolivina thalmanni Renz

PLATE 6: FIGURES 76, 77

Bolivina thalmanni Renz, 1948:120, pl. 12: fig. 13.

DISTRIBUTION.—Common in thanatotope E. DSDP.

Bolivina zedirecta Finlay

Bolivina zedirecta Finlay, 1947:278, pl. 5: figs. 70–72.—Hornibrook, 1961:73, pl. 9: fig. 176.

DISTRIBUTION.—Frequent in thanatotope D, rare in thanatotopes A, B, C, and F. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation, Puketi Formation, undifferentiated Hukatere Subgroup, Waitemata Group.

Bolivinella australis Cushman

PLATE 7: FIGURES 78, 79, 82

Bolivinella australis Cushman, 1929a:32, pl. 5: figs. 6, 7.—Quilty, 1974:78, pl. 4: fig. 126.

DESCRIPTION.—Test elongate, with rapidly broadening early portion, margins nearly parallel in adult; margins acutely angled, with irregular spines; sutures curved, limbate; median line marked by straight furrow with slightly raised sides.

DISCUSSION.—This is the first record of *Bolivinella australis* Cushman from New Zealand, previously known only from the Oligocene to Miocene of Australia. A study of the type material of the French Miocene species *Bolivinella margaritacea* Cushman suggests that it may be conspecific with *B. australis.*

DISTRIBUTION.—One specimen in N28/f458. Pakaurangi Formation.

Bolivinella subpectinata Cushman

PLATE 7: FIGURES 80, 81

Bolivinella subpectinata Cushman, 1929a:34, pl. 5: fig. 8.

DESCRIPTION.—Test flaring, very compressed, of uniform thickness from one margin to opposite margin; margins squarely angled, with irregular spines; chambers numerous, curved; sutures limbate, raised above smooth test surface, irregularly beaded; median line marked by straight, partly beaded rib.

DISCUSSION.—This is the first New Zealand record of *Bolivinella subpectinata* Cushman, previously recorded from the Oligocene of the United States and Oligocene to Miocene of Europe.

DISTRIBUTION.—Two specimens in N28/f458. Pakaurangi Formation.

Buccella lotella Hornibrook

Buccella lotella Hornibrook, 1961:110, pl. 15: figs. 314–316; 1968:63, fig. 10.

DISTRIBUTION.—Extremely rare in thanatotope D. Pakaurangi Formation.

Bueningia creeki Finlay

Bueningia creeki Finlay, 1939b:123, pl. 14: figs. 82–84.—Hornibrook, 1968:60, fig. 9.

DISTRIBUTION.—Rare in thanatotopes B and D, extremely rare in thanatotope A. Nihotupu Formation, Pakaurangi Formation, undifferentiated Hukatere Subgroup, Waitemata Group.

Bulimina elongata d'Orbigny

Bulimina elongata d'Orbigny, 1826:269, no. 9; 1846:187, pl. 11: figs. 19, 20.—Cushman and Parker, 1947:108, pl. 25: figs. 14–17.—Barker, 1960, pl. 51: figs. 1, 2.

DISTRIBUTION.—Extremely rare in thanatotope E. DSDP.

Bulimina miolaevis Finlay

Bulimina miolaevis Finlay, 1940:454, pl. 64: figs 70, 71.—Hornibrook, 1961:62.—1968:63, fig. 10.

DISTRIBUTION.—Extremely rare in thanatotopes B, D, and E. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation, DSDP.

Bulimina pupula Stache sensu lato

PLATE 7: FIGURE 83

Bulimina pupula Stache, 1864:265, pl. 24: fig. 13.—Cushman and Parker, 1947:101, pl. 24: figs. 7, 8.—Hornibrook, 1961: 63, pl. 8: fig. 141; 1971:48, pl. 10: fig. 180.—Scott, 1970a, fig. 6, no. 10.

DISCUSSION.—Populations referred here to *Bulimina pupula* Stache have a wide range of form, from smooth, oval specimens with flush sutures to more tapering individuals with inflated chambers. The degree of chamber overlap is also extremely variable.

DISTRIBUTION.—Common in thanatotope C, frequent in thanatotopes D, E, and F, rare in thanatotope B. Cornwallis Formation, Nihotupu Formation, Parakaurangi Formation, undifferentiated Hukatere Subgroup.

Bulimina semicostata Nuttall

PLATE 7: FIGURES 84, 85

Bulimina semicostata Nuttall, 1930:274, pl. 23: figs. 15, 16.—Cushman and Parker, 1947:93, pl. 21: figs. 28, 29.—Douglas, 1973:628, pl. 4: figs. 6, 9.

DISTRIBUTION.—Common in thanatotope E. DSDP.

Bulimina senta Finlay

Bulimina senta Finlay, 1940:454, pl. 64: figs. 73, 74.—Gibson, 1967:25, pl. 6: fig. 105.—Hornibrook, 1968:70, fig. 13.

DISTRIBUTION.—Extremely rare, specimens in N42/f705, N42/f727. Nihotupu Formation, Waitemata Group.

Bulimina striata d'Orbigny

PLATE 7: FIGURE 86

Bulimina striata d'Orbigny, 1826:269.—Cushman and Parker, 1947:119, pl. 28: figs. 1–3.
Bulimina cf. *striata* d'Orbigny.—Gibson, 1967:25, pl. 6: fig. 110.

DISTRIBUTION.—Extremely rare in thanatotopes B, C, and D. Nihotupu Formation, Pakaurangi Formation, Waitemata Group.

Bulimina truncana Gümbel

PLATE 7: FIGURES 87, 88

Bulimina truncana Gümbel, 1868:644, pl. 2: figs. 77a, b.—Cushman and Parker, 1947:89, pl. 21: figs. 7, 8.
Bulimina rostrata Brady, 1884:408, pl. 51: figs. 14, 15.—Cushman and Parker, 1947:124, pl. 28: fig. 34.
Bulimina alazanensis Cushman, 1927c:161, pl. 25: fig. 4.—Cushman and Parker, 1947:103, pl. 24: figs. 14–16.
Bulimina bremneri Finlay, 1940:455, pl. 64: figs. 84–86.

DISCUSSION.—Study of types and topotypic suites of *Bulimina alazanensis* Cushman, *B. bremneri* Finlay, *B. rostrata* Brady and *B. truncana* Gümbel suggests that all belong to one species. Within populations there is considerable variability in test inflation.

DISTRIBUTION.—Rare in thanatotopes D and E, extremely rare in thanatotopes B and C. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation, DSDP.

Buliminella elegantissima (d'Orbigny)

Bulimina elegantissima d'Orbigny, 1839b:51, pl. 7: figs. 13, 14.
Buliminella elegantissima (d'Orbigny).—Cushman and Parker, 1947:67, pl. 17: figs. 10–12.—Barker, 1960, pl. 50: figs. 20–22.—Vella, 1963:6.

DISTRIBUTION.—Extremely rare in thanatotopes B, D, and F. Nihotupu Formation, Pakaurangi Formation, undifferentiated Hukatere Subgroup.

Buliminella missilis Vella

PLATE 7: FIGURE 89

Buliminella missilis Vella, 1963:6, pl. 1: fig. 3.

DISCUSSION.—These records extend the known time range of *Buliminella missilis* (New Zealand, early Pliocene) back to early Miocene (upper Po—Tk).

DISTRIBUTION.—Extremely rare in thanatotopes B and F. Cornwallis Formation, Pakaurangi Formation.

Cancris brevior Finlay

Cancris brevior Finlay, 1940:463, pl. 64: figs. 95–98.

DISTRIBUTION.—Extremely rare in thanatotope B. Pakaurangi Formation.

Cancris laevinflatus Hornibrook

Cancris laevinflatus Hornibrook, 1961:120, pl. 15: figs. 328, 331, 332.

DISTRIBUTION.—Rare in thanatotopes B and D, extremely rare in thanatotope C. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation.

Cassidulina carapitana Hedberg

PLATE 8: FIGURES 94, 95

Cassidulina carapitana Hedberg, 1937:680, pl. 92: fig. 6.

DESCRIPTION.—Test biconvex, close-coiled, involute; periphery sharp, no umbos; chambers long, narrow, sharply curved at inner ends, about five pairs per whorl; sutures distinct, flush with smooth surface; aperture elongate, subparallel to periphery.

DISCUSSION.—This is the first New Zealand record of *Cassidulina carapitana* Hedberg, previously known from the Oligocene and Miocene of Central America, Europe and Guam.

DISTRIBUTION.—Extremely rare in thanatotope D. Nihotupu Formation.

Cassidulina laevigata d'Orbigny

PLATE 7: FIGURE 90

Cassidulina laevigata d'Orbigny, 1826:282, pl. 15: figs. 4, 5. —Hornibrook, 1961:85, pl. 10: fig. 199.

Cassidulina neocarinata Thalmann.—Hornibrook, 1961:86, pl. 10: fig. 200.

DISCUSSION.—Individuals with a translucent boss, low elongate aperture and sharp periphery (sometimes with a small keel) are here referred to *Cassidulina laevigata.* The species *C. carinata* Silvestri is similar but has a much broader keel.

DISTRIBUTION.—Abundant in thanatotope D, common in thanatotope C, rare in thanatotopes A, C, E, and F. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation, Piha Formation, Puketi Formation, undifferentiated Hukatere Subgroup, Waitemata Group, DSDP.

Cassidulina margareta Karrer

PLATE 7: FIGURE 91

Cassidulina margareta Karrer, 1877:386, pl. 16b: fig. 52.—Asano, 1953:6, pl. 3: fig. 11.

DISCUSSION.—*Cassidulina margareta* Karrer is distinguished by its rounded periphery, somewhat compressed profile, high aperture, lack of a translucent umbo, four pairs of chambers per coil, and very slightly depressed sutures.

DISTRIBUTION.—Common in thanatotopes B and D, rare in thanatotopes C and E, extremely rare in thanatotopes A and F. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation, Piha Formation, undifferentiated Hukatere Subgroup, Waitemata Group.

Cassidulina monstruosa Voloshinova

PLATE 7: FIGURES 92, 93; PLATE 8: FIGURE 96

Cassidulina limbata var. *monstruosa* Voloshinova, 1952:94, pl. 3: figs. 5a, b.

DESCRIPTION.—Test biconvex, inflated, close-coiled; periphery rounded; umbos lacking; chambers long, narrow, constricted in central part, with sharply curved inner ends, about five pairs per whorl; sutures limbate, flush or slightly depressed; surface surgary textured; small slit aperture, subparallel to periphery.

DISCUSSION.—This is the first New Zealand record of *Cassidulina monstruosa* Voloshinova, previously recorded from the Miocene of the USSR. This species differs from *C. carapitana* in its rounded periphery, limbate sutures and sugary texture. *C. monstruosa's* closest relative is probably *Globocassidulina tumida* (Heron-Allen and Earland) (Recent, New Zealand; Eade, 1967:440, fig. 5: nos. 5, 6), which differs in its smoother surface and greater number of chambers.

DISTRIBUTION.—Rare in thanatotopes D and E. Cornwallis Formation, DSDP.

Ceratobulimina kellumi Finlay

PLATE 9: FIGURE 112

Ceratobulimina kellumi Finlay, 1939b:115, pl. 13: fig. 60.

DISTRIBUTION.—Extremely rare in thanatotopes B, C, and D. Cornwallis Formation, Pakaurangi Formation, Nihotupu Formation.

Ceratocancris clifdenensis Finlay

Ceratobulimina (Ceratocancris) clifdenensis Finlay, 1939b:117, pl. 13: fig. 62.—Hornibrook, 1961:126, pl. 17: fig. 375.

Ceratocancris clifdenensis Finlay.—Hornibrook, 1968:69, fig. 67.

DISTRIBUTION.—Extremely rare in thanatotopes B, D, and F. Pakaurangi Formation, undifferentiated Hukatere Subgroup, Waitemata Group.

Cerobertina bartrumi Finlay

Cerobertina bartrumi Finlay, 1939b:118, pl. 11: figs. 2, 3.—Hornibrook, 1961:127, pl. 17: figs. 379, 380.

DISTRIBUTION.—Extremely rare in thanatotopes B, D, and F. Pakaurangi Formation, undifferentiated Hukatere Subgroup.

Cerobertina crepidula Finlay

Cerobertina crepidula Finlay, 1939b:121, pl. 11: fig. 1.—Hornibrook, 1961:126, pl. 17: fig. 378.

DISTRIBUTION.—Extremely rare in thanatotope D. Nihotupu Formation.

Cerobertina mahoenuica Finlay

Cerobertina mahoenuica Finlay, 1939b:119, pl. 13: fig. 58.

DISTRIBUTION.—Extremely rare in thanatotopes B and D. Nihotupu Formation, Pakaurangi Formation.

Chilostomella czizeki Reuss

PLATE 9: FIGURES 113, 114

Chilostomella czizeki Reuss, 1850:380, pl. 48: fig. 13.—Cushman, 1926:74, pl. 11: figs. 2a–d.

DESCRIPTION.—Test elongate ovoid, circular in section; about twice as long as wide; sides gently convex; wall smooth; aperture a narrow slit of variable length along suture.

DISCUSSION.—This is the first New Zealand record of *Chilostomella czizeki* Reuss, known from Paleocene-Recent sediments from many parts of the world.

DISTRIBUTION.—Rare in thanatotope D, extremely rare in thanatotope B. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation.

Chilostomella globata Galloway and Heminway

PLATE 9: FIGURES 115, 116

Chilostomella globata Galloway and Heminway, 1941:409, pl. 28: fig. 2.

DESCRIPTION.—Test subglobular, subcircular in section, with last chamber forming about two-thirds of test; wall smooth; aperture a narrow slit, with large, everted lip.

DISCUSSION.—This is the first New Zealand record of *Chilostomella globata* Galloway and Heminway, previously known from the Oligocene and lower Miocene of central America.

DISTRIBUTION.—Extremely rare in thanatotope D. Cornwallis Formation, Nihotupu Formation.

Chilostomella ovoidea Reuss

PLATE 9: FIGURES 117, 118

Chilostomella ovoidea Reuss, 1850:380, pl. 48: fig. 12.—Cushman, 1926:74, pl. 11: figs. 1a–c.—Hornibrook, 1961:89, pl. 11: fig. 209.—Gibson, 1967:45, pl. 10: fig. 166.

DISCUSSION.—*Chilostomella ovoidea* is broader and more inflated than *C. czizeki*. Both these are more inflated than the two parallel-sided species *C. oolina* Schwager and *C. tenuis* Bornemann.

DISTRIBUTION.—Extremely rare in thanatotopes A, C, and D. Nihotupu Formation, Pakaurangi Formation.

Chilostomelloides oviformis (Sherborn and Chapman)

PLATE 9: FIGURES 119, 120

Lagena (Obliquina) oviformis Sherborn and Chapman, 1886: 745, pl. 14: fig. 19.
Chilostomelloides oviformis (Sherborn and Chapman).—Cushman, 1926:77, pl. 11: figs. 17, 21.

DESCRIPTION.—Test elongate ovoid, circular in cross-section; last chamber envelopes about four-fifths of test; aperture circular or nearly so, standing out at distinct angle from general contour of test, with thickened lip.

DISCUSSION.—This is the first New Zealand record of *Chilostomelloides oviformis* (Sherborn and Chapman), previously known from the Eocene-Miocene of Europe, North Africa, North and South America, and Taiwan.

DISTRIBUTION.—Extremely rare in thanatotopes C and D. Nihotupu Formation.

Cibicides ihungia Finlay

Cibicides ihungia Finlay, 1940:465, pl. 67: figs. 201–206.—Hornibrook 1961:162, pl. 24: figs. 488–489; 1968:74; fig. 14.

DISTRIBUTION.—Rare in thanatotopes B, C, and D, extremely rare in thanatotopes A and F. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation, Puketi Formation, undifferentiated Hukatere Subgroup, Waitemata Group.

Cibicides lobatulus (Walker and Jacob)

PLATE 10: FIGURES 124–126

Nautilus lobatulus Walker and Jacob, 1798:642, pl. 14: fig. 36.
Cibicides lobatulus (Walker and Jacob).—Barker, 1960, pl. 92: fig. 10; pl. 93: fig. 1.

DESCRIPTION.—Test trochospiral; involute side convex; spiral side flat; periphery acute, unkeeled, lobulate; 6–8 inflated chambers per whorl; sutures on involute side almost radial, slightly curved, depressed; sutures on spiral side curved, limbate, flush; aperture low, lipped peripheral opening at base of final chamber and extending back along spiral suture a short distance.

DISCUSSION.—This is the first New Zealand record of *Cibicides lobatus* (Walker and Jacob). This universal species is easily recognized by its slightly lobulate periphery, convex rather than conical ventral profile and lack of a keel or bosses.

DISTRIBUTION.—Frequent in thanatotopes B and F, rare in thanatotopes C and D, extremely rare in thanatotope A. Nihotupu Formation, Pakaurangi Formation, Puketi Formation, undifferentiated Hukatere Subgroup, Waitemata Group.

Cibicides mediocris Finlay

PLATE 10: FIGURES 127–129

Cibicides mediocris Finlay, 1940:464, pl. 67: figs. 198, 199.—Hornibrook, 1961:160, pl. 25: figs. 499, 500, 502.—Scott, 1970a, fig. 5, no. 1.

DISTRIBUTION.—Abundant in thanatotope B, frequent in thanatotopes A, C, and D, rare in thanatotope F, extremely rare in thanatotope E. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation, Piha Formation, Puketi Formation, undifferentiated Hukatere Subgroup, Waitemata Group, DSDP.

Cibicides notocenicus Dorreen

PLATE 10: FIGURES 132–134

Cibicides perforatus var. *notocenicus* Dorreen, 1948:299, pl. 41: fig. 4.
Cibicides notocenicus Dorreen.—Hornibrook, 1961:158, pl. 25: figs. 496, 498; 1968:57, fig. 8.

DISTRIBUTION.—Frequent in thanatotopes A, B, and D, rare in thanatotopes C and F, extremely rare in thanatotope E. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation, Piha Formation, Puketi Formation, undifferentiated Hukatere Subgroup, Waitemata Group, DSDP.

Cibicides refulgens de Montfort

PLATE 10: FIGURES 130, 131

Cibicides refulgens de Montfort, 1808:123, text-fig. p. 122.—Barker, 1960, pl. 92: figs. 7–9.—Hornibrook and Schofield, 1963:48.—Scott, 1970a, fig. 5, no. 5.

DISTRIBUTION.—Rare in thanatotopes B and D, extremely rare in thanatotopes A, C, and F. Nihotupu Formation, Pakaurangi Formation, Piha Formation, undifferentiated Hukatere Subgroup.

Cibicides vortex Dorreen

PLATE 11: FIGURES 138, 139

Cibicides vortex Dorreen, 1948:299, pl. 41: fig. 5.—Hornibrook, 1961:160, pl. 24: figs. 490–492.—Scott, 1970a fig. 6, no. 4.

DISTRIBUTION.—Abundant in thanatotope B, common in thanatotope D, frequent in thanatotopes A and F, rare in thanatotope C, extremely rare in thanatotope E. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation, Piha Formation, Puketi Formation, undifferentiated Hukatere Subgroup, Waitemata Group, DSDP.

Cibicides wuellerstorfi (Schwager)

PLATE 11: FIGURES 140–142

Anomalina wuellerstorfi Schwager, 1866:258, pl. 7: figs. 105–107.

Cibicides wuellerstorfi (Schwager).—Barker, 1960, pl. 93: fig. 9.

Cibicidoides wuellerstorfi (Schwager).—Douglas, 1973, pl. 18: figs. 7–9; pl. 25: figs. 15, 16.

DISTRIBUTION.—Frequent in thanatotope E. DSDP.

Cibicidoides brevoralis (Carter)

Cibicides brevoralis Carter, 1958:47, pl. 6. figs. 54–56.

Cibicides molestus Hornibrook, 1961:163, pl. 24: figs. 478, 479, 483; 1968:76: fig. 14.—Gibson, 1967:67, pl. 19: figs. 275, 276.

DISCUSSION.—There are no apparent differences between *Cibicidoides brevoralis* (Australian Tertiary) and *C. molestus* (New Zealand Tertiary) to justify continued separate recognition.

DISTRIBUTION.—Extremely rare in thanatotopes A, B, C, and D. Nihotupu Formation, Pakaurangi Formation, undifferentiated Hukatere Subgroup.

Cibicidoides karreriformis (Hornibrook)

PLATE 9: FIGURES 121, 122

Cibicides karreriformis Hornibrook, 1961:164, pl. 26: figs. 512–514.

DISTRIBUTION.—Rare in thanatotopes A, B, C, and D. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation, undifferentiated Hukatere Subgroup.

Cibicidoides kullenbergi (Parker)

PLATE 10: FIGURE 123

Cibicides kullenbergi Parker *in* Phleger, Parker, and Peirson, 1953:49, pl. 11: figs. 7, 8.

DISCUSSION.—Our material is identical to the holotype and paratype of the recent, deep-water species, *Cibicidoides kullenbergi* Parker (USNM 689859, 689860).

DISTRIBUTION.—Frequent in thanatotope E. DSDP.

Cibicidoides perforatus (Karrer)

Rotalia perforata Karrer, 1864:81, pl. 16: fig. 13.

Cibicides perforatus (Karrer).—Hornibrook, 1961: 161 [in part]; 1971:21, pl. 4: figs. 69–71.

DISTRIBUTION.—Extremely rare in thanatotopes A, B, D, and E. Nihotupu Formation, Pakaurangi Formation, undifferentiated Hukatere Subgroup, DSDP.

Cibicidoides semiperforatus (Hornibrook)

Cibicides semiperforatus Hornibrook, 1961:162, pl. 25: figs. 506–508.

DISTRIBUTION.—Extremely rare in thanatotopes A, C, and D. Nihotupu Formation, undifferentiated Hukatere Subgroup.

Cibicidoides temperatus (Vella)

PLATE 11: FIGURES 135–137

Cibicides temperata Vella, 1957:40, pl. 9: figs. 201–203.—Hornibrook, 1961:162, pl. 24: figs. 476, 477, 482.—Scott, 1970a, fig. 5, no. 7.

DISTRIBUTION.—Abundant in thanatotope B, frequent in thanatotope A, rare in thanatotopes C, D, and F. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation, Puketi Formation, undifferentiated Hukatere Subgroup, Waitemata Group.

Dentalina cf. *D. albatrossi* (Cushman)

PLATE 11: FIGURE 143

DISCUSSION.—Several specimens of *Dentalina* are most similar to *Dentalina albatrossi* (Cushman) (as

Nodosaria vertebralis var. *albatrossi* Cushman, 1923:87, pl. 15: fig. 1; and as *Dentalina albatrossi* (Cushman), Hornibrook, 1961:46).

DISTRIBUTION.—Extremely rare in thanatotopes C, D, and E. Nihotupu Formation, Pakaurangi Formation, DSDP.

Dentalina filiformis (d'Orbigny)

Nodosaria filiformis d'Orbigny, 1826:253.—Brady, 1884:500, pl. 63: figs. 3–5.—Hornibrook, 1961:47, pl. 6: fig. 92.

DISTRIBUTION.—Rare in thanatotopes B, C, D, and E. Nihotupu Formation, Pakaurangi Formation, DSDP.

Dentalina intorta (Dervieux)

PLATE 11: FIGURE 144

Nodosaria intorta Dervieux, 1894:610, pl. 5: figs. 32–34.
Dentalina intorta (Dervieux).—Barker, 1960, pl. 62: figs. 27–31.

DISTRIBUTION.—Extremely rare in thanatotope E. DSDP.

Dentalina obliquecostata (Stache)

Nodosaria obliquecostata Stache, 1864:197, pl. 22: fig. 24.
Dentalina substrigata (Stache).—Hornibrook, 1961:45, pl. 6: fig. 89.
Dentalina obliquecostata (Stache).—Hornibrook, 1971:38, pl. 7: figs. 100–102.

DISTRIBUTION.—Extremely rare in thanatotopes A, B, D, and E. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation, DSDP.

Dentalina soluta Reuss

Dentalina soluta Reuss, 1851:60, pl. 3: fig. 4.—Chapman, 1926:50, pl. 3: fig. 29.—Hornibrook, 1961:45, pl. 6: fig. 90.

DISTRIBUTION.—Rare in thanatotopes C, D, and E. Cornwallis Formation, Nihotupu Formation, DSDP.

Dentalina spirostriolata (Cushman)

PLATE 11: FIGURE 145

Nodosaria spirostriolata Cushman, 1917:656; 1921:212, pl. 38, fig. 4.

DESCRIPTION.—Test elongate, slightly tapering towards the broadly rounded initial end; chambers numerous, short; sutures slightly depressed; ornamentation numerous, strong, narrow longitudinal costae very gently spiralling over entire test.

DISCUSSION.—Specimens are very similar to Cushman's holotype and paratypes of *Nodosaria spirostriolata* (USNM 9119, 11602).

DISTRIBUTION.—Extremely rare in thanatotopes B, D, and E. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation, Waitemata Group, DSDP.

Dentalina subcostata Chapman

Nodosaria (Dentalina) obliqua var. *subcostata* Chapman, 1926: 50, pl. 11: fig. 3.
Dentalina subcostata Chapman.—Hornibrook, 1961:45, pl. 6: fig. 88.

DISTRIBUTION.—Extremely rare in thanatotopes B and E. Pakaurangi Formation, DSDP.

Dentalina subemaciata Parr

PLATE 11: FIGURE 146

Dentalina subemaciata Parr, 1950:329, pl. 12: fig. 1—Barker, 1960, pl. 62: figs. 25, 26.

DISTRIBUTION.—Rare in thanatotopes A, B, C, D, E, and F. Nihotupu Formation, Pakaurangi Formation, Puketi Formation, undifferentiated Hukatere Subgroup, Waitemata Group, DSDP.

Discorbinella bertheloti (d'Orbigny)

PLATE 8: FIGURES 100–102

Rosalina bertheloti d'Orbigny, 1839c:135, pl. 1: figs. 28–30.
Discorbina bertheloti (d'Orbigny).—Brady, 1884:650, pl. 89: figs. 10–12.
Discopulvinulina bertheloti (d'Orbigny).—Hornibrook, 1961: 106, pl. 14: fig. 286.

DISTRIBUTION.—Frequent in thanatotopes B, C, D, and F. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation, undifferentiated Hukatere Subgroup, Waitemata Group.

Discorbinella complanata (Sidebottom)

PLATE 8: FIGURES 103–105; PLATE 12: FIGURES 151, 152

Discorbina bertheloti var. *complanata* Sidebottom, 1918:253, pl. 6: figs. 1–3.

Discorbinella cf. *complanata* (Sidebottom).—Hornibrook, 1961:117, pl. 27: fig. 532.

DISTRIBUTION.—Extremely rare in thanatotope B. Pakaurangi Formation.

Discorbinella galera (Finlay)

PLATE 8: FIGURES 106–108

Discorbis galerus Finlay, 1940:466.—Dorreen, 1948:293.

DISCUSSION.—This species has never been figured before and has only twice been recorded, originally by Finlay (1940) from the Altonian type locality (Pakaurangi Point) and later by Dorreen (1948) from the Eocene of the South Island. A further three specimens referrable to *Discorbinella galera* were found in samples from the type locality during this study.

DISTRIBUTION.—Extremely rare in thanatotope B. Pakaurangi Formation.

Discorbinella cf. *D. scopos* (Finlay)

DISCUSSION.—Several specimens of *Discorbinella* are most similar to *Discorbinella scopos* (Finlay) (as *Discorbis scopos* Finlay, 1940:466, pl. 67: figs. 212, 213; and as *Discopulvinulina scopos* (Finlay), Hornibrook, 1961:105, pl. 14; figs. 284, 285, 290).

DISTRIBUTION.—Extremely rare in thanatotopes A, B, C, and F. Nihotupu Formation, Pakaurangi Formation.

Discorbinella stachi (Asano)

PLATE 8: FIGURES 97–99; PLATE 12: FIGURES 153, 154

Discopulvinulina stachi Asano, 1951:7, figs. 46–48.

DESCRIPTION.—Test plano-convex, scale-like, subcircular in outline; periphery acute, slightly rounded; dorsal side evolute, composed of 2–3 whorls of about 6 narrow chambers each; ventral side flat to gently concave, partly involute; short umbilical flaps developing on chambers; aperture on elongate slit along inner umbilical border of last chamber; secondary slit apertures along flap margins.

DISCUSSION.—This is the first New Zealand record of *Discorbinella stachi* (Asano); previously recorded from the Pliocene and Pleistocene of Japan.

DISTRIBUTION.—Rare in thanatotope B, extremely rare in thanatotopes D and F. Nihotupu Formation, Pakaurangi Formation, undifferentiated Hukatere Subgroup.

Discorbinella turgida (Finlay)

Discorbis turgidus Finlay, 1940:467, pl. 67: figs. 214–216.
Discopulvinulina turgida (Finlay).—Hornibrook, 1961:105, pl. 14: figs. 287, 291, 295.

DISTRIBUTION.—Extremely rare in thanatotopes A, B, and C. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation.

Discorbinella species

PLATE 8: FIGURES 109–111

DISCUSSION.—This species belongs to the *Discorbinella bertheloti* group, but differs from the two species recorded here (*D. bertheloti, D. complanata*) in being extremely compressed, scale-like, very slightly concavo-convex; in both dorsal and ventral sides being evolute; and having strongly curved limbate sutures with more chambers per whorl (10–12).

DISTRIBUTION.—Extremely rare in thanatotopes B and D. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation.

Discorbis balcombensis Chapman, Parr and Collins

PLATE 11: FIGURE 147

Discorbis balcombensis Chapman, Parr and Collins, 1934:562, pl. 8: fig. 10.—Hornibrook, 1961:98, pl. 13: fig. 252.
Discorbis finlayi Dorreen, 1948:293, pl. 38, fig. 12a–c.

DISTRIBUTION.—Frequent in thanatotopes B and F, rare in thanatotopes A and D, extremely rare in thanatotope C. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation, undifferentiated Hukatere Subgroup.

Discorbis semiopercularis Hornibrook

PLATE 11: FIGURES 148, 149

Discorbis semiopercularis Hornibrook, 1961:100, pl. 13: figs. 260–262.

DISTRIBUTION.—Extremely rare in thanatotopes

B and F. Cornwallis Formation, Pakaurangi Formation, undifferentiated Hukatere Subgroup.

Discorbis zealandica (Vella)

PLATE 12: FIGURE 150

Pileolina zealandica Vella, 1957:37, pl. 8: fig. 175, 176.
Discorbis zealandica (Vella).—Hornibrook, 1961:99, pl. 13: figs. 254–256.

DISTRIBUTION.—Frequent in thanatotope F, rare in thanatotope A, B, and D. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation, undifferentiated Hukatere Subgroup.

Discorotalia aranea (Hornibrook)

Notorotalia aranea Hornibrook, 1958:662: figs. 12–14.
Discorotalia aranea (Hornibrook).—Hornibrook, 1961:141, pl. 18: fig. 389–91.

DISTRIBUTION.—Extremely rare in thanatotope C. Nihotupu Formation, Pakaurangi Formation.

Discorotalia tenuissima (Karrer)

Polystomella tenuissima Karrer, 1864:83, pl. 16: fig. 16.
Discorotalia tenuissima (Karrer).—Hornibrook, 1961:141, pl. 18: figs. 387, 388; pl. 28: fig. 547; 1968:98, fig. 20; 1971:21, pl. 3: figs. 50–54.—Hofker, 1969:470: figs. 49–56.

DISTRIBUTION.—Rare in thanatotopes A and B, extremely rare in thanatotopes C. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation, Puketi Formation, undifferentiated Hukatere Subgroup.

Dyocibicides biserialis Cushman and Valentine

PLATE 12: FIGURE 155

Dyocibicides biserialis Cushman and Valentine, 1930:31. pl. 10: figs. 1, 2.—Hornibrook, 1961:165, pl. 26: fig. 516.

DISTRIBUTION.—Frequent in thanatotope B, rare in thanatotopes C, D, and F, extremely rare in thanatotope F. Nihotupu Formation, Pakaurangi Formation, Puketi Formation, undifferentiated Hukatere Subgroup, Waitemata Group.

Dyocibicides primitiva Vella

Dyocibicides primitiva Vella, 1957:41, pl. 9: figs. 198–200.—Hornibrook, 1961:165, pl. 26: fig. 517.

DISTRIBUTION.—Extremely rare in thanatotopes B, D, and F. Nihotupu Formation, Pakaurangi Formation, undifferentiated Hukatere Subgroup.

Ehrenbergina marwicki Finlay

PLATE 12: FIGURE 156

Ehrenbergina marwicki Finlay, 1939c:322, pl. 28: figs. 112–118; 1947:283, pl. 7: fig. 118.—Hornibrook, 1961:87, pl. 10: figs. 195–197; 1968:64; fig. 62.—Scott, 1973a:55, figs. 10, 11.
Ehrenbergina healyi Finlay, 1947:284, pl. 7: figs. 106–115.—Hornibrook, 1961:87.—Scott, 1973a:55, figs. 7, 9.
Ehrenbergina willetti Finlay, 1947:284, pl. 7: figs. 116–117.—Hornibrook, 1961:88.—Scott, 1973a:55, figs. 8, 12.

DISCUSSION.—Scott's (1973a) study on the variability of lower Miocene populations of *Ehrenbergina* led him to conclude that Finlay's three species could be reduced to two subspecies of *Ehrenbergina marwicki*. The subspecies were not separated in this study.

DISTRIBUTION.—Frequent in thanatotopes C and D, extremely rare in thanatotopes A and B. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation.

Elphidium advenum (Cushman)

PLATE 12: FIGURE 157

Polystomella advena Cushman, 1922b:56, pl. 9: figs. 11, 12.
Elphidium advenum (Cushman).—Cushman, 1939:60, pl. 16: figs. 31–35.—Finlay, 1952:61, 62.

DISTRIBUTION.—Frequent in thanatotopes B and F, rare in thanatotopes A, C, and D. Nihotupu Formation, Pakaurangi Formation, Piha Formation, Puketi Formation, undifferentiated Hukatere Subgroup, Waitemata Group.

Elphidium gibsoni Hayward, new species

PLATE 12: FIGURES 158–160; PLATE 15: FIGURE 182

DESCRIPTION.—Test medium to large, lenticular, about 2½ times longer than wide in peripheral view; large, rounded, slightly projecting umbos of semi-opaque shell, ringed by a row of small rounded pores; periphery acutely keeled; 16–22 chambers in adult coil; sutures slightly depressed, radial near umbo but curving backwards toward periphery; retral processes very short, 7–10 per adult chamber;

aperture a row of small rounded openings along base of apertural face.

DISCUSSION.—This species is distinguished by its large umbos and short retral processes. It differs from *Elphidium chapmani* Cushman (Miocene, Australia) in having fewer chambers and retral processes. It is named for Drs. G. W. Gibson (University of Auckland) and T. G. Gibson (U. S. Geological Survey) both of whom assisted greatly during this study.

HOLOTYPE.—TF 1579/1, New Zealand Geological Survey.

