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Stratigraphic Significance of Uvigerinid Foraminifers in the Western Hemisphere

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STRATIGRAPHIC SIGNIFICANCE OF UVIGERINID FORAMINIFERS IN THE WESTERN HEMISPHERE[1]

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Abstract—Uvigerinid foraminifers increasingly are recognized as particularly useful paleobathymetric indices. For example, spinose-costate species become more spinose and platy-costate species larger with increasing depth. Existing data provide easily applied bases for their additional use in biostratigraphy. This is due in part to refinements in the planktonic foraminiferal time scale to which the uvigerinid development can be compared. Thirty species in five genera of the family Uvigerinidae are discussed and illustrated from the Western Hemisphere. Informal species groups of *Uvigerina* and related genera are used to illustrate lineage concepts and to facilitate paleobathymetric considerations. Biostratigraphic interpretations based on ranges of commonly occurring benthonic species are widely applicable in areas lacking the warm-water planktonic organisms normally used in dating.

The genus *Tiptonina* (type species *Siphogenerina nodifera*) and the species *Uvigerina praehubbardi* are new. An index includes names of taxa here recognized as valid as well as those treated as synonyms.

THE FINDINGS reported here developed during several decades of routine surface and subsurface observations of uvigerinids from the Western Hemisphere. Benthonic foraminifers, earlier used in age correlations, are no less important now than they were prior to the intense research concentrated on planktonic species. What has changed is that we now have a sequence of well-defined planktonic zones to which we can relate the stratigraphic distributions of benthonic species over wide areas. This provides a fresh impetus for study and understanding of benthonic species and their evolution. The uvigerinids are only one of the many benthonic groups that benefit by this application.

The family Uvigerinidae, as generally interpreted, comprises related foraminiferal genera as well as others here regarded as homeomorphs. This study includes only *Uvigerina* and genera interpreted to have origins in uvigerinid stock. Although *Uvigerina* may be polyphyletic, it includes species having many similar morphologic characters. During the middle Tertiary at least four highly evolved genera, assigned to at least three separate lineages, developed from uvigerinid species. Although species of these advanced genera have been little recognized, they provide important biostratigraphic and paleobathymetric application within the Cenozoic of the Western Hemisphere.

For this study many well-preserved specimens were selected from both surface and subsurface localities and analyzed by scanning electron microscope to show relationships and distinguishing features more clearly. The 40 plates document fine details of the foraminiferal test with markedly more clarity than do morphologic descriptions. Related species are naturally grouped and discussed according to biostratigraphic and paleobathymetric concepts. We recognize three main species groups (hispid-spinose, spinose-costate, and platy-costate) plus a group of miscellaneous species whose affinities are unclear.

Only four hispid-spinose species could be recognized, although many more have been named and described in the literature. In the spinose-costate group we could not differentiate modern specimens of *Uvigerina peregrina* Cushman (1923) from Middle to Late Eocene specimens previously assigned to *Uvigerina gardnerae* Cushman and Applin (1926). This demon-

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strates that *U. peregrina* (interpreted on basis of morphology only) has a very long range, and the name has priority over the name *U. gardnerae*. Moreover, recognition of counterparts of modern clinal members in sections as old as Middle Eocene enhances paleobathymetric interpretations and suggests that other spinose-costate species also could be interpreted as clinal members of a central species.

Phyletic relationships within the platy-costate species group also were clarified by using photomicrographs in which fine details of the test and ornamentation support other evidence for recognition of two separate, widely distributed lineages. This platy-costate species group is particularly useful for correlations between warm-water, plankton-rich regions and those regions lacking critical planktonic index species (e.g., northeastern Pacific). Elements of this species group are recognized in such widely separated areas as the Scotian shelf and Grand Banks of Canada, offshore Georgia embayment, Amazon basin of Brazil, Progresso basin of Ecuador, Maturin and Falcón basins of Venezuela, coastal Colombia, Tampico embayment of Mexico, Gulf Coast region, and northeastern Pacific region. Lamb (1964) and Lamb and Hickernell (1972) used platy-costate species (e.g., *Uvigerina jacksonensis, U. tumeyensis, Tiptonina nodifera,* and *Transversigerina transversa*) to date and redefine Oligocene and Lower Miocene stages of California in terms of range-zones and partial range-zones. We conclude that the zones proposed for California are applicable throughout the Western Hemisphere.

A few miscellaneous uvigerinid species show no obvious relationship to each other and are recorded here primarily because they occur widely and locally in large numbers. When combined with other species, they may be stratigraphically useful in defining zones and they have paleoecological significance.

Thirty species belonging to five genera of the family Uvigerinidae are illustrated and discussed systematically. Less important species or clinal members are cited but not illustrated. All are included in an alphabetical species-genus index. Photographs were made using a scanning electron microscope except for Plate 35, figures 5 to 7, which were made using a light microscope. To facilitate comparisons of species, most specimens are illustrated at magnifications of ×75 or ×150. An enlarged view of the youngest chamber and suture on the left side of the test is the preferred view.

Where possible, specimens used to illustrate species were selected from different geographic regions to provide critical comparisons. Quality of preservation was also a factor in selecting specimens for illustration. Topotypes or specimens from type areas of species were used as much as possible; this is important when one considers the broad interpretations of species applied in most published literature. For example, specimens here assigned to *Tiptonina nodifera* have been described under four known synonyms, and *Uvigerina gallowayi* has all but lost its identity owing to synonyms and misidentifications.

Species groups.—To emphasize interspecies relationships, species are discussed in groups in essentially the same order shown on the range charts (Figs. 1,3). Plates are arranged in the same order. Citations of species are so presented as to give chronologic changes in nomenclature and to indicate geographic occurrences. Generic and specific diagnoses include distinguishing morphologic characteristics, comparisons with other species, and geographic distribution.

Depository.—Illustrated holotype and paratype specimens are in collections of the U. S. National Museum of Natural History (USNM).

Acknowledgments.—We express our appreciation to the following persons for helping in the preparation of this study: F. J. Collier, Smithsonian Institution, for making available type specimens of *Uvigerina gallowayi* and *Siphogenerina basispinata* from the Cushman collection; C. W. Poag, United States Geological Survey, for loan of material; G. R. Stude and C. E. Pflum, Exxon Company, U.S.A. and Exxon Production Research Company, respectively, for loan of material and discussions; M. S. Srinivasan, University of Rhode Island, for donation of topotype specimens of *Uvigerina hispida* and *Uvigerina proboscidea;* and W. A. van den Bold, Louisiana State University, for topotype specimens of *Siphogenerina lamellata.* R. D. Hockett, Exxon Production Research Company, did the very fine scanning microscope analysis, with help from the junior author. R. C. Wright and C. E. Pflum, Exxon Production Research Company, reviewed the manuscript and offered advice. R. M. Jeffords, consultant for Exxon Production Research Company, gave editorial assistance. Specimens in figures 1 and 3 were drawn by Bonnie Wilder, Houston Texas.

HISPID-SPINOSE SPECIES

Species of this group (Fig. 1) differ from other uvigerinid groups in that ornamentation consists entirely of spines rather evenly distributed over the chambers and neck. Shape and relative size of spines are important characters for differentiating species (e.g., fine hairlike spines in *Uvigerina auberiana* and *U. proboscidea,* slightly but noticeably thicker spines in *U. hispida,* and shortened thick spines in *U. rustica*). In abyssal environments spines on both *U. hispida* and *U. rustica* commonly are not the characteristic finely pointed projections but rather papillae or rounded knobs. This seems to result from partial solution of spines or their lack of development.

Early formed chambers of this group are distinctly triserial, but later chambers may coil so loosely as to appear biserial. The test surface is finely perforate; the neck varies in length and tapers gently toward a distinctive lip.

The common occurrence of representatives of this group in stratigraphic columns offers a dependable means to determine minimum water depths. *Uvigerina hispida* and *U. rustica* have an upper-depth limit of about 3,000 feet. Both Bandy (1953) and Pflum and Frerichs (1976) recorded *U. proboscidea* as living slightly deeper, and the small *U. auberiana* is known to live from about 300 to more than 6,000 feet. We have recorded *U. hispida* and *U. auberiana* as far back as the Lower Eocene in the Lodo and Canoas formations of California, whereas *U. rustica* appears for the first time rather abruptly in the Lower Miocene of the Caribbean region.

Genus UVIGERINA d'Orbigny, 1826

Type species.—Uvigerina pygmea d'Orbigny, 1826. [*U. pigmea* of authors. Loeblich and Tappan (1964) stated that d'Orbigny spelled the trivial name *pigmea* in the text but *pygmea* on the plate explanations. In accord with the first-reviser principle of the International Code of Zoological Nomenclature (ICZN), we follow their use of the name *pygmea.*]

All species of *Uvigerina* in this study have a calcareous, perforate test, are triserial, and show a terminal aperture consisting of a neck with a phialine or saucer-shaped lip. In well-preserved specimens a tooth plate may be present; it consists of a semicircular tube connecting the apertures and it twists or turns about 60 degrees as each chamber is added. Surface ornamentation consists of hairlike to thick spines, costae, or striae. No smooth species were observed in this study, although some are known to exist.

UVIGERINA HISPIDA Schwager

Plates 1-3; Figure 1

Uvigerina hispida SCHWAGER, 1866, p. 249, pl. 7, fig. 95; PFLUM and FRERICHS, 1976, p. 26, pl. 8, figs. 8-10.
Uvigerina mantaensis CUSHMAN and EDWARDS, 1938, p. 84, pl. 14, fig. 8; GAMERO, 1977, p. 42, pl. 4, figs. 1-3.
Uvigerina garzaensis CUSHMAN and SIEGFUS, 1939, p. 28, pl. 6, fig. 15; CUSHMAN and SIMONSON, 1944, p. 199, pl. 32, figs. 20, 21; MALLORY, 1959, p. 208, pl. 37, fig. 2; FAIRCHILD, WESENDUNK, and WEAVER, 1969, p. 56, pl. 12, fig. 9.

The surface ornamentation of this loosely coiled species was described originally in German by Schwager (1866) as having "somewhat thick spine-hairs," whereas his species *Uvigerina proboscidea* (Pls. 5, 6 herein) was said to have "fine spine-hairs." Schwager's descriptions agree closely with his figured specimens. Cushman (1939, p. 151, pl. 10) figured topotype specimens of Schwager's species, but he transposed the names by assigning forms with "fine spine-hairs" to *U. hispida* and forms with "somewhat thick spine-hairs" to *U. proboscidea.* He evidently did this using a literal translation of the Latin *hispidus* meaning hairy or hairlike, believing this name best suited Schwager's species *U. proboscidea* and not his *U. hispida.* According to Article 32 of the ICZN, a name cannot be rejected because of inappropriateness. Thus, Schwager's original description of the surface ornamentation of *U. hispida* (e.g., "having somewhat thick spine-hairs") is legitimate.

UVIGERINA AUBERIANA d'Orbigny

Plate 4; Figure 1

Uvigerina auberiana D'ORBIGNY, 1839, p. 106, pl. 2, figs. 23, 24; BERMÚDEZ and FUENMAYOR, 1966, p. 603, pl. 1, fig. 8.
Uvigerina auberiana d'Orbigny forma *laevis* GOËS, 1896, p. 51, pl. 4, figs. 71-74; PHLEGER and PARKER, 1951, p. 18, pl. 8, figs. 12-14.
Uvigerina auberiana d'Orbigny var. *attenuata* CUSHMAN and RENZ, 1941, p. 21, pl. 3, fig. 17; RENZ, 1948, p. 173, pl. 7, fig. 20.
Uvigerina elongata COLE, 1927, p. 26, pl. 4, figs. 2, 3; MALLORY, 1959, p. 207, pl. 29, fig. 4.

This loosely coiled hispid species is identified easily by its very small size and tendency for the penultimate aperture to be incompletely covered by the last chamber, or the last chamber has a deep cleft marking its position.

UVIGERINA PROBOSCIDEA Schwager

Plates 5, 6

Uvigerina proboscidea SCHWAGER, 1866, p. 250, pl. 7, fig. 96; GALLOWAY and MORREY, 1929, p. 39, pl. 6, fig. 4; BERMÚDEZ, 1949, p. 209, pl. 13, fig. 45; BANDY, 1953, p. 177, pl. 25, fig. 11.
Uvigerina senticosa CUSHMAN, 1927b, p. 159, pl. 3, fig. 14; BANDY, 1953, p. 177, pl. 25, fig. 12; PFLUM and FRERICHS, 1976, p. 25-26, pl. 8, figs. 11, 12.
Uvigerina chirana CUSHMAN and STONE, 1947, p. 17, pl. 2, fig. 25.

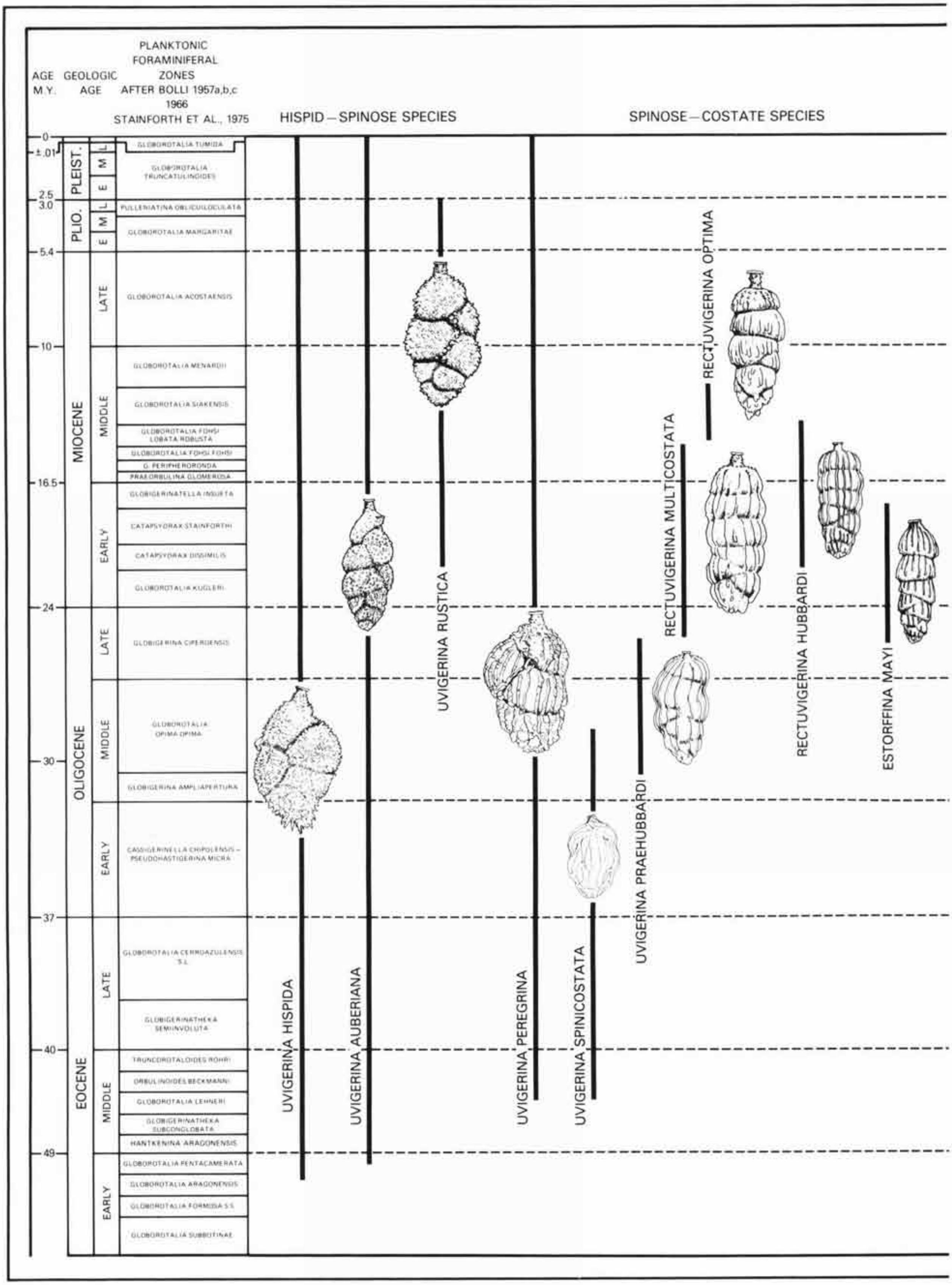

Fig. 1. See facing page.