PARATYPES.—USNM 243352 (N28/f781; 4 specimens); USNM 243351 (N28/f792; 1 specimen); TF 1579/2–6, USMN 243349, 243354 (N28/f455; 11 specimens); F83 a–f, USNM 243353 (N28/f457; 15 specimens); USNM 243350 (N42/f709; 1 specimen).

TYPE LOCALITY.—N41/f539, Huia Stream, Waitakere Ranges, Grid. Reference N41/074464. Nihotupu Formation, lower Altonian (P1), early Miocene.

DISTRIBUTION.—Rare in thanatotopes A and B, extremely rare in thanatotope D. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation, Puketi Formation.

Elphidium hornibrooki Srinivasan

Elphidium hornibrooki Srinivasan, 1966:248, pl. 4: figs. 8, 12.

DISTRIBUTION.—Frequent in thanatotope B, rare in thanatotopes A, C, D, and F. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation, Puketi Formation, undifferentiated Hukatere Subgroup.

Elphidium nigarense Cushman

PLATE 13: FIGURES 161–165

Elphidium nigarense Cushman, 1936c:85, pl. 15: figs. 3a, b; 1939:63, pl. 17: fig. 19.

DESCRIPTION.—Test lenticular, 2½ times longer than wide in peripheral view; no umbos; umbilical region flat to slightly depressed; periphery acutely keeled; 12–15 chambers in adult coil; anterior rim of chambers thickened and slightly raised, sloping back to suture; sutures depressed, strongly curved; 7–10 retral processes per chamber, extending ¼–⅔ rds distance across adjacent chamber; aperture a row of rounded openings along base of triangular apertural face.

DISCUSSION.—This is the first New Zealand record of *Elphidium nigarense* Cushman; previously recorded from the Pleistocene to Recent of Europe.

DISTRIBUTION.—Rare in thanatotope C, extremely rare in thanatotopes A, B, D, and F. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation, Piha Formation, undifferentiated Hukatere Subgroup, Waitemata Group.

Elphidium pseudoinflatum Cushman

PLATE 13: FIGURES 166–168

Elphidium pseudoinflatum Cushman, 1936c:80, pl. 14: figs. 5a, b; 1939:41, pl. 11: fig. 8.—Carter, 1964:122, pl. 13: figs. 254, 255.
Elphidium subinflatum Cushman, 1936c:84, pl. 15: figs. 1a, b; 1939:48, pl. 12: fig. 20.

DESCRIPTION.—Test inflated; narrow umbilici, often infilled; periphery weakly keeled 8–10 chambers in adult coil; retral processes long, forming narrow, elevated costae that branch from recurved sutural costae; which sutural costae becoming weaker on later adult chambers; aperture a row of rounded openings along base of heart-shaped apertural face.

DISCUSSION.—This is the first New Zealand record of *Elphidium pseudoinflatum* Cushman; previously known from the Miocene of Australia.

DISTRIBUTION.—Rare in thanatotope B, extremely rare in thanatotopes A and D. Nihotupu Formation, Pakaurangi Formation, Puketi Formation.

Elphidium subrotatum Hornibrook

Elphidium subrotatum Hornibrook, 1961:129, pl. 18: figs. 384, 385.

DISTRIBUTION.—One specimen in N28/f458. Pakaurangi Formation.

Elphidium kanoum Hayward, new species

PLATE 13: FIGURES 169, 170; PLATE 15: FIGURES 183, 184

DESCRIPTION.—Test of medium size, about 2½ to 3 times longer than wide in peripheral view, lenticular; umbos glassy, translucent, pitted; periphery acute, weakly keeled; 17–20 chambers in adult coil; sutures slightly depressed, curved; retral processes

7–10 per chamber, arranged in subannular rows around the umbo; aperture a row of small rounded openings along base of apertural face.

DISCUSSION.—*Elphidium kanoum* is distinguished from the following similar species: *E. subrotatum* Hornibrook (Miocene, New Zealand) by its greater inflation and lack of a spinose keel; *E. parri* Cushman (Miocene, Australia) by its smaller size, glassy umbos and fewer chambers per coil; *E. glabratum* Cushman (Miocene, France) and *E. chipolense* (Cushman) (Miocene, Florida) by its keel and more sharply angled periphery; *E. rolshauseni* Cushman and Ellisor (Miocene, Louisiana) by its greater inflation. Hornibrook (1961:129) refers specimens from the Waitakian and Otaian (Lw, Po) of northern New Zealand "to *subrotatum* although they either lack well developed peripheral spines or are rather more inflated." These are most likely good specimens of *E. kanoum.*

HOLOTYPE.—TF 1580/1, New Zealand Geological Survey.

PARATYPES.—USNM 243361 (N28/f454, 11 specimens); F 84 a–d (N28/f781, 4 specimens); TF 1580/2–3, USNM 243360 (N28/f792, 3 specimens).

TYPE LOCALITY.—N28/f457, west side of Pakaurangi Point, Grid. Reference N28/811348. Pakaurangi Formation, lower Altonian (P1), early Miocene.

DISTRIBUTION.—Rare in thanatotopes A and B, extremely rare in thanatotopes C and D. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation, Puketi Formation.

Eoeponidella scotti Hayward, new species

PLATE 14: FIGURES 171–175; PLATE 15: FIGURES 187–189

DESCRIPTION.—Test small, trochospiral; dorsal side evolute, convex, of 2 to 3 whorls; ventral side involute, flat to concave; periphery broadly rounded, slightly lobulate in outline; chambers 4–6 per whorl, rapidly expanding, with final chamber forming one third of test; dorsal sutures curved, almost flush with smoothly perforate surface; ventral sutures slightly depressed, radial to gently curved; ventral supplementary chambers, rhomboidal, covering inner portions of sutures and partially filling the umbilicus; aperture high and narrow, located in infolded depression near base of ventral face of last chamber.

DISCUSSION.—This species most closely resembles *Eoeponidella linki* Wickenden (upper Cretaceous, Canada) from which it differs by its much narrower aperture. A combination of its rhomboidal supplementary chambers, broadly rounded periphery and its high, narrow aperture distinguish *E. scotti* from *E. zealandica* (Hornibrook) (Hornibrook, 1961:114, pl. 16: figs. 352, 354, 355), and other species of this genus. This new species is named for Dr. G. H. Scott (N. Z. Geological Survey), who first recognized *Eoeponidella* in material from Pakaurangi Point (Jones, 1970).

HOLOTYPE.—TF 1581/1, New Zealand Geological Survey.

PARATYPES.—TF 1581/2–4, USNM 243363 (N28/f458, 4 specimens); USNM 243364, 243365 (N28/f795, 7 specimens); USNM 243362, 243366 (N28/f912, 9 specimens); F 85 a–f (N33/f505, 6 specimens); USNM 243367 (N33/f534, 9 specimens).

TYPE LOCALITY.—N28/f457, west side of Pakaurangi Point, Grid. Reference N28/811348. Pakaurangi Formation, lower Altonian (P1), early Miocene.

DISTRIBUTION.—Frequent in thanatotopes B, D, and F, extremely rare in thanatotopes A, C, and E. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation, Puketi Formation, undifferentiated Hukatere Subgroup, DSDP.

Epistominella cassidulinoides Hornibrook

Epistominella cassidulinoides Hornibrook, 1961:121, pl. 17: figs. 360, 362, 364.

DISTRIBUTION.—Rare in thanatotope D, extremely rare in thanatotopes B, C, and F. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation, undifferentiated Hukatere Subgroup, Waitemata Group.

Epistominella exigua (Brady)

PLATE 14: FIGURES 176, 177

Pulvinulina exigua Brady, 1884:696, pl. 103: figs. 13, 14.
Epistominella exigua (Brady).—Barker, 1960, pl. 103: figs. 13, 14.

DISTRIBUTION.—Abundant in thanatotope E. DSDP.

Epistominella iota Hornibrook

Epistominella iota Hornibrook, 1961:122, pl. 17: figs. 359, 361, 363.

DISTRIBUTION.—Extremely rare in thanatotopes B and D. Nihotupu Formation, Pakaurangi Formation.

Epistominella minima (Cushman)

Eponides minima Cushman, 1933:17, pl. 2: figs. 8a–c.

DISTRIBUTION.—Frequent in thanatotope E. DSDP.

Eponides broeckhianus (Karrer)

Rotalia broeckhiana Karrer, 1878:98, pl. 5: fig. 26.
Gyroidina broeckhiana (Karrer).—Barker, 1960, pl. 107: fig. 4.
Eponides broeckhianus (Karrer).—Hornibrook, 1961:109, pl. 15: figs. 321–322.

DISTRIBUTION.—Rare in thanatotope D, extremely rare in thanatotopes B, C, and F. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation, undifferentiated Hukatere Subgroup, Waitemata Group.

Eponides repandus (Fichtel and Moll)

Nautilus repandus Fichtel and Moll, 1803:35, pl. 3: figs. a-d.
Pulvinulina repanda (Fichtel and Moll).—Chapman, 1926:84, pl. 17: fig. 1.
Eponides repandus (Fichtel and Moll).—Hornibrook, 1961: 109, pl. 15: fig. 324.

DISTRIBUTION.—Extremely rare in thanatotopes A, B, and F. Cornwallis Formation, Pakaurangi Formation, undifferentiated Hukatere Subgroup.

Eulepidina dilatata dilatata (Michelotti)

Orbitoides dilatata Mitchelotti, 1861:17, pl. 1: figs. 1, 2.
Eulepidina dilatata dilatata (Mitchelotti).—Matsumaru, 1971: 184, pl. 22: figs. 28–38.

DISTRIBUTION.—Extremely rare in thanatotope A. Nihotupu Formation.

Eouvigerina zelandica (Finlay)

Zeauvigerina zelandica Finlay, 1939a:541, pl. 69: fig. 4—Hornibrook, 1968:84, fig. 16.

DISTRIBUTION.—Extremely rare in thanatotope E. DSDP. Possibly reworked from the Paleocene or Eocene.

Euuvigerina aff. *E. brunnensis* (Karrer)

DISCUSSION.—A single specimen of *Euuvigerina* is most similar to *Euuvigerina brunnensis* (Karrer) (as *Uvigerina brunnensis Karrer,* 1877:385, pl. 16b: 49).

DISTRIBUTION.—Extremely rare in thanatotope E. DSDP.

Euuvigerina aff. *E. cushmani* (Todd)

DISCUSSION.—Several specimens of *Euuvigerina* are most similar to *Euuvigerina cushmani* (Todd) (as *Uvigerina cushmani* Todd, 1948:257, pl. 33: fig. 1).

DISTRIBUTION.—Extremely rare in thanatotope E. DSDP.

Euuvigerina miozea (Finlay)

PLATE 14: FIGURE 178

Uvigerina miozea Finlay, 1939b:102, pl. 12: figs. 12–14.—Hornibrook, 1961:65, pl. 8: fig. 144.
Hofkeruva (*Trigonouva*) *miozea* (Finlay).—Vella, 1961:477, pl. 1: figs. 5, 8, 9.
Euuvigerina (*Hofkeruva*) *miozea* (Finlay).—Hornibrook, 1968: 103, fig. 22.

DISTRIBUTION.—Common in thanatotope C, frequent in thanatotope B, rare in thanatotope D, extremely rare in thanatotopes A and F. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation, undifferentiated Hukatere Subgroup.

Evolvocassidulina bradyi (Norman)

PLATE 14: FIGURE 179

Cassidulina bradyi Norman.—Brady, 1881:59.
Cassidulinoides bradyi (Norman).—Barker, 1960, pl. 54: figs. 6–9.—Hornibrook, 1961:87.

DISTRIBUTION.—Extremely rare in thanatotopes B, C, and E. Pakaurangi Formation, DSDP.

Evolvocassidulina cf. *E. chapmani* Parr

PLATE 15: FIGURE 180

DISCUSSION.—Several specimens of *Evolvocassidu-*

lina are most similar to *Evolvocassidulina chapmani* Parr (as *Cassidulinoides chapmani* Parr, 1931:100; figs. a–c).

DISTRIBUTION.—Extremely rare in thanatotopes B and D. Nihotupu Formation, Pakaurangi Formation.

Evolvocassidulina orientalis (Cushman)

PLATE 14: FIGURE 181

Cassidulina bradyi Norman.—Brady, 1884, pl. 54: fig. 10 [not of Norman].—Chapman, 1926:42, pl. 9: fig. 11.

Cassidulina orientalis Cushman, 1922c:129.

Cassidulinoides orientalis (Chapman).—Hornibrook, 1961:86, pl. 10: fig. 201.—Gibson, 1967:43, pl. 10: fig. 162.

Evolvocassidulina orientalis (Chapman).—Eade, 1967:431, fig. 4, nos. 1, 2.

DISTRIBUTION.—Frequent in thanatotopes C and D, extremely rare in thanatotope B. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation, undifferentiated Hukatere Subgroup, Waitemata Group.

Fissurina alveolata (Brady)

Lagena alveolata Brady, 1884:487, pl. 40: figs. 30–32.—Cushman, 1913:33, pl. 18: fig. 1.

Fissurina alveolata (Brady).—Barker, 1960, pl. 60: figs. 30, 32.

DISTRIBUTION.—Extremely rare in thanatotope F. Undifferentiated Hukatere Subgroup.

Fissurina aperta Seguenza

PLATE 16: FIGURES 200, 201

Fissurina (Fissurine) aperta Seguenza, 1862:60, pl. 1: fig. 60.

Fissurina aperta Seguenza.—Parr. 1950:312.

DESCRIPTION.—Test subcircular in side view, moderately compressed; periphery faintly keeled, broadly rounded; apertural edge broadly truncate; test surface smooth; aperture a long narrow fissure, approximately two-thirds width of test; apertural lip distinct, raised.

DISCUSSION.—This is the first New Zealand record of *Fissurina aperta* Seguenza. This species is easily distinguished by its very broad aperture and subcircular test.

DISTRIBUTION.—Rare in thanatotope B, extremely rare in thanatotope D. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation, undifferentiated Hukatere Subgroup.

Fissurina aureoligera (Buchner)

PLATE 16: FIGURES 202, 203

Lagena aureoligera Buchner, 1940:457, pl. 9: figs. 144–145.

DISTRIBUTION.—Extremely rare in thanatotopes B and C. Nihotupu Formation, Pakaurangi Formation.

Fissurina auriculata (Brady)

Lagena auriculata Brady, 1881:61.—1884:487, pl. 60: fig. 29.

Fissurina auriculata (Brady).—Barker, 1960, pl. 60: fig. 29.

DISTRIBUTION.—Extremely rare in thanatotope E. DSDP.

Fissurina basifimbriata Parr

PLATE 16: FIGURE 204

Fissurina basifimbriata Parr, 1950:312, pl. 9. figs. 6, 7.

DISTRIBUTION.—Extremely rare in thanatotope E. DSDP.

Fissurina biancae Seguenza

Fissurina biancae Seguenza, 1862:57, pl. 1: figs. 48–50.

DISTRIBUTION.—Extremely rare in thanatotope D. Nihotupu Formation, Pakaurangi Formation.

Fissurina bradii Silvestri

Fissurina bradii Silvestri, 1902:147.—Barker, 1960, pl. 59: fig. 24.

DISTRIBUTION.—Extremely rare in thanatotopes B, C, D, and E. Pakaurangi Formation, Piha Formation, Waitemata Group, DSDP.

Fissurina clypeato-marginata (Jones)

Lagena vulgaris var. *clypeato-marginata* Jones, 1872:58, pl. 19: fig. 37.

DISTRIBUTION.—Extremely rare in thanatotope D. DSDP.

Fissurina crenulata (Cushman)

Lagena orbignyana var. *crenulata* Cushman, 1913:44, pl. 10: fig. 2.

DISTRIBUTION.—Extremely rare in thanatotope D. Waitemata Group.

Fissurina hartiana (Earland)

Lagena hartiana Earland, 1933:112, pl. 4: figs. 12–13.

DISTRIBUTION.—Extremely rare in thanatotope E. DSDP.

Fissurina kerguelenensis Parr

PLATE 16: FIGURE 206

Fissurina kerguelenensis Parr, 1950:305, pl. 8: figs. 7a, b.—Barker, 1960, pl. 59: figs. 8–11.—Kennett, 1966a, table 6.

DISTRIBUTION.—Extremely rare in thanatotope E. DSDP.

Fissurina laevigata Reuss

Fissurina laevigata Reuss, 1850:366, pl. 46: fig. 1.—Barker, 1960, pl. 114: fig. 8.—Kennett, 1966a, table 6.
Lagena laevigata (Reuss).—Cushman, 1913:7, pl. 2: fig. 1; 1923:28, pl. 5: figs. 1, 2.

DISTRIBUTION.—Rare in thanatotope D, extremely rare in thanatotopes B, C, and E. Nihotupu Formation, Pakaurangi Formation, Waitemata Group, DSDP.

Fissurina lagenoides (Williamson)

PLATE 16: FIGURE 205

Entosolenia marginata var. *lagenoides* Williamson, 1858:11, pl. 1: figs. 25,26.
Lagena lagenoides (Williamson).—Cushman, 1913:39, pl. 16: fig. 2; 1923:30, pl. 5: figs. 6–8.—Barker, 1960, pl. 60: figs. 6, 9, 12.
Fissurina lagenoides (Williamson).—Hornibrook, 1961, table 6.

DISTRIBUTION.—Extremely rare in thanatotope E. DSDP.

Fissurina marginata (Walker and Boys)

PLATE 16: FIGURE 207

Serpula (*Lagena*) *marginata* Walker and Boys, 1784:2, pl. 1: fig. 7.
Lagena marginata (Walker and Boys).—Cushman, 1923:35, pl. 6: fig. 9.
Fissurina marginata (Walker and Boys).—Parr, 1950:305.—Hornibrook, 1961, table 6.—Kennett, 1966a, table 6.

DISTRIBUTION.—Frequent in thanatotope D, extremely rare in thanatotopes B, E, and F. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation, undifferentiated Hukatere Subgroup, Waitemata Group, DSDP.

Fissurina aff. *F. obscurocostata* Galloway and Wissler

PLATE 16: FIGURE 208

DISCUSSION.—Several specimens of *Fissurina* are most similar to *Fissurina obscurocostata* Galloway and Wissler (1927:52, pl. 9:fig. 1).

DISTRIBUTION.—Rare in thanatotope D, extremely rare in thanatotopes B and C. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation, Piha Formation, Waitemata Group.

Fissurina orbignyana Seguenza

PLATE 16: FIGURE 210

Fissurina orbignyana Seguenza, 1862:66, pl. 2: figs. 25, 26.—Barker, 1960, pl. 59: fig. 26.—Hornibrook, 1961, table 6.
Lagena orbignyana (Seguenza).—Cushman, 1923:39.

DISTRIBUTION.—Extremely rare in thanatotopes B, D, E, and F. Nihotupu Formation, Pakaurangi Formation, undifferentiated Hukatere Subgroup, DSDP.

Fissurina quadrata (Williamson)

Entosolenia marginata var. *quadrata* Williamson, 1858:11, pl. 1: figs. 27, 28.
Lagena quadrata (Williamson).—Cushman, 1913:35, pl. 14: fig. 9; 1923:47, pl. 9: figs. 5, 6.
Fissurina quadrata (Williamson).—Barker, 1960, pl. 59: fig. 3.

DISTRIBUTION.—Extremely rare in thanatotopes D and F. Pakaurangi Formation, undifferentiated Hukatere Subgroup, Waitemata Group.

Fissurina radiata Seguenza

PLATE 16: FIGURE 209

Fissurina radiata Seguenza, 1862:70, pl. 2: figs. 42–43.—Barker, 1960, pl. 60: figs. 13, 14.

DISTRIBUTION.—Extremely rare in thanatotope E. DSDP.

Fissurina unguiculata (Brady)

Lagena unguiculata Brady, 1881:61; 1884:474, pl. 59: fig. 12. —Cushman, 1913:32, pl. 11: fig. 1.
Fissurina unguiculata (Brady).—Barker, 1960, pl. 59: fig. 12.

DISTRIBUTION.—Extremely rare in thanatotope E. DSDP.

Florilus stachei (Cushman)

PLATE 17: FIGURE 211

Nonion stachei Cushman, 1936b:66, pl. 12: fig. 7a, b; 1939: 16, pl. 3: fig. 18.
Pseudononion stachei (Cushman).—Hornibrook, 1961:93, pl. 11: figs. 216, 220.

DISTRIBUTION.—Extremely rare in thanatotopes A, B, and C. Nihotupu Formation, Pakaurangi Formation.

Frondicularia bassensis Parr

Frondicularia bassensis Parr, 1950:331, pl. 12: fig. 113.
Frondicularia cf. *bassensis* Parr.—Hornibrook, 1961:53, pl. 6: fig. 113.

DISTRIBUTION.—Extremely rare in thanatotope D. Pakaurangi Formation.

Frondicularia tenuissima Hantken

PLATE 15: FIGURES 185, 186

Frondicularia tenuissima Hantken, 1875:43, pl. 13: fig. 11.

DESCRIPTION.—Test compressed, flattened, elongate with both extremities tapered; initial end with stout spine; periphery truncately rounded; chambers narrow, elongate, early ones in loose coil, later ones chevron shaped, partially enveloping early chambers; sutures distinct, slightly depressed; wall smooth; aperture terminal, radiate, on a short neck.

DISCUSSION.—This is the first New Zealand record of *Frondicularia tenuissima* Hantken, previously recorded from the Paleocene to Miocene of the Americas and Europe, Eocene of Pakistan and Australia, and Miocene of Java.

DISTRIBUTION.—Extremely rare in thanatotopes C and D. Cornwallis Formation, Pakaurangi Formation.

Fursenkoina bramletti (Galloway and Morrey)

Virgulina bramletti Galloway and Morrey, 1929:37, pl. 5: fig. 14.—Cushman, 1937:19, pl. 3: figs. 6–9.—Hornibrook, 1961:64, pl. 8, fig. 139.

DISTRIBUTION.—Extremely rare in thanatotopes B, D, and E. Nihotupu Formation, Pakaurangi Formation, DSDP.

Fursenkoina schreibersiana (Czjzek)

PLATE 17: FIGURE 212

Virgulina schreibersiana Czjzek, 1848:147, pl. 13: figs. 18–21. —Cushman, 1937:13, pl. 2: figs. 11–20.—Hornibrook, 1961: 64, pl. 8: fig. 138.

DISTRIBUTION.—Rare in thanatotope D, extremely rare in thanatotopes B, C, and E. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation, Piha Formation, DSDP.

Gavelinopsis pukeuriensis Hornibrook

Gavelinopsis pukeuriensis Hornibrook, 1961:104, pl. 13: figs. 267, 270, 271.

DISTRIBUTION.—Extremely rare in thanatotopes B, C, and D. Nihotupu Formation, Pakaurangi Formation.

Glabratella crassa Dorreen

Glabratella crassa Dorreen, 1948:294, pl. 39: fig. 1.—Hornibrook, 1961:108, pl. 14: fig. 289.—Seiglie and Bermudez, 1965:28.

DISTRIBUTION.—Extremely rare in thanatotope B. Pakaurangi Formation.

Glabratellina sigali Seiglie and Bermudez

PLATE 15: FIGURE 190; PLATE 17: FIGURES 213–215

Glabratellina sigali Seiglie and Bermudez, 1965:42, pl. 9: figs. 4–7.

DESCRIPTION.—Test trochospiral; dorsal side evolute, conically domed with three to four whorls visible; ventral side involute, convex around periphery, flat to concave towards open umbilicus; periphery obtusely angled, somewhat rounded; five to six chambers per whorl; sutures slightly limbate, usually flush with surface; dorsal sutures curved backwards; ventral sutures radial; dorsal surface smooth, coarsely perforate; ventral surface with narrow radiating grooves around periphery, centrally papilose; aperture umbilical.

DISCUSSION.—This is the first New Zealand record of *Glabratellina sigali* Seiglie and Bermudez, known from the Miocene of Cuba. This species differs from the New Zealand species *Discorbis patelliformis* (Brady) and *D. zealandica* (Vella) in its higher, more domed dorsal side and less angular periphery. *Glabratellina sigali* is commonly found as plastagamic pairs.

DISTRIBUTION.—Extremely rare in thanatotopes B, D, and F. Cornwallis Formation, Pakaurangi Formation, undifferentiated Hukatere Subgroup.

Globobulimina pacifica Cushman

PLATE 17: FIGURES 216, 217

Globobulimina pacifica Cushman, 1927a:67, pl. 14: fig. 12.—Cushman and Parker, 1947:134, pl. 29: fig. 37.—Hornibrook, 1961:63.—Gibson, 1967:27, pl. 7: fig. 115.

DISTRIBUTION.—Rare in thanatotope C, extremely rare in thanatotopes B and D. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation.

Globobulimina monteryana (Kleinpell)

Bulimina monteryana Kleinpell, 1938:254, pl. 13: fig. 13.
Bulimina (Desinobulimina) monteryana Kleinpell.—Cushman and Parker, 1947:129, pl. 29: figs. 20, 21.—Gibson, 1967; pl. 7: fig. 114.

DISTRIBUTION.—Extremely rare in thanatotope C. Nihotupu Formation.

Globocassidulina arata (Finlay)

PLATE 17: FIGURE 218

Cassidulina arata Finlay, 1939b:112, pl. 14: figs. 74, 75.

DISTRIBUTION.—Frequent in thanatotope B, rare in thanatotopes A, C, D, and F. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation, Puketi Formation, undifferentiated Hukatere Subgroup, Waitemata Group.

Globocassidulina subglobosa (Brady)

PLATE 17: FIGURES 219, 220

Cassidulina subglobosa Brady, 1881:60; 1884:430, pl. 54: fig. 17.—Hornibrook, 1961:85, pl. 10: fig. 198.—Gibson, 1967:42, pl. 10: fig. 163.

DISTRIBUTION.—Abundant in thanatotope E, common in thanatotope D, frequent in thanatotope C, extremely rare in thanatotope B. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation, Waitemata Group, DSDP.

Globulina gibba d'Orbigny

Globulina gibba d'Orbigny, 1826:266, "Modèle" 63.—Cushman and Ozawa, 1930:60, pl. 16: figs. 1–4.—Dorreen, 1948: 289, pl. 37: fig. 1.—Hornibrook, 1961:60, pl. 7: fig. 124.

DISTRIBUTION.—Extremely rare in thanatotope C. Pakaurangi Formation.

Guttulina austriaca d'Orbigny

Guttulina austriaca d'Orbigny, 1846:223, pl. 12: figs. 23–25.—Cushman and Ozawa, 1930:29, pl. 4: figs. 3–5.—Hornibrook, 1961:55, pl. 7: fig. 120.

DISTRIBUTION.—Extremely rare in thanatotopes D and E. Nihotupu Formation, DSDP.

Guttulina fissurata Stache

Guttulina fissurata Stache, 1864:263, pl. 24: figs. 10a, b.—Hornibrook, 1961:48, fig. 12, pl. 10: figs. 178, 179.

DISTRIBUTION.—Extremely rare in thanatotope B. Pakaurangi Formation.

Guttulina problema d'Orbigny

Guttulina problema d'Orbigny, 1826:266.—Cushman and Ozawa, 1930:19, pl. 2: figs. 1–6; pl. 3: fig. 1.—Hornibrook, 1961:54, pl. 7: fig. 118 [in part].

DISTRIBUTION.—Extremely rare in thanatotopes B and E. Pakaurangi Formation, DSDP.

Gyroidina danvillensis Howe and Wallace

PLATE 18: FIGURES 224, 225

Gyroidina danvillensis Howe and Wallace, 1932:69, pl. 13: fig. 3.

Gyroidinoides prominula (Stache).—Hornibrook, 1961:111, pl. 16: figs. 348, 349.

DESCRIPTION.—Test small, subglobose; ventral side involute, high convex, with small umbilicus; dorsal side evolute, low convex to flat; periphery broadly rounded; 6–7 chambers per whorl; sutures nonlimbate, slightly depressed and radial on both sides; surface smooth; aperture a low slit extending almost from umbilicus to periphery.

DISCUSSION.—This is the first New Zealand record of *Gyroidina danvillensis* Howe and Wallace; previously recorded from the Paleocene to Miocene of the Americas, Europe, and Russia. *G. danvillensis* is distinguished by its small size, rounded periphery, high dorsal side, 6–7 chambers per whorl and radial sutures.

DISTRIBUTION.—Frequent in thanatotope C, rare in thanatotopes B and D. Nihotupu Formation, Pakaurangi Formation.

Gyroidina cf. *G. orbicularis* d'Orbigny

DISCUSSION.—Several specimens of *Gyroidina* are most similar to *Gyroidina orbicularis* d'Orbigny (1826:278; "Modéle no." 13; Barker, 1960, pl. 115: figs. 6a–c). *Gyroidina* cf. *G. orbicularis* is distinguished from *G. danvillensis* and *G. zelandica* by its more compressed profile, its limbate ventral sutures, angled periphery, 8–10 chambers per whorl and small umbilicus.

DISTRIBUTION.—Rare in thanatotope C. Pakaurangi Formation.

Gyroidina zelandica Finlay

PLATE 18: FIGURES 221–223

Gyroidina zelandica Finlay, 1939c:323, pl. 28: figs. 138–140. —Douglas, 1973, pl. 12: figs. 4–9; pl. 24: figs. 5, 6.

Gyroidinoides zelandica (Finlay).—Hornibrook, 1961:113, pl. 16: figs. 339–344; 1968:69, fig. 12.

DISTRIBUTION.—Abundant in thanatotope C, common in thanatotopes B, D, and E, rare in thanatotopes A and F. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation, Piha Formation, undifferentiated Hukatere Subgroup, Waitemata Group, DSDP.

Gyroidina species

PLATE 18: FIGURES 226–228

DISCUSSION.—This species occurs commonly with *Gyroidina zelandica* in DSDP samples. It is very distinctive with its strongly tangential dorsal sutures, its angled periphery, closed umbilicus with limbate ventral sutures and its small aperture.

DISTRIBUTION.—Common in thanatotope E. DSDP.

Hanzawaia laurisae (Mallory)

PLATE 18: FIGURES 229, 230

Cibicides laurisae Mallory, 1959:267, pl. 24: fig. 8.

DESCRIPTION.—Test plano-convex; periphery angled dorsal side flat, partly involute with flaps on lower margins of chambers overlapping chambers of previous whorl; ventral side high convex, involute, non-umbilicate; 8–10 chambers per whorl; sutures curved, flush or slightly depressed; aperture a peripheral arched opening extending to join supplementary openings beneath dorsal flaps.

DISTRIBUTION.—Rare in thanatotopes C and D, extremely rare in thanatotopes A and B. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation, Piha Formation, Waitemata Group.

Hanzawaia species

DISCUSSION.—This species has a very similar plano-convex profile to *Hanzawaia laurisae;* it differs in being more involute on the dorsal side, having 10–12 chambers per whorl, sinuously curved ventral sutures and limbate dorsal sutures.

DISTRIBUTION.—Extremely rare in thanatotopes B and D. Pakaurangi Formation.

Heronallenia lingulata (Burrows and Holland)

Discorbina lingulata Burrows and Holland *in* Jones, 1895, pl. 7: figs. 33a–c.

Heronallenia lingulata (Burrows and Holland).—Carter, 1958: 42, pl. 5: figs. 40–42.—Barker, 1960, pl. 91: fig. 3.

DISTRIBUTION.—Rare in thanatotope E. DSDP.

Heterostegina borneensis van der Vlerk

Heterostegina borneensis van der Vlerk, 1930:16, figs. 6, 25. —Hornibrook, 1968:108, fig. 1.

DISTRIBUTION.—Extremely rare in thanatotope A and C. Nihotupu Formation, undifferentiated Hukatere Subgroup.

Hoeglundina elegans (d'Orbigny)

PLATE 18: FIGURE 231

Rotalia (Turbinuline) elegans d'Orbigny, 1826:276.
Pulvinulina elegans (d'Orbigny).—Chapman, 1926:82, pl. 16: fig. 11.
Epistomina elgans (d'Orbigny).—Hornibrook, 1961:122, pl. 17: fig. 367.
Hoeglundina elegans (d'Orbigny).—Gibson, 1967:51, pl. 12: fig. 194.—Hornibrook, 1968:52, fig. 7.

DISTRIBUTION.—Frequent in thanatotopes B and C, rare in thanatotopes D and F. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation, undifferentiated Hukatere Subgroup.

Hofkerina semiornata (Howchin)

PLATE 19: FIGURE 232

Pulvinulina semiornata Howchin, 1889:14, pl. 1: fig. 12.
Hofkerina semiornata (Howchin).—Carter, 1958:58, pl. 9: figs. 88–90.—Hornibrook, 1961:169, pl. 26: figs. 521, 522; 1968:64, fig. 11.

DISTRIBUTION.—Extremely rare in thanatotope A. Undifferentiated Hukatere Subgroup.

Karreria maoria (Finlay)

PLATE 19: FIGURES 233, 234

Vagocibicides maoria Finlay, 1939c:326, pl. 29: figs. 148–151, 158.—Hornibrook, 1961:165, pl. 26: fig. 515.

DISTRIBUTION.—Frequent in thanatotope B, rare in thanatotope D, extremely rare in thanatotopes A and C. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation, Waitemata Group.

Lagena acuticostata Reuss

PLATE 19: FIGURE 235

Lagena acuticostata Reuss, 1862:305, pl. 1: fig. 4.—Cushman, 1913:23, pl. 8: figs. 9, 10; 1923:5, pl. 1, figs. 1–3.—Hornibrook, 1961, table 6.

DISTRIBUTION.—Extremely rare in thanatotope D. Nihotupu Formation, Waitemata Group.

Lagena costata (Williamson)

Entosolenia costata Williamson, 1858:9, pl. 1: fig. 18.
Lagena costata (Williamson).—Cushman, 1913:21, pl. 9: fig. 6; 1923:12, pl. 1: fig. 16; pl. 2: figs. 1, 2; pl. 3: fig. 8.—Hornibrook, 1961, table 6.

DISTRIBUTION.—Extremely rare in thanatotope C. Pakaurangi Formation.

Lagena distoma Parker and Jones

PLATE 19: FIGURE 236

Lagena distoma Parker and Jones, *in* Brady, 1864:467, pl. 48: fig. 6.—Cushman, 1923:14, pl. 3: figs. 2, 3.—Barker, 1960, pl. 58: figs. 11–15.—Hornibrook, 1961, table 6.—Kennett, 1966a, table 6.

DISTRIBUTION.—Extremely rare in thanatotopes C and D. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation.

Lagena elongata (Ehrenberg)

PLATE 19: FIGURE 239

Miliola elongata Ehrenberg, 1844:274.
Lagena elongata (Ehrenberg).—Cushman, 1913:12, pl. 1: fig. 5; 1923:15, pl. 3: fig. 4.—Barker, 1960, pl. 56: figs. 27–29.—Hornibrook, 1961, table 6.—Kennett, 1966a, table 6.

DISTRIBUTION.—Extremely rare in thanatotopes B, C, and D. Nihotupu Formation, Pakaurangi Formation.

Lagena gracilis Williamson

PLATE 19: FIGURE 237

Lagena gracilis Williamson, 1848:13, pl. 1: figs. 3, 4.—Cushman, 1913:22, pl. 8: figs. 5, 6; 1923:22, pl. 4: figs. 3, 4.—Barker, 1960, pl. 58: figs. 2, 3, 7–10.—Hornibrook, 1961, table 6.

DISTRIBUTION.—Extremely rare in thanatotope B and E. Pakaurangi Formation, DSDP.

Lagena hispidula Cushman

Lagena laevis Brady, 1884 [in part], pl. 56: figs. 10, 11.
Lagena hispidula Cushman, 1913:14, pl. 5: figs. 2, 3.—Barker, 1960, pl. 56; figs. 10, 11.—Kennett, 1966a, table 6.—Quilty, 1974:67, pl. 3: fig. 100.

DISTRIBUTION.—Extremely rare in thanatotopes

C and D. Cornwallis Formation, Pakaurangi Formation.

Lagena laevis (Montagu)

Vermiculum laeve Montagu, 1803:524.
Lagena laevis (Montagu).—Cushman, 1913:5, pl. 1: fig. 3; pl. 38: fig. 5.—Barker, 1960, pl. 56: figs. 7–9; pl. 57: figs. 14, 16, 17.—Hornibrook, 1961, table 6.—Quilty, 1974:68, pl. 3: figs. 101, 102.

DISTRIBUTION.—Extremely rare in thanatotopes A, B, C, and D. Nihotupu Formation, Pakaurangi Formation, Waitemata Group.

Lagena striata (d'Orbigny)

PLATE 19: FIGURE 240

Oolina striata d'Orbigny, 1839b:21, pl. 5: fig. 12.
Lagena striata (d'Orbigny).—Cushman, 1913:19, pl. 7: figs. 4, 5; 1923:54, pl. 10: fig. 9.—Hornibrook, 1961, table 6. —Quilty, 1974:69, pl. 3: fig. 105.

DISTRIBUTION.—Frequent in thanatotope C, rare in thanatotope D, extremely rare in thanatotope B. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation, Piha Formation, Waitemata Group.

Lagena substriata Williamson

PLATE 19: FIGURE 238

Lagena substriata Williamson, 1848:15, pl. 1: fig. 12.—Cushman, 1923:56, pl. 10: fig. 11.

DISTRIBUTION.—Extremely rare in thanatotopes C and D. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation.

Lagena sulcata Walker and Jacob

Serpula (Lagena) sulcata Walker and Jacob, 1798:634, pl. 14: fig. 5.
Lagena sulcata Walker and Jacob.—Cushman, 1913:22, pl. 9: fig. 2; 1923:58, pl. 11: fig. 1.—Barker, 1960, pl. 57: figs. 33, 34.—Hornibrook, 1961, table 6.—Quilty, 1974:69, pl. 3: fig. 106.

DISTRIBUTION.—Extremely rare in thanatotopes B, C, and D. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation.

Lagenoglandulina annulata (Stache)

PLATE 19: FIGURE 241

Glandulina annulata Stache, 1864:184, pl. 22: figs. 6a, b.
Lagenoglandulina annulata (Stache).—Hornibrook, 1971:35, pl. 6: figs. 93, 94.

DISTRIBUTION.—Rare in thanatotope C, extremely rare in thanatotope D. Nihotupu Formation, Pakaurangi Formation, Waitemata Group.

Laticarinina altocamerata (Heron-Allen and Earland)

PLATE 19: FIGURES 242, 243

Truncatulina tenuimargo var. *altocamerata* Heron-Allen and Earland, 1922:209, pl. 7: figs. 24–27.
Parvicarinina altocamerata (Heron-Allen and Earland).—Finlay, 1940:467, pl. 62: figs. 30–34.—Hornibrook, 1961:118, pl. 14: figs. 296, 299, 301, 302, 305.

DISTRIBUTION.—Extremely rare in thanatotopes B and C. Nihotupu Formation, Pakaurangi Formation.

Laticarinina pauperata (Parker and Jones)

Pulvinulina repanda var. *menardii* subvar. *pauperata* Parker and Jones, 1865:395, pl. 16: figs. 50, 51.
Laticarinina halophora (Stache).—Finlay, 1940:468, pl. 62: figs. 27–29.—Hornibrook, 1961:119, pl. 14: figs. 300, 303–304 [not of Stache].
Laticarinina pauperata (Parker and Jones).—Hornibrook, 1968:58; fig. 9; 1971:45.

DISTRIBUTION.—Frequent in thanatotope E. DSDP.

Lenticulina callifera (Stache)

PLATE 19: FIGURES 244–246

Cristellaria callifera Stache, 1864:236, pl. 23: figs. 15a, b.
Robulus calliferus (Stache).—Hornibrook, 1971: 42, pl. 9: figs. 148, 149.

DISTRIBUTION.—Rare in thanatotopes B, C, and D. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation, Waitemata Group.

Lenticulina colorata (Stache)

Cristellaria colorata Stache, 1864:229, pl. 23: figs. 9a, b.
Robulus coloratus (Stache).—Hornibrook, 1971:42, pl. 8: figs. 139–146.

DISTRIBUTION.—Extremely rare in thanatotope C. Pakaurangi Formation.

Lenticulina dorothiae (Finlay)

Robulus dorothiae Finlay, 1939c:314, pl. 27: figs. 107, 108.

DISTRIBUTION.—Extremely rare in thanatotopes C and D. Nihotupu Formation, Waitemata Group.

Lenticulina foliata (Stache)

Robulina foliata Stache, 1864:245, pl. 23: fig. 24.
Robulus dicampylus (Franzenau).—Hornibrook, 1961:38, pl. 3: fig. 52.
Robulus foliatus (Stache).—Hornibrook, 1961:42, pl. 9: figs. 151, 152.

DISTRIBUTION.—Extremely rare in thanatotopes C and D. Cornwallis Formation, Nihotupu Formation.

Lenticulina formosa (Cushman)

Cristellaria formosa Cushman, 1923:110, pl. 29: fig. 1; pl. 30, fig. 6.
Lenticulina formosa (Cushman).—Barker, 1960, pl. 70: figs. 13, 14, 15.

DISTRIBTION.—Extremely rare in thanatotope E. DSDP.

Lenticulina gibba (d'Orbigny)

Cristellaria gibba d'Orbigny, 1839a:40: pl. 7: figs. 20, 21.
Lenticulina gibba (d'Orbigny).—Hornibrook, 1961:39, pl. 3: fig. 50.

DISTRIBUTION.—Frequent in thanatotopes C and D, rare in thanatotope B, extremely rare in thanatotope A. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation, Puketi Formation, undifferentiated Hukatere Subgroup.

Lenticulina gyroscalpra (Stache)

Cristellaria gyroscalprum Stache, 1864:243, pl. 23: fig. 22.
Robulus gyroscalprus (Stache).—Hornibrook, 1961:36, pl. 5: fig. 67; 1971:43, pl. 9: figs. 160, 161.

DISTRIBUTION.—Rare in thanatotope B, extremely rare in thanatotopes A and D. Nihotupu Formation, Pakaurangi Formation, undifferentiated Hukatere Subgroup.

Lenticulina iota (Cushman)

Cristellaria iota Cushman, 1923:111, pl. 29: fig. 2; pl. 30, fig. 1.
Robulus iotus (Cushman).—Hornibrook, 1961:36.—Gibson, 1967, pl. 4: figs. 64, 65.

DISTRIBUTION.—Extremely rare in thanatotope B and E. Pakaurangi Formation, DSDP.

Lenticulina lenticula (Stache)

Robulina lenticula Stache, 1864:246, pl. 23: fig. 25.
Robulus lenticulus (Stache).—Hornibrook, 1971:43, pl. 9: figs. 158, 159.

DISTRIBUTION.—Extremely rare in thanatotopes B, C, and D. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation.

Lenticulina loculosa (Stache)

Robulina loculosa Stache, 1864:244, pl. 22: fig. 23.
Robulus loculosus (Stache).—Hornibrook, 1961:37, pl. 4: fig. 63; 1971:43, pl. 9: fig. 147.

DISTRIBUTION.—Extremely rare in thanatotope A. Undifferentiated Hukatere Subgroup.

Lenticulina cf. *L. lucida* (Cushman)

DISCUSSION.—Several specimens of *Lenticulina* are most similar to *Lenticulina lucida* (Cushman) (as *Cristellaria lucida* Cushman, 1923:111, pl. 30: fig. 2; and as *Robulus lucidus* (Cushman), Hornibrook, 1961:36, pl. 3: fig. 51).

DISTRIBUTION.—Extremely rare in thanatotope D. Cornwallis Formation.

Lenticulina mamilligera (Karrer)

PLATE 20: FIGURE 247

Cristellaria mamilligera Karrer, 1864:76, pl. 16: fig. 5.
Lenticulina mamilligera (Karrer).—Hornibrook, 1968:63, fig. 10; 1971:17, pl. 2: fig. 21.—Gibson, 1967, pl. 4: fig. 67.

DISTRIBUTION.—Rare in thanatotope C. Pakaurangi Formation.

Lenticulina cf. *L. nitida* (Reuss)

PLATE 20: FIGURES 248, 249

DISCUSSION.—Numerous individuals of *Lenticu-*

lina are similar to *Lenticulina nitida* (Reuss) (as *Cristellaria nitida* Reuss, 1863b:54, pl. 6: fig. 66).

DISTRIBUTION.—Common in thanatotope C, frequent in thanatotopes B and D, rare in thanatotopes A and F, abundant in ungrouped N33/f579. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation, undifferentiated Hukatere Subgroup, Waitemata Group.

Lenticulina planula (Galloway and Heminway)

PLATE 15: FIGURES 191, 192; PLATE 20: FIGURES 250–252

Robulus planula Galloway and Heminway, 1941:350, pl. 11: fig. 14.

DESCRIPTION.—Test compressed, glassy, almost flat on both sides, planispiral, evolute; chambers six to seven per whorl, slightly inflated; sutures limbate, gently curved and continuing parallel to periphery on both sides; periphery square-shouldered with narrow flange-like keel; aperture a narrow, elongate slit, situated on peripheral angle; apertural slit surrounded by slim, raised lip that may be slightly crenulated on the sides; aperture joined to the chamber cavity by narrow internal tube clearly visible through translucent shell.

DISCUSSION.—*Lenticulina planula* (Galloway and Heminway) has previously only been recorded from its Oligocene type locality in Puerto Rico. This species may belong to a new monotypic genus characterized by its *Lenticulina*-like chamber arrangement, *Fissurina*-like internal tube, and unique slit peripheral aperture.

DISTRIBUTION.—Rare in thanatotope C, extremely rare in thanatotope D. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation.

Lenticulina pseudocalcarata (Stache)

Robulina pseudocalcarata Stache, 1864:252, pl. 23: fig. 31.
Robulus pseudocalcaratus (Stache).—Hornibrook, 1971:44, pl. 9: figs. 154–157.

DISTRIBUTION.—Extremely rare in thanatotopes C and D. Nihotupu Formation.

Lenticulina pusilla (Stache)

Robulina pusilla Stache, 1864:247, pl. 23: figs. 26a, b.
Robulus pusillus (Stache).—Hornibrook, 1971:44, pl. 9: figs. 150, 153.

DISTRIBUTION.—Extremely rare in thanatotope C. Nihotupu Formation.

Lenticulina vortex (Fichtel and Moll)

Nautilus vortex Fichtel and Moll, 1803:33, pl. 2: figs. d-i.
Robulus vortex (Fichtel and Moll).—Hornibrook, 1961:38, pl. 3: fig. 49.

DISTRIBUTION.—Extremely rare in thanatotope C. Nihotupu Formation, Pakaurangi Formation.

Loxostomum goodwoodensis Hornibrook

Loxostomum goodwoodensis Hornibrook, 1961:76, pl. 10: figs. 185, 186.

DISTRIBUTION.—Rare in thanatotopes B, C, and D. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation.

Loxostomum pakaurangiensis Hornibrook

PLATE 20: FIGURE 253

Loxostomum pakaurangiensis Hornibrook, 1958:659, fig. 17; 1961:76, pl. 10: fig. 187; 1968:66, fig. 12.

DISTRIBUTION.—Rare in thanatotope B, extremely rare in thanatotopes A, C, and D. Nihotupu Formation, Pakaurangi Formation, Piha Formation.

Marginulina angistoma Stache

Marginulina angistoma Stache, 1864:213, pl. 22: figs. 46a, b. —Hornibrook, 1971:52, pl. 7: figs. 109–114.

DISTRIBUTION.—Extremely rare in thanatotope E. DSDP.

Marginulina obliquesuturata (Stache)

Dentalina obliquesuturata Stache, 1864:207, pl. 22: fig. 36.
Marginulina obliquesuturata (Stache).—Hornibrook, 1971:38, pl. 7: figs. 115–118.

DISTRIBUTION.—Extremely rare in thanatotopes B and C. Pakaurangi Formation.

Marginulina subbullata Hantken

Marginulina subbullata Hantken, 1875:46, pl. 4: figs. 9, 10; pl. 5. fig. 9.—Dorreen, 1948:288, pl. 37: fig. 2.—Hornibrook, 1961:45, pl. 5: fig. 84.

DISTRIBUTION.—Extremely rare in thanatotope D. Nihotupu Formation.

Marginulinopsis hydropica Hornibrook

Marginulinopsis hydropica Hornibrook, 1961:43, pl. 5: figs. 74, 75, 79, 80.

DISTRIBUTION.—Extremely rare in thanatotope B. Pakaurangi Formation.

Melonis affinis (Reuss)

PLATE 20: FIGURE 256

Nonionina affinis Reuss, 1851:49, pl. 5: fig. 32.
Melonis affinis (Reuss).—Douglas, 1973, pl. 9: figs. 1, 2.

DISTRIBUTION.—Rare in thanatotope E. DSDP.

Melonis dorreeni (Hornibrook)

Nonion dorreeni Hornibrook, 1961:91, pl. 11: figs. 212, 213.

DISTRIBUTION.—Extremely rare in thanatotopes C and D. Nihotupu Formation.

Melonis maorica (Stache)

Rosalina maorica Stache, 1864:282, pl. 24: figs. 32a-c.
Nonion maoricum (Stache).—Hornibrook, 1961:91, pl. 11: fig. 211.
Melonis maorica (Stache).—Hornibrook, 1971:49, pl. 11: figs. 184, 185.

DISTRIBUTION.—Extremely rare in thanatotopes B, C, D, and F. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation, undifferentiated Hukatere Subgroup.

Melonis pompilioides (Fichtel and Moll)

Nautilus pompilioides Fichtel and Moll, 1803:124, pl. 2: figs. a-c.
Nonion pompilioides (Fichtel and Moll).—Barker, 1960, pl. 109: figs. 10, 11.
Melonis pompilioides (Fichtel and Moll).—Douglas, 1973, pl. 9: figs. 8, 9.

DISTRIBUTION.—Extremely rare in thanatotope E. DSDP.

Melonis simplex (Karrer)

PLATE 20: FIGURES 254, 257

Nonionina simplex Karrer, 1864:82, pl. 16: fig. 17.
Melonis simplex (Karrer).—Hornibrook, 1971:19, pl. 2. figs. 43–46.

DISTRIBUTION.—Common in thanatotope E, frequent in thanatotope B, rare in thanatotopes A and D, extremely rare in thanatotopes C and F. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation, Puketi Formation, undifferentiated Hukatere Subgroup, Waitemata Group, DSDP.

Miogypsina intermedia Drooger

PLATE 20: FIGURE 258

Miogypsina intermedia Drooger, 1952:35, 36, 54, 55, pl. 2: figs. 30–34; pl. 3: fig. 4.—Hornibrook, 1968:108: figs. 3, 4.

DISTRIBUTION.—Common in thanatotope A, extremely rare in thanatotope B. Nihotupu Formation, Pakaurangi Formation, Puketi Fomation, undifferentiated Hukatere Subgroup.

Neoconorbina terquemi (Rzehak)

Discorbina terquemi Rzehak, 1888:228.
Rosalina terquemi (Rzehak).—Hornibrook, 1961:101, pl. 13: fig. 272.
Neconorbina terquemi (Rzehak).—Barker, 1960, pl. 88: figs. 4–8.

DISTRIBUTION.—Extremely rare in thanatotopes B and D. Pakaurangi Formation, Waitemata Group.

Nephrolepidina orakeiensis (Karrer)

Orbitoides orakeiensis Karrer, 1864:86, pl. 16: fig. 21.
Lepidocyclina (*Nephrolepidina*) *orakeiensis* (Karrer).—Hornibrook, 1968:108, fig. 24: nos. 6, 7; fig. 25.—1971:24, pl. 12: figs. 1–5: pl. 13: fig. 1; text–fig. 6.
Nephrolepidina orakeiensis (Karrer).—Matsumaru, 1971:185, pl. 22: figs. 1–27.

DISTRIBUTION.—Common in N42/f706. Nihotupu Formation.

Nodosarella tuberosa (Gümbel)

PLATE 21: FIGURES 259, 260

Lingulina tuberosa Gümbel, 1868:629, pl. 1: figs. 52a, b.
Nodosarella tuberosa (Gümbel).—Loeblich and Tappan, 1964, C730: fig. 594, no. 11.

DISTRIBUTION.—Extremely rare in thanatotope E. DSDP.

Nodosaria callosa Stache

Nodosaria callosa Stache, 1864:197, pl. 22: fig. 23.—Hornibrook, 1971:37, pl. 7: fig. 99.

DISTRIBUTION.—Extremely rare in thanatotopes A and C. Nihotupu Formation, undifferentiated Hukatere Subgroup.

Nodosaria hochstetteri Schwager

Nodosaria hochstetteri Schwager, 1866:214, pl. 5: fig. 32.—Hornibrook, 1961:47, pl. 6: fig. 91.

DISTRIBUTION.—Extremely rare in thanatotope D. Nihotupu Formation.

Nodosaria holoserica Schwager

PLATE 21: FIGURE 261

Nodosaria holoserica Schwager, 1866:221, pl. 5: fig. 49.—Hornibrook, 1961:47, pl. 6: fig. 96.

DISTRIBUTION.—Rare in thanatotope D, extremely rare in thanatotopes B, C, and E. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation, Waitemata Group, DSDP.

Nodosaria longiscata d'Orbigny

PLATE 21: FIGURE 262

Nodosaria longiscata d'Orbigny, 1846:32, pl. 1: figs. 10–12.—Hornibrook, 1961:46, pl. 6: figs. 93–94.

DISTRIBUTION.—Frequent in thanatotope C, rare in thanatotopes B, D, and E, extremely rare in thanatotope A. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation, Puketi Formation, Waitemata Group, DSDP.

Nodosaria pyrula d'Orbigny

Nodosaria pyrula d'Orbigny, 1826:253.—Brady, 1884:497, pl. 62: figs. 10–12.—Hornibrook, 1961:47, pl. 6: fig. 97.

DISTRIBUTION.—Extremely rare in thanatotopes B, C, D, and E. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation, DSDP.

Nodosaria substrigata Stache

PLATE 21: FIGURE 263

Nodosaria substrigata Stache, 1864:196, pl. 22: figs. 22a-c.—Hornibrook, 1971:37, pl. 7: fig. 98.

DISTRIBUTION.—Rare in thanatotopes C and D. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation, Waitemata Group.

Nonion cassidulinoides Hornibrook

Nonion cassidulinoides Hornibrook, 1961:92, pl. 11: figs. 214, 215.

DISTRIBUTION.—Rare in thanatotopes B and D, extremely rare in thanatotopes A, C, E, and F. Nihotupu Formation, Pakaurangi Formation, undifferentiated Hukatere Subgroup, Waitemata Group, DSDP.

Nonion deceptrix Hornibrook

Nonion deceptrix Hornibrook, 1961:92, pl. 11: figs. 218, 219.

DISTRIBUTION.—Rare in thanatotope A, extremely rare in thanatotope F. Puketi Formation, undifferentiated Hukatere Subgroup.

Nonion cf. *N. mexicanum* Cole

PLATE 21: FIGURES 264, 265

DISCUSSION.—Several individuals of *Nonion* are most similar to *Nonion mexicanum* Cole, as *Nonion turgidus* var. *mexicanus* Cole, 1927:23, pl. 2: fig. 11; and as *Nonion mexicanus Cole* (Cushman, 1939:6, pl. 1: figs. 23, 24).

DISTRIBUTION.—Extremely rare in thanatotopes B, D, and E. Nihotupu Formation, Pakaurangi Formation, DSDP.

Nonion tuberculatum (d'Orbigny)

PLATE 22: FIGURES 272, 273

Nonionina tuberculatum d'Orbigny, 1846:108, pl. 5: figs. 13, 14.
Nonion tuberculatum (d'Orbigny).—Cushman, 1939:13, pl. 13: figs. 12, 16, 17.

DESCRIPTION.—Test planispiral, compressed, involute; periphery broadly rounded; umbilical regions filled with pustular shell material; 9–12 chambers per whorl; sutures depressed, curved.

DISCUSSION.—This is the first New Zealand record of *Nonion tuberculatum* (d'Orbigny); previously recorded from Oligocene to Pliocene rocks of Europe, Africa, and California.

DISTRIBUTION.—Rare in thanatotope D, extremely rare in thanatotopes B, C, and F. Nihotupu Formation, Pakaurangi Formation, undifferentiated Hukatere Subgroup, Waitemata Group.

Nonionella novozealandica Cushman

PLATE 21: FIGURES 266–271

Nonionella novo-zealandica Cushman, 1936c:88, pl. 13: fig. 16a–c; 1939:31, pl. 8: fig. 10.—Hornibrook, 1961:94, pl. 11: fig. 217, 221.

DISCUSSION.—*Nonionella novozealandica* is more variable in the number of chambers, peripheral outline and development of the chamber extension than Cushman's original description indicates.

DISTRIBUTION.—Frequent in thanatotopes B, C, D, and F. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation, Piha Formation, undifferentiated Hukatere Subgroup, Waitemata Group.

Nonionella magnalingua Finlay

Nonionella magnalingua Finlay, 1940:456, pl. 65: figs. 144, 146.—Hornibrook, 1961:94, pl. 12: figs. 226, 232–233.—Kennett, 1966a:55, pl. 6: figs. 91–92.

DISTRIBUTION.—Rare in thanatotope D. Nihotupu Formation.

Nonionella zenitens Finlay

Nonionella zenitens Finlay, 1940:457, pl. 65: figs. 145, 152–156.—Hornibrook, 1961:93, pl. 12: figs. 225, 231.—Kennett, 1966a:55, pl. 6: figs. 93–96.

DISTRIBUTION.—Frequent in thanatotope D, extremely rare in thanatotope C. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation.

Notorotalia miocenica (Cushman)

PLATE 22: FIGURES 274–278

Polystomellina miocenica Cushman, 1936c:87, pl. 15: fig. 8a–c.

DESCRIPTION.—Test lenticular, nearly equally biconvex; periphery acute, weakly keeled; 14–18 chambers per whorl; sutures curved, parallelled by strong ribs, from which branch retral processes; 5–6 retral processes per chamber on dorsal side, 6–9 on ventral side; ventral side involute with solid to nodulose boss covering umbilical area; dorsal side evolute with early chambers obscured by secondary shell material; aperture a low opening at the base of the apertural face.

DISCUSSION.—This is the first New Zealand record of *Notorotalia miocenica* (Cushman), which is known from the early Miocene of south-east Australia. This species is similar to *Notorotalia targetensis* Hornibrook (Miocene, New Zealand) but is distinguished by its ventral boss and dorsal secondary shell material. Comparison of our material with the holotype and seven paratypes of *Notorotalia miocenica* (Cushman Collection Nos. 22726, 23624) confirmed the identification.

DISTRIBUTION.—Frequent in thanatotope B, rare in thanatotopes A, C, and D. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation, Waitemata Group.

Notorotalia powelli Finlay

Notorotalia powelli Finlay, 1939c:323.—Collen, 1974:113, fig. 1; pl. 1: figs. 1–8.

DISTRIBUTION.—Rare in thanatotope C, extremely rare in thanatotopes A, B, and D. Nihotupu Formation, Pakaurangi Formation, Piha Formation, Waitemata Group.

Oolina botelliformis (Brady)

PLATE 23: FIGURE 282

Lagena botelliformis Brady, 1881:60; 1884:454, pl. 56: fig. 6.—Cushman, 1923:8, pl. 1: fig. 10.
Oolina botelliformis (Brady).—Hornibrook, 1961, table 6.

DISTRIBUTION.—Rare in thanatotope D, extremely rare in thanatotope E. Cornwallis Formation, Nihotupu Formation, DSDP.

Oolina aff. *O. collaris* (Cushman)

PLATE 23: FIGURE 283

DISCUSSION.—Several specimens of *Oolina* are most similar to *Oolina collaris* (Cushman) (as *Lagena collaris* Cushman, 1913:10, pl. 1: fig. 2).

DISTRIBUTION.—Extremely rare in thanatotopes A, B, C, and D. Nihotupu Formation, Pakaurangi Formation, Waitemata Group.

Oolina aff. *O. felsinea* (Fornasini)

DISCUSSION.—Several individuals of *Oolina* are most similar to *Oolina felsinea* (Fornasini) (as *Lagena emaciata* var. *felsinea* Fornasini, 1901:47, fig. 1; and as *Lagena felsinea* Fornasini—Cushman, 1913:10, pl. 4: fig. 1;and as *Oolina felsinea* (Fornasini)—Barker, 1960, pl. 56: fig. 4).

DISTRIBUTION.—Extremely rare in thanatotope D and E. Nihotupu Formation, DSDP.

Oolina globosa (Montagu)

PLATE 23: FIGURES 284, 285

Vermiculum globosum Montagu, 1803:523.

Lagena globosa (Montagu).—Cushman, 1913:3, pl. 4: fig. 2; 1923:20, pl. 4: figs. 1, 2.

Oolina globosa (Montagu).—Barker, 1960, pl. 56. figs. 1–3.—Hornibrook, 1961, table 6, part 2.

DISTRIBUTION.—Rare in thanatotopes D and E, extremely rare in thanatotopes B, C, and F. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation, Waitemata Group, DSDP.

Oolina hexagona (Williamson)

PLATE 23: FIGURE 286

Entosolenia squamosa var. *hexagona* Williamson, 1848:20, pl. 2: fig. 23.

Lagena hexagona (Williamson).—Cushman, 1913:17, pl. 6: figs. 2, 3; Cushman, 1923:24, pl. 4: fig. 6.

Oolina hexagona (Williamson).—Barker, 1960, pl. 58: figs. 32, 33.—Hornibrook, 1961, table 6.

DISTRIBUTION.—Extremely rare in thanatotope C. Pakaurangi Formation.

Oolina hispida (Reuss)

PLATE 23: FIGURE 287

Lagena hispida Reuss, 1863a:335, pl. 6: figs. 77–79.—Cushman, 1913:13, pl. 4: figs. 4, 5; pl. 5: fig. 1; 1923:26, pl. 4: figs. 7,8.

Oolina hispida (Reuss).—Hornibrook, 1961, table 6.

DISTRIBUTION.—Extremely rare in thanatotopes B, C, and D. Nihotupu Formation, Pakaurangi Formation.

Oolina punctulata (Sidebottom)

PLATE 23: FIGURE 288

Lagena apiculata var. *punctulata* Sidebottom, 1912:382, pl. 14: figs. 21–25.

DISTRIBUTION.—Extremely rare in thanatotope E. DSDP.

Oolina setosa (Earland)

PLATE 23: FIGURE 289

Lagena globosa var. *setosa* Earland, 1934:150, pl. 6: fig. 52.

Oolina globosa var. *setosa* (Earland).—Barker, 1960, pl. 56: figs. 33–35.

DISTRIBUTION.—Extremely rare in thanatotope E, DSDP.

Oolina squamosa (Montagu)

PLATE 23: FIGURE 292

Vermiculum squamosa Montagu, 1803:526, pl. 14: fig. 2.

Lagena squamosa (Montagu).—Cushman, 1913:16, pl. 6: fig. 1; 1923:51, pl. 10: figs. 3, 4.

Oolina squamosa (Montagu).—Hornibrook, 1961, table 6.

DISTRIBUTION.—Extremely rare in thanatotope D. Nihotupu Formation, Waitemata Group.

Oolina stelligera (Brady)

Lagena stelligera Brady, 1881:60; 1884:466, pl. 57: figs. 35, 36. —Cushman, 1913:26, pl. 12: fig. 3; 1923:53, pl. 10: figs. 5, 6.

DISTRIBUTION.—Extremely rare in thanatotope E. DSDP.

Oridorsalis umbonatus (Reuss)

PLATE 24: FIGURES 295, 296

Rotalina umbonata Reuss, 1851:75, pl. 5: fig. 35.

Eponides umbonatus (Reuss).—Hornibrook, 1961:109.

Oridorsalis umbonatus (Reuss).—Srinivasan, 1966:252, pl. 5: figs. 2, 7, 11.—Douglas, 1973, pl. 13: figs. 1–6; pl. 24: figs. 9–12.

DISTRIBUTION.—Common in thanatotope E, frequent in thanatotope D, rare in thanatotopes B and C. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation, Waitemata Group, DSDP.

Orthomorphina challengeriana (Thalmann)

Nodosaria perversa Schwager.—Brady, 1884, pl. 64: figs. 25–27 [not of Schwager].

Nodogenerina challengeriana Thalmann, 1937:341.

Orthomorphina challengeriana (Thalmann).—Hornibrook, 1961:53.

Distribution.—Extremely rare in thanatotopes C, D, and E. Nihotupu Formation, DSDP.

Osangularia culter (Parker and Jones)

Plate 15: figures 163, 164; Plate 22: figures 279–281

Planorbulina farcata var. *ungeriana* subvar. *culter* Parker and Jones. 1865:382, 421, pl. 19: fig. 1.

Anomalina bengalensis Schwager, 1866:259, pl. 7: fig. 111.

Osangularia culter (Parker and Jones).—Todd, 1965:25, pl. 15: fig. 1.

Osangularia bengalensis (Schwager).—Gibson, 1967:53, pl. 12: fig. 197.

Description.—Test strongly convex ventrally, gently convex dorsally; peripheral keel narrow and flange-like, less pronounced in adults; 7–9 chambers per whorl in juveniles, increasing up to 12 in adults; ventral sutures flush to gently depressed, slightly limbate in adults, radial near umbo, slightly kinked and then curving to meet periphery; dorsal sutures limbate, oblique, forming 45° angle with periphery, flush with surface; umbo on ventral side, small, glassy and slightly elevated; surface mostly smooth, with pustular area around umbo on adults; aperture narrow, elongate, rimmed, extending up into apertural face from its base.

Discussion.—As indicated by Todd (1965) there seems to be no specific difference between *Osangularia culter* and *O. bengalensis*.

Distribution.—Frequent in thanatotopes C and D, extremely rare in thanatotope A. Cornwallis Formation, Nihotupu Formation, Puketi Formation.

Parafissurina abnormis Parr

Plate 23: figuers 290, 291

Parafissurina abnormis Parr, 1950:314, pl. 9: figs. 11a-c.

Distribution.—Extremely rare in thanatotopes C and E. Nihotupu Formation, DSDP.

Parafissurina basicarinata Parr

Plate 23: figure 293

Parafissurina basicarinata Parr, 1950:314, pl. 9: figs. 12, 13.

Distribution.—Extremely rare in thanatotope E. DSDP.

Parafissurina himatiostoma Loeblich and Tappan

Parafissurina himatiostoma Loeblich and Tappan, 1953:80, pl. 14: figs. 12–14.

Distribution.—Extremely rare in thanatotope E. DSDP.

Parafissurina lateralis (Cushman)

Plate 23: figure 294

Lagena lateralis Cushman, 1913:9, pl. 1: fig. 1.

Parafissurina lateralis (Cushman).—Parr, 1950:316.—Barker, 1960, pl. 56: figs. 17, 18.

Distribution.—Extremely rare in thanatotope E. DSDP.

Pararotalia mackayi (Karrer)

Rosalina mackayi Karrer, 1864:82, pl. 16: fig. 14.

Neorotalia mackayi (Karrer).—Hornibrook, 1968:63: fig. 10.

Pararotalia mackayi (Karrer).—Hornibrook, 1971:19, pl. 3: figs. 55–57; pl. 13: figs. 3–7; text figs. 2a–g.

Distribution.—One specimen in N41/f568. Nihotupu Formation.

Discussion.—The rareness of this species in this study is strange, since it occurs in abundance in sediments of Otaian age around Hokianga and Orakei Bay (Hayward, 1972; Hornibrook, 1971).

Pavonina triformis Parr

Plate 24: figure 297

Pavonina triformis Parr, 1933:29, pl. 7: figs. 1–3.—Hornibrook, 1968:66, fig. 11.

Distribution.—Rare in thanatotope B. Pakaurangi Formation.

Planodiscorbis rarescens (Brady)

Discorbina rarescens Brady, 1884:651, pl. 90: figs. 2, 3.

Discorbinella rarescens (Brady).—Hornibrook, 1961:117, pl. 14: figs. 292–294, 298.

DISTRIBUTION.—Extremely rare in thanatotopes B, C, and D. Nihotupu Formation, Pakaurangi Formation, Waitemata Group.

Planodiscorbis timida (Hornibrook)

Discorbinella timida Hornibrook, 1961:116, pl. 14: figs. 288, 293, 297.

DISTRIBUTION.—Extremely rare in thanatotopes B, C, D, and F. Cornwallis Formation, Pakaurangi Formation.

Planorbulinella plana (Heron-Allen and Earland)

Planorbulina plana Heron-Allen and Earland, 1924:174, pl. 12: figs. 92–95.
Planorbulinella plana (Heron-Allen and Earland).—Hornibrook, 1961:166, pl. 20: fig. 428.

DISTRIBUTION.—Extremely rare in thanatotope D. Nihotupu Formation.

Planorbulinella zelandica Finlay

PLATE 24: FIGURES 298, 299

Planorbulinella zelandica Finlay, 1947:290, pl. 8: figs. 119–124.—Hornibrook, 1968:68, fig. 12.

DISTRIBUTION.—Extremely rare in thanatotopes B and D. Nihotupu Formation, Pakaurangi Formation.

Planulina catilla (Finlay)

PLATE 24: FIGURE 302

Cibicides catillus Finlay, 1940:465, pl. 67: fig. 200.
Planulina catilla (Finlay).—Hornibrook, 1968:63, fig. 10.

DISTRIBUTION.—Extremely rare in thanatotopes C and D. Cornwallis Formation, Nihotupu Formation.

Planulina cf. *P. crassa* Galloway and Heminway

PLATE 15: FIGURES 195–197

DISCUSSION.—Several specimens of *Planulina* are most similar to *Planulina crassa* Galloway and Heminway (1941:398, pl. 25: figs. 2a–c).

DISTRIBUTION.—Extremely rare in thanatotopes B and D. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation.

Plectofrondicularia awamoana Finlay

PLATE 24: FIGURE 301

Plectofrondicularia awamoana Finlay, 1939c:319, pl. 27: fig. 109.—Hornibrook, 1961:83, pl. 12: fig. 243.

DISTRIBUTION.—Extremely rare in thanatotope C. Nihotupu Formation.

Plectofrondicularia fyfei, Finlay

Plectofrondicularia fyfei Finlay, 1939c:319, pl. 27: fig. 110.

DISTRIBUTION.—Extremely rare in thanatotope C. Nihotupu Formation.