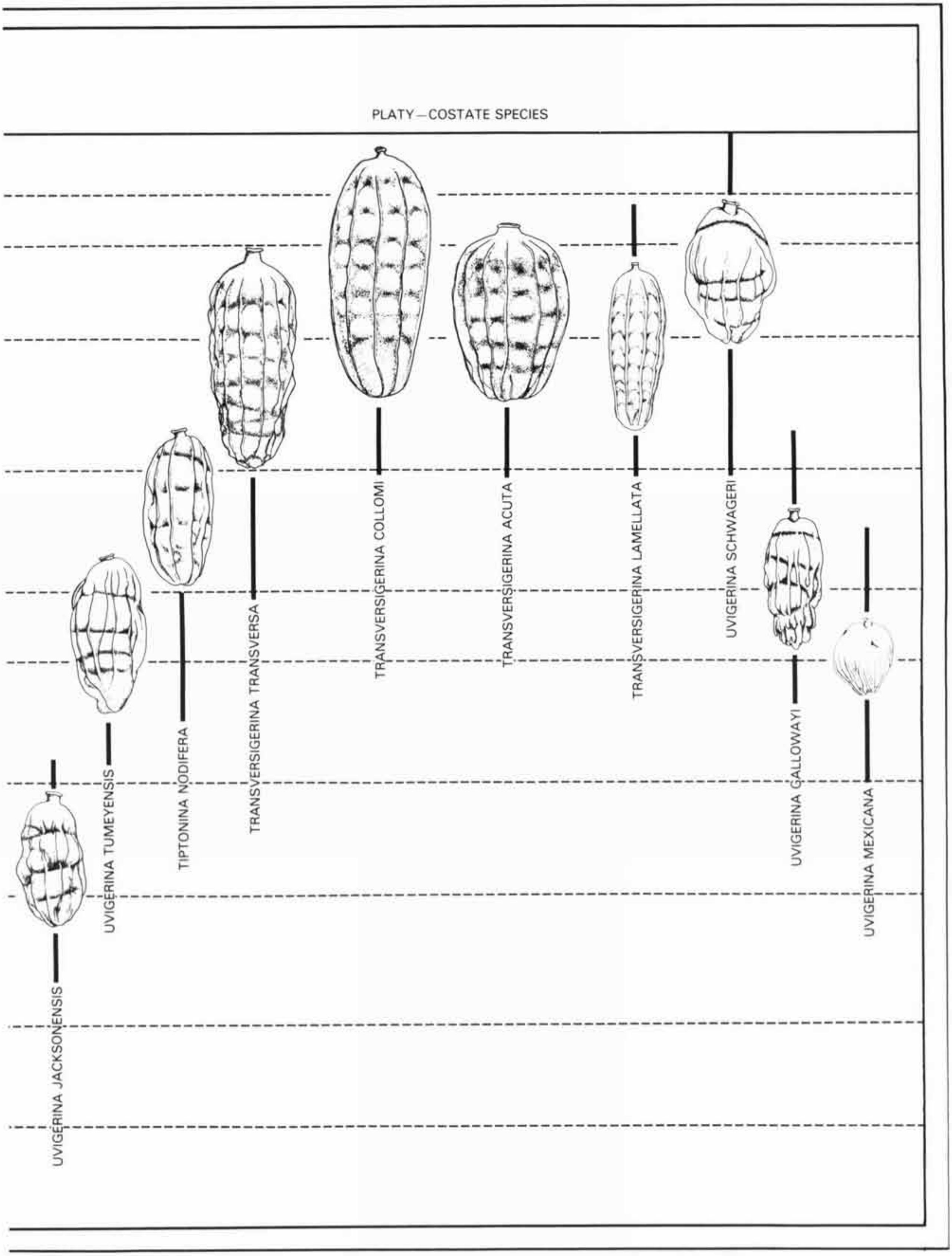

Fig. 1. Stratigraphic ranges of hispid-spinose, spinose-costate, and platy-costate species of Uvigerinidae in the Western Hemisphere.

This loosely coiled species is ornamented with minute spines and is hispid in the true sense of the word, as is *U. auberiana.* Specimens are nearly twice the size of *U. auberiana* and lack exposure of the penultimate aperture.

This species is recognized easily in well-preserved assemblages, but in much of the fossil material we examined the minute spines are mostly abraded so that it is difficult to differentiate *U. hispida* from *U. proboscidea.* We have not seen well-preserved specimens of this species that are certainly older than Late Miocene. Inasmuch as Bandy (1953), Boersma (1976), and C. E. Pflum (personal communication, 1980) have observed subtle gradients between *U. hispida* and *U. proboscidea* and because both species seemingly have a similar water-depth preference, it is convenient to treat them as a single taxon in the fossil record. We have done this on our range chart (Fig. 1) by selecting the name *U. hispida* to represent both species.

UVIGERINA RUSTICA Cushman and Edwards

Plate 7; Figure 1

Uvigerina hispida Schwager CUSHMAN, 1929, p. 95, pl. 13, fig. 35; GALLOWAY and MORREY, 1929, p. 39, pl. 6, fig. 3; KLEINPELL, 1938, p. 295, pl. 5, figs. 8, 16 [not *U. hispida* Schwager, 1866, p. 249, pl. 7, fig. 95].

Uvigerina rustica CUSHMAN and EDWARDS, 1938, p. 83, pl. 14, fig. 6; PALMER, 1941, p. 184, pl. 15, fig. 19; RENZ, 1948, p. 175, pl. 7, figs. 23, 24; STAINFORTH, 1948, p. 130, pl. 24, fig. 25; FAIRCHILD, WESENDUNK, and WEAVER, 1969, p. 57, pl. 13, fig. 1.

Uvigerina rustica resembles *U. hispida* except for being about twice as large and having short, thick spines. The later chambers may be coiled so loosely that they appear biserial. The last chamber of many specimens has a cleft marking the position of the penultimate aperture.

SPINOSE-COSTATE SPECIES

This group includes species with serrate costae and spines (Fig. 1) in the triserial genus *Uvigerina* and the triserial to uniserial genera *Rectuvigerina* and *Estorffina.*

The main evolutionary line of this group is seemingly *Uvigerina peregrina* with its many clinal members, including *Uvigerina pygmea* d'Orbigny, 1826, the type species of *Uvigerina.* We make no attempt here, however, to controvert the specific name *Uvigerina peregrina* Cushman, 1923, for reasons of historical usage. Thus we consider *U. peregrina* as essentially the prototype of the genus *Uvigerina,* irrespective of minor nomenclatural complications.

In an effort to remove certain triserial to uniserial species from the genus *Siphogenerina* (type species *Siphogenerina costata* Schlumberger, 1883) [which ranges from the Pliocene to Holocene, and which was likely derived from *Rectobolivina*], Mathews (1945) proposed the genus *Rectuvigerina* to include the subgenera *Rectuvigerina* and *Transversigerina* (here interpreted as genera). The main distinction between the genera is in the uniserial stage where *Rectuvigerina* has straight sutures but *Transversigerina* has arched sutures. These genera define separate lineages, which may or may not be closely related. We do not, however, consider all of Mathews' subgeneric groupings of species to be correct.

Paleobathymetry of *Uvigerina peregrina* and its clinal members is discussed under the species heading. Species of *Rectuvigerina* are considered here as bathyal dwelling and, like *U. peregrina,* develop increasing spinosity with increasing depth of water.

UVIGERINA PEREGRINA Cushman

Plates 8, 9; Figure 1

Uvigerina peregrina CUSHMAN, 1923, p. 166, pl. 42, figs. 7-10.

Uvigerina gardnerae CUSHMAN and APPLIN, 1926, p. 175, pl. 8, figs. 16, 17.

This tightly coiled triserial species is characterized by mostly parallel, discontinuous, deeply serrate costae composed of rows of closely aligned calcite blades. Most specimens have at least a few spines that are remarkably similar to discrete elements of the costae. The test surface is finely perforate. The neck region has a few spines and a distinctive lip.

Bandy (1960) related the many variations seen in this species to a cline in which dominantly costate forms become more spinose with increasing depth of water. A similar conclusion was reached by Pflum and Frerichs (1976).

The following morphologic depth-of-water cline is now rather widely recognized and applied to paleobathymetric interpretations by paleontologists in the Gulf Coast region: small, dominantly costate clinal members (locally referred to *Uvigerina pygmea, U. juncea,* or *U. subperegrina*) define depths of water from about 300 to 600 feet; a large costate clinal member (referred to *U. peregrina, sensu stricto*) defines depths of water from about 600 to 3,000 feet; a clinal member in which the last two or three chambers are spinose (generally referred to *U. dirupta*) defines depth of water from about 800 to 6,000 feet; and heavily spinose clinal members (locally referred to *U. spinicostata* or *U. hispidocostata*) define depths of water from about 2,000 to 7,000 feet.

We see no clear distinction between *Uvigerina gardnera* in the Late Eocene (Shubuta Member and Moodys Branch Formation of the Jackson Group) and modern *Uvigerina peregrina*. A detailed study of the "*Uvigerina gardnerae*" cline was not attempted, but clinal relationship of variants is suggested by the observed ratio of costae to spines seen in different assemblages. See, for example, *Uvigerina gardnerae* Cushman var. *texana* Cushman and Applin (1926), especially figures by Howe and Wallace (1932, pl. 12), and *U. gardnerae* Cushman var. *pachecoensis* Smith (1957), where the degree of spinosity was used to differentiate species. It seems evident that *U. peregrina*, with its clinal members, affords paleobathymetric criteria at least as far back as the Middle Eocene, for we have provisionally placed small spinose-costate species in the Middle Eocene Guayabal Formation of Mexico in *U. peregrina;* records show it to be a cosmopolitan species.

UVIGERINA SPINICOSTATA
Cushman and Jarvis

Plates 10, 11; Figure 1

Uvigerina spinicostata CUSHMAN and JARVIS, 1929, p. 12, pl. 3, figs. 9, 10; CUSHMAN and STAINFORTH, 1945, p. 48, pl. 7, fig. 16.

Uvigerina cf. *spinicostata* Cushman and Jarvis BERMÚDEZ and GAMEZ, 1966, p. 243, pl. 7, fig. 12.

Uvigerina havanensis CUSHMAN and BERMÚDEZ, 1936, p. 59, pl. 10, figs. 19-21; GAMERO, 1977, p. 42, pl. 3, fig. 22.

The early growth stage of this species resembles typical *Uvigerina*, whereas the more adult stages become loosely coiled and elongate and approach *Rectuvigerina*. Prominent discontinuous, serrated costae tend to swirl or twist about the aperture. This species is widely recorded from the Caribbean region but is not as yet recognized in the Gulf of Mexico or California regions.