Plectofrondicularia parri Finlay

Plectofrondicularia parri Finlay, 1939a:516, pl. 68: fig. 4.—Hornibrook, 1961:82, pl. 12: figs. 244–245; 1968:107, fig. 23.

DISTRIBUTION.—Extremely rare in thanatotopes C and D. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation.

Plectofrondicularia proparri Finlay

PLATE 24: FIGURE 300

Plectofrondicularia proparri Finlay, 1947:276. pl. 4: figs. 46–48.—Hornibrook, 1961:81, pl. 12: fig. 246; 1968:107, fig. 23.

DISTRIBUTION.—Extremely rare in thanatotopes B and C. Pakaurangi Formation.

Plectofrondicularia turgida Hornibrook

Plectofrondicularia turgida Hornibrook, 1961:82, pl. 12: figs. 239, 247, 248.

DISTRIBUTION.—Rare in thanatotope C, extremely rare in thanatotopes A, B, and D. Nihotupu Formation, Pakaurangi Formation, undifferentiated Hukatere Subgroup, Waitemata Group.

Plectofrondicularia (Proxifrons) whaingaroica (Stache)

Frondicularia whaingaroica Stache, 1864:210, pl. 22: fig. 43.

Plectofrondicularia whaingaroica (Stache).—Hornibrook, 1961: 81.
Plectofrondicularia (Proxifrons) whaingaroica (Stache).—Hornibrook, 1971:45, fig. 11, pl. 11: figs. 182, 183.

DISTRIBUTION.—Extremely rare in thanatotope D. Cornwallis Formation, Nihotupu Formation.

Pleurostomella aguafrescaensis Todd and Kniker

PLATE 25: FIGURES 307, 308

Pleurostomella aguafrescaensis Todd and Kniker, 1952:23, pl. 4: fig. 17.

DISTRIBUTION.—Rare in thanatotope E. DSDP.

Pleurostomella bierigi Palmer and Bermudez

PLATE 25: FIGURES 309, 310

Pleurostomella bierigi Palmer and Bermudez, 1936:294,, pl. 17: figs. 7, 8.

DESCRIPTION.—Test oval in outline, apical extremity pointed, maximum breadth at middle of test; chambers strongly embracing, inflated, final chamber occupying over half test; aperture a slit "T" shaped opening.

DISCUSSION.—This is the first New Zealand record of *Pleurostomella bierigi* Palmer and Bermudez, previously recorded from the Eocene to Miocene of central America, Africa, Europe, and Guam.

DISTRIBUTION.—Rare in thanatotope E, extremely rare in thanatotopes C and D. Cornwallis Formation, Nihotupu Formation, DSDP.

Pleurostomella obtusa Berthelin

PLATE 25: FIGURES 311, 312

Pleurostomella obtusa Berthelin, 1880:29, pl. 1: figs. 9a, b.—Cushman, 1927b:131, pl. 25: fig. 22.

DISCUSSION.—This species is distinguished by its short, slightly inflated chambers and its tendency towards partial uniserial arrangement.

DISTRIBUTION.—Rare in thanatotope E. DSDP.

Pleurostomella rimosa Cushman and Bermudez

Pleurostomella rimosa Cushman and Bermudez, 1937:17, pl. 1: figs. 62–63.

DISTRIBUTION.—Extremely rare in thanatotope E. DSDP.

Pleurostomella tenuis Hantken

PLATE 25: FIGURES 313–317

Pleurostomella tenuis Hantken, 1883:25, pl. 1: fig. 5.

DESCRIPTION.—Test small, elongate; chambers elongate, inflated, arranged in a regular alternating series, never becoming uniserial; aperture in an oval depression, two small teeth; some individuals have an incompletely developed final chamber with a small terminal aperture.

DISCUSSION.—This is the first New Zealand record of *Pleurostomella tenuis* Hantken. It is distinguished by its elongate, inflated chambers and lack of any uniserial development.

DISTRIBUTION.—Frequent in thanatotope E, rare in thanatotopes C and D. Cornwallis Formation, Nihotupu Formation, DSDP.

Pseudonodosaria aperta (Stache)

Glandulina aperta Stache, 1864:188, pl. 22: figs. 11a-c.
Pseudonodosaria aperta (Stache).—Hornibrook, 1971:36, pl. 7: fig. 95.

DISTRIBUTION.—Rare in thanatotopes B and C, extremely rare in thanatotopes A and D. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation, undifferentiated Hukatere Subgroup.

Pseudonodosaria symmetrica (Stache)

Glandulina symmetrica Stache, 1864:187, pl. 22: figs. 9a-b.
Pseudonodosaria symmetrica (Stache).—Hornibrook, 1971:36, pl. 10: fig. 172.

DISTRIBUTION.—Extremely rare in thanatotopes A, B, and C. Nihotupu Formation, Pakaurangi Formation.

Pseudopatellinoides aff. *P. primus* Krasheninnikov

PLATE 25: FIGURES 318, 319

DESCRIPTION.—Test small, trochospiral, conical; periphery sharply angled; dorsal side high, conically convex, evolute; ventral side involute, flat; three chambers per whorl; dorsal sutures limbate, flush, strongly oblique; ventral sutures radial, slightly depressed; aperture an arched umbilical opening.

DISCUSSION.—This species is represented in our collections by a single specimen. It resembles *Pseudopatellinoides primus* Krasheninnikov (1958:242, pl. 8: figs. 1, 2; Loeblich and Tappan, 1964: fig. 458, nos. 9a–d), of the Russian Miocene, more closely than the other three described species of this genus, but differs in being more highly conical.

DISTRIBUTION.—Extremely rare in thanatotope F. Cornwallis Formation.

Pullenia bulloides (d'Orbigny)

PLATE 24: FIGURES 303, 304

Nonionina bulloides d'Orbigny, 1846:107, pl. 5: figs. 9, 10.
Pullenia bulloides (d'Orbigny).—Hornibrook, 1961:90, pl. 11: figs. 205, 206.—Vella, 1963:12, pl. 1: figs. 7, 8.—Kennett, 1966a:51, pl. 5: figs. 73, 74.—Gibson, 1967:45, pl. 10: figs. 168, 169.

DISTRIBUTION.—Rare in thanatotopes C, D, and E, extremely rare in thanatotopes A and B. Nihotupu Formation, Pakaurangi Formation, Waitemata Group, DSDP.

Pullenia quinqueloba (Reuss)

Nonionina quinqueloba, Reuss, 1851:71, pl. 5: fig. 31.
Pullenia compressiuscula var. *quadriloba* Reuss, 1867:55, pl. 3: fig. 8.
Pullenia quinqueloba (Reuss).—Hornibrook, 1961:90, pl. 11: figs. 207, 208.—Vella, 1963:12.—Kennett, 1966a:52, pl. 5: figs. 75, 76.—Gibson, 1967:46, pl. 10: figs. 172, 173.
Pullenia quadriloba Reuss.—Vella, 1963:12, pl. 1: figs. 9, 10. —Gibson, 1967:46, pl. 10: figs. 170–171.

DISTRIBUTION.—Frequent in thanatotope E, rare in thanatotope D, extremely rare in thanatotopes B and C. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation, Waitemata Group, DSDP.

Pyrulina acuminata d'Orbigny

Pyrulina acuminata d'Orbigny, 1840:43, pl. 4: figs. 18, 19.—Cushman and Ozawa, 1930:58, pl. 14: figs. 7a-c.

DISTRIBUTION.—Extremely rare in thanatotope E. DSDP.

Pyrulina fusiformis (Roemer)

Polymorphina (Globulinen) fusiformis Roemer, 1838:386, pl. 3: fig. 37.
Pyrulina fusiformis (Roemer).—Cushman and Ozawa, 1930: 54, pl. 13: figs. 3–8.—Hornibrook, 1961:61, pl. 7: fig. 127.

DISTRIBUTION.—Extremely rare in thanatotopes B and D. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation.

Pyrulina gutta d'Orbigny

Pyrulina gutta d'Orbigny, 1826:267, no. 28, "Modele" 30.—Cushman and Ozawa, 1930:51, pl. 13: figs. 1a-c.

DISTRIBUTION.—Extremely rare in thanatotope E. DSDP.

Rumulina species

PLATE 26: FIGURE 324

DISTRIBUTION.—Extremely rare in thanatotopes B, C, and F. Nihotupu Formation, Pakaurangi Formation, undifferentiated Hukatere Subgroup.

Rectobolivina maoriella Finlay

PLATE 24: FIGURES 305, 306

Rectobolivina maoriella Finlay, 1939c:321, pl. 27, figs. 78–81. —Hornibrook, 1961:77, pl. 10: fig. 190; 1968:63, fig. 10.

DISTRIBUTION.—Frequent in thanatotope D, extremely rare in thanatotopes B and C. Nihotupu Formation, Pakaurangi Formation, Waitemata Group.

Rectobolivina striatula (Cushman)

PLATE 26: FIGURES 320, 321

Siphogenerina bifrons var. *striatula* Cushman, 1917:662.
Rectobolivina striatula (Cushman).—Carter, 1964:69, pl. 2: figs. 35, 36.—Kennett, 1966a:47, pl. 4: fig. 59.—Hornibrook, 1968:73, fig. 13.

DISCUSSION.—A single individual identical to *Rectobolivina striatula* Cushman was found during this study. Hornibrook (1968) cites the stratigraphic range as Tongaporutuan to Recent (upper Miocene to Recent) and this record extends the range. Carter (1964) records *R. striatula* from the lower and mid Miocene of Victoria, Australia.

DISTRIBUTION.—Single specimen in N41/f660. Piha Formation.

Rectuvigerina rerensis (Finlay)

Siphogenerina rerensis Finlay, 1939b:108, pl. 11: fig. 8.
Rectuvigerina rerensis (Finlay).—Vella, 1961:480, pl. 2: figs. 22, 23.—Hornibrook, 1961:66, pl. 8: fig. 146; 1968:104, fig. 22.

DISTRIBUTION.—Extremely rare in thanatotopes C and D. Nihotupu Formation.

Rectuvigerina ruatoria (Vella)

PLATE 26: FIGURE 322

Ruatoria ruatoria Vella, 1961:480, pl. 2: figs. 12, 13.

DISTRIBUTION.—Rare in thanatotopes C and D. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation.

Rectuvigerina vesca (Finlay)

PLATE 26: FIGURE 323

Siphogenerina vesca Finlay, 1939b:109, pl. 13: figs. 46, 47.
Rectuvigerina vesca (Finlay).—Vella, 1961:481, pl. 2: figs. 24, 25.—Hornibrook, 1968:104, fig. 22.

DISTRIBUTION.—Rare in thanatotopes C and D. Nihotupu Formation.

Reussella spinulosa (Reuss)

PLATE 27: FIGURE 330

Verneuilina spinulosa Reuss, 1850:374, pl. 47: fig. 12.
Reussella spinulosa (Reuss).—Cushman, 1945:33, pl. 6: figs. 8, 9.
Reussella aff. *spinulosa* (Reuss).—Hornibrook, 1961:78.

DESCRIPTION.—Test acute triangular pyramid; apertural end convex; edges carinate and spinose; sutures acuate, flush or slightly raised.

DISTRIBUTION.—Frequent in thanatotope B, extremely rare in thanatotopes A, C, D, and F. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation, undifferentiated Hukatere Subgroup.

Rosalina augur Hornibrook

Rosalina augur Hornibrook, 1961:102, pl. 13: figs. 263, 265, 268.

DISTRIBUTION.—Extremely rare is thanatotope B. Pakaurangi Formation.

Rosalina concinna (Brady)

PLATE 26: FIGURES 325, 326

Discorbina concinna Brady, 1884:646, pl. 90: figs. 7, 8.
Rosalina concinna (Brady).—Hornibrook, 1961:101, pl. 13: figs. 273, 274.

DISTRIBUTION.—Rare in thanatotopes B and D. Cornwallis Formation, Nihotupu Formation, Waitemata Group.

Saracenaria arcuatula (Stache)

Hemirobulina arcuatula Stache, 1864:227, pl. 23: figs. 6a, b.
Saracenaria arcuatula (Stache).—Hornibrook, 1961:40, 1971:41, pl. 8: figs. 130, 131.

DISTRIBUTION.—Extremely rare in thanatotopes C and D. Nihotupu Formation, Pakaurangi Formation.

Saracenaria kellumi Dorreen

Saracenaria kellumi Dorreen, 1948:289, pl. 37: fig. 4.

DISTRIBUTION.—Extremely rare in thanatotopes B, C, and D. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation, Waitemata Group.

Saracenaria latifrons (Brady)

PLATE 27: FIGURE 331

Cristellaria latifrons Brady, 1884:544, pl. 68: fig. 19; pl. 113: fig. 11.
Saracenaria latifrons (Brady).—Kennett, 1966a, table 6.—Gibson, 1967, pl. 4: fig. 69.

DISTRIBUTION.—Extremely rare in thanatotope C. Pakaurangi Formation.

Saracenaria obesa Cushman and Todd

PLATE 26: FIGURES 327–329

Saracenaria obesa Cushman and Todd, 1945:31, pl. 5: fig. 2.

DESCRIPTION.—Test pyriform; dorsal margin and sides of apertural face bluntly angled; chambers few, 3–5; sutures curved, flush with surface; wall smooth; apertural face broad, somewhat inflated towards its sides; aperture terminal, radiate.

DISCUSSION.—This is the first New Zealand record of *Saracenaria obesa* Cushman and Todd, previously recorded from the Miocene and Pliocene of Jamaica and Spain, respectively. This species is distinguished by its broad, inflated apertural face, pyriform shape and few chambers.

DISTRIBUTION.—Rare in thanatotope C. Nihotupu Formation, Pakaurangi Formation.

Sherbornina cuneimarginata Wade

Sherbornina cuneimarginata Wade, in Wade and Carter, 1957: 158, pl. 1: figs. 6–7.

DISCUSSION.—This species is confined to the lower Miocene of Australia and New Zealand (Hayward, 1978) and is distinguished by its greatly enlarged ventral retral processes and asymmetric profile.

DISTRIBUTION.—Extremely rare in thanatotope A. Nihotupu Formation.

Sigmoidella elegantissima (Parker and Jones)

Polymorphina elegantissima Parker and Jones, in Brady, Parker, and Jones, 1870:231, pl. 40: fig. 15.
Sigmoidella elegantissima (Parker and Jones).—Cushman and Ozawa, 1930:140, pl. 39: fig. 1.—Hornibrook, 1961:61, pl. 7: fig. 119.

DISTRIBUTION.—Rare in thanatotope B, extremely rare in thanatotope A. Pakaurangi Formation, Puketi Formation.

Sigmoidina pacifica Cushman and Ozawa

PLATE 15: FIGURES 198, 199; PLATE 27: FIGURE 332

Sigmoidella (Sigmoidina) pacifica Cushman and Ozawa, 1928: 19, pl. 2: fig. 13.
Guttulina (Sigmoidina) pacifica (Cushman and Ozawa).—Cushman and Ozawa, 1930:50, pl. 37: figs. 3–5.
Polymorphina elegantissima Parker and Jones.—Chapman, 1926:67, pl. 13: fig. 10 [not of Parker and Jones].
Sigmoidella pacifica Cushman and Ozawa.—Loeblich and Tappan, 1964:C534, fig. 418, 2a, b.

DESCRIPTION.—Test "tear-drop" shape; walls smooth with flush sutures; chambers elongate in quinqueloculine series; aperture terminal, radiate.

DISCUSSION.—This is the first New Zealand fossil record of *Sigmoidina pacifica* Cushman and Ozawa, previously recorded from the Miocene and Pliocene of Australia, Japan, China, and Russia, and Recent sediments of the West Pacific from New Zealand to Japan.

DISTRIBUTION.—Frequent in thanatotope B, extremely rare in thanatotopes A, C, D, and F. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation, undifferentiated Hukatere Subgroup, Waitemata Group.

Siphonina australis Cushman

PLATE 27: FIGURE 333

Siphonina australis Cushman, 1927d:8, pl. 2: fig. 6; pl. 3: figs. 7, 8.—Hornibrook, 1961:121, pl. 16: fig. 353; 1968:58, fig. 9.

DISTRIBUTION.—Frequent in thanatotopes C and D, extremely rare in thanatotope B. Nihotupu Formation, Pakaurangi Formation, Waitemata Group.

Siphouvigerina proboscidea (Schwager)

PLATE 27: FIGURE 334

Uvigerina proboscidea Schwager, 1866:250, pl. 7: fig. 96.—Douglas, 1973, pl. 8: fig. 8.
Neouvigerina plebeja Vella, 1961:470, figs. 4d-g, pl. 2: fig. 19.
Uvigerina canariensis d'Orbigny.—Hornibrook, 1961:65, pl. 8: fig. 143

DISTRIBUTION.—Common in thanatotopes C and D, rare in thanatotope B, extremely rare in thanatotope E. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation, Waitemata Group, DSDP.

Sphaeroidina bulloides d'Orbigny

PLATE 27: FIGURE 335

Sphaeroidina bulloides d'Orbigny, 1826:267, "Modèles" 65.—Hornibrook, 1961:90, pl. 11: fig. 210; 1968:58, fig. 9.—Kennett, 1966a:51, pl. 4: fig. 72.

DISTRIBUTION.—Common in thanatotope C, frequent in thanatotopes B and D, rare in thanatotope E, extremely rare in thanatotope A. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation, Waitemata Group, DSDP.

Spirillina aff. *S. plana* Möller

DISCUSSION.—One specimen of *Spirillina* is most similar to *Spirillina plana* Möller (1879:28).

DISTRIBUTION.—A single specimen in N42/f731. Cornwallis Formation.

Spirillina vivipara Ehrenberg

PLATE 27: FIGURE 336

Spirillina vivipara Ehrenberg, 1843:323, 422, pl. 3: fig. 41.—Barker, 1960, pl. 85: figs. 1–4.

DISTRIBUTION.—Extremely rare in thanatotopes D and F. Nihotupu Formation, Pakaurangi Formation, undifferentiated Hukatere Subgroup.

Stetsonia species

PLATE 27: FIGURES 337, 338

DESCRIPTION.—Test medium-sized, lenticular, partly trochospiral; periphery narrowly rounded; one side involute with semi-opaque shell material filling umbillicus; opposite side partly evolute with portions of early whorls visible beneath subtranslucent umbonal material; 7–9 chambers per whorl; sutures distinct, strongly curved, flush; aperture an elongate slit on periphery extending up into apertural face from base of final chamber.

DISCUSSION.—This species differs from all described species in its larger size, and more trochospiral coiling.

DISTRIBUTION.—Common in thanatotope E. DSDP.

Stilostomella antillea (Cushman)

PLATE 28: FIGURE 339

Nodosaria antillea Cushman, 1923:91, pl. 14: fig. 9.
Stilostomella antillea (Cushman).—Kennett, 1966a, table 6.
Stilostomella basicarinata Hornibrook, 1961:50, pl. 6: figs. 104, 105.

DISTRIBUTION.—Frequent in thanatotope E, rare in thanatotopes C and D, extremely rare in thanatotope B. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation, Waitemata Group, DSDP.

Stilostomella awamoana Hornibrook

Stilostomella awamoana Hornibrook, 1961:51, pl. 6: fig. 107.

DISTRIBUTION.—Extremely rare in thanatotopes B, C, D, and E. Pakaurangi Formation, DSDP.

Stilostomella fijiensis (Cushman)

PLATE 28: FIGURE 340

Siphonodosaria fijiensis Cushman, 1931:30, pl. 4: fig. 10.
Stilostomella fijiensis (Cushman).—Hornibrook, 1961:49, pl. 6: fig. 106.

DISTRIBUTION.—Rare in thanatotopes C, D, and E, extremely rare in thanatotope B. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation, DSDP.

Stilostomella lepidula (Schwager)

Nodosaria lepidula Schwager, 1866:210, pl. 5: figs. 27–28.
Stilostomella finlayi Hornibrook, 1961:50, pl. 6: fig. 108.

DISTRIBUTION.—Extremely rare in thanatotopes C and D. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation.

Stilostomella pomuligera (Stache)

PLATE 28: FIGURES 341, 342

Dentalina pomuligera Stache, 1864:204, pl. 22: fig. 31.
Stilostomella pomuligera (Stache).—Hornibrook, 1961:49, pl. 6: fig. 110; 1971:38, pl. 7: figs. 103–108.

DISTRIBUTION.—Common in thanatotope E, frequent in thanatotope D, rare in thanatotope C, extremely rare in thanatotopes A, B, and F. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation, undifferentiated Hukatere Subgroup, Waitemata Group, DSDP.

Stilostomella subspinosa (Cushman)

PLATE 28: FIGURE 343

Ellipsonodosaria subspinosa Cushman, 1943:92, pl. 16: figs. 6, 7.
Stilostomella subspinosa (Cushman).—Douglas, 1973, pl. 5: fig. 10.

DISTRIBUTION.—Extremely rare in thanatotopes C and E. Pakaurangi Formation, DSDP.

Stilostomella verneuilii (d'Orbigny)

Dentalina verneuilii d'Orbigny, 1846:48, pl. 2: figs. 7–8.
Dentalina aequalis Karrer, 1864:74, pl. 16: fig. 1.
Stilostomella verneuilii (d'Orbigny).—Hornibrook, 1961:50, pl. 6: fig. 109.
Stilostomella aequalis (Karrer).—Hornibrook, 1971:16, pl. 2: figs. 34–42.

DISTRIBUTION.—Frequent in thanatotopes D and E, rare in thanatotopes B and C, extremely rare in thanatotope A. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation, undifferentiated Hukatere Subgroup, Waitemata Group, DSDP.

Stomatorbina concentrica (Parker and Jones)

Pulvinulina concentrica Parker and Jones, in Brady, 1864:470, pl. 48: fig. 14.—Brady, 1884:686, pl. 105: fig. 1.
Mississippina concentrica (Parker and Jones).—Hornibrook, 1961:114, pl. 17: figs. 369, 374; 1968:56, fig. 8.

DISTRIBUTION.—Extremely rare in thanatotope F. Undifferentiated Hukatere Subgroup.

Trifarina bradyi Cushman

PLATE 28: FIGURE 344

Trifarina bradyi Cushman, 1923:99, pl. 22: figs. 3–9.—Hornibrook, 1961:70, pl. 9: figs. 163, 164.—Kennett, 1966a:44, pl. 3: figs. 49, 50.

DISTRIBUTION.—Common in thanatotopes B and D, frequent in thanatotope C, rare in thanatotopes A and F. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation, Puketi Formation, undifferentiated Hukatere Subgroup, Waitemata Group.

Trifarina costornata (Hornibrook)

PLATE 28: FIGURE 345

Angulogerina costornata, Hornibrook, 1961:68, pl. 9: figs. 149, 150.

DISTRIBUTION.—Extremely rare in thanatotopes B and D. Nihotupu Formation, Pakaurangi Formation.

Trifarina esuriens (Hornibrook)

PLATE 28: FIGURE 346

Angulogerina esuriens Hornibrook, 1961:69, pl. 9: figs. 154, 155.

DISTRIBUTION.—Rare in thanatotopes C and D, extremely rare in thanatotopes B and E. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation, Waitemata Group, DSDP.

Trifarina tortuosa (Hornibrook)

PLATE 28: FIGURE 347

Angulogerina tortuosa Hornibrook, 1961:68, pl. 9, figs. 151, 152.

DISTRIBUTION.—Rare in thanatotopes B, C, D, and F, extremely rare in thanatotope A. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation, undifferentiated Hukatere subgroup, Waitemata Group.

Vaginulina awamoana Hornibrook

Vaginulina awamoana Hornibrook, 1961:44, pl. 5: figs. 77, 81, 82.

DISTRIBUTION.—Extremely rare in thanatotope B. Pakaurangi Formation.

Vaginulina cristellata (Stache)

Marginulina cristellata Stache, 1864:212, pl. 22: fig. 44.
Vaginulina cristellata (Stache).—Hornibrook, 1968:60, fig. 9; 1971:39, pl. 8: figs. 128, 129.

DISTRIBUTION.—Extremely rare in thanatotope B. Pakaurangi Formation.

Vaginulina elegans d'Orbigny

Vaginulina elegans d'Orbigny, 1826:257, "Modèles" 54.—Hornibrook, 1961:44, pl. 5: figs. 86, 87.

DISTRIBUTION.—Extremely rare in thanatotopes A, B, and C. Nihotupu Formation, Pakaurangi Formation.

Vaginulina neglecta (Karrer)

Marginulina neglecta Karrer, 1864:75, pl. 16: fig. 4.
Vaginulina neglecta (Karrer).—Hornibrook, 1971:17, pl. 2: figs. 24–27, 32, 33.

DISTRIBUTION.—Extremely rare in thanatotopes A, B, C, D, and E. Cornwallis Formation, Pakaurangi Formation, Puketi Formation, DSDP.

Vaginulina vagina (Stache)

Dentalina vagina Stache, 1864:206, pl. 22: fig. 34.
Vaginulina vagina (Stache).—Hornibrook, 1961:44, pl. 5: fig. 85; 1971:39, pl. 7: figs. 119–124.

DISTRIBUTION.—Frequent in thanatotope C, rare in thanatotopes B, D, and E, extremely rare in thanatotope A. Cornwallis Formation, Nihotupu Formation, Pakaurangi Formation, Waitemata Group, DSDP.

Vaginulinopsis recta (Karrer)

PLATE 28: FIGURE 348

Vaginulina recta Karrer, 1864:74, pl. 16: fig. 2.
Vaginulinopsis clifdenensis Hornibrook, 1961:42, pl. 5: figs. 71, 72.
Vaginulinopsis recta (Karrer).—Hornibrook, 1971:17, pl. 2: figs. 28–31.

DISTRIBUTION.—Extremely rare in thanatotopes A and B. Pakaurangi Formation, Puketi Formation.

Victoriella conoidea (Rutten)

PLATE 28: FIGURE 349

Carpenteria conoidea Rutten, 1914:47, pl. 7: figs. 6–9.
Victoriella conoidea (Rutten).—Hornibrook, 1961:168, pl. 26: fig. 520; 1968:64, fig. 11.

DISTRIBUTION.—Frequent in thanatotope A. Nihotupu Formation, undifferentiated Hukatere Subgroup.

Virgulopsis reticulata Hornibrook

Virgulopsis reticulata Hornibrook, 1961:79, pl. 28: figs. 542, 543.

DISTRIBUTION.—Extremely rare in thanatotope B. Pakaurangi Formation.

Appendix I

Location, Lithostratigraphic Unit, and Age of Samples Used in Thanatotope Analysis

Grid references are from NZMS 1, Sheets N28, Maungaturoto (2nd ed., 1965); N33 Kaipara (3rd ed., 1971); N37 Helensville (2nd ed., 1964); N41 Waitakere (3rd ed., 1964); and N42 Auckland (3rd ed., 1966).

N28/f452 (Grid. Ref. N28/807350), west Pakaurangi Point. Pakaurangi Formation, Hollands Member. Lower Pl.

N28/f453 (Grid. Ref. N28/807350), west Pakaurangi Point. Pakaurangi Formation, Hollands Member. Lower Pl.

N28/f454 (Grid. Ref. N28/810349), west Pakaurangi Point. Pakaurangi Formation, Waipukua Member. Lower Pl.

N28/f455 (Grid. Ref. N28/814345), Pakaurangi Point. Pakaurangi Formation, Funnel Member. Lower Pl.

N28/f456 (Grid. Ref. N28/814344), Pakaurangi Point. Pakaurangi Formation. Funnel Member. Lower Pl.

N28/f457 (Grid. Ref. N28/811348), west Pakaurangi Point. Pakaurangi Formation, Pakaurangi Member. Lower Pl.

N28/f458 (Grid. Ref. N28/797349), west Pakaurangi Point. Pakaurangi Formation, Tapu Member. Lower Pl.

N28/f781 (Grid. Ref. N28/815345), Pakaurangi Point. Puketi Formation, Miogypsina Sandstone. Lower Pl.

N28/f785 (Grid. Ref. N28/815346), north Pakaurangi Point. Pakaurangi Formation, Pakaurangi Member. Lower Pl.

N28/f788 (Grid. Ref. N28/815347), north Pakaurangi Point. Pakaurangi Formation. Hollands Member. Lower Pl.

N28/f792 (Grid. Ref. N28/800350), west Pakaurangi Point. Pakaurangi Formation, Tapu Member. Lower Pl.

N28/f793 (Grid. Ref. N28/800350), west Pakaurangi Point. Pakaurangi Formation, Waiteroa Member. Lower Pl.

N28/f795 (Grid. Ref. N28/798350), west Pakaurangi Point. Pakaurangi Formation, Waiteroa Member. Lower Pl.

N28/f912 (Grid. Ref. N28/737321), north of Bushy Point, Hukatere Peninsula. Undifferentiated Hukatere Subgroup. Pl.

N28/f913 (Grid. Ref. N28/695362), Nihotetea Creek mouth, Hukatere Peninsula. Undifferentiated Hukatere Subgroup. Pl.

N28/f914 (Grid. Ref. N28/695362), Nihotetea Creek mouth, Hukatere Peninsula. Undifferentiated Hukatere Subgroup. Pl.

N33/f505 (Grid. Ref. N33/825211), Okahukura Peninsula, borehole, 1951 (12 m level). Pakaurangi Formation. Lower Pl.

N33/f531 (Grid. Ref. N33/796297), Puketotara Peninsula. Pakaurangi Formation. Lower Pl.

N33/f532 (Grid. Ref. N33/798292), Puketotara Peninsula. Pakaurangi Formation. Lower Pl.

N33/f534 (Grid. Ref. N33/798289), Puketotara Peninsula. Pakaurangi Formation. Lower Pl.

N33/f536 (Grid. Ref. N33/795286), Puketotara Peninsula. Pakaurangi Formation. Lower Pl.

N33/f578 (Grid. Ref. N33/814207), Okahukara Peninsula, Tapora Flats borehole (30 m level). Pakaurangi Formation. Lower Pl.

N33/f579 (Grid. Ref. N33/814207), Okahukura Peninsula, Tapora Flats borehole (31 m level). Pakaurangi Formation. Lower Pl.

N33/f580 (Grid. Ref. N33/814207), Okahukura Peninsula, Tapora Flats borehole (42 m level). Pakaurangi Formation. Lower Pl.

N33/f581 (Grid. Ref. N33/814207), Okahukura Peninsula, Tapora Flats borehole (46 m level). Pakaurangi Formation. Lower Pl.

N37/f585 (Grid. Ref. N37/971939), Jordans Road, south Kaipara. Cornwallis Formation. Upper Po.

N41/f2d (Grid. Ref. N41/955612), south Muriwai. Nihotupu Formation, Maori Bay Member. Mid Pl.

N41/f533 (Grid. Ref. N41/069408), Marama Stream. Nihotupu Formation. Upper Po.

N41/f537 (Grid. Ref. N41/098461), Huia Stream, Smiths Creek. Nihotupu Formation. Lower Pl.

N41/f539 (Grid. Ref. N41/074464), Huia Stream. Nihotupu Formation. Lower Pl.

N41/f555 (Grid. Ref. N41/056547), Waitakere River, Kellys Creek. Nihotupu Formation. Mid Pl.

N41/f590n (Grid. Ref. N41/954616), south Muriwai. Nihotupu Formation, Maori Bay Member. Mid Pl.

N41/f590u (Grid. Ref. N41/954616), south Muriwai. Nihotupu Formation, Maori Bay Member. Mid Pl.

N41/f592 (Grid. Ref. N41/957606), south Muriwai. Nihotupu Formation, Wairere Member. Mid Pl.

N41/f604 (Grid. Ref. N41/955615), south Muriwai. Nihotupu Formation, Maori Bay Member. Mid Pl.

N41/f622 (Grid. Ref. N41/091479), Nihotupu Stream. Nihotupu Formation. Lower Pl.

N41/f632 (Grid. Ref. N41/043559), Waitakere River. Nihotupu Formation. Swanson Member. Upper Po.

N41/f644 (Grid. Ref. N41/071451), Huia Stream, Georges Creek. Nihotupu Formation. Lower Pl.

N41/f653 (Grid. Ref. N41/069408), Marama Stream. Nihotupu Formation. Upper Po.

N41/f657 (Grid. Ref. N41/084405), Huia coast Road. Cornwallis Formation. Upper Po.

N41/f660 (Grid. Ref. N41/992477), Lion Rock, Piha. Piha Formation. Pl.

N42/f683 (Grid. Ref. N42/285514), Taylors Bay. Waitemata Group. Po.

N42/f694 (Grid. Ref. N42/117454), Kakamatua Stream. Cornwallis Formation. Upper Po.

N42/f696 (Grid. Ref. N42/102455), Huia Stream, Smiths Creek. Nihotupu Formation. Lower Pl.

N42/f701 (Grid. Ref. N42/101474), Nihotupu Stream. Nihotupu Formation. Lower Pl.

N42/f715 (Grid. Ref. N42/120490), Scenic Drive. Nihotupu Formation, Swanson Member. Upper Po.

N42/f719 (Grid. Ref. N42/120490), Scenic Drive. Nihotupu Formation, Swanson Member. Upper Po.

N42/f723 (Grid. Ref. N42/137485), Parau Dam tributary. Nihotupu Formation, Swanson Member. Upper Po.

N42/f728 (Grid. Ref. N42/122512), Waikumete West Coast Road. Waitemata Group. Upper Po.

N42/f729 (Grid. Ref. N42/104417), Huia Road. Cornwallis Formation. Upper Po.

N42/f730 (Grid. Ref. N42/104417), Huia Road. Cornwallis Formation. Upper Po.

DSDP 34 (Leg 21, site 206), Core 34 CC. New Caledonia Basin.

DSDP 35 (Leg 21, site 206), Core 35–2 (50–56 cm). New Caledonia Basin.

DSDP 37 (Leg 21, site 206), Core 37 CC. New Caledonia Basin.

DSDP 38 (Leg 21, site 206), Core 38–2 (48–51 cm). New Caledonia Basin.

Appendix II

Location, Lithostratigraphic Unit, and Age of Additional Samples Referred to in Systematic Section

Grid References are from NZMS 1 Sheets N41 Waitakere (3rd Ed., 1964); and N42 Auckland (3rd Ed., 1966).

N41/f568 (Grid. Ref. N41/954615), south Muriwai. Nihotupu Formation, Maori Bay Member. Mid Pl.

N41/f609 (Grid. Ref. N41/099535), Henderson Stream. Waitemata Group. Upper Po.

N41/f612 (Grid. Ref. N41/088545), Henderson Stream. Cornwallis Formation. Upper Po.

N41/f645 (Grid. Ref. N41/084476), Christies Creek. Nihotupu Formation. Lower Pl.

N42/f705 (Grid. Ref. N42/130488), Scenic Drive. Nihotupu Formation, Parekura Member. Upper Po.

N42/f706 (Grid. Ref. N42/103498), Scenic Drive. Nihotupu Formation. Lower Pl.

N42/f722 (Grid. Ref. N42/132481), Parau Dam tributary. Waitemata Group. Upper Po.

N42/f725 (Grid. Ref. N42/124507), Oratia Stream. Waitemata Group. Upper Po.

N42/f727 (N42/122512), Waikumete West Coast Road. Waitemata Group. Upper Po.

N42/f731 (N42/104417), Huia Road. Cornwallis Formation. Upper Po.