UVIGERINA PRAEHUBBARDI
Lamb and Miller, new species

Plate 12; Figure 1

Uvigerina tenuistriata Reuss NUTTALL, 1932, p. 21, pl. 5, fig. 8 [not *U. tenuistriata* Reuss, 1870, p. 484, *fide* Cushman and Edwards, 1938, p. 84].

Uvigerina topilensis Cushman STAINFORTH, 1948, p. 130, pl. 24, fig. 23 [not *U. topilensis* Cushman, 1925b, p. 5, pl. 1, fig. 5].

Uvigerina gallowayi Cushman FAIRCHILD, WESENDUNK, and WEAVER, 1969, p. 56, figs. 14, 18 [not *U. gallowayi* Cushman, 1929, p. 94, pl. 13, figs. 33, 34].

Uvigerina cf. *gallowayi* Cushman GAMERO, 1977, p. 42, pl. 3, fig. 20.

Type specimens.—Holotype, Plate 12,*1*, USNM 382686; paratypes, Plate 12,*2*,*3*, USNM 382687, 382688, respectively.

Description.—Test elongate, about twice as high as wide; chambers inflated, early triserial ones tightly coiled, later ones more loosely coiled; costae serrate, locally breaking into spines, mostly discontinuous on early chambers, tending to be continuous on later chambers; test wall with fine pores; aperture a short neck with phialine lip. Length of holotype 0.8 mm.

Remarks.—This species is recorded widely from the Caribbean, Mexico, Ecuador, and California. It may be the predecessor of *Rectuvigerina hubbardi*, from which it differs in lacking a partially uniserial test.

Genus RECTUVIGERINA Mathews, 1945

Type species.—*Siphogenerina multicostata* Cushman and Jarvis, 1929.

Proposed as a subgenus of *Rectuvigerina* by Mathews (1945), characterized by straight sutures in the uniserial stage (see discussion of lineage under Spinose-Costate Species).

RECTUVIGERINA HUBBARDI
(Galloway and Heminway)

Plate 13; Figure 1

Siphogenerina hubbardi GALLOWAY and HEMINWAY, 1941, p. 434, pl. 34, fig. 2; LAMB, 1964, p. 466, pl. 4, figs. 1, 2.

Siphogenerina multicostata Cushman and Jarvis CUSHMAN, 1929, p. 95, pl. 13, fig. 38 [not *S. multicostata* Cushman and Jarvis, 1929]; RENZ, 1948, p. 165, pl. 7, fig. 26 [not *S. multicostata* Cushman and Jarvis, 1929].

Rectuvigerina (Rectuvigerina) hubbardi (Galloway and Heminway) MATHEWS, 1945, p. 592, 598, pl. 82, fig. 3.

This is a large, elongate species in which the triserial portion occupies about one-third of the test and the uniserial portion the remainder. Straight sutural planes and parallel, serrate, mostly continuous costae characterize the adult form. It occurs widely in the Caribbean, Gulf Coast, Mexico, Ecuador, and California.

RECTUVIGERINA MULTICOSTATA (Cushman and Jarvis)

Plate 14,*1-3;* Figure 1

Siphogenerina multicostata CUSHMAN and JARVIS, 1929, p. 14, pl. 3, fig. 6; GALLOWAY and HEMINWAY, 1941, p. 435, pl. 34, figs. 3, 4; CUSHMAN and STAINFORTH, 1945, p. 49, pl. 8, fig. 1; STAINFORTH, 1948, p. 132, pl. 24, fig. 22.

Rectuvigerina (Rectuvigerina) multicostata (Cushman and Jarvis) MATHEWS, 1945, p. 593, 598, pl. 82, fig. 6 (designation of type species); BECKER and DUSENBURY, 1958, p. 34, pl. 4, fig. 10.

Although similar in chamber arrangement to *Rectuvigerina hubbardi,* this large species differs in having mostly discontinuous, serrated costae that rarely bridge the sutures. It has a wide range in the Caribbean and Gulf of Mexico regions and is the type species of *Rectuvigerina.*

RECTUVIGERINA OPTIMA (Cushman)

Plate 14,*4,5;* Figure 1

Siphogenerina multicostata Cushman and Jarvis var. *optima* CUSHMAN 1943, p. 91, pl. 16, figs. 9, 10.

Rectuvigerina (Rectuvigerina) optima (Cushman) MATHEWS, 1945, p. 594, 598, pl. 82, figs. 4, 5.

Cushman described this taxon as differing from typical *Rectuvigerina multicostata* in the finer costae and uniserial chambers, which tend to be in an irregular line. Our specimens show numerous costae extending part or all of the length of the chamber and thickening toward the earlier chambers. Many specimens we observed have a prominent apiculate basal chamber. This species has been found only in the Caribbean region.

Genus ESTORFFINA Kleinpell and Tipton, 1980

Type species.—*Siphogenerina mayi* Cushman and Parker, 1931.

ESTORFFINA MAYI (Cushman and Parker)

Plate 15; Figure 1

Siphogenerina mayi CUSHMAN and PARKER, 1931, p. 10, pl. 2, fig. 7; LAMB, 1964, p. 468, pl. 4, figs. 3-6; FAIRCHILD, WESENDUNK, and WEAVER, 1969, p. 57, pl. 13, fig. 3; TIPTON, KLEINPELL, and WEAVER, 1973, p. 58, pl. 7, figs. 11, 12.

Siphogenerina fredsmithi GARRETT, 1939, p. 577, pl. 66, fig. 1.

Estorffina mayi (Cushman and Parker) KLEINPELL and TIPTON, 1980, p. 79, pl. 14, fig. 13 (designation of type species).

This small slender species is placed in the spinose-costate group because of its weakly serrate costae. It resembles a *Rectuvigerina,* although the aperture and coarsely punctate test wall are not typical of that genus as illustrated on the plates. It occurs widely throughout the Western Hemisphere and is the type species of the monotypic genus *Estorffina.*

PLATY-COSTATE SPECIES

Species in this group are characterized by broad, smooth, platelike costae and unornamented phialine apertures. Evolutionary grades within this group are shown in Figure 2. The Late Eocene species *Uvigerina jacksonensis* gave rise to several evolutionary branches in the middle Cenozoic, and it culminated in the Late Pliocene with *Transversigerina lamellata.* Evolutionary changes occurred in the manner of coiling of the megaspheric generations, costae ornamentation, and nature of the sutural planes. These features are used in the differentiation of the platy-costate species.

There are no obvious relationships between this species group and others discussed herein. Some members of the miscellaneous species group have similar broad costae, but they differ in other taxonomic characters; the one exception is *Uvigerina adelinensis,* which may be related closely to *Uvigerina tumeyensis.*

This group is important because its species are widespread throughout the Western Hemisphere and are reliable age and environmental indicators. For example, Oligocene to Middle Miocene biostratigraphic correlations are refined by using species of this group, especially for regions that lack planktonic fossils. Reliable dating and correlation can be extended from the plankton-rich Caribbean and Gulf of Mexico regions into areas such as the northeastern Pacific, which lack or have nondescript planktonic faunas.

The second lineage in the platy-costate group includes the species, from oldest to youngest, *Uvigerina mexicana, U. gallowayi,* and *U. schwageri* (Fig. 1). This lineage is not well documented, for evolutionary grades between the species have not been observed. The species are known primarily from the Caribbean and Gulf Coast warm-water region. *U. schwageri* lives today in the southwestern Pacific Ocean.