N42/f733 (N42/104417), Huia Road. Cornwallis Formation. Upper Po.

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PLATES

PLATE 1

Globorotalia zealandica incognita Walters
1. Involute side, N42/f696, hypotype, USNM 243240, ×200.
2. Peripheral view, N42/f696, hypotype, USNM 243240, ×200.

Globorotalia zealandica zealandica Hornibrook
3. Involute side, N41/f590, hypotype, USNM 243241, ×175.
4. Peripheral view, N41/f590, hypotype, USNM 243241 ×175.

Globorotalia kugleri Bolli
5. Involute side, N37/f585, hypotype, USNM 243242, ×300.

Globoquadrina dehiscens (Chapman, Parr and Collins)
6. Involute side, DSDP 206–38–2, hypotype, USNM 243243, ×130.

Ammodiscus finlayi Parr
7. Side view, N41/f612, hypotype, USNM 243244, ×120.

Bathysiphon sp.
8. Side view, N42/f715, hypotype, USNM 243245, ×50.

Martinotiella communis (d'Orbigny)
9. Side view, N33/f581, hypotype, USNM 243246, ×90.
10. Apertural view, N33/f581, hypotype, USNM 243246, ×90.

Martinotiella sp.
11. Side view, DSDP 206–45 CC, hypotype, USNM 243247, ×66.

Bolivinopsis sp.
12. Side view, DSDP 206–34 CC, hypotype, USNM 243248, ×220.

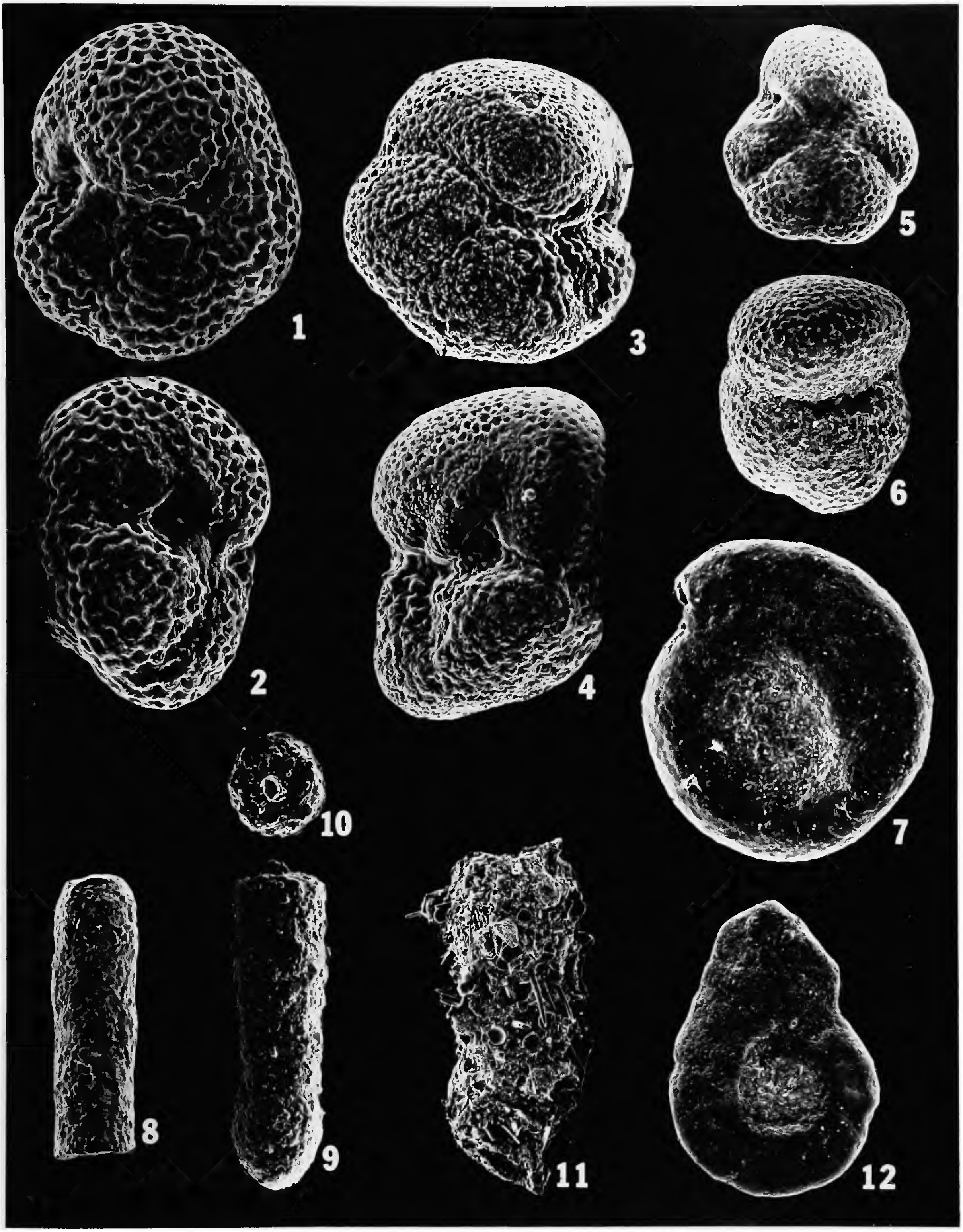
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PLATE 2

Pelosina complanata Franke
13. Side view, N41/f533, hypotype, USNM 243249, ×75.

Recurvoides sp.
14. Side view, N41/f632, hypotype, USNM 243250, ×100.

Semivulvulina capitata (Stache)
15. Apertural view, N33/f581, hypotype, USNM 243251, ×100.
16. Side view, N33/f581, hypotype, USNM 243251, ×100.

Triplasia marwicki Loeblich and Tappan
17. Side view, N41/f644, hypotype, USNM 243252, ×100.

Articulina parri Cushman
18. Apertural view, paratype, Victoria, Australia, USNM 243253, ×75.
19. Side view, paratype, Victoria, Australia, USNM 243253, ×75.
20. Apertural view N33/f505, hypotype, USNM 243254, ×200.
21. Side view, N33/f505, hypotype, USNM 243254, ×200.

Lachlanella cf. *L. schroekingeri* (Karrer)
22. Side view, N28/f914, hypotype, USNM 243255, ×50.
23. Apertural view, N28/f914, hypotype, USNM 243255, ×165.

Pyrgo anomala (Schlumberger)
24. Front view, N28/f914, hypotype, USNM 243256, ×200.

Pyrgo depressa (d'Orbigny)
25. Front view, N28/f914, hypotype, USNM 243257, ×60.

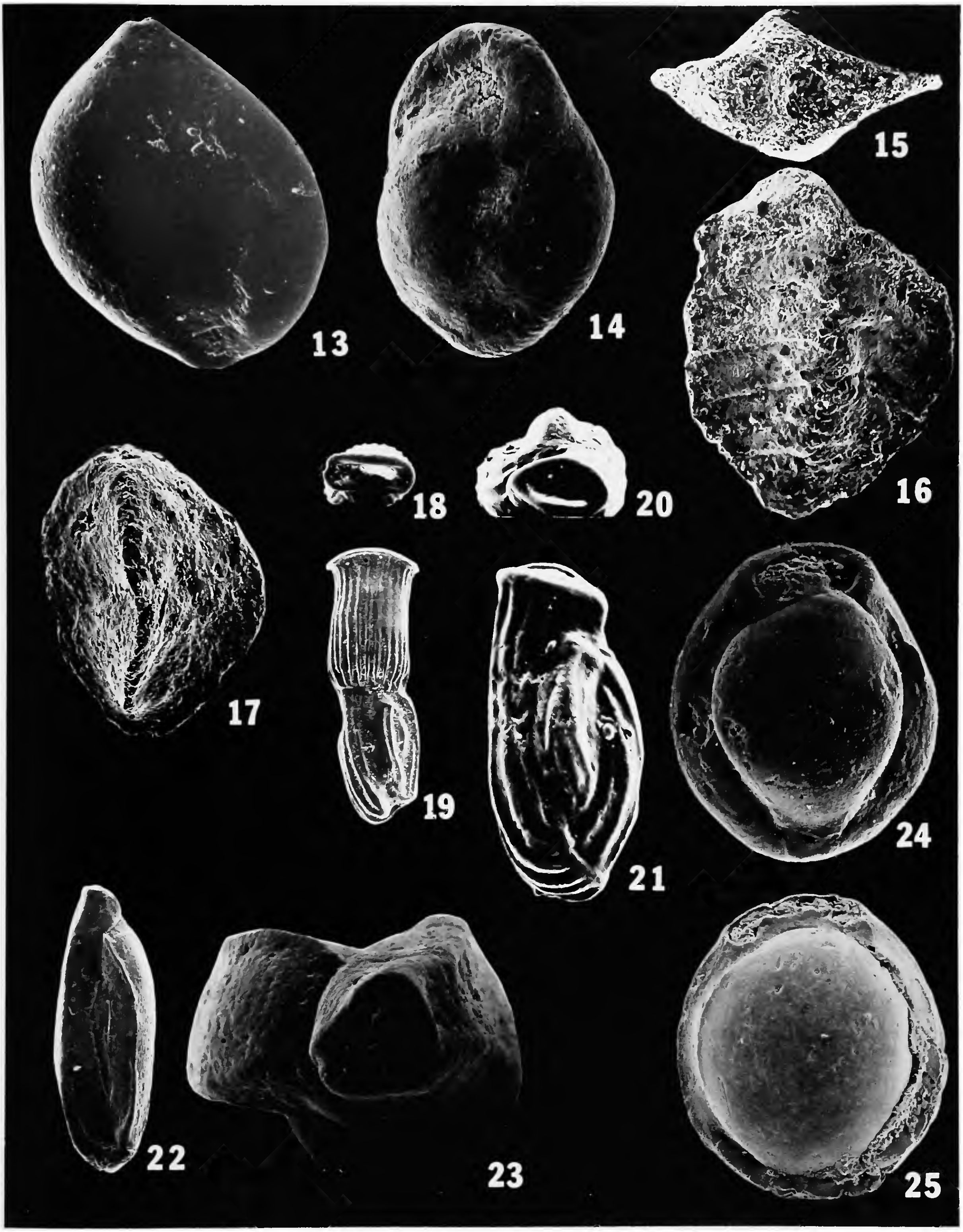
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PLATE 3

Pyrgo cf. *P. lucernula* (Schwager)
26. Side view, N28/f914, hypotype, USNM 243258, ×65.

Quinqueloculina angulostriata Cushman and Valentine
27. Apertural view, N28/f914, hypotype, USNM 243259, ×130
28. Front view, N28/f914, hypotype, USNM 243259, ×130.

Quinqueloculina cf. *Q. buchiana* d'Orbigny
29. Front view, N28/f914, hypotype, USNM 243260, ×160.
30. Back view, N28/f914, hypotype, USNM 243261, ×160.
31. Apertural view, N28/f914, hypotype, USNM 243260, ×160.

Quinqueloculina plana d'Orbigny
32. Front view, N33/f534, hypotype, USNM 243262, ×210.
33. Apertural view, N33/534, hypotype, USNM 243262, ×210.

Quinqueloculina seminula (Linnaeus)
34. Front view, N28/f912, hypotype, USNM 243263, ×175.

Quinqueloculina singletoni Crespin
35. Front view, N28/f912, hypotype, USNM 243264, ×80.
36. Apertural view, N28/912, hypotype, USNM 243264, ×80.

Sigmoilina victoriensis Cushman
37. Side view, N28/f452, hypotype, USNM 243265, ×100.

Spiroloculina excavata d'Orbigny
38. Side view, DSDP 206–39–2, hypotype, USNM 243266, ×100.

Triloculina trigonula (Lamarck)
39. Front view, N28/f914, hypotype, USNM 243267, ×75.

Wiesnerella sp.
40. Front view, N28/f458, hypotype, USNM 243268, ×140.

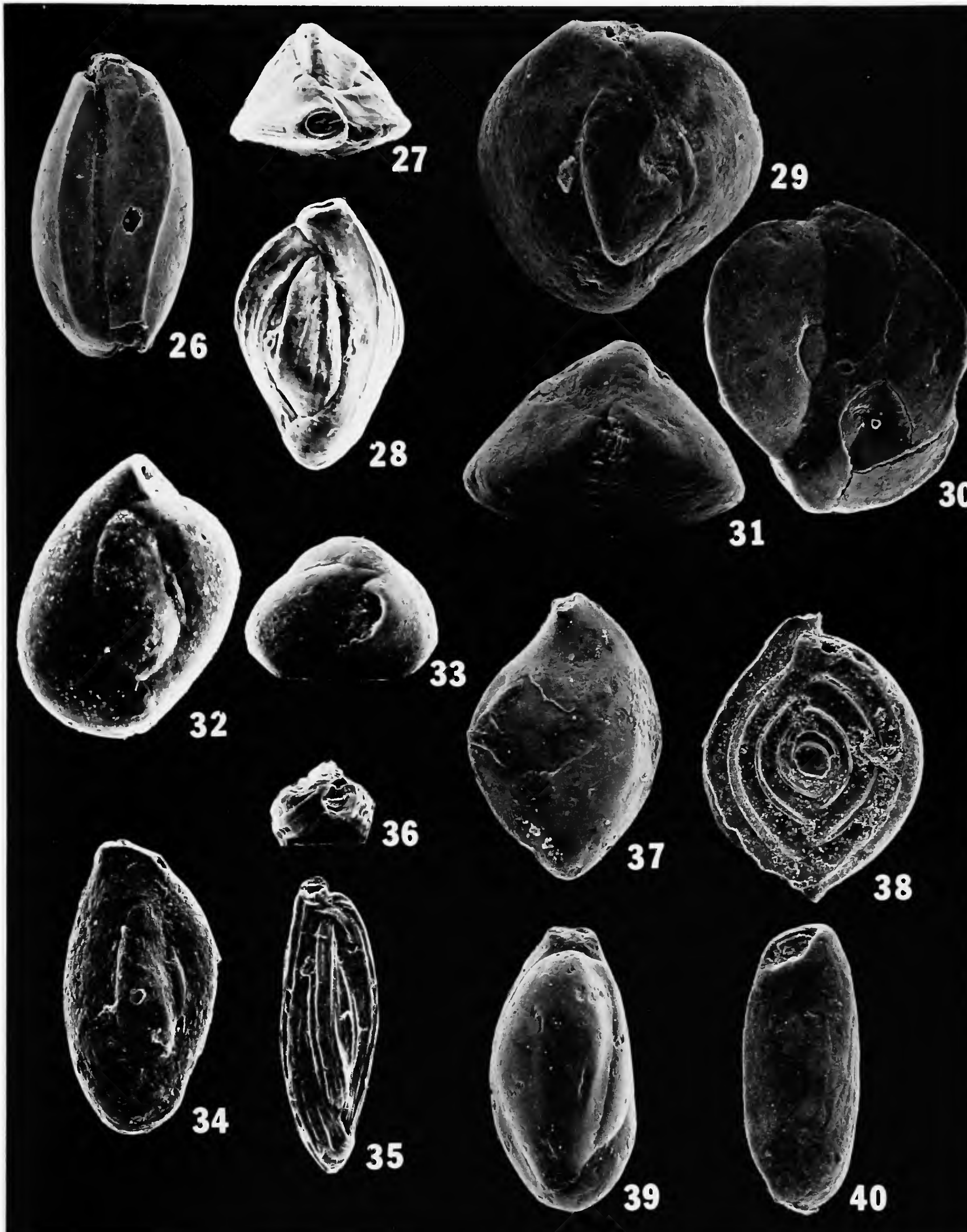
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PLATE 4

Alabamina tenuimarginata (Chapman, Parr and Collins)
41. Involute side, N28/f456, hypotype, USNM 243269, ×120.

Allomorphina cubensis Palmer and Bermudez
42. Apertural side, N37/f585, hypotype, USNM 243270, ×160.

Allomorphina pacifica Cushman and Todd
43. Apertural side, N42/f719, hypotype, USNM 243271, ×90.
44. Apertural side, DSDP 206-32-2, hypotype, USNM 243272, ×130.
45. Spiral side, DSDP 206-32-2, hypotype, USNM 243273, ×100.

Amphicoryna nebulosa (Ishizaki)
46. Side view, N41/f539, hypotype, USNM 243274, ×160.

Amphicoryna scalaris seminuda (Chapman)
47. Side view, N41/f653, hypotype, USNM 243275, ×130.

Amphistegina madagascariensis d'Orbigny
48. Ventral side, robust individual, N28/f913, hypotype, USNM 243276, ×25.
49. Dorsal side, fragile individual, N28/f456, hypotype, USNM 243277, ×120.

Anomalinoides globulosa (Chapman and Parr)
50. Involute ventral side, N42/f696, hypotype, USNM 243278, ×130.
51. Peripheral view, N42/f696, hypotype, USNM 243278, ×130.

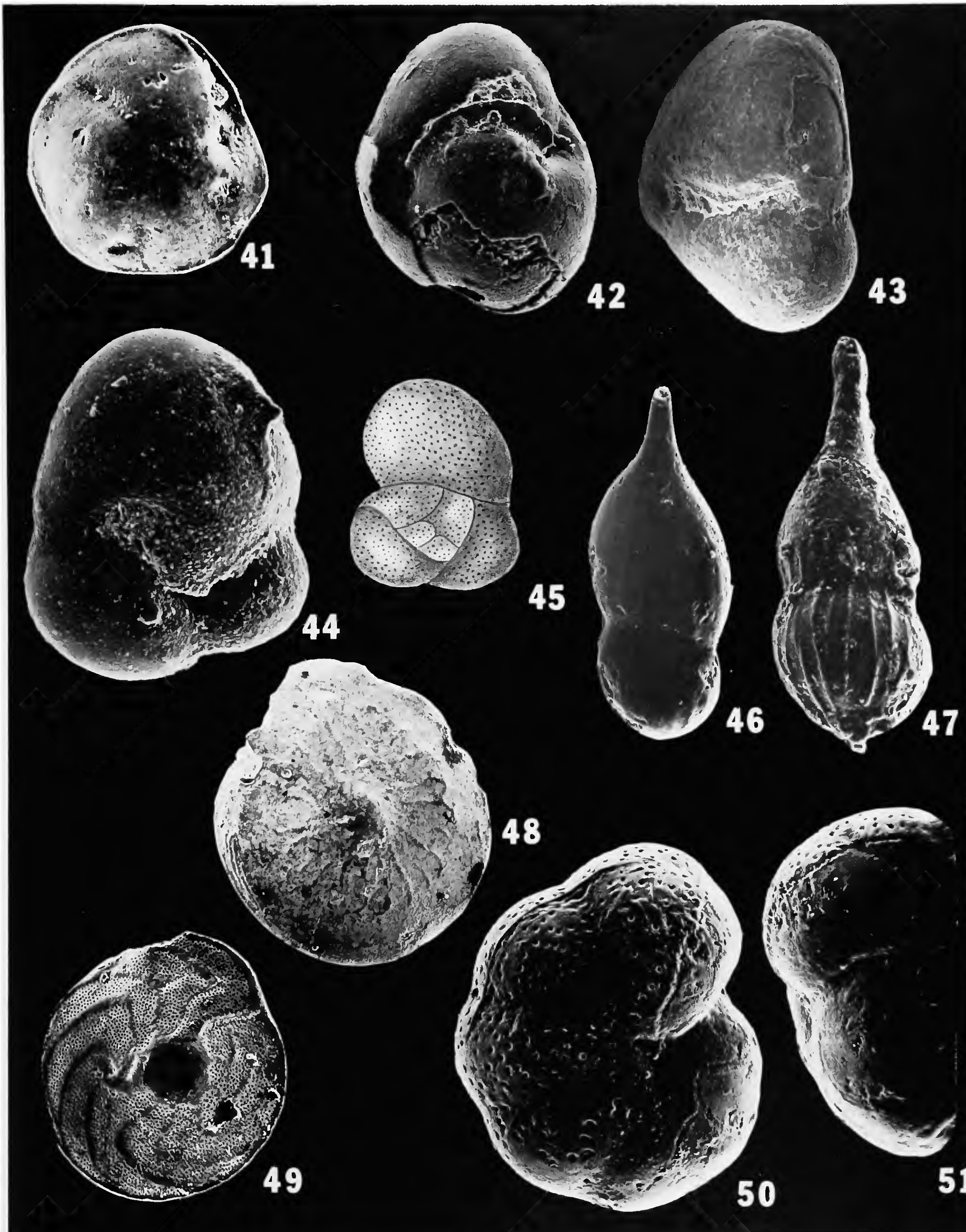
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PLATE 5

Anomalinoides macraglabra (Finlay)

52. Peripheral view, N28/f455, hypotype, USNM 243279, ×160.
53. Spiral side, N28/f455, hypotype, USNM 243279, ×160.

Anomalinoides semicribrata (Beckman)

54. Involute ventral side, DSDP 206–39–2, hypotype, USNM 243280, ×130.
55. Evolute dorsal side, N41/f590n, hypotype, USNM 243281, ×110.

Anomalinoides sp.

56. Dorsal side, DSDP 206C–2–2, hypotype, USNM 243283, ×175.

Astrononion stelligerum (d'Orbigny)

57. Side view, N28/f456, hypotype, USNM 243283, ×125.

Astacolus insolitus (Schwager)

58. Side view, N41/f644, hypotype, USNM 243284, ×50.
59. Peripheral view, N41/f644, hypotype, USNM 243284, ×50.
60. Side view, N41/f644, hypotype, USNM 243284, ×50.

Bolivina plicatella mera Cushman and Ponton

61. Side view, N37/f585, hypotype, USNM 243285, ×210.
62. Side view, N41/f590u, hypotype, USNM 243286, ×350.

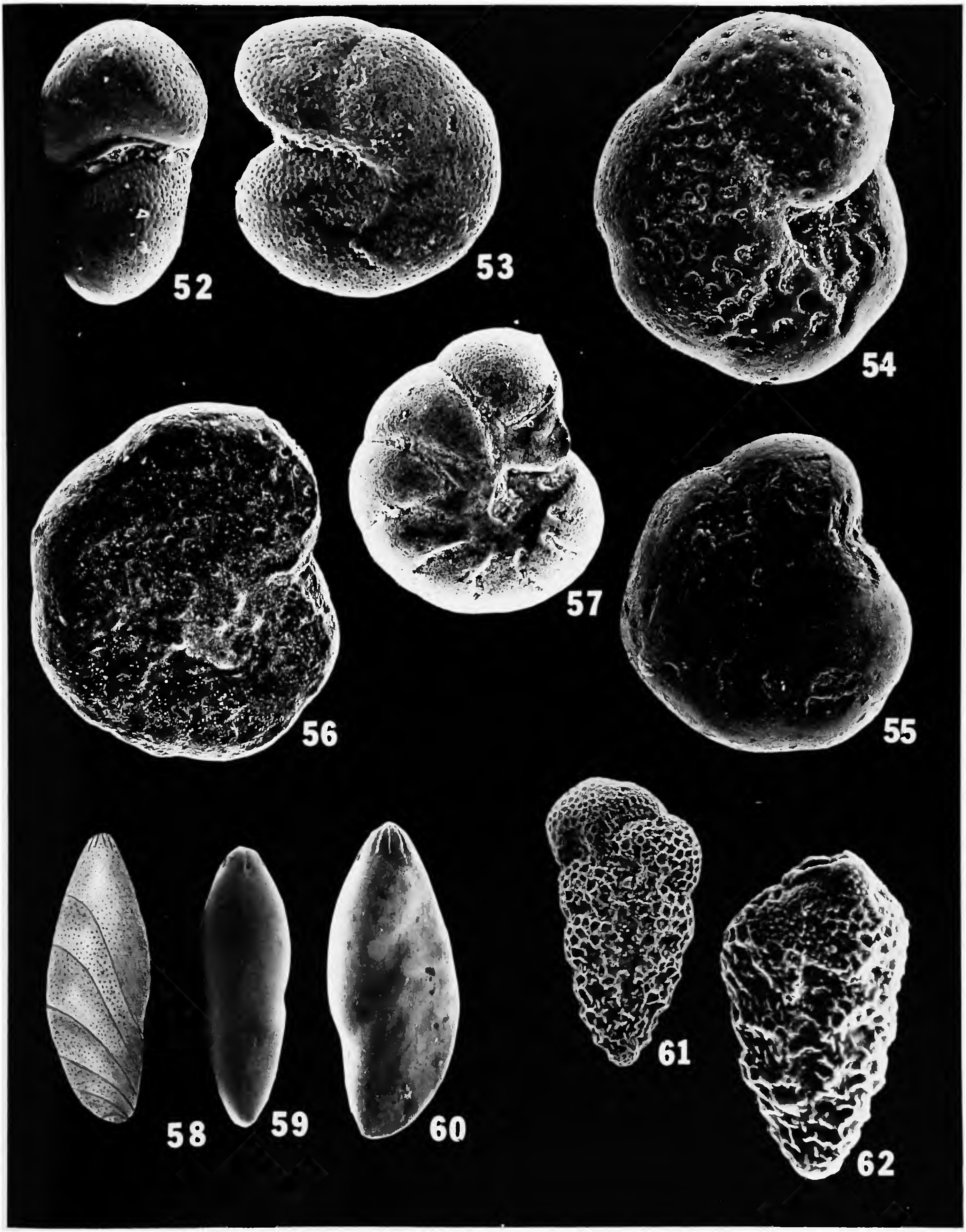
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PLATE 6

Bolivina acerosa Cushman
63. Side view, N33/f532, hypotype, USNM 243287, ×175.

Bolivina aenariensis (Costa)
64. Apertural view, DSDP 206–37 CC, hypotype, USNM 243288, ×130.
65. Side view, DSDP 206–37 CC, hypotype, USNM 243288, ×130.

Bolivina beyrichi Reuss
66. Side view, N41/f539, hypotype, USNM 243289, ×80.

Bolivina finlayi Hornibrook
67. Side view, N42/f729, hypotype, USNM 243290, ×140.

Bolivina mitcheli Gibson
68. Side view, N41/f609, hypotype, USNM 243291, ×120.

Bolivina mantaensis Cushman
69. Side view, N41/f2d, hypotype, USNM 243292, ×280.
70. Side view, N41/f2d, hypotype, USNM 243293, ×200.

Bolivina punctatostriata Kreuzberg
71. Side view, N41/f644, hypotype, USNM 243294, ×80.

Bolivina reticulata Hantken
72. Side view, N33/f581, hypotype, USNM 243295, ×130.

Bolivina silvestrina Cushman
73. Oblique peripheral view, N41/f609, hypotype, USNM 243296, ×200.
74. Side view, N41/f609, hypotype, USNM 243296, ×200.

Bolivina subcompacta Finlay
75. Side view, N37/f585, hypotype, USNM 243297, ×160.

Bolivina thalmanni Renz
76. Apertural view, DSDP 206–37 CC, hypotype, USNM 243298, ×200.
77. Side view, DSDP 206–37 CC, hypotype, USNM 243298, ×200.

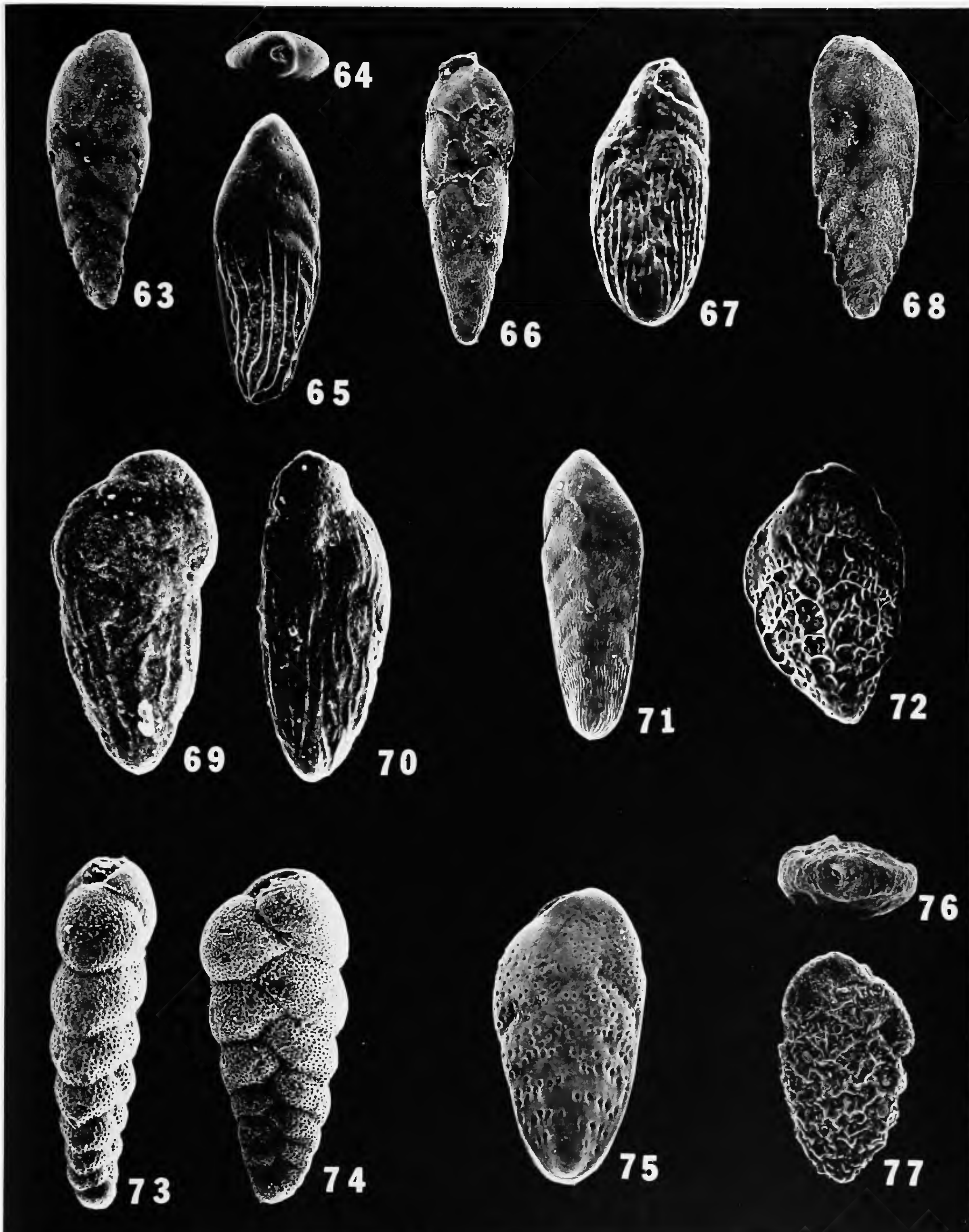
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PLATE 7

Bolivinella australis Cushman
78. Apertural view, N28/f458, hypotype, USNM 243299, ×100.
79. Side view, N28/f458, hypotype, USNM 243299, ×100.
82. Enlarged apertural view, N28/f458, hypotype, USNM 243299, ×420.

Bolivinella subpectinata Cushman
80. Side view, N28/f458, hypotype, USNM 243300, ×100.
81. Apertural view, N28/f458, hypotype, USNM 243300, ×100.

Bulimina pupula Stache s.l
83. Side view, N28/912, hypotype, USNM 243301, ×80.

Bulimina semicostata Nuttall
84. Apertural view, DSDP 206–38–2, hypotype, USNM 243302, ×200.
85. Side view, DSDP 206–38–2, hypotype, USNM 243302, ×200.

Bulimina striata d'Orbigny
86. Side view, N42/f696, hypotype, USNM 243303, ×100.

Bulimina truncana Gümbel
87. Side view, DSDP 206–38–2, hypotype, USNM 243304, ×140.
88. Side view, N33/f581, hypotype, USNM 243305, ×160.

Buliminella missilis Vella
89. Side view, N42/f694, hypotype, USNM 243306, ×80.

Cassidulina laevigata d'Orbigny
90. Side view, N28/f785, hypotype, USNM 243307, ×260.

Cassidulina margareta Karrer
91. Side view, N33/f581, hypotype, USNM 243308, ×140.

Cassidulina monstruosa Voloshinova
92. Side view, DSDP 206–34 CC, hypotype, USNM 243309, ×240.
93. Peripheral view, DSDP 206–34 CC, hypotype, USNM 243309, ×240 (see Plate 8: figure 96).

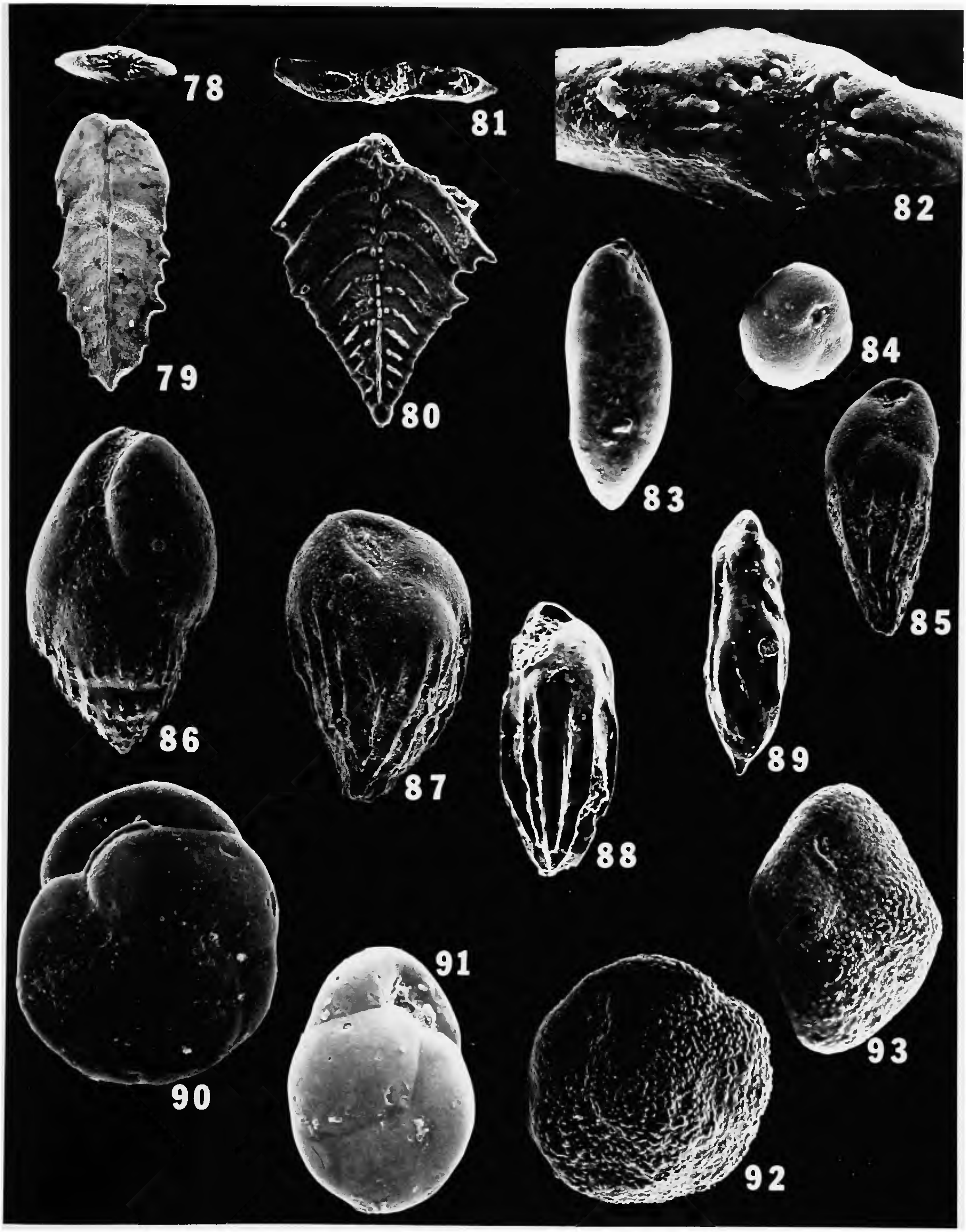
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PLATE 8

Cassidulina carapitana Hedberg

94. Peripheral view, N41/f555, hypotype, USNM 243310, ×130.
95. Side view, N41/f555, hypotype, USNM 243310, ×130.

Cassidulina monstruosa Voloshinova

96. Side view, N42/f729, hypotype, USNM 243311, ×130 (see Plate 7: figures 92, 93).

Discorbinella stachi (Asano)

97. Dorsal side, N41/f539, hypotype, USNM 243312, ×200.
98. Peripheral view, N41/f539, hypotype, USNM 243312, ×200.
99. Ventral side, N41/f539, hypotype, USNM 243312, ×200 (see Plate 12: figures 153, 154).

Discorbinella bertheloti (d'Orbigny)

100. Spiral side, N41/f590n, hypotype, USNM 243313, ×175.
101. Peripheral view, N41/f590n, hypotype, USNM 243313, ×175.
102. Involute side, N41/f590n, hypotype, USNM 243313, ×175.

Discorbinella complanata (Sidebottom)

103. Partly involute side, N41/f590n, hypotype, USNM 243314, ×175.
104. Peripheral view, N41/f590n, hypotype, USNM 243314, ×175.
105. Spiral side, N41/f590n, hypotype, USNM 243314, ×175 (see Plate 12: figures 151, 152).

Discorbinella galera (Finlay)

106. Spiral side, paratype, Pakaurangi Point, USNM 243315, ×66.
107. Peripheral view, paratype, Pakaurangi Point, USNM 243315, ×66.
108. Partly involute side, paratype, Pakaurangi Point, USNM 243315, ×66.

Discorbinella sp.

109. Convex spiral side, N42/f729, hypotype, USNM 243316, ×175.
110. Peripheral view, N42/f729, hypotype, USNM 243316, ×175.
111. Flat side, N42/f729, hypotype, USNM 243316, ×175.

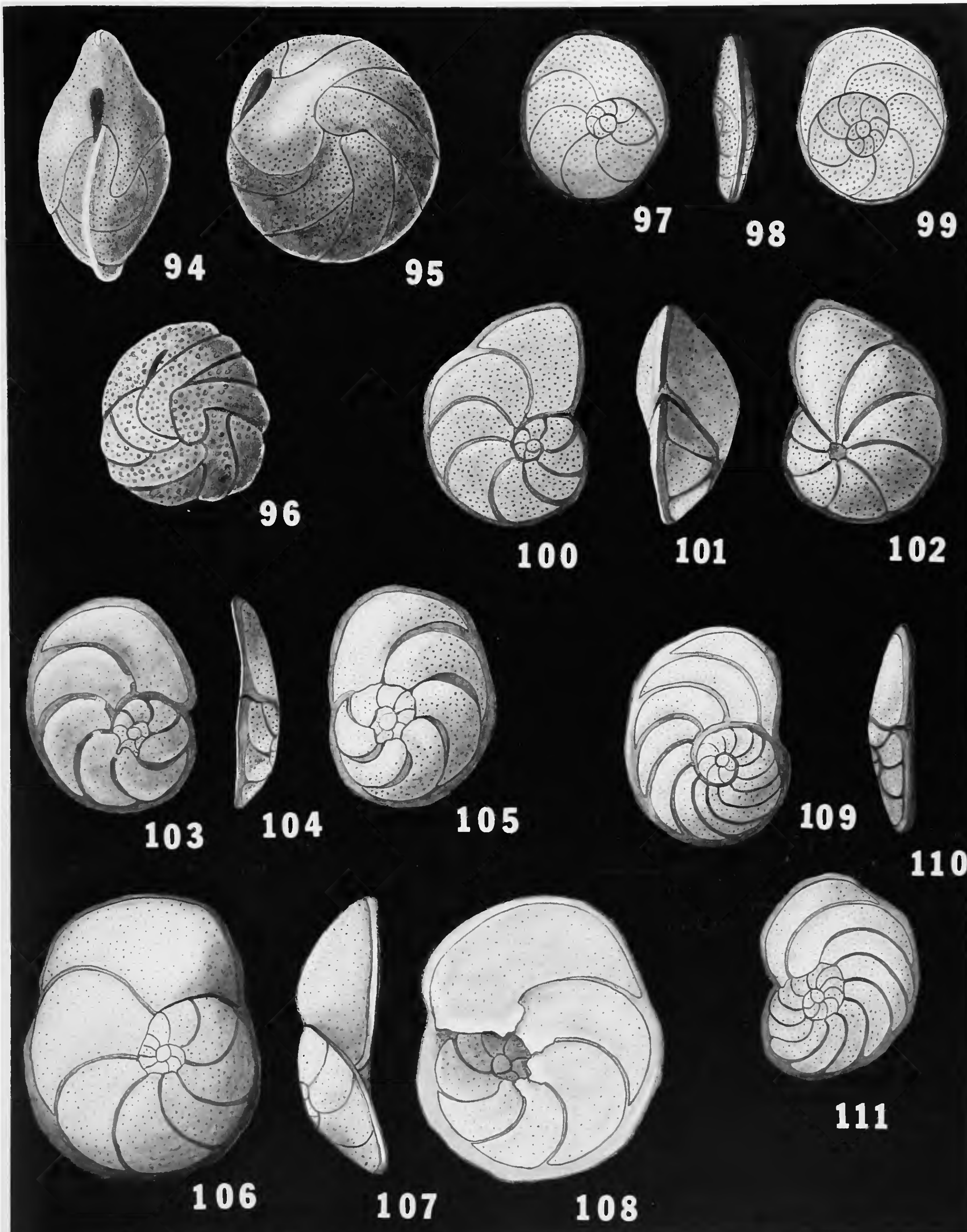
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PLATE 9

Ceratobulimina kellumi Finlay

112. Side view, N37/f585, hypotype, USNM 243317, ×100.

Chilostomella czizecki Reuss

113. Front view, N28/f452, hypotype, USNM 243318, ×90.
114. Side view, N28/f452, hypotype, USNM 243318, ×90.

Chilostomella globata Galloway and Heminway

115. Side view, N37/f585, hypotype, USNM 243319, ×85.
116. Front view, N37/f585, hypotype, USNM 243319, ×85.

Chilostomella ovoidea Reuss

117. Front view, N33/f581, hypotype, USNM 243320, ×120.
118. Side view, N33/f581, hypotype, USNM 243320, ×120.

Chilostomelloides oviformis (Sherborn and Chapman)

119. Side view, N46/f501, hypotype, USNM 243321, ×33.
120. Apertural end view, N46/f501, hypotype, USNM 243321, ×55.

Cibicidoides karreriformis (Hornibrook)

121. Involute side, N28/f452, hypotype, USNM 243322, ×66.
122. Spiral side, N42/f696, hypotype, USNM 243323, ×60.

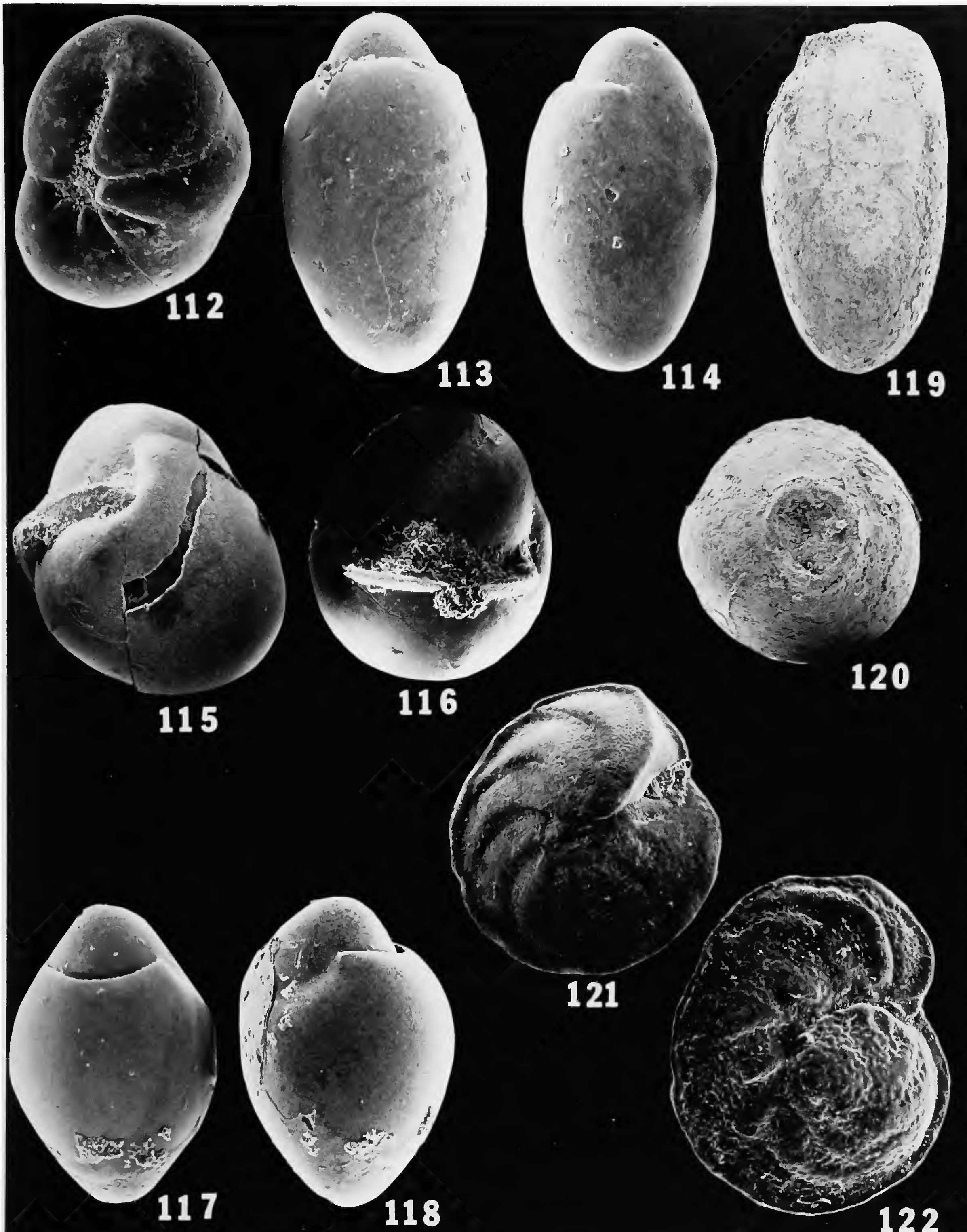
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PLATE 10

Cibicidoides kullenbergi (Parker)

123. Involute side, DSDP 206–34 CC, hypotype, USNM 243324, ×200.

Cibicides lobatulus (Walker and Jacob)

124. Involute side, N28/f456, hypotype, USNM 243325, ×130.
125. Peripheral view, N28/f456, hypotype, USNM 243325, ×130.
126. Spiral side, N28/f455, hypotype, USNM 243326, ×100.

Cibicides mediocris Finlay

127. Involute side, N28/f456, hypotype, USNM 243327, ×150.
128. Peripheral view, N28/f456, hypotype, USNM 243327, ×150.
129. Spiral side, N28/f456, hypotype, USNM 243328, ×120.

Cibicides refulgens de Montfort

130. Peripheral view, N28/f456, hypotype, USNM 243329, ×170.
131. Involute side, N28/f456, hypotype, USNM 243329, ×170.

Cibicides notocenicus Dorreen

132. Peripheral view, N41/f555, hypotype, USNM 243330, ×100.
133. Spiral side, N41/f555, hypotype, USNM 243330, ×100.
134. Peripheral view, N41/f537, hypotype, USNM 243331, ×85.

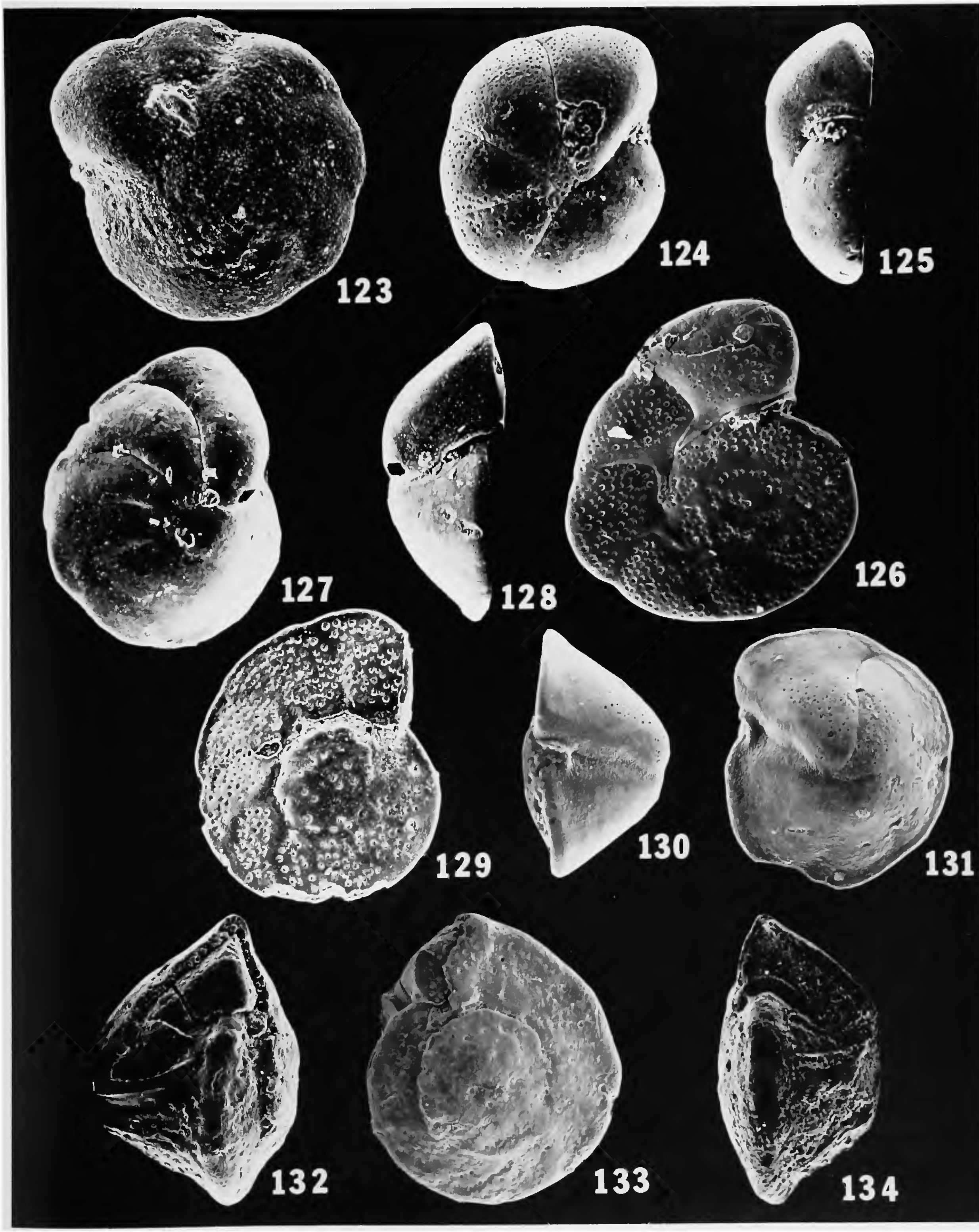
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PLATE 11

Cibicidoides temperatus (Vella)
135. Spiral side, N28/f456, hypotype, USNM 243332, ×125.
136. Peripheral view, N28/f456, hypotype, USNM 243333, ×120.
137. Involute side, N28/f456, hypotype, USNM 243333, ×120.
Cibicides vortex Dorreen
138. Peripheral view, N28/f456, hypotype, USNM 243334, ×175.
139. Involute side, N28/f456, hypotype, USNM 243334, ×175.
Cibicides wuellerstorfi (Schwager)
140. Spiral side, DSDP 206-32-2, hypotype, USNM 243335, ×80.
141. Peripheral view, DSDP 206-32-2, hypotype, USNM 243336, ×80.
142. Involute side, DSDP 206-32-2, hypotype, USNM 243336, ×80.
Dentalina cf. *D. albatrossi* (Cushman)
143. Side view, N33/f581, hypotype, USNM 243337, ×30.
Dentalina intorta (Dervieux)
144. Side view, DSDP 206-41-1, hypotype, USNM 243338, ×70.
Dentalina spirostriolata (Cushman)
145. Side view, N41/f632, hypotype, USNM 243339, ×30.
Dentalina subemaciata Parr
146. Side view, N33/f581, hypotype, USNM 243340, ×30.
Discorbis balcombensis Chapman, Parr and Collins
147. Involute side, N28/f914, hypotype, USNM 243341, ×130.
Discorbis semiopercularis Hornibrook
148. Involute side, N28/f455, hypotype, USNM 243342, ×80.
149. Peripheral view, N28/f455, hypotype, USNM 243342, ×80.

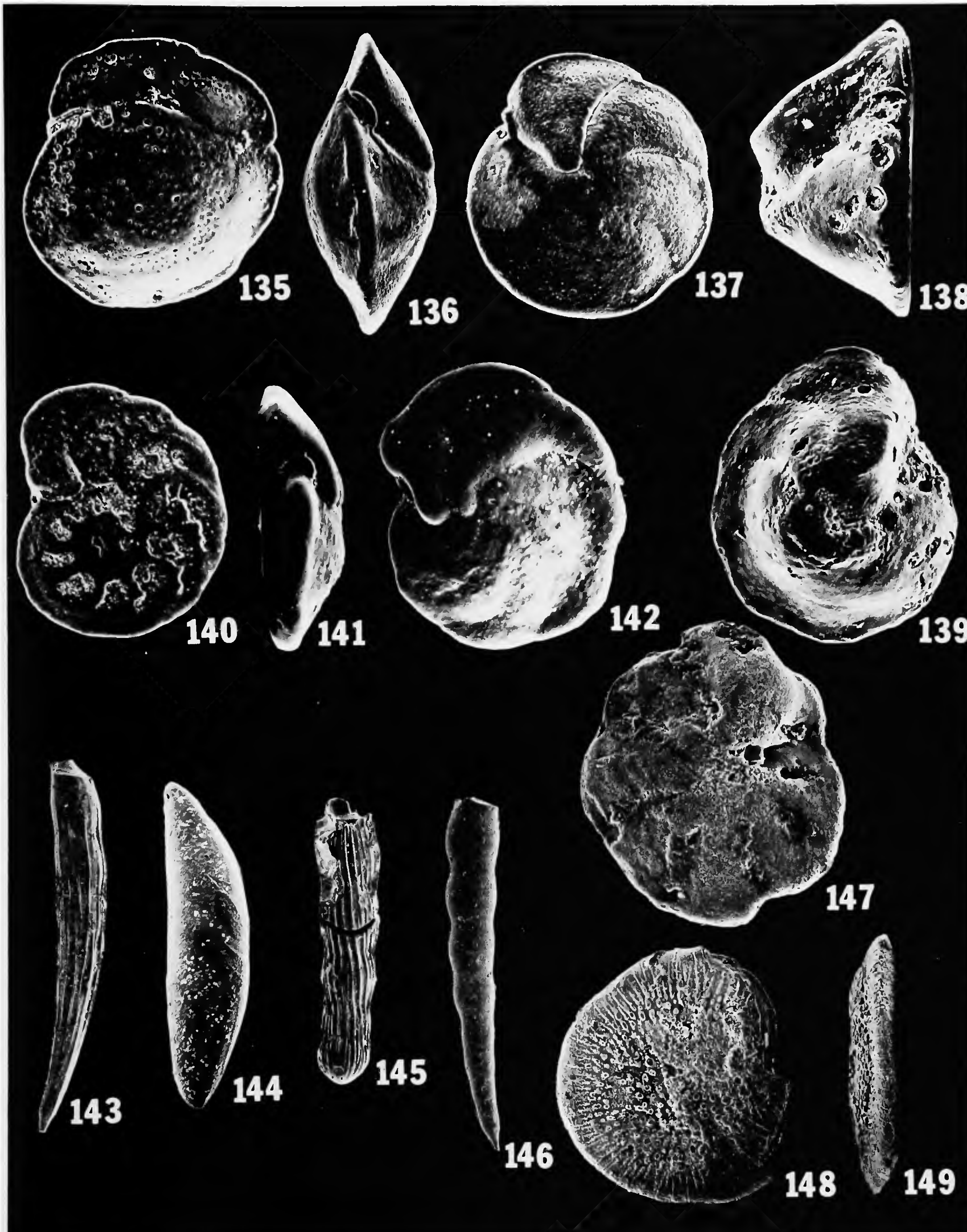
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PLATE 12

Discorbis zealandica (Vella)

150. Involute side, N28/f458, hypotype, USNM 243343, ×175.

Discorbinella complanata (Sidebottom)

151. Partly involute side, N28/f456, hypotype, USNM 243344, ×120.
152. Peripheral view, N28/f456, hypotype, USNM 243344, ×120.

Discorbinella stachi (Asano)

153. Partly involute side, N28/f795, hypotype, USNM 243345, ×140.
154. Peripheral view, N28/f795, hypotype, USNM 243345, ×140.

Dyocibicides biserialis Cushman and Valentine

155. Spiral side, N28/f455, hypotype, USNM 243346, ×120.

Ehrenbergina marwicki Finlay

156. Face view, N33/f581, hypotype, USNM 243347, ×160.

Elphidium advenum (Cushman)

157. Side view, N41/f537, hypotype, USNM 243348, ×200.

Elphidium gibsoni Hayward, new species

158. Side view, N28/f455, paratype, USNM 243349, ×100.
159. Peripheral view, N42/f709, paratype, USNM 243350, ×95.
160. Side view, N28/f792, paratype, USNM 243351, ×110 (see Plate 15: figure 182).

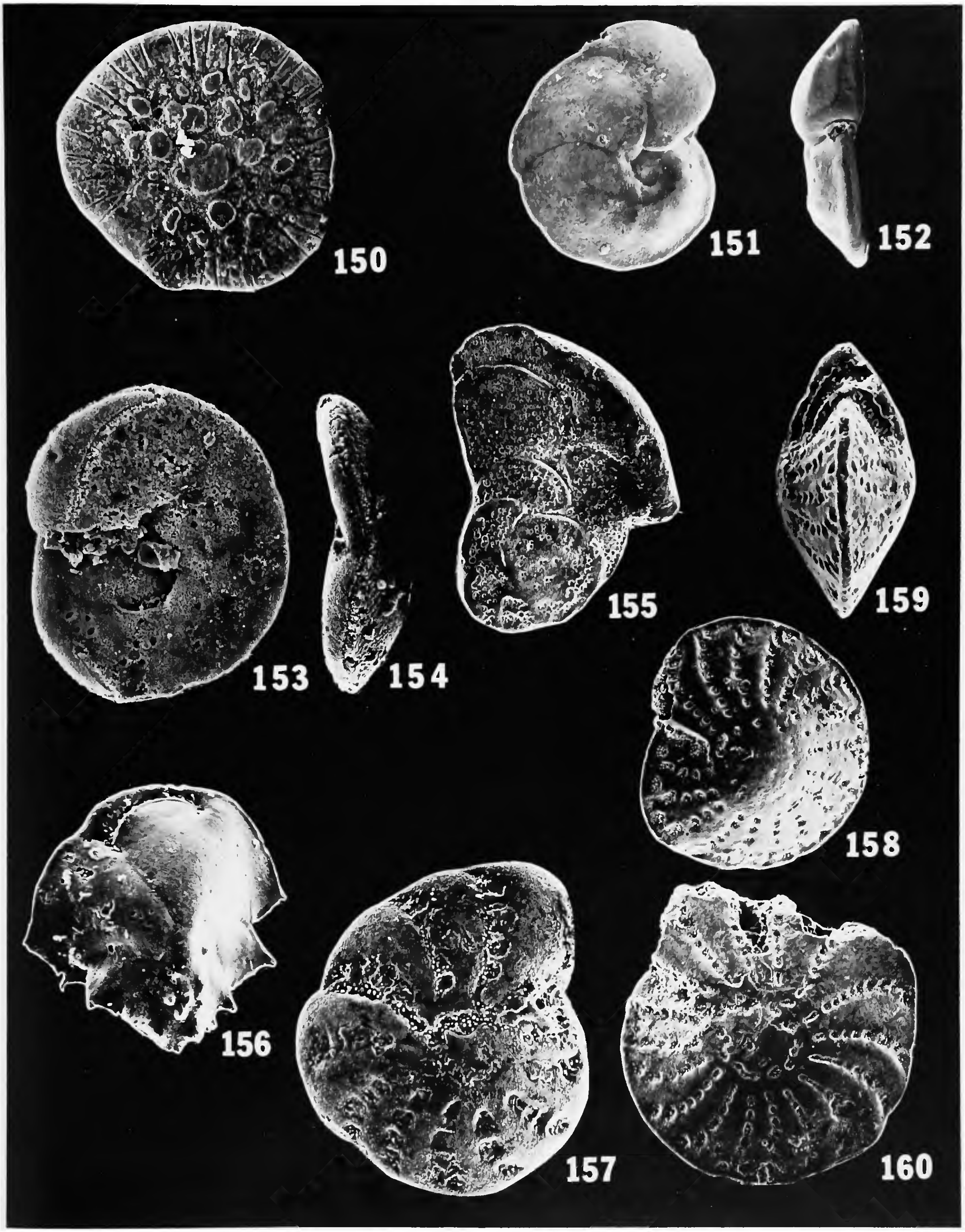
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PLATE 13

Elphidium nigarense Cushman

161. Side view, N33/f581, hypotype, USNM 243355, ×180.
162. Peripheral view, N33/f505, hypotype, USNM 243356, ×120.
163. Side view, N33/f532, hypotype, USNM 243357, ×110.
164. Side view, N33/f505, hypotype, USNM 243356, ×120.
165. Peripheral view, N33/f581, hypotype, USNM 243355, ×180.

Elphidium pseudoinflatum Cushman

166. Side view, N28/f455, hypotype, USNM 243358, ×125.
167. Peripheral view, N28/f457, hypotype, USNM 243359, ×120.
168. Peripheral view, N28/f455, hypotype, USNM 243358, ×125.

Elphidium kanoum Hayward, new species

169. Side view, N28/f792, paratype, USNM 243360, ×90.
170. Peripheral view, N28/f792, paratype, USNM 243360, ×90 (see Plate 15: figures 183, 184).

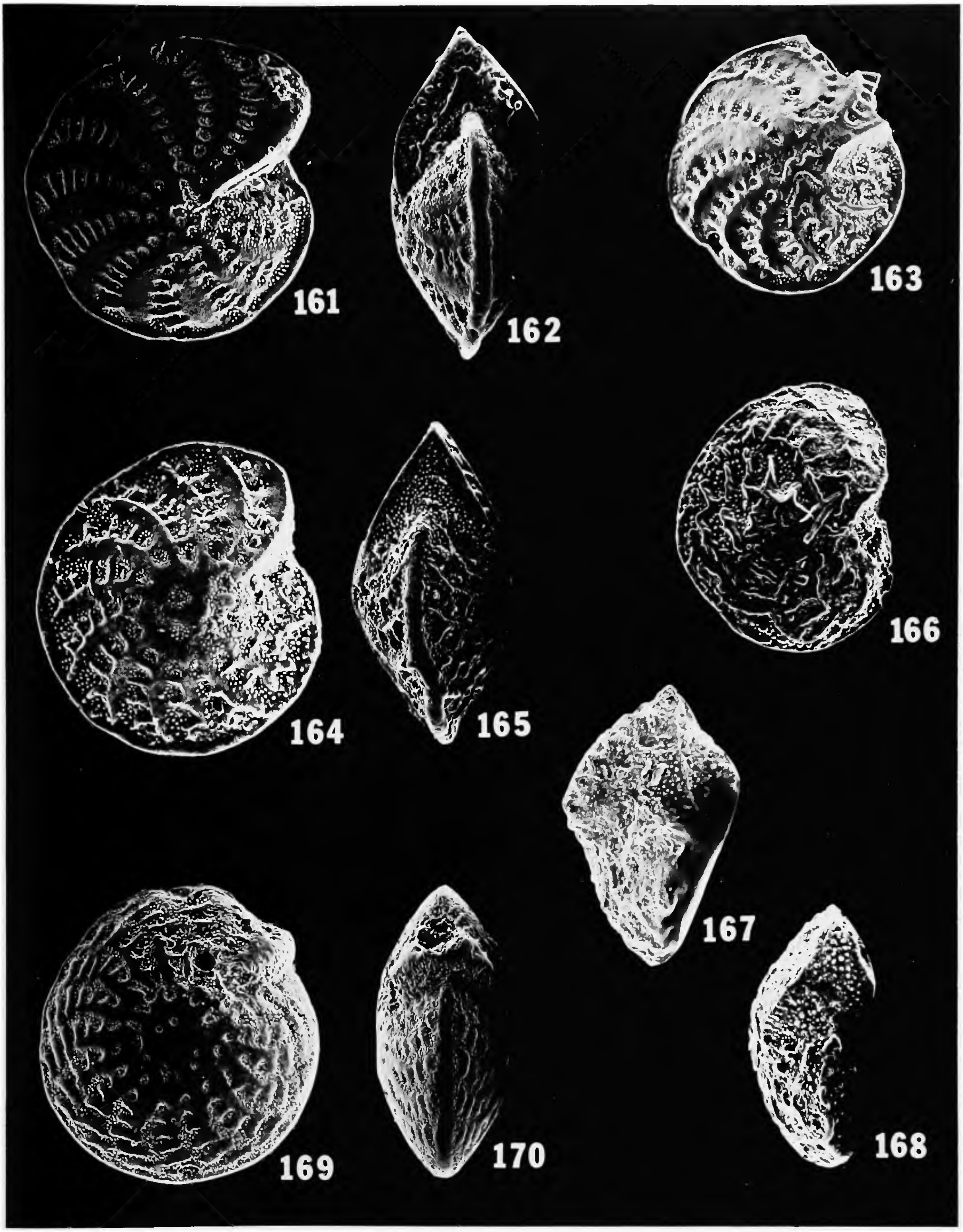
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PLATE 14

Eoeponidella scotti Hayward, new species

171. Involute side, last chamber broken off, N28/f912, paratype, USNM 243362, ×270.
172. Peripheral view, N28/f458, paratype, USNM 243363, ×220.
173. Spiral side, N28/f458, paratype, USNM 243363, ×220.
174. Involute side, N28/f795, paratype, USNM 243364, ×230.
175. Peripheral view, N28/f795, paratype, USNM 243364, ×230 (see Plate 15: figures 187–189).

Epistominella exigua (Brady)

176. Involute side, DSDP 206–34 CC, hypotype, USNM 243368, ×200.
177. Peripheral view, DSDP 206–34 CC, hypotype, USNM 243368, ×200.

Euuvigerina miozea (Finlay)

178. Side view, N33/f581, hypotype, USNM 243369, ×90.

Evolvocassidulina bradyi (Norman)

179. Side view, DSDP 206–32–2, hypotype, USNM 243370, ×360.

Evolvocassidulina cf. *E. chapmani* Parr

180. Side view, N33/f532, hypotype, USNM 243371, ×200.

Evolvocassidulina orientalis (Cushman)

181. Side view, N33/f505, hypotype, USNM 243372, ×220.

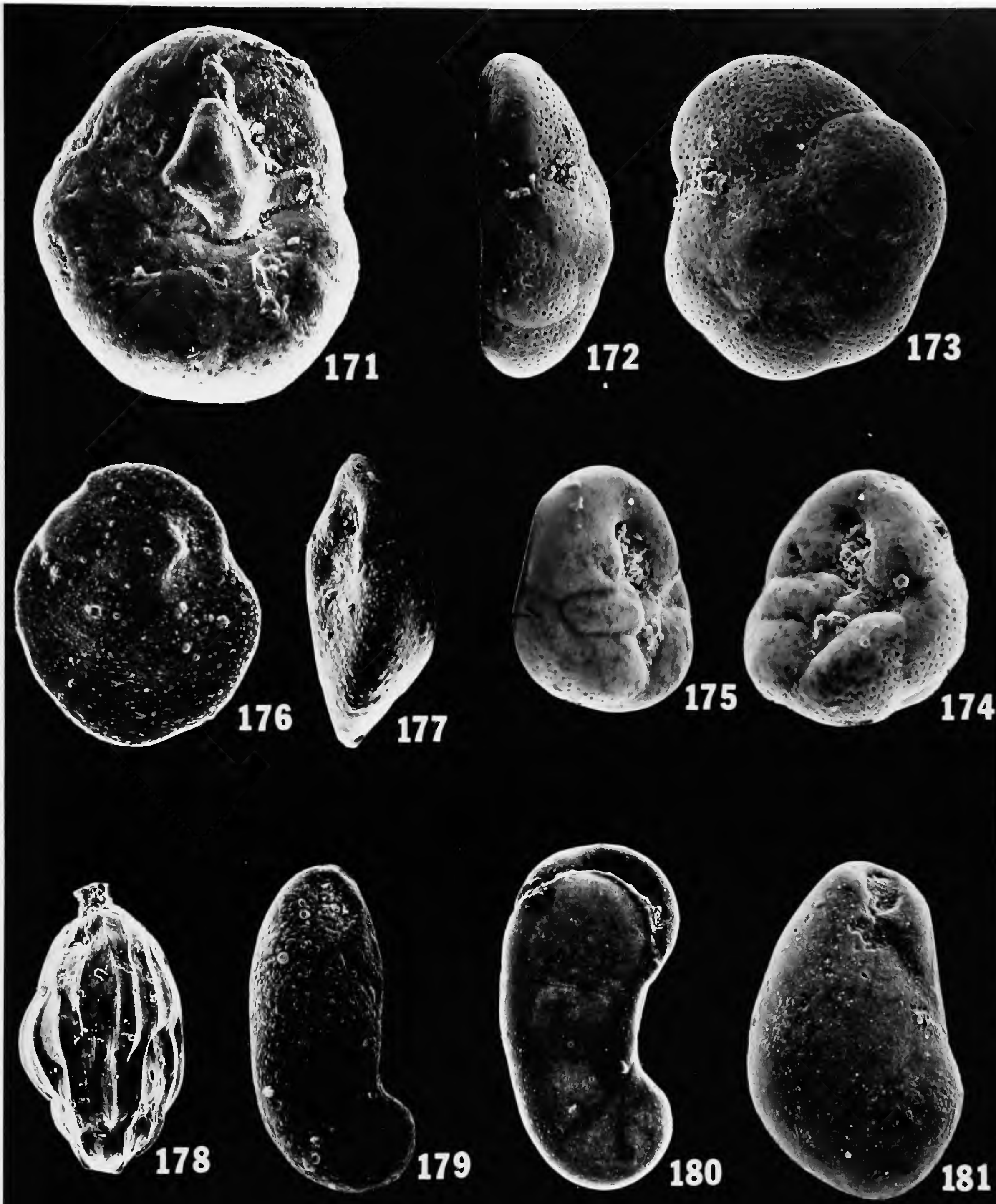
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PLATE 15

Elphidium gibsoni Hayward, new species
- 182. Side view, N41/f539, holotype, TF 1579/1, ×50 (see Plate 12: figures 158–160).