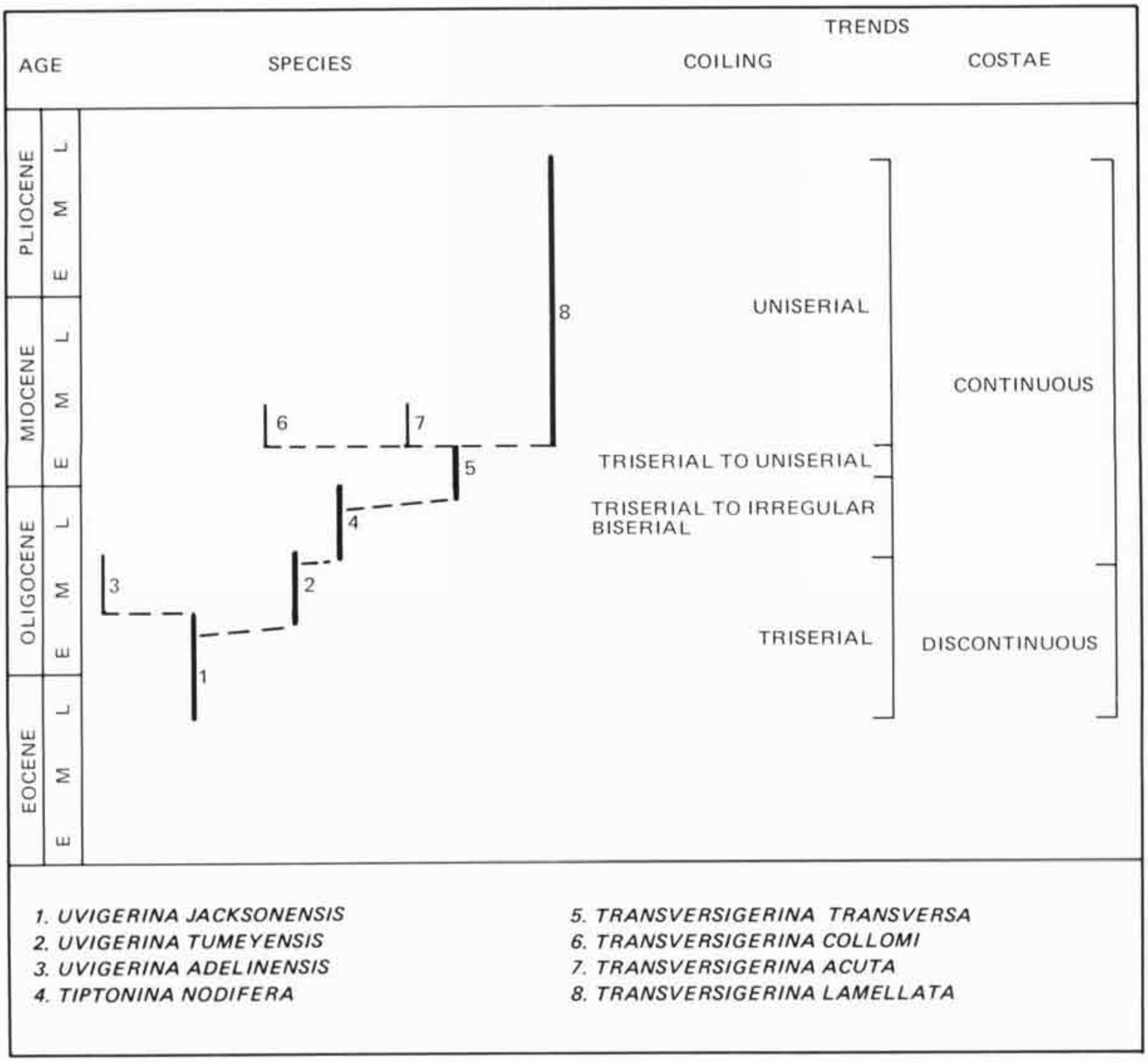

Fig. 2. Lineage relationships in the megaspheric generation of platy-costate Uvigerinidae showing life-range (thinner bars), the main line of descent (thicker bars), and overlaps in range (dashed lines). Trends within this lineage are development of a uniserial test with continuous costae and arched sutures from a triserial ancestor with discontinuous costae.

UVIGERINA JACKSONENSIS Cushman

Plate 16; Figures 1, 2

Uvigerina jacksonensis Cushman, 1925c, p. 67, pl. 10, fig. 13; Cushman, 1927a, p. 163, pl. 25, fig. 3; Smith, 1956, p. 97, pl. 12, fig. 12; Lamb, 1964, p. 462-463, pl. 1, figs. 5-9.

Uvigerina cocoaensis Cushman, 1925c, p. 68, pl. 10, fig. 12; Cushman, 1935, p. 39, pl. 15, figs. 12, 13; Cushman and Simonson, 1944, p. 199-200, pl. 33, fig. 1.

Uvigerina vicksburgesis Cushman and Ellisor, 1931, p. 54, pl. 7, fig. 7.

Test of medium size for genus, with inflated chambers; some costae are restricted to individual chambers, whereas others are confluent over more than one chamber and tend to hug the curvature of the chamber wall.

This species probably is related to such look-alikes as *Uvigerina topilensis* Cushman and *Uvigerina continuosa* Lamb, which range no higher than upper Eocene. We consider this species also to be ancestral to *Uvigerina tumeyensis*, the precursor of the *Tiptonina-Transversigerina* lineage.

It is widespread in the Western Hemisphere and known from Africa and Europe. This is a good upper bathyal indicator species.

UVIGERINA TUMEYENSIS Lamb

Plates 17, 18; Figures 1, 2

Uvigerina gallowayi Cushman CUSHMAN and SIMONSON, 1944, p. 200, pl. 32, fig. 19 [not *U. gallowayi* Cushman, 1929, p. 94, pl. 13, figs. 33, 34]; TIPTON, KLEINPELL, and WEAVER, 1973, p. 56, pl. 7, fig. 2 [not *U. gallowayi* Cushman, 1929]; ASCOLI, 1976, pl. 6, fig. 5 [not *U. gallowayi* Cushman, 1929].

Uvigerina gallowayi Cushman (?) SMITH, 1956, p. 96-97, pl. 12, fig. 13a-b [not *U. gallowayi* Cushman, 1929].

Uvigerina tumeyensis LAMB, 1964, p. 463, pl. 1, fig. 10; pl. 2, figs. 1-8; pl. 3, fig. 1; GAMERO, 1977, p. 43, pl. 4, figs. 6, 7.

Uvigerina beccarii Fornasini FAIRCHILD, WESENDUNK, and WEAVER, 1969, p. 56, pl. 12, fig. 17 [not *U. beccarii* Fornasini, 1898].

Lamb (1964) wrote: "Test of medium size for genus, chambers inflated, triserial, except for gerontic forms which tend to become irregularly biserial in the later portion, greatest breadth near the terminal end; suture lines clear but often obscured by the costae; costae usually heavy, at times platelike, mostly continuous over the entire test but occasionally broken and discontinuous, usually sinuous and occasionally anastomosing; aperture with a short neck and phialine lip."

Middle Oligocene (upper *Globigerina ampliapertura* Zone) uvigerinid assemblages may contain a series of gradational forms leading from *Uvigerina jacksonensis* to *U. tumeyensis*. Near the highest occurrence of this species, it can be seen to grade into *Tiptonina nodifera*. It is widespread in the Western Hemisphere and a good upper to middle bathyal indicator.

UVIGERINA ADELINENSIS Palmer and Bermúdez

Plate 19; Figures 2, 3

Uvigerina cubana PALMER and BERMÚDEZ, 1936, p. 292, pl. 17, figs. 5, 6 [*nomen invalidum* (homonym); not *Uvigerina gardnerae* Cushman and Applin var. *cubana* Hadley, 1934].

Uvigerina adelinensis PALMER and BERMÚDEZ in BERMÚDEZ, 1949, p. 203.

Similar to *Uvigerina tumeyensis* but differing in ornamentation, having three broad, platelike costae extending from the apex to or beyond the middle portion of the test, giving the test a triangular shape.

This striking species commonly occurs with *U. tumeyensis* and has a similar range. We have not seen it outside of the Caribbean region.

Genus TIPTONINA Lamb and Miller, new genus

Type species.—*Siphogenerina nodifera* Cushman and Kleinpell, 1934, from the upper Oligocene of California.

Description.—Test elongate, usually 2.0 to 2.5 times as long as broad; early chambers triserial, tightly coiled as in *Uvigerina,* later chambers coiled more loosely, approaching an irregular biserial mode, but not uniserial as in *Transversigerina;* perforate test ornamented with subparallel to parallel, platelike, mostly longitudinal costae; sutures not arched as in *Transversigerina,* except very late Oligocene specimens may show occasional incipient sutural arches; aperture with a short neck and phialine lip, being more centralized on the final chamber than in *Uvigerina.*

Remarks.—This genus is an evolutionary grade between *Uvigerina* and *Transversigerina* and presently is monotypic in that *Tiptonina nodifera* is the only species we assign to this genus. The name is proposed in recognition of the many contributions of Ann Tipton Donnelly.

Range.—Middle to upper Oligocene.

TIPTONINA NODIFERA (Cushman and Kleinpell)

Plates 20-22; Figures 1, 2

Uvigerina gesteri BARBAT and VON ESTORFF, 1933, p. 171, pl. 23, figs. 7, 18 [see appeal by Lamb, 1964, p. 465].

Siphogenerina nodifera CUSHMAN and KLEINPELL, 1934, p. 13, pl. 2, figs. 15, 16; LAMB, 1964, p. 464-465, pl. 3, figs. 3-6; HORNADAY, 1972, p. 43, pl. 1, figs. 4, 5; GAMERO, 1977, p. 43, pl. 4, fig. 8, TIPTON, KLEINPELL, and WEAVER, 1973, p. 58, pl. 8, figs. 6-8.

Uvigerina gallowayi Cushman KLEINPELL, 1938, p. 294, pl. 5, figs. 1, 2, 5 [not *U. gallowayi* Cushman, 1929].

Uvigerina israelskyi GARRETT, 1939, p. 577, pl. 65, figs. 15, 16.

Siphogenerina texana CUSHMAN and ELLISOR, 1945, p. 566, pl. 76, figs. 15, 16.

Rectuvigerina (Rectuvigerina) nodifera (Cushman and Kleinpell) MATHEWS, 1945, p. 594, 598, pl. 82, fig. 20.

This species is the type of the monotypic genus *Tiptonina* and has the characteristics of the genus. The synonymy indicates that it has been described widely under the genera *Uvigerina, Siphogenerina,* and *Rectuvigerina.* The generic designation *Tiptonina* should help to clarify its biological affinities and taxonomic position within the lineage *Uvigerina tumeyensis–Tiptonina nodifera–Transversigerina transversa.*

The species is an excellent benthonic index species of the middle to late Oligocene. It occurs throughout the Western Hemisphere. Its bathymetric preference is upper to middle bathyal.