Elphidium vitrum Hayward, new species
- 183. Side view, N28/f457, holotype, TF 1580/1, ×50.
- 184. Peripheral view, N28/f457, holotype, TF 1580/, ×50 (see Plate 13: figure 169, 170).

Frondicularia tenuissima Hantken
- 185. Broken basal portion, N37/f585, hypotype, USNM 243373, ×50.
- 186. Broken apertural portion, N33/f581, hypotype, USNM 243374, ×60.

Eoeponidella scotti Hayward, new species
- 187. Involute side, N28/f457, holotype, TF 1581/1, ×160.
- 188. Peripheral view, N28/f457, holotype, TF 1581/1, ×160.
- 189. Spiral side, N28/f457, holotype, TF 1581/1, ×160 (see Plate 14: figures 171–175).

Glabratellina sigali Seiglie and Bermudez
- 190. Spiral side, N28/f458, hypotype, USNM 243375, ×175 (see Plate 17: figures 213–215).

Lenticulina planula (Galloway and Heminway)
- 191. Side view, N37/f585, hypotype, USNM 243376, ×50.
- 192. Peripheral view, N33/f580, hypotype, USNM 243377, ×130 (see Plate 20; figures 250–252).

Osangularia culter (Parker and Jones)
- 193. Involute side, N37/f585, hypotype, USNM 243378, ×50.
- 194. Spiral side, N37/f585, hypotype, USNM 243378, ×50 (see Plate 22: figures 279–281).

Planulina cf. *P. crassa* Galloway and Heminway
- 195. Spiral side, N42/f715, hypotype, USNM 243379, ×130.
- 196. Peripheral view, N42/f715, hypotype, USNM 243379, ×130.
- 197. Involute side, N42/f715, hypotype, USNM 243379, ×130.

Sigmoidina pacifica Cushman and Ozawa
- 198. Face view, N28/f781, hypotype, USNM 243380, ×85.
- 199. Back view, N28/f781, hypotype, USNM 243380, ×85 (see Plate 27: figure 332).

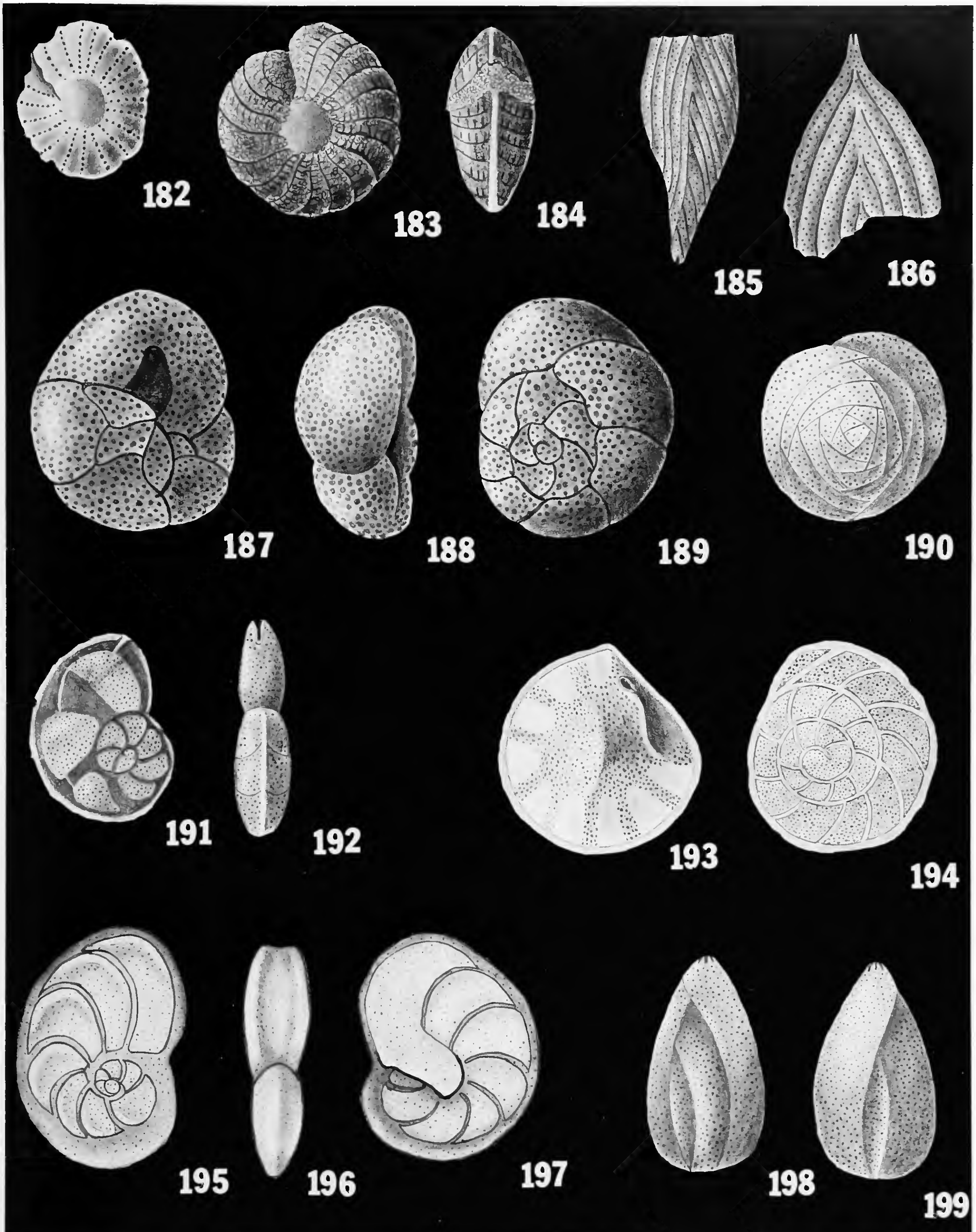
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PLATE 16

Fissurina aperta Seguenza
200. Apertural view, N28/f456, hypotype, USNM 243381, ×200.
201. Side view, N28/f456, hypotype, USNM 243381, ×200.

Fissurina aureoligera (Buchner)
202. Apertural view, N28/f788, hypotype, USNM 243382, ×230.
203. Side view, N28/f788, hypotype, USNM 243382, ×230.

Fissurina basifimbriata Parr
204. Side view, DSDP 206–38–2, hypotype, USNM 243383, ×200.

Fissurina lagenoides (Williamson)
205. Side view, DSDP 206–32–2, hypotype, USNM 243384, ×130.

Fissurina kerguelenensis Parr
206. Side view, DSDP 206–37 CC, hypotype, USNM 243385, ×400.

Fissurina marginata (Walker and Boys)
207. Side view, N33/f581, hypotype, USNM 243386, ×200.

Fissurina aff. *F. obscurocostata* Galloway and Wissler
208. Side view, N28/f914, hypotype, USNM 243387, ×160.

Fissurina radiata Seguenza
209. Side view, DSDP 206–37 CC, hypotype, USNM 243388, ×400.

Fissurina orbignyana Seguenza
210. Side view, N41/f660, hypotype, USNM 243389, ×200.

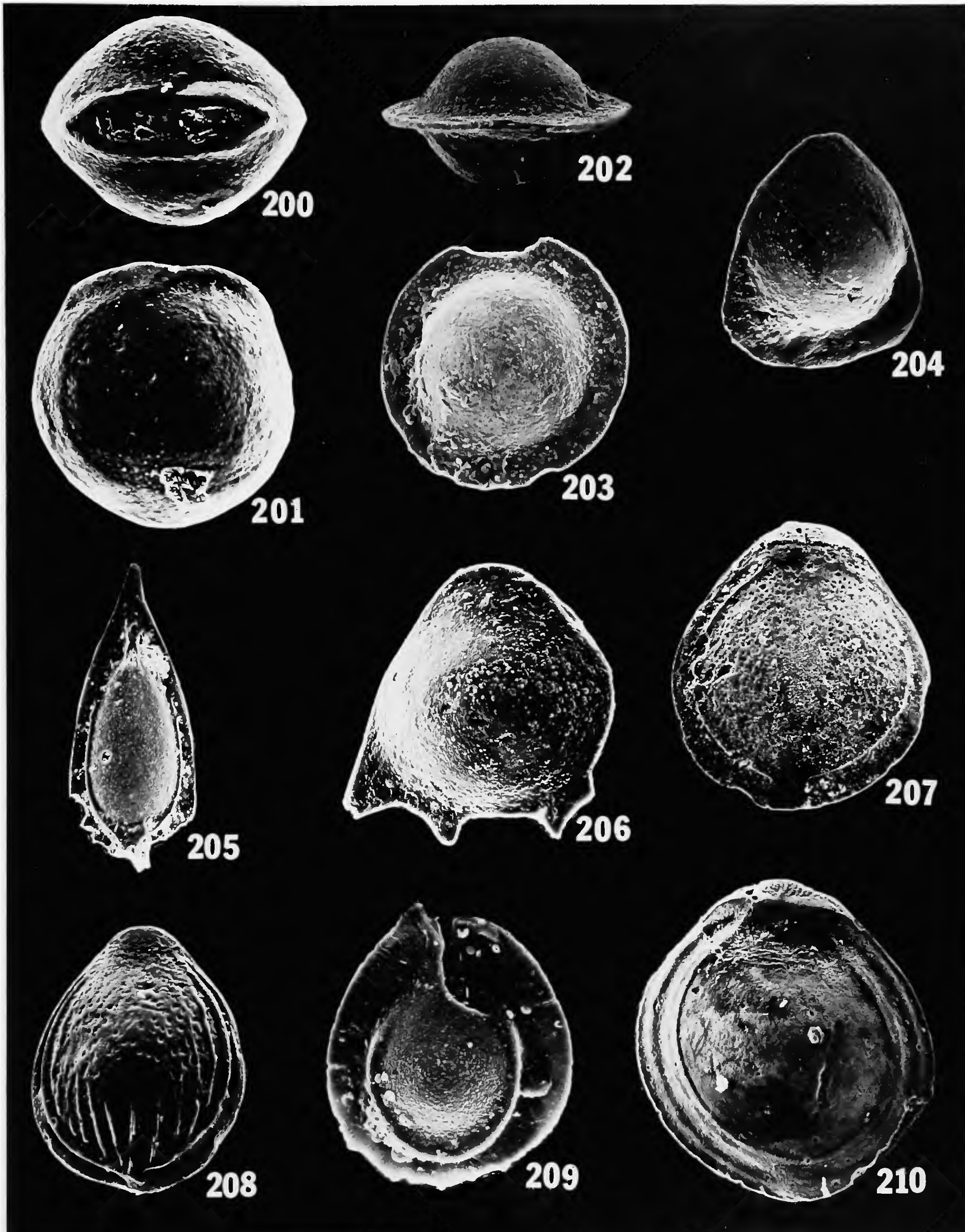
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PLATE 17

Florilus stachei (Cushman)

211. Side view, last chamber broken, N28/f455, hypotype, USNM, 243390, ×90.

Fursenkoina schreibersiana (Czjzek)

212. Side view, N33/f581, hypotype, USNM 243391, ×120.

Glabratellina sigali Seiglie and Bermudez

213. Side view, N28/f458, hypotype, USNM 243392, ×175.
214. Involute side, N28/f458, hypotype, USNM 243392, ×175.
215. Side view of plastagamic pair, hypotype, N28/f458, USNM 243393, ×175 (see Plate 15: figure 190).

Globobulimina pacifica Cushman

216. Side view, N42/f705, specimen lost, ×130.
217. Side view, N42/f696, specimen lost, ×100.

Globocassidulina arata (Finlay)

218. Side view, N28/f456, hypotype, USNM 243394, ×200.

Globocassidulina subglobosa (Brady)

219. Side view, N33/f581, hypotype, USNM 243395, ×240.
220. Side view, DSDP 206-38-2, hypotype, USNM 243396, ×230.

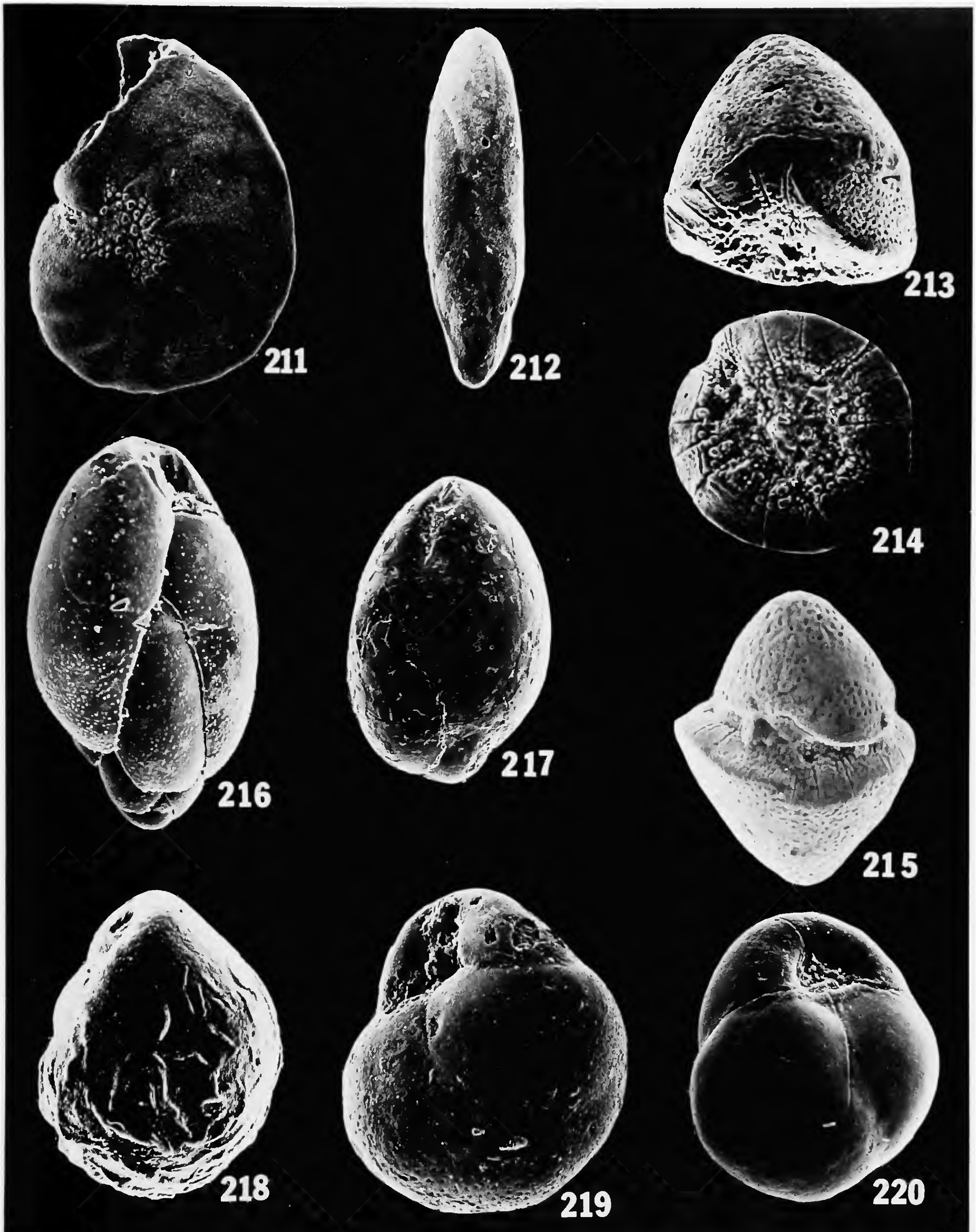

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PLATE 18

Gyroidina zelandica Finlay

221. Involute side, N33/f581, hypotype, USNM 243397, ×130.
222. Peripheral view, N33/f581, hypotype, USNM 243397, ×130.
223. Spiral side, N33/f581, hypotype, USNM 243398, ×200.

Gyroidina danvillensis Howe and Wallace

224. Involute side, N33/f581, hypotype, USNM 243399, ×200.
225. Spiral side, N33/f581, hypotype, USNM 243400, ×200.

Gyroidina sp.

226. Spiral side, DSDP 206–38–2, hypotype, USNM 243401, ×160.
227. Peripheral view, DSDP 206–38–2, hypotype, USNM 243401, ×160.
228. Involute side, DSDP, 206–38–2, hypotype, USNM 243402, ×200.

Hanzawaia laurisae (Mallory)

229. Involute side, N42/f723, hypotype, USNM 243403, ×180.
230. Dorsal side, N28/f788, hypotype, USNM 243404, ×130.

Hoeglundina elegans (d'Orbigny)

231. Oblique view of involute side, N28/f456, hypotype, USNM 243405, ×160.

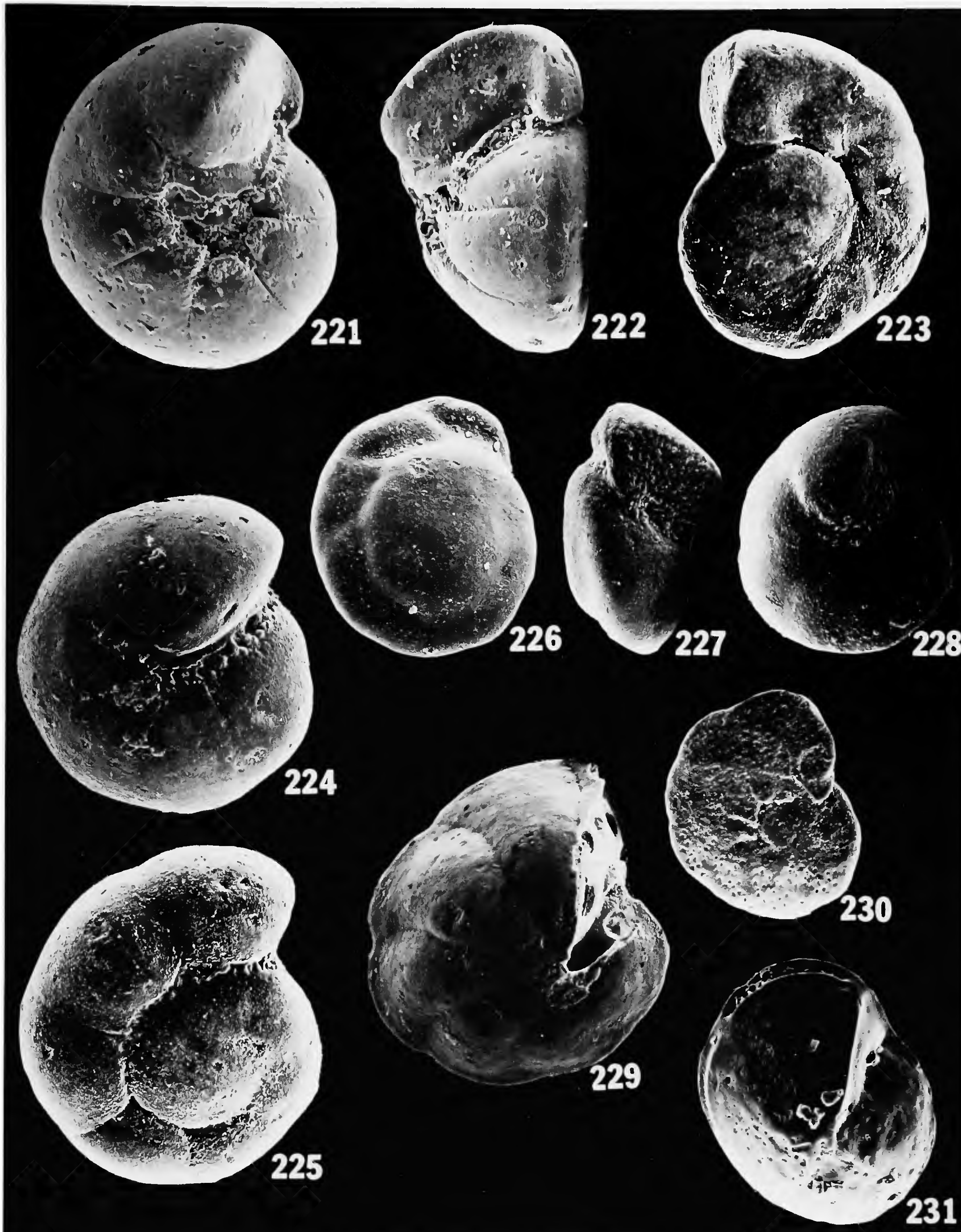
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PLATE 19

Hofkerina semiornata (Howchin)
232. Spiral side, N28/f913, hypotype, USNM 243406, ×50.
Karreria maoria (Finlay)
233. Involute side, N28/f456, hypotype, USNM 243407, ×120.
234. Peripheral view, N28/f456, hypotype, USNM 243407, ×120.
Lagena acuticostata Reuss
235. Side view, N41/f2d, hypotype, USNM 243408, ×250.
Lagena distoma Parker and Jones
236. Side view, N33/f581, hypotype, USNM 243409, ×60.
Lagena gracilis Williamson
237. Side view, N28/f458, hypotype, USNM 243410, ×120.
Lagena substriata Williamson
238. Side view, N33/f581, hypotype, USNM 243411, ×200.
Lagena elongata (Ehrenberg)
239. Side view, N42/f696, hypotype, USNM 243412, ×160.
Lagena striata (d'Orbigny)
240. Side view, N33/f581, hypotype, USNM 243413, ×100.
Lagenoglandulina annulata (Stache)
241. Side view, N33/f581, hypotype, USNM 243414, ×200.
Laticarinina altocamerata (Heron-Allen and Earland)
242. Convex side, N41/f632, hypotype, USNM 243415, ×100.
243. Peripheral view, N41/f632, hypotype, USNM 243415, ×100.
Lenticulina callifera (Stache)
244. Side view, N28/f785, hypotype, USNM 243416, ×175.
245. Apertural view, N33/f579, hypotype, USNM 243417, ×160.
246. Side view, N33/f579, hypotype, USNM 243417, ×160.

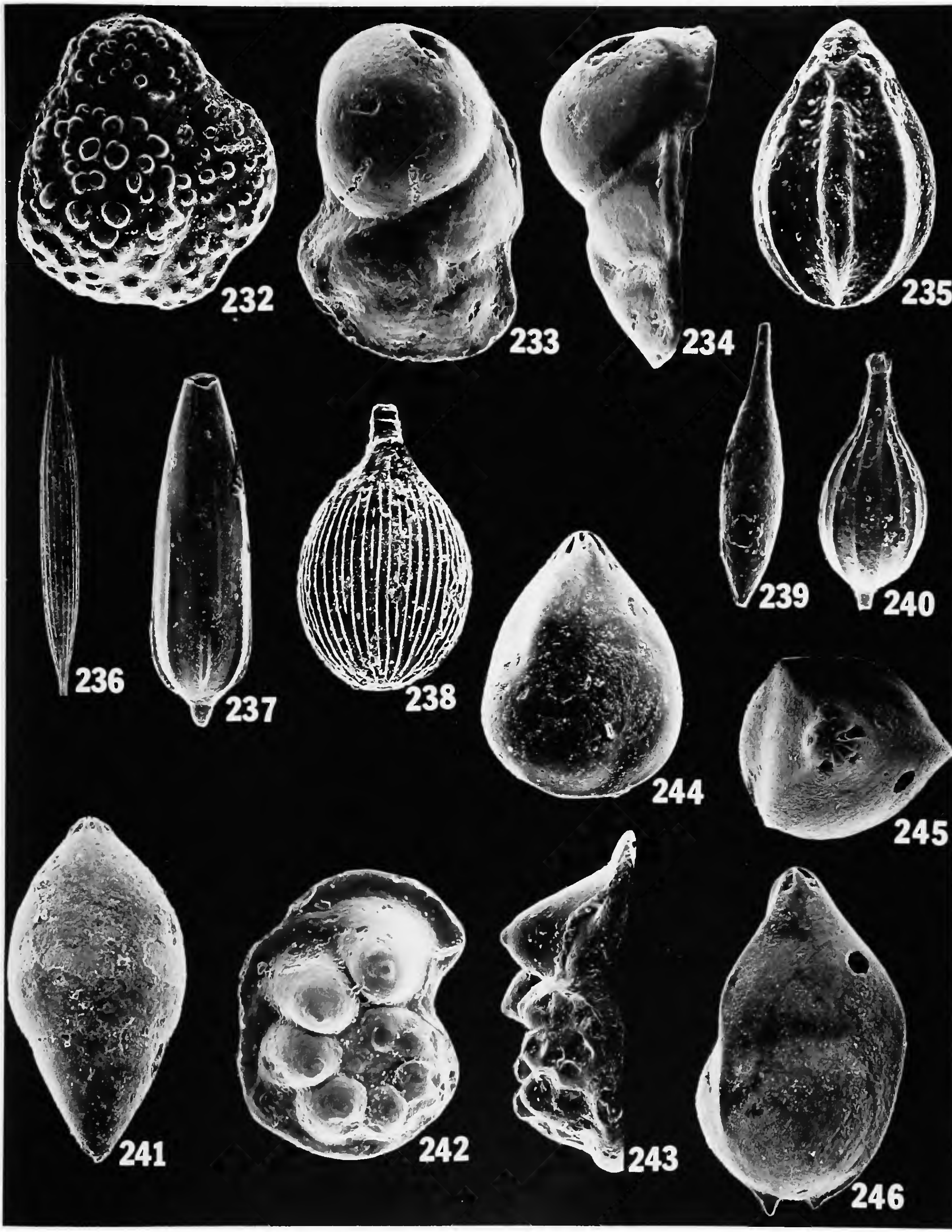
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PLATE 20

Lenticulina mamilligera (Karrer)

247. Side view, N33/f579, hypotype, USNM 243418, ×40.

Lenticuline cf. L. nitida (Reuss)

248. Peripheral view, N33/f581, hypotype, USNM 243419, ×90.
249. Side view, N33/f581, hypotype, USNM 243419, ×90.

Lenticulina planula (Galloway and Heminway)

250. Side view, N42/f723, hypotype, USNM 243420, ×130.
251. Peripheral view, N42/f723, hypotype, USNM 243420, ×130.
252. Peripheral apertural view, N42/f723, hypotype, USNM 243420, ×130 (see Plate 15: figures 191, 192).

Loxostomum pakaurangiensis Hornibrook

253. Side view, last chamber broken off, N28/f456, hypotype, USNM 243421, ×100.

Melonis simplex (Karrer)

254. Peripheral view, DSDP 206–44–2, hypotype, USNM 243422, ×230.
257. Side view, DSDP 206–44–2, hypotype, USNM 243422, ×230.

Melonis affinis (Reuss)

256. Side view, DSDP 206–33–2, hypotype, USNM 243423, ×150.

Miogypsina intermedia Drooger

258. Side view, N28/f913, hypotype, USNM 243424, ×30.

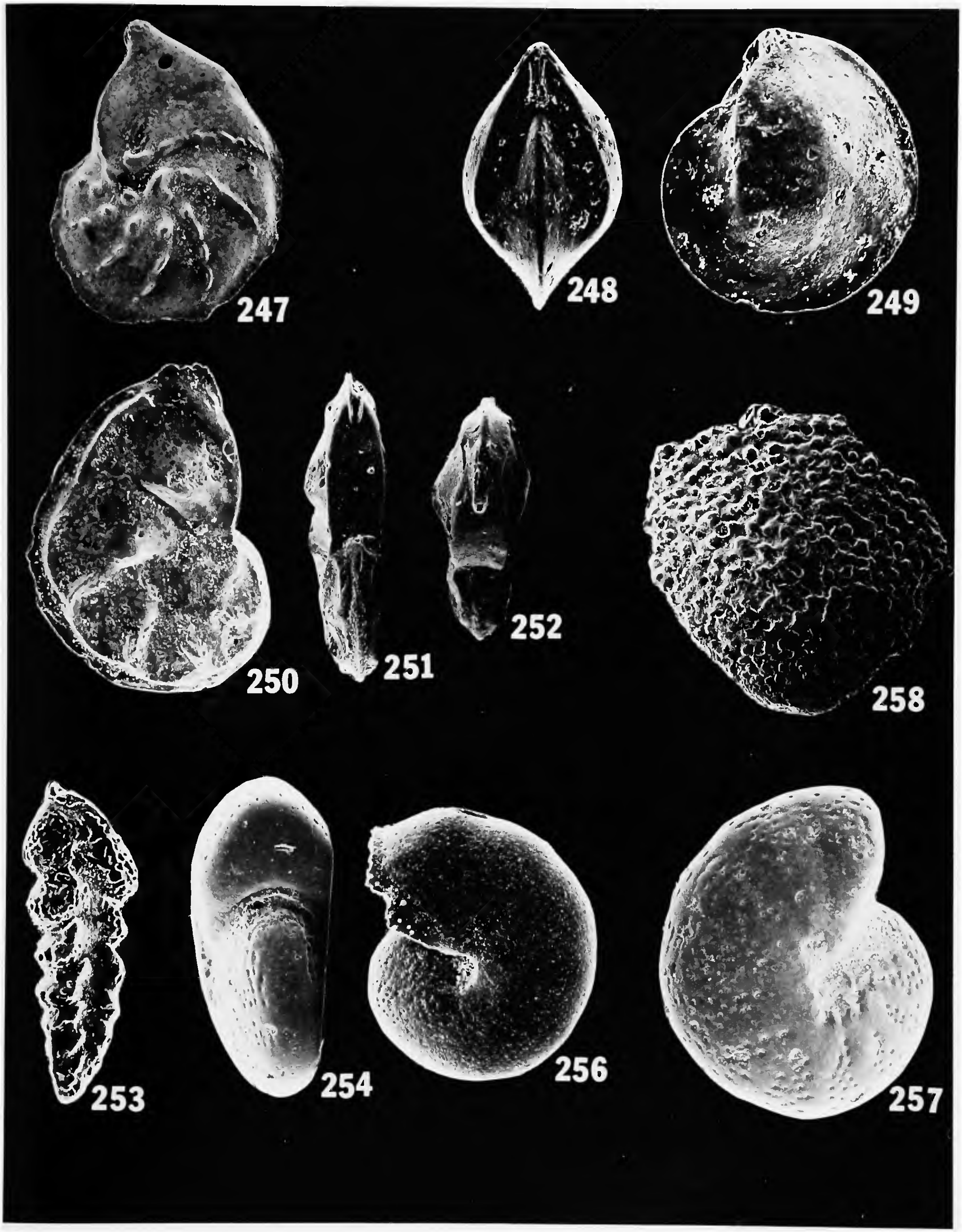
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PLATE 21

Nodosarella tuberosa (Gümbel)

259. Side view, DSDP 206C-2-2, hypotype, USNM 243425, ×40.
260. Enlarged apertural view, DSDP 206C-2-2, hypotype, USNM 243425, ×90.

Nodosaria holoserica Schwager

261. Side view, N33/f581, hypotype, USNM 243426, ×100.

Nodosaria longiscata d'Orbigny

262. Side view, broken section, N33/f581, hypotype, USNM 243427, ×50.

Nodosaria substrigata Stache

263. Side view, broken basal section, N33/f578, hypotype, USNM 243428, ×40.

Nonion cf. *N. mexicanum* Cole

264. Peripheral view, N41/f539, hypotype, USNM 243429, ×125.
265. Side view, N41/f539, hypotype, USNM 243429, ×125.

Nonionella novozealandica Cushman

266. Involute side, N41/f660, hypotype, USNM 243430, ×100.
267. Peripheral view, N41/f660, hypotype, USNM 243430, ×100.
268. Spiral side, N33/f580, hypotype, USNM 243431, ×160.
269. Peripheral view, N33/f580, hypotype, USNM 243431, ×160.
270. Involute side, N33/f580, hypotype, USNM 243432, ×150.
271. Involute side, N33/f581, hypotype, USNM 243433, ×110.

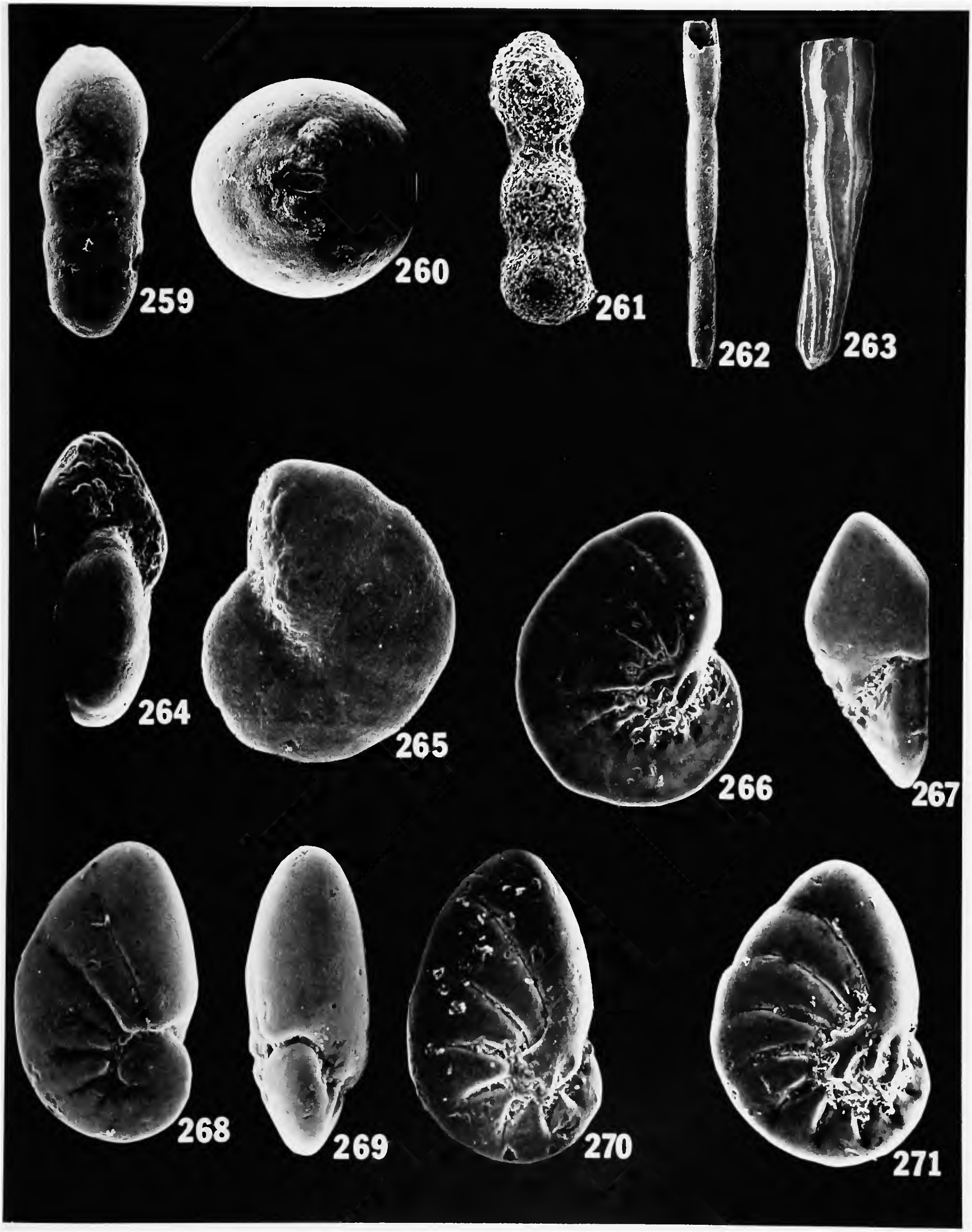
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PLATE 22

Nonion tuberculatum (d'Orbigny)

272. Side view, N28/f455, hypotype, USNM 243434, ×175.
273. Peripheral view, N28/f455, hypotype, USNM 243434, ×175.

Notorotalia miocenica (Cushman)

274. Peripheral view, N42/f732, hypotype, USNM 243435, ×80.
275. Spiral side, N42/f732, hypotype, USNM 243435, ×80.
276. Involute side, N28/f793, hypotype, USNM 243436, ×90.
277. Spiral side, N28/f793, hypotype, USNM 243437, ×80.
278. Involute side, N41/f555, hypotype, USNM 243438, ×105.