Genus TRANSVERSIGERINA Mathews, 1945

Type species.—*Siphogenerina raphanus* var. *tranversus* Cushman, 1918b.

Proposed by Mathews (1945) as a subgenus of *Rectuvigerina;* characterized by arched sutures in the uniserial stage and broad platelike, parallel costae (note discussion of lineage relationships under Spinose-Costate Species and Platy-Costate Species).

TRANSVERSIGERINA TRANSVERSA (Cushman)

Plates 23, 24; Figures 1, 2

Siphogenerina raphanus (Parker and Jones) var. *transversus* Cushman, 1918b, p. 64, pl. 22, fig. 8.

Siphogenerina transversa Cushman Cushman and Laiming, 1931, p. 112, pl. 12, fig. 13; Cushman and Parker, 1931, p. 10, pl. 2, figs. 5, 6; Hedberg, 1937, p. 677-678, pl. 91, fig. 18; Tipton, Kleinpell, and Weaver, 1973, p. 59, pl. 8, figs. 13, 14; Ascoli, 1976, p. 691, pl. 6, fig. 6; Gamero, 1977, p. 43-44, pl. 4, fig. 9.

Rectuvigerina (Transversigerina) transversa (Cushman) Mathews, 1945, p. 598-599, pl. 83, fig. 7 (designation of type species); Becker and Dusenbury, 1958, p. 35, pl. 4, fig. 11.

Rectuvigerina transversa (Cushman) Loeblich and Tappan, 1964, p. C569, fig. 448,*6*.

Unlike later species of *Transversigerina, T. transversa* is always triserial to uniserial in both the megaspheric and microspheric generations. The megaspheric generations of later transversigerines are essentially uniserial with perhaps a very short biserial stage at times. Therefore, megaspheric transversigerines having an early triserial stage are likely to be members of *T. transversa*.

This is the earliest species of *Transversigerina* to develop prominent sutural arches. The 8 to 12 platelike costae are decidedly more parallel and continuous over the sutures than in *Tiptonina nodifera*.

It is a good index species of very late Oligocene to Early Miocene, with an upper to middle bathyal preference. The species ranges throughout the Western Hemisphere.

TRANSVERSIGERINA COLLOMI (Cushman)

Plates 25-28; Figures 1, 2

Siphogenerina collomi Cushman, 1925a, p. 2, pl. 4, fig. 3; Kleinpell, 1938, p. 300, pl. 15, fig. 11; Kleinpell and Tipton, 1980, pl. 16, figs. 1, 2, pl. 17, figs. 3-5.

Rectuvigerina (Transversigerina) collomi (Cushman) Mathews, 1945, p. 591, 599, pl. 83, fig. 1.

Test large for genus, with some specimens approaching 1.5 mm in length; sutural arches prominent with 8 to 10 high, platelike, longitudinal costae. Differing from *T. transversa* in its larger size, fewer costae, higher arched sutures in larger specimens, and its essentially uniserial megaspheric generation.

A good index species for the very late Early Miocene to early Middle Miocene; this species is an upper to middle bathyal indicator. It is widespread in the California and Caribbean regions.

TRANSVERSIGERINA ACUTA (Bermúdez)

Plates 29, 30; Figures 1,2

Siphogenerina acuta Bermúdez, 1949, p. 220, pl. 14, figs. 7, 8.

?*Siphogenerina reedi* Cushman, 1925a, p. 3, pl. 4, fig. 4; Kleinpell, 1938, p. 303, pl. 14, fig. 7.

Siphogenerina transversa Cushman Cushman and Renz, 1947, p. 30, pl. 7, figs. 2, 3; Renz, 1948, p. 166, pl. 7, figs. 27, 28.

In the Caribbean region, assemblages containing *T. collomi* commonly include specimens that differ from the normal in having fewer costae and a squat sometimes fusiform test. We identify this form as *T. acuta*. A similar form, *S. reedi* Cushman, occurs in the California region.

TRANSVERSIGERINA LAMELLATA (Cushman)

Plates 31, 32; Figures 1, 2

Siphogenerina lamellata Cushman, 1918a, p. 55, pl. 12, fig. 3; Cushman, 1930, p. 49, pl. 9, fig. 10; Renz, 1948, p. 165, pl. 7, fig. 25; Bermúdez, 1949, p. 221, pl. 14, figs. 9, 10.

Rectuvigerina (Transversigerina) lamellata (Cushman) Mathews, 1945, p. 593, 599, pl. 83, figs. 22, 23.

This species closely resembles *T. transversa* but differs in being slightly smaller on the average, and in having fewer costae (7-9), an essentially uniserial megaspheric generation, and a more slender and delicate appearance. Microspheric adults frequently have short discontinuous costae inserted between normal continuous costae in the upper part of the test.

This is the last (youngest) of the transversigerinids ranging from the very late Early Miocene to Late Pliocene. It overlaps slightly in stratigraphic range with true siphogenerinids.

TRANSVERSIGERINA TENUA (Cushman and Kleinpell)

Plate 33

Siphogenerina tenua CUSHMAN and KLEINPELL, 1934, p. 13, pl. 2, fig. 13.
Siphogenerina senni CUSHMAN and RENZ, 1941, p. 22, pl. 3, fig. 21, 22.

Megaspheric generation usually small for the genus with 6 to 8 longitudinal, parallel costae in the adult; rarely as few as 4 to 5 costae in nepionic specimens; chambers essentially uniserial with nearly parallel sides; sutures arched.

Microspheric generation commonly twice as large as the megaspheric generation, reportedly approaching 2 mm in length; costae about 10 in number owing to shorter, intermediate costae being inserted toward the apertural end; chambers triserial to uniserial; sutures usually arched in the uniserial portion of the test.

This species is seemingly closely related to *Transversigerina transversa,* from which it differs in the megaspheric generation by its smaller size, fewer costae, and nearly parallel sides; and in the microspheric generation by its long, tapering test and intermediate costae inserted near the apertural end.

In California the range of this species overlaps slightly with that of *Tiptonina nodifera,* in uppermost Oligocene, and it ranges upward into the *Transversigerina transversa* Zone or lowermost Miocene. Its junior synonym, *Transversigerina senni,* was described from lowermost Miocene strata of the Falcón basin, coastal Venzuela.

In morphology, this species closely resembles *Transversigerina lamellata,* and the two may appear to be conspecific. Neither species, however, has been observed in the middle or upper Lower Miocene, and there are problems in demonstrating this relationship with stratigraphy.

UVIGERINA MEXICANA Nuttall

Plate 34; Figure 1

Uvigerina mexicana NUTTALL, 1932, p. 22, pl. 5, figs. 12, 13; GALLOWAY and HEMINWAY, 1941, p. 430, pl. 33, fig. 9; BERMÚDEZ, 1949, p. 208, pl. 13, fig. 9; GAMERO, 1977, p. 43, pl. 3, fig. 23.

This species was described from Mexico at or near the middle Oligocene (*Globigerina ampliapertura* Zone) interval. It is characterized by its short, stout test (due to its tight coiling) and numerous, mostly continuous, longitudinal, locally anastomosing costae. It is likely to have been derived from a species such as *Uvigerina curta* Cushman and Jarvis, which occurs sparsely in the uppermost Eocene of the Gulf Coast and Caribbean regions.

It was apparently a deep upper bathyal or deeper species that occurred widely throughout the Western Hemisphere.

The upper limit of the range of this bathyal species approaches the top of the *Catapsydrax dissimilis* Zone. It is confined mostly to the Caribbean region.

UVIGERINA GALLOWAYI Cushman

Plate 35; Figure 1

Uvigerina alata Cushman and Applin GALLOWAY and MORREY, 1929, p. 38, pl. 6, fig. 1 [not *U. alata* Cushman and Applin, 1926, p. 176, pl. 8, figs. 11-13].
Uvigerina gallowayi CUSHMAN, 1929, p. 94, pl. 13, figs. 33, 34; BERMÚDEZ, 1949, p. 204, pl. 13, fig. 7.
Siphogenerina basispinata CUSHMAN and JARVIS, 1929, p. 13, pl. 3, figs. 4, 5; CUSHMAN and STAINFORTH, 1945, p. 49, pl. 8, fig. 3; CUSHMAN and RENZ, 1947, p. 29, pl. 7, fig. 1.
?*Uvigerina gallowayi basicordata* CUSHMAN and RENZ, 1941, p. 21, pl. 3, fig. 18; RENZ, 1948, p. 174, pl. 7, fig. 19; BERMÚDEZ, 1949, p. 204, pl. 13, fig. 8.
?*Uvigerina gallowayi basiquadrata* PETTERS and SARMIENTO, 1956, p. 30, pl. 1, fig. 5.

The lowest record of this species is middle Oligocene, within the upper *Globorotalia opima opima* Zone. It is likely to have been derived from *U. mexicana,* probably through such intermediate species as *U. gallowayi basicordata* Cushman and Renz or *U. gallowayi basiquadrata* Petters and Sarmiento. It is a variable species with inflated chambers and low, continuous, longitudinal costae that hug the chamber contours in the late portion of the test, and short, discontinuous, overhanging costae in the early portion of the test. No evidence for sutural arches was observed, making it highly unlikely that this species is related to the transversigerines.