Osangularia culter (Parker and Jones)

279. Involute side, N41/f622, hypotype, USNM 243452, ×200.
280. Peripheral view, N37/f585, hypotype, USNM 243453, ×70.
281. Involute side, N37/f585, hypotype, USNM 243454, ×66 (see Plate 15: figures 163, 164).

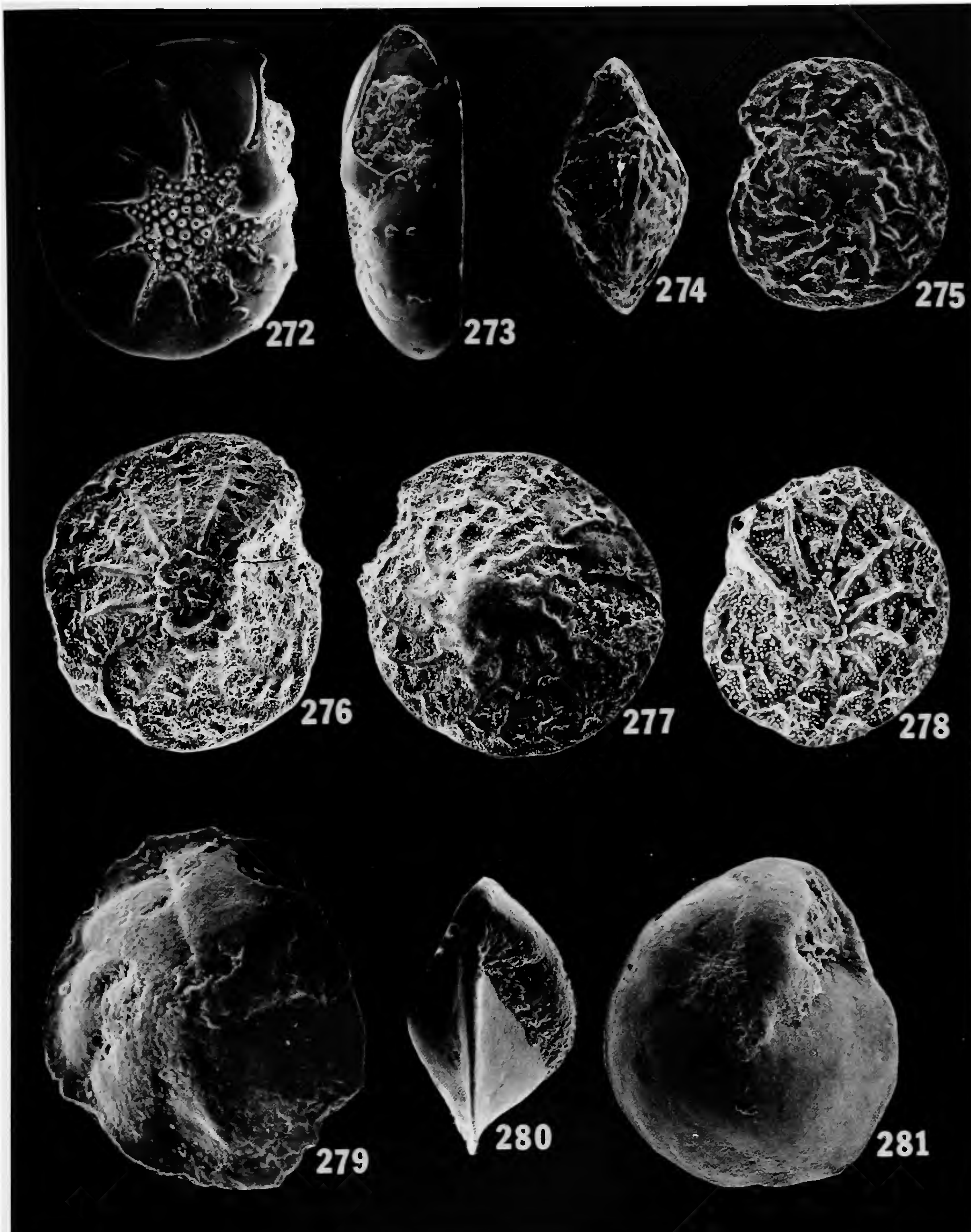
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PLATE 23

Oolina botelliformis (Brady)
282. Side view, N33/f536, hypotype, USNM 243455, ×130.
Oolina aff. *O. collaris* (Cushman)
283. Side view, N41/f533, hypotype, USNM 243456, ×160.
Oolina globosa (Montagu)
284. Side view, N42/f719, hypotype, USNM 243457, ×100.
285. Side view, N42/f696, hypotype, USNM 243458, ×180.
Oolina hexagona (Williamson)
286. Side view, N33/f581, hypotype, USNM 243459, ×180.
Oolina hispida (Reuss)
287. Side view, N42/f696, hypotype, USNM 243460, ×160.
Oolina punctulata (Sidebottom)
288. Side view, DSDP 206–38–2, hypotype, USNM 243461, ×120.
Oolina setosa (Earland)
289. Side ivew, DSDP 206–38–2, hypotype, USNM 243462, ×90.
Parafissurina abnormis Parr
290. Front view, N42/f696, hypotype, USNM 243463, ×66.
291. Enlarged apertural view, N42/696, hypotype, USNM 243463, ×85.
Oolina squamosa (Montagu)
292. Side view, N33/f581, hypotype, USNM 243464, ×175.
Parafissurina basicarinata Parr
293. Front view, DSDP 206–41–1, hypotype, USNM 243465, ×80.
Parafissurina lateralis (Cushman)
294. Front view, DSDP 206–37 CC, hypotype, USNM 243466, ×260.

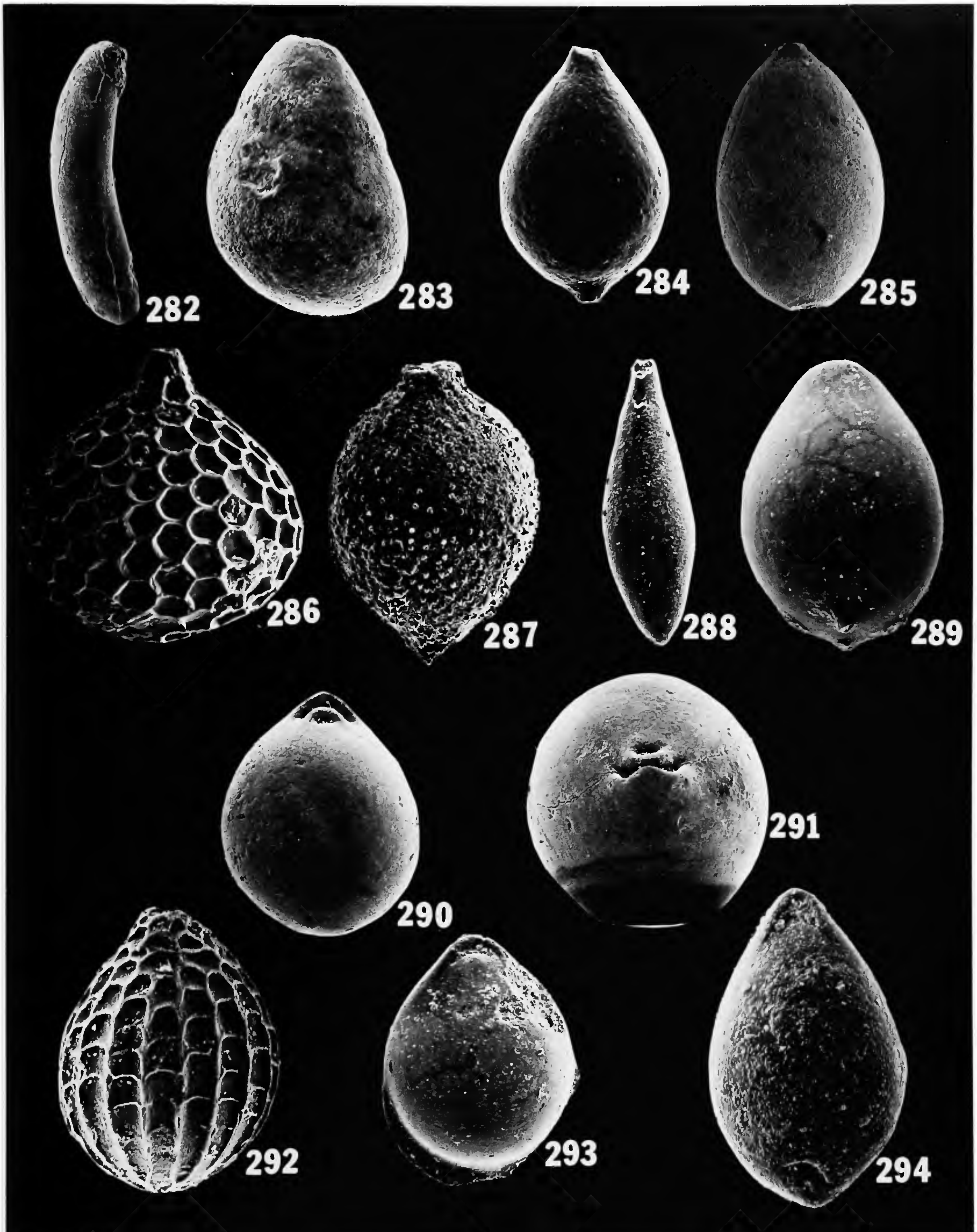
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PLATE 24

Oridorsalis umbonatus (Reuss)

295. Involute side, DSDP 206–32–2, hypotype, USNM 243467, ×130.
296. Peripheral view, DSDP 206–32–2, hypotype, USNM 243467, ×130.

Pavonina triformis Parr

297. Side view, N28/f455, hypotype, USNM 243468, ×66.

Planorbulinella zelandica Finlay

298. Convex side, N28/f453, hypotype, USNM 243469, ×80.
299. Peripheral view, N28/f453, hypotype, USNM 243469, ×80.

Plectofrondicularia proparri Finlay

300. Side view, N33/f580, hypotype, USNM 243470, ×80.

Plectofrondicularia awamoana Finlay

301. Side view, broken section, N33/f581, hypotype, USNM 243471, ×100.

Planulina catilla (Finlay)

302. Partly involute side, N37/f585, hypotype, USNM 243472, ×60.

Pullenia bulloides (d'Orbigny)

303. Peripheral view, DSDP 206–44–2, hypotype, USNM 243473, ×140.
304. Side view, DSDP 206–44–2, hypotype, USNM 243473, ×140.

Rectobolivina maoriella Finlay

305. Apertural view, N33/f505, hypotype, USNM 243474, ×140.
306. Side view, N33/f505, hypotype, USNM 243474, ×140.

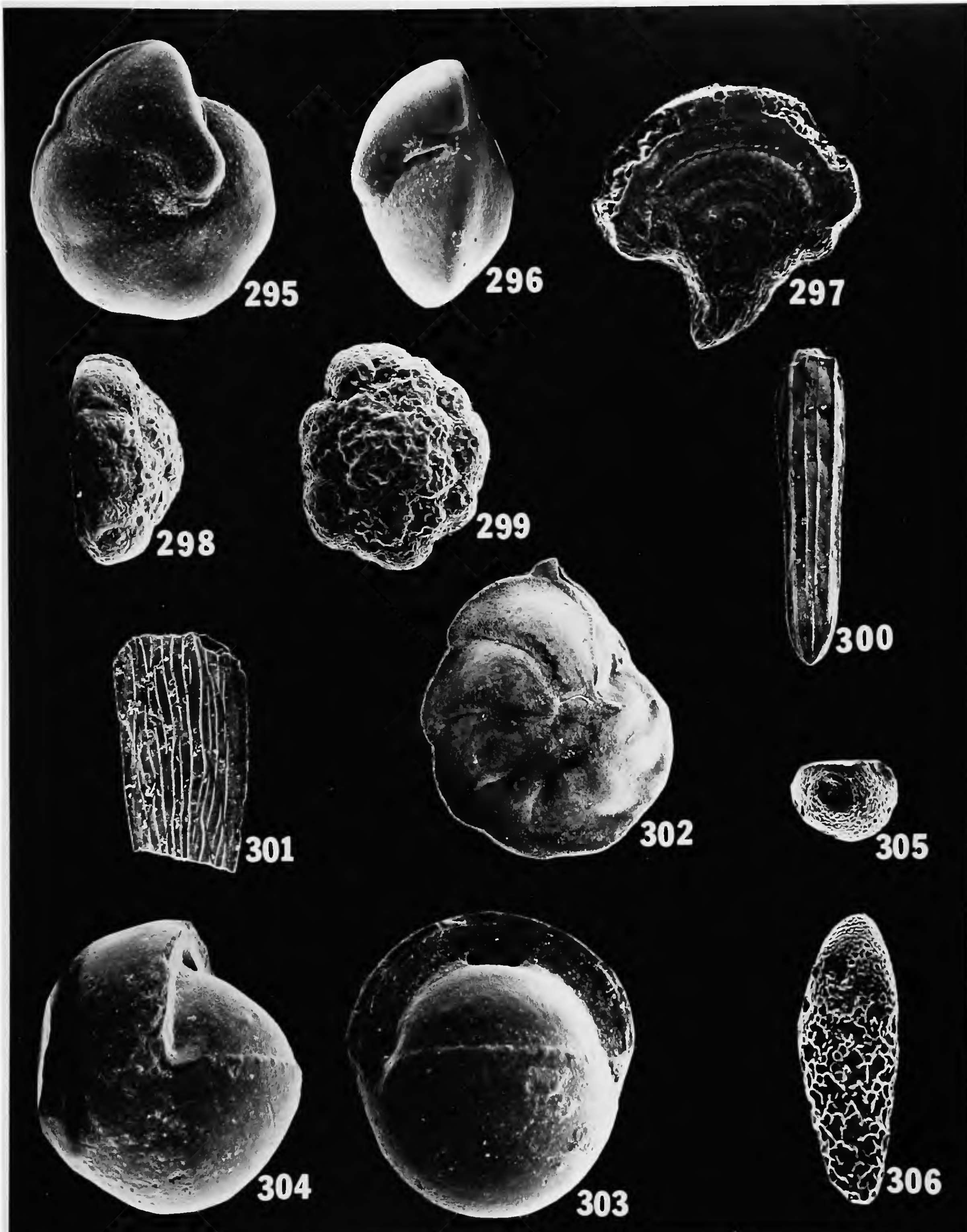
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PLATE 25

Pleurostomella aguafrescaenis Todd and Kniker
307. Side view, DSDP 206–38–2, hypotype, USNM 243475, ×130.
308. Front view, DSDP 206–38–2, hypotype, USNM 243475, ×130.

Pleurostomella bierigi Palmer and Bermudez
309. Side view, N42/f723, hypotype, USNM 243476, ×80.
310. Front view, N42/f723, hypotype, USNM 243476, ×80.

Pleurostomella obtusa Berthelin
311. Side view, DSDP 206–38–2, hypotype, USNM 243477, ×260.
312. Front view, DSDP 206–38–2, hypotype, USNM 243477, ×260.

Pleurostomella tenuis Hantken
313. Side view, small aperture, N41/f644, hypotype, USNM 243478, ×120.
314. Side view, DSDP 206–38–2, hypotype, USNM 243479, ×200.
315. Front view, DSDP 206–38–2, hypotype, USNM 243479, ×200.
316. Side view, N41/f644, specimen lost, ×140.
317. Front view, N41/f644, specimen lost, ×140.

Pseudopatellinoides aff. *P. primus* Krasheninnikov
318. Apertural view, N42/f694, hypotype, USNM 243480, ×130.
319. Side view, N42/f694, hypotype, USNM 243480, ×130.

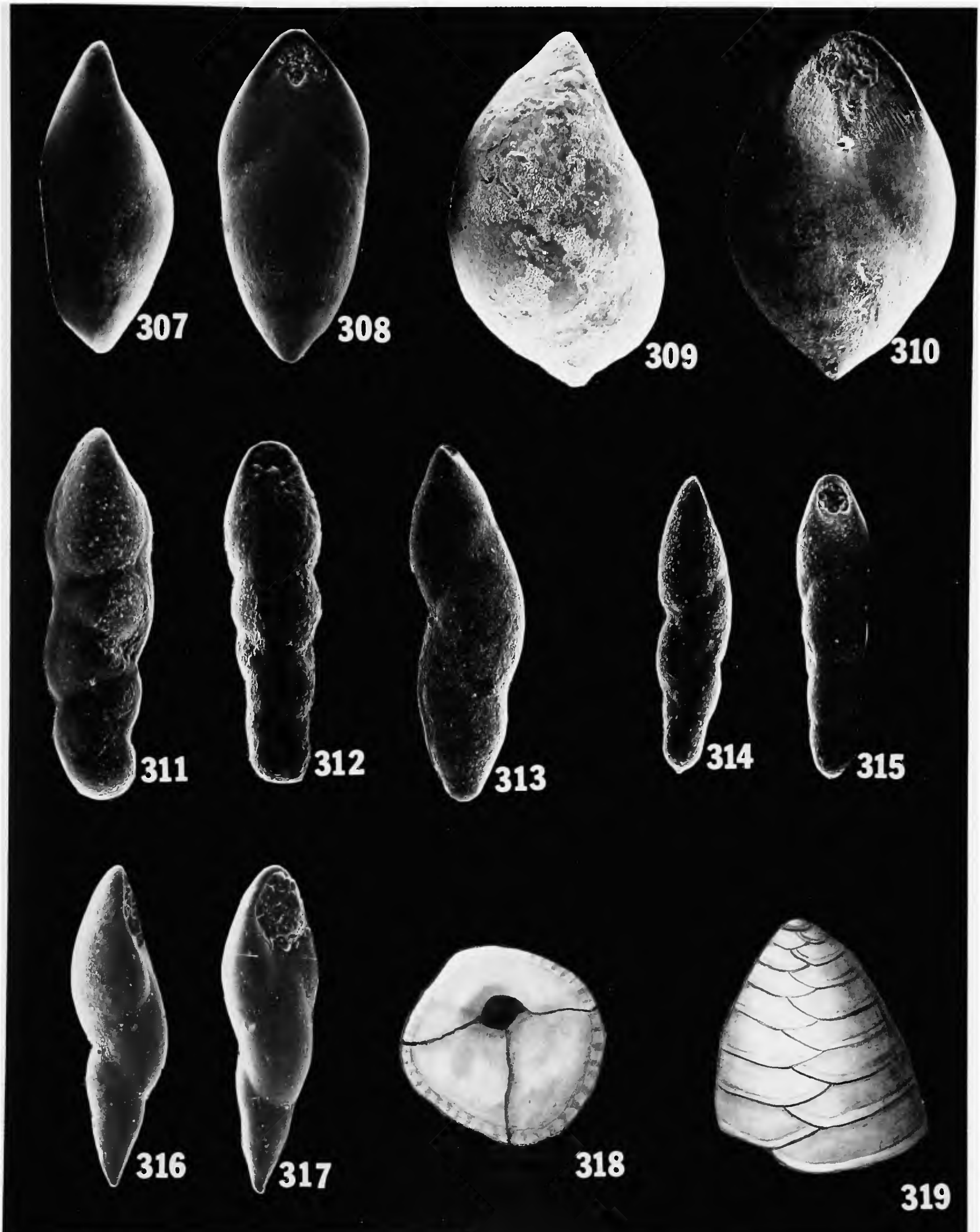
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PLATE 26

Rectobolivina striatula (Cushman)

320. Side view, N41/f660, hypotype, USNM 243481, ×100.
321. Enlarged apertural view, N41/f660, hypotype, USNM 243481, ×215.

Rectuvigerina ruatoria (Vella)

322. Side view, N33/f581, hypotype, USNM 243482, ×120.

Rectuvigerina vesca (Finlay)

323. Side view, N41/f590, hypotype, USNM 243483, ×120.

Ramulina sp.

324. Side view, N33/f581, hypotype, USNM 243484, ×100.

Rosalina concinna (Brady)

325. Involute side, N28/f781, hypotype, USNM 243485, ×100.
326. Peripheral view, N28/f781, hypotype, USNM 243485, ×100.

Saracenaria obesa Cushman and Todd

327. Face view, N33/f579, hypotype, USNM 243486, ×90.
328. Side view, N33/f579, hypotype, USNM 243486, ×90.
329. Side view, N33/f578, hypotype, USNM 243487, ×45.

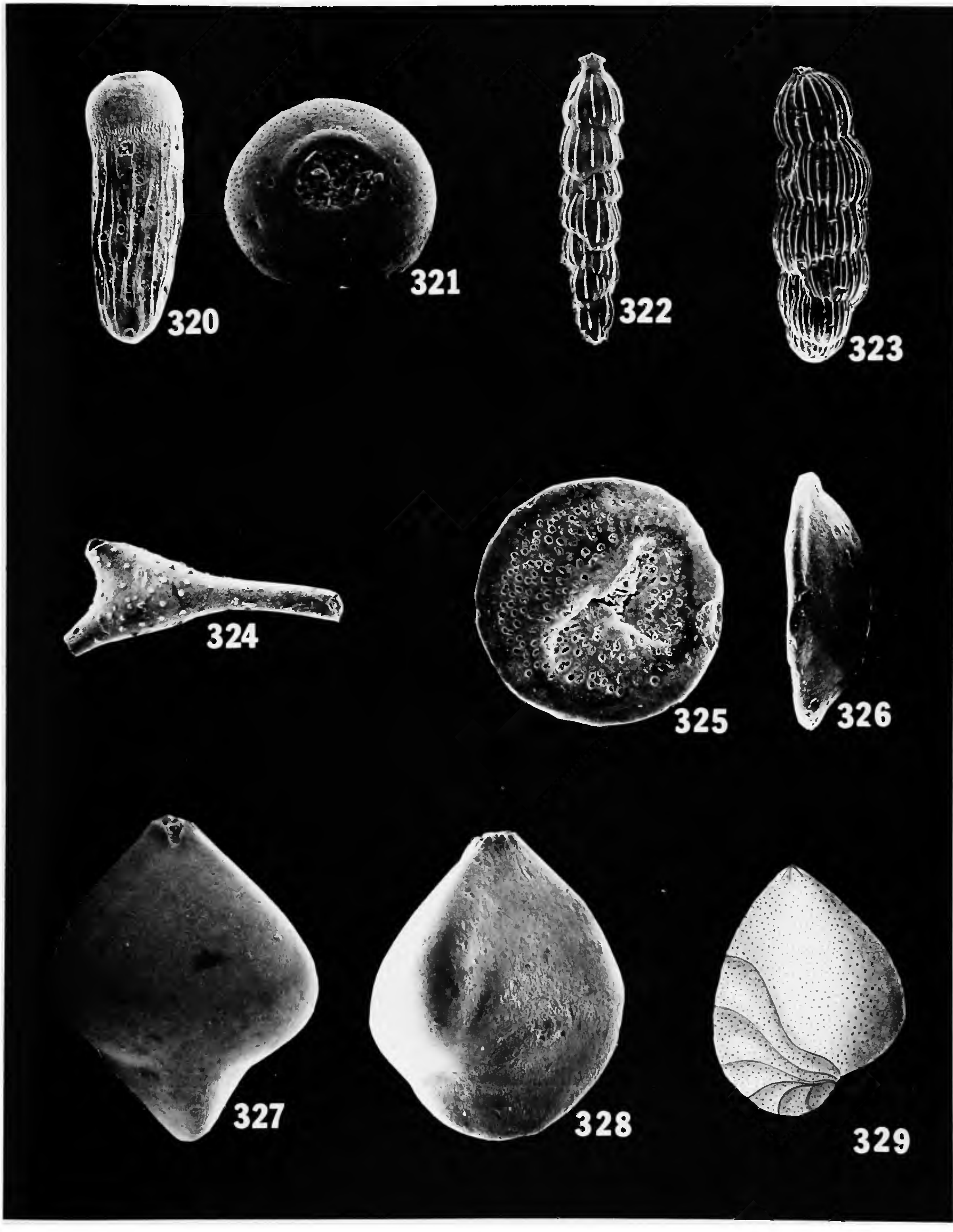
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PLATE 27

Reussella spinulosa (Reuss)
330. Side view, N33/f578, hypotype, USNM 243488, ×130.
Saracenaria latifrons (Brady)
331. Side view, N33/f581, hypotype, USNM 243489, ×100.
Sigmoidina pacifica Cushman and Ozawa
332. Front view, N41/f622, hypotype, USNM 243490, ×220 (see Plate 15: figures 198, 199).
Siphonina australis Cushman
333. Involute side, N41/f622, hypotype, USNM 243491, ×90.
Siphouvigerina proboscidea (Schwager)
334. Side view, N33/f581, hypotype, USNM 243492, ×160.
Sphaeroidina bulloides d'Orbigny
335. Front view, N33/f581, hypotype, USNM 243493, ×130.
Spirillina vivipara Ehrenberg
336. Side view, N41/f624, hypotype, USNM 243494, ×270.
Stetsonia sp.
337. Peripheral view, DSDP 206-38-2, hypotype, USNM 243495, ×210.
338. Side view, DSDP 206-38-2, hypotype, USNM 243495, ×210.

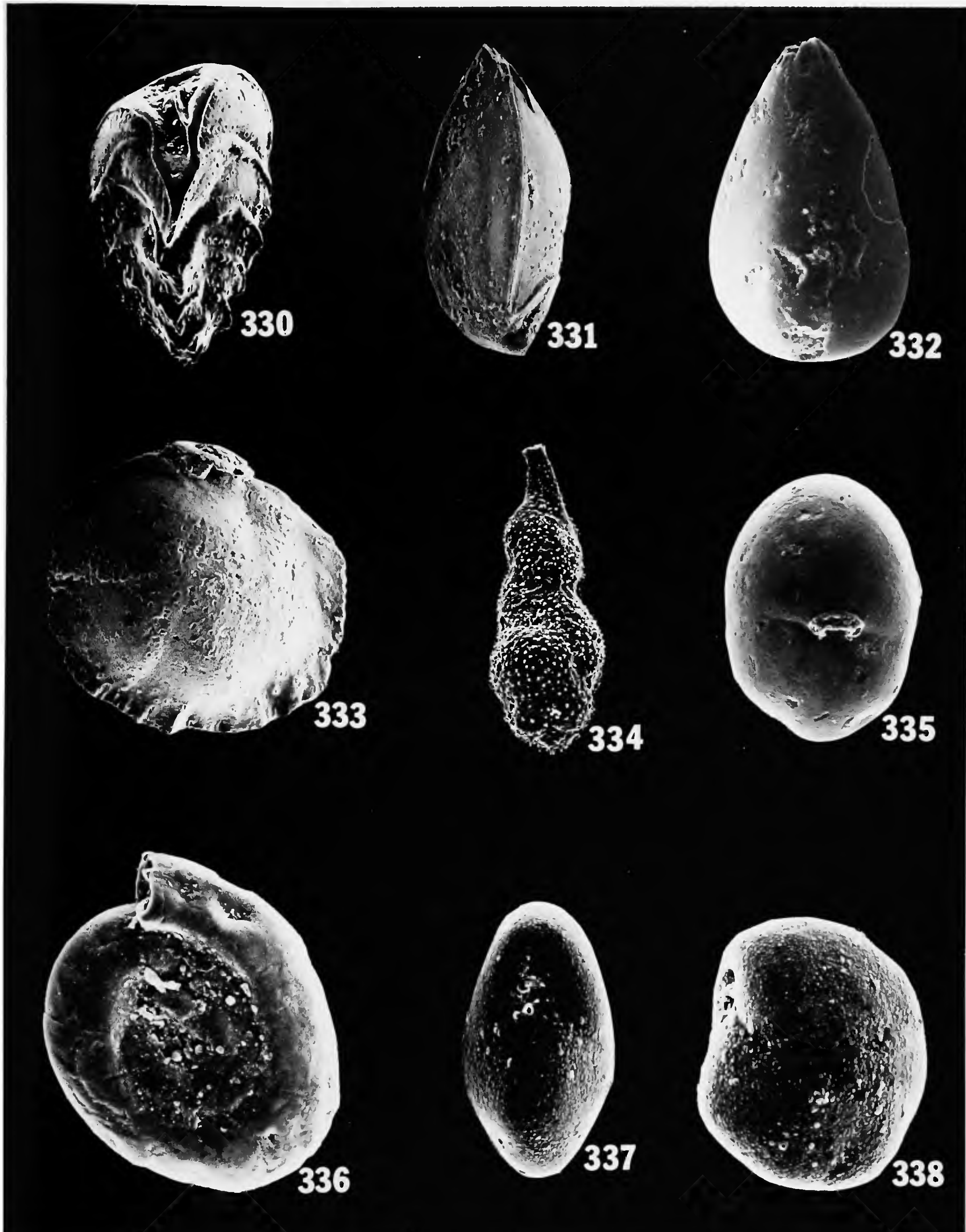
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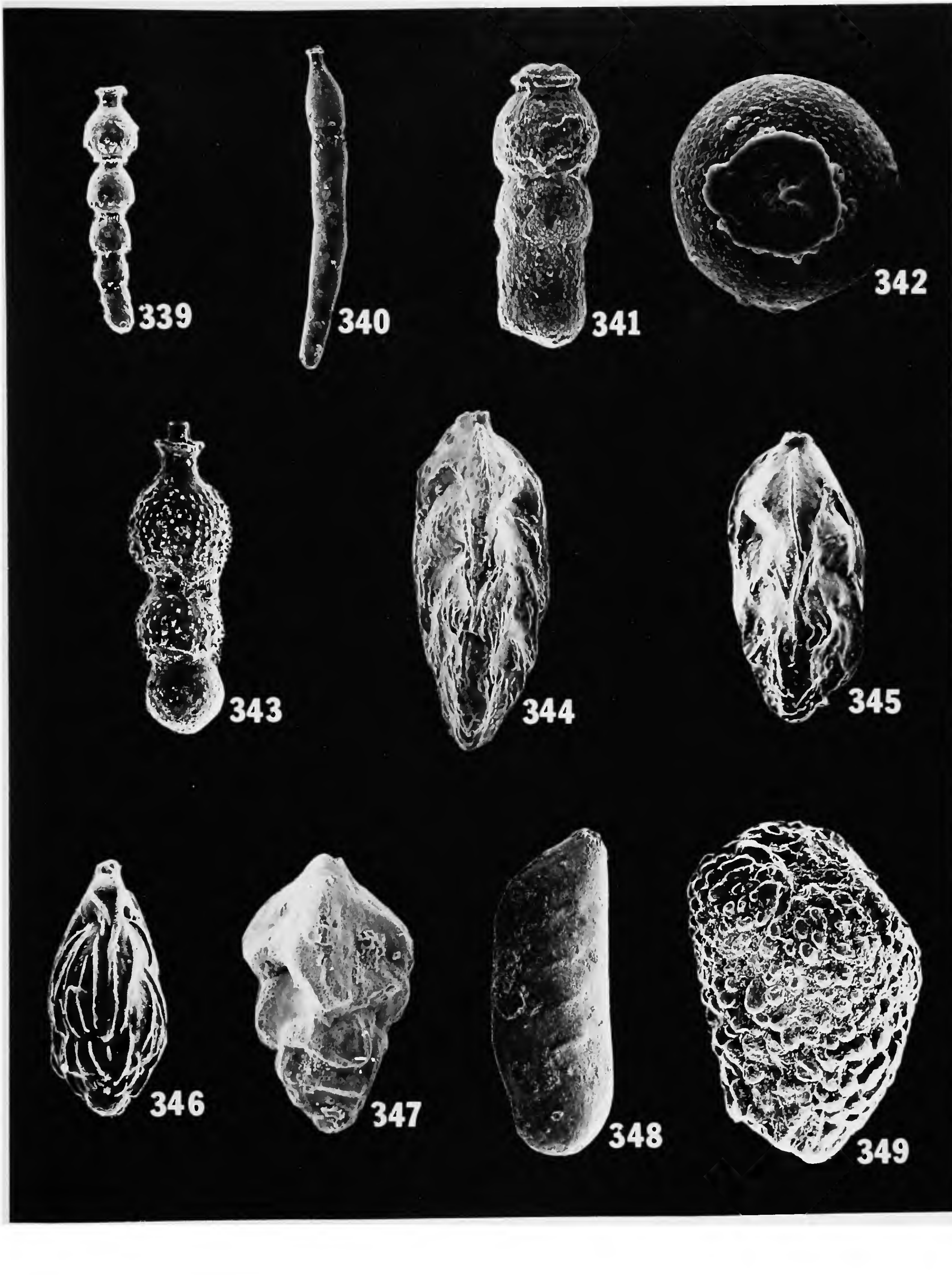
PLATE 28

Stilostomella antillea (Cushman)
339. Side view, N33/f581, hypotype, USNM 243496, ×90.
Stilostomella fijiensis (Cushman)
340. Side view, N33/f581, hypotype, USNM 243497, ×90.
Stilostomella pomuligera (Stache)
341. Side view, N42/f730, hypotype, USNM 243498, ×200.
342. Enlarged apertural view, DSDP 206–35–2, hypotype, USNM 243499, ×630.
Stilostomella subspinosa (Cushman)
343. Side view, N33/f581, hypotype, USNM 243500, ×100.
Trifarina bradyi Cushman
344. Side view, N28/f788, hypotype, USNM 243501, ×150.
Trifarina costornata (Hornibrook)
345. Side view, N28/f792, hypotype, USNM 243502, ×160.
Trifarina esuriens (Hornibrook)
346. Side view, N42/f729, hypotype, USNM 243503, ×200.
Trifarina tortuosa (Hornibrook)
347. Side view, N33/f581, hypotype, USNM 243504, ×150.
Vaginulinopsis recta (Karrer)
348. Side view, N28/f781, hypotype, USNM 243505, ×35.
Victoriella conoidea (Rutten)
349. Side view, N28/f913, hypotype, USNM 243506, ×30.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(Synonyms and page numbers of principal accounts in italics)

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