Gerontic specimens of this species from the Middle Miocene (*Globorotalia fohsi fohsi* Zone) of Trinidad were described as *Siphogenerina basispinata* Cushman and Jarvis. Paratypes are figured herein to show their relationship to *U. gallowayi* (Pl. 35,*5-7*).

UVIGERINA SCHWAGERI Brady

Plate 36; Figure 1

Uvigerina schwageri BRADY, 1884 (see also Barker, 1960), p. 575, pl. 74, figs. 8-10.
Uvigerina beccarii FORNASINI, 1898, p. 14, pl. 1, fig. 5; GALLOWAY and MORREY, 1929, p. 38, pl. 6, fig. 2; CUSHMAN, 1929, p. 95, pl. 13, fig. 37; RENZ, 1948, p. 174, pl. 7, fig. 22.

This species resembles *U. mexicana* with its inflated chambers and stout test but differs in having thicker and less continuous costae.

We compared our specimens with ones from the Pliocene-Pleistocene interval of the South China Sea region and found them to be quite similar to what is called *Uvigerina schwageri* there.

The bathymetric range of this species is probably outer neritic to deep bathyal. It seems to be a rather cosmopolitan species in warm-water regions.

MISCELLANEOUS SPECIES

The selection of this small group of uvigerinid species (Fig. 3) for discussion was rather arbitrary. Certainly some uvigerinid species have not been considered, but they are either endemic to some areas or are seldom encountered. On the other hand, few intervals of marine strata in the late Tertiary of the Caribbean and Gulf of Mexico lack the species discussed here.

UVIGERINA DUMBLEI Cushman and Applin

Plate 37,*1*, Figure 3

Uvigerina dumblei CUSHMAN and APPLIN, 1926, p. 177, pl. 8, fig. 19.; CUSHMAN, 1935, p. 39, pl. 15, fig. 17.

This is a rather distinctive species with inflated chambers and, on some specimens, nearly parallel test sides. Rather erratic fine costae tend to ramble over each other.

This uncommonly occurring species is included here because specimens are identified readily and the stratigraphic range is well defined (uppermost Eocene). No occurrences are know outside of the Gulf Coast region.

UVIGERINA CONTINUOSA Lamb

Plate 37,*2,3*; Figure 3

Uvigerina cocoaensis Cushman CUSHMAN, 1946, p. 28, pl. 5, figs. 15-20 [not *U. cocoaensis* Cushman, 1925c, which is a junior synonym of *Uvigerina jacksonensis* Cushman, 1925c].

Uvigerina continuosa LAMB, 1964, p. 462, pl. 1, figs. 3, 4 [type specimen herein designated as that of Cushman (1946) figure 17 on plate 5].

When Cushman (1946) refigured specimens from near the type locality of his *Uvigerina cocoaensis* he figured mostly specimens that had decidedly more confluent or continuous costae than those on the specimens assigned originally to his *U. cocoaensis, sensu stricto*. For these later specimens Lamb (1964) proposed the name *Uvigerina continuosa,* with recognition, however, that the new species is closely related to *U. cocoaensis* (= *Uvigerina jacksonensis*).

Several described species in the Upper Eocene are closely related to *U. jacksonensis;* for example, *Uvigerina curta* Cushman and Jarvis, a short, stout, heavily costate species; *Uvigerina topilensis* Cushman, a species similar to *U. continuosa* but becoming nearly uniserial with a centralized aperture; and rare specimens of *U. jacksonensis* lacking costae in the upper portion of the test, which resemble *Uvigerina atwilli* Cushman and Simonson.

All these look-alikes of *U. jacksonensis* are considered to be restricted to the highest Eocene. We selected only *U. continuosa* for discussion here as it occurs commonly and is recognized readily.

UVIGERINA CHURCHI Cushman and Siegfus

Plate 37,*4,5*

Uvigerina churchi CUSHMAN and SIEGFUS, 1939, p. 29, pl. 6, fig. 16.

We have little information about this small species except that it has not been reported outside of California. It is recorded here, however, because it is one of the earliest costate uvigerinids found in the Western Hemisphere and has been cited as an important biostratigraphic marker in the Middle Eocene of California.

UVIGERINA ATWILLI Cushman and Simonson

Plate 38; Figure 3

Uvigerina atwilli CUSHMAN and SIMONSON, 1944, p. 200, pl. 33, figs. 2-4; SMITH, 1956, p. 96, pl. 12, fig. 10; FAIRCHILD, WESENDUNK, and WEAVER, 1969, p. 55, pl. 6, figs. 6, 7.

This species with strongly inflated chambers and few platelike costae on early parts of the test occurs rather commonly in the middle Oligocene of California in association with *Uvigerina jacksonensis* (= *Uvigerina cocoaensis* of authors). Outside the northeastern Pacific we record it only from the Progresso basin of southern Ecuador in an undifferentiated part of the Oligocene.

Kleinpell and Tipton (1980) derived *Uvigerina atwilli* from *U. cocoaensis* (= *U. jacksonensis*) and considered it ancestral to *Atwillina pseudococoaensis* (Cushman

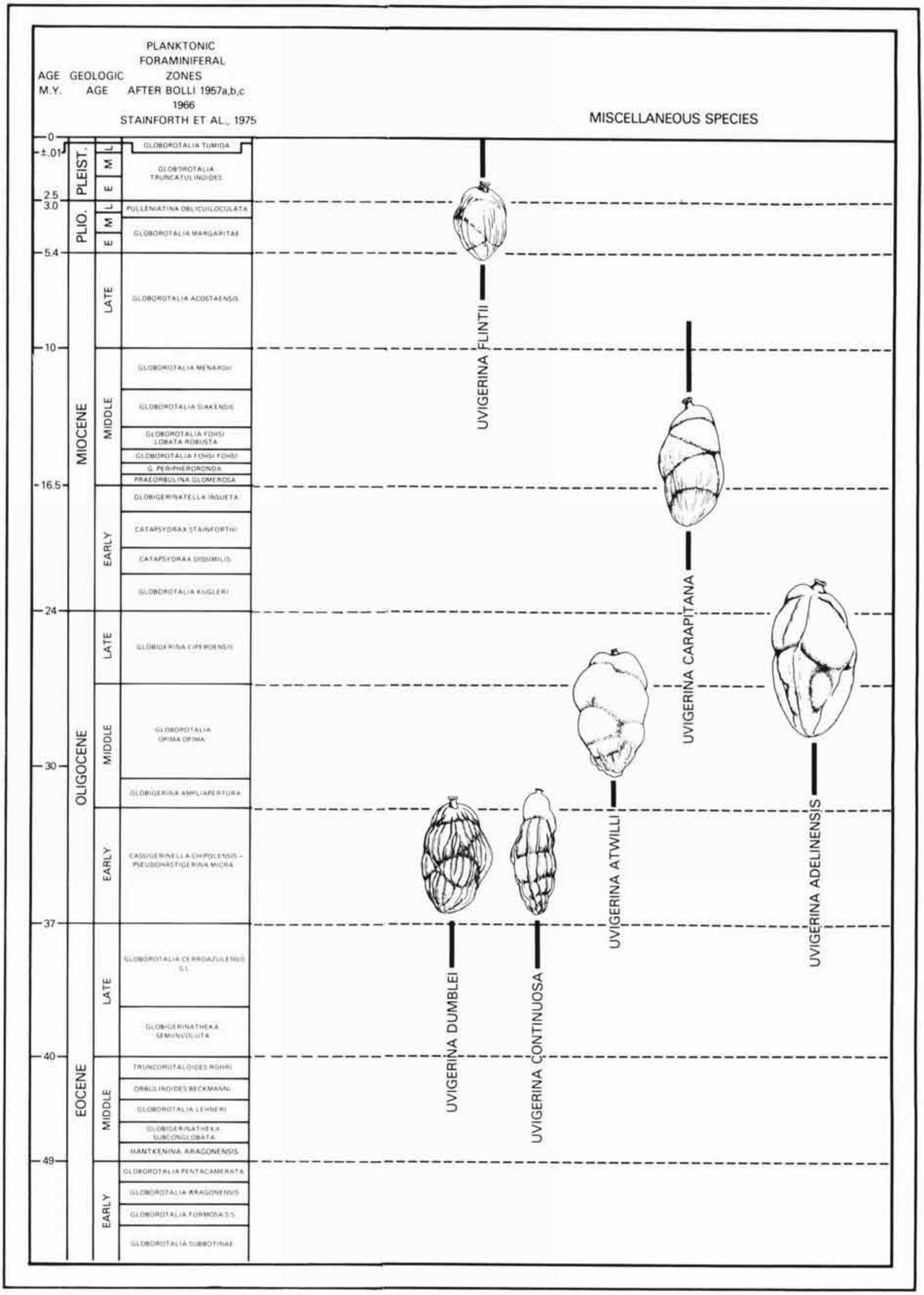

Fig. 3. Stratigraphic ranges of miscellaneous species of Uvigerinidae in the Western Hemisphere.

and Kleinpell) (=*Siphogenerina pseudococoaensis* Cushman and Kleinpell of authors). This now seems a reasonable postulate. Earlier, however, Lamb (1964:465) considered *Atwillina pseudococoaensis* to represent an early evolutionary stage of *Tiptonina* (i.e., conspecific with *Tiptonina nodifera*). Lacking evidence for occurrences in other regions, we now accept the assessment of Kleinpell and Tipton.

UVIGERINA CARAPITANA Hedberg

Plate 39; Figure 3

Uvigerina carapitana Hedberg, 1937, p. 677, pl. 91, fig. 20; Cushman and Renz, 1947, p. 29, pl. 6, fig. 15; Renz, 1948, p. 174, pl. 7, fig. 21; Bermúdez, 1949, p. 202, pl. 13, fig. 1.

This medium-sized, stout species, having inflated chambers, may appear locally as having a smooth test; however, close inspection invariably reveals fine striae.

A widely distributed, bathyal species in the Caribbean and Gulf of Mexico regions, the taxon is a very useful indicator for the Miocene Epoch.

UVIGERINA FLINTII Cushman

Plate 40; Figure 3

Uvigerina flintii Cushman, 1923, p. 165, pl. 42, fig. 13; Bermúdez, 1949, pl. 13, figs. 31, 32; Phleger and Parker, 1951, p. 18, pl. 8, figs. 15, 16; Pflum and Frerichs, 1976, p. 25, pl. 7, fig. 9.

The test of this species is ornamented with fine, continuous to discontinuous costae and the slender neck has ringlike projections. The taxon is an indicator for the Late Neogene and Quaternary. It is distributed widely in the Caribbean, Far East, and Gulf of Mexico, and occurs there also in modern faunas at the depth range of 300 to 1,000 feet.

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INDEX TO TAXA

The following index lists each member of the family Uvigerinidae that is described, mentioned, or illustrated in this report.

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Plate 1

UVIGERINA HISPIDA Schwager, 1866

Topotype specimens from the Pliocene of Car Nicobar Island, northeastern Indian Ocean.

Fig. 1.—*1a.* Side view of small microspheric specimen with random thick spines and apiculate base, ×150.—*1b.* Enlarged view of test wall with broken spine tips, ×750.

Fig. 2.—*2a.* Oblique front view of large megaspheric specimen, ×75.—*2b.* Enlargement of test wall showing random distribution of pores and a broken spine base, ×3,000.—*2c.* Enlargement of neck region. The neck is encircled with fine spines and capped by a narrow phialine lip, ×300.

Fig. 3—*3a.* Frontal view of large megaspheric specimen showing apertural cleft, ×75.—*2b.* Enlarged view of nearly complete spines, ×750.

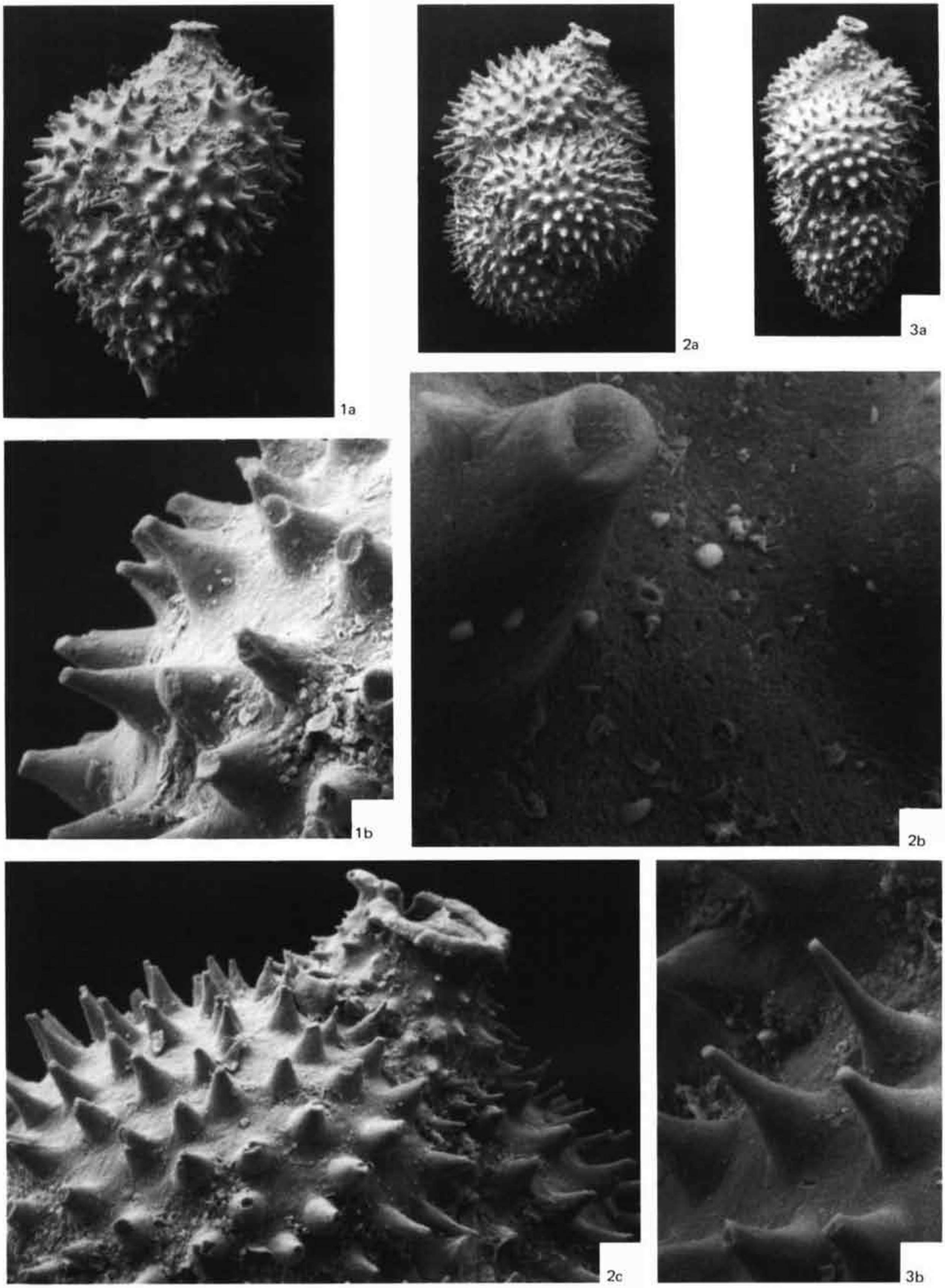

1a
2a
3a
1b
2b
2c
3b

Plate 2

UVIGERINA HISPIDA Schwager, 1866

Specimens from the Pliocene of the northeastern Pacific Ocean, Pliocene of coastal Ecuador, and the Middle Eocene of California.

Figs. 1,5. Specimens from DSDP Leg 36, northeastern Pacific Ocean, core 8, section 5, Pliocene.—*1a;* Broken megaspheric specimen, ×75.—*1b.* Enlargement of radial calcite wall and pore channels, ×1,500.—*5a.* Heavily spinose megaspheric specimen, ×75.—*5b.* Same view as *5a,* ×150.—*5c.* Magnified detail of test surface showing random, closely packed, well-preserved spines, some with connecting buttresses, ×750.

Figs. 2,3. Specimens from the Upper Pliocene (*Pulleniatina obliquiloculata* Zone) of the Punta Gorda Formation, coastal Ecuador.—*2.* Oblique view of a loosely coiled microspheric specimen, ×75.—*3a.* Front view of a microspheric specimen with broken last chamber, ×75.—*3b, 3c.* Enlargements of specimen in *3a,* ×150 and ×300, respectively.

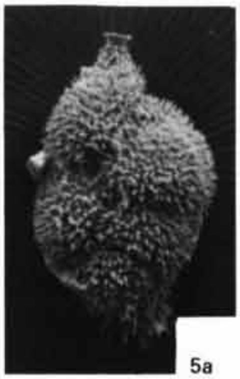
Fig. 4. Megaspheric specimen from the California Seaboard Welch Well 1, northern San Joaquin Valley, California, from a depth of 4,179 feet in the Middle Eocene "transition zone" of Cushman and Simonson, 1944 (=Kreyenhagen Formation of authors), ×75. Locally referred to *Uvigerina garzaensis* by California authors.


1a

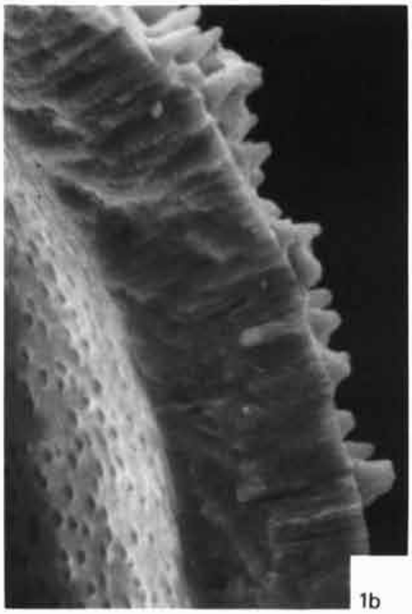

2


3a


4


5a


3b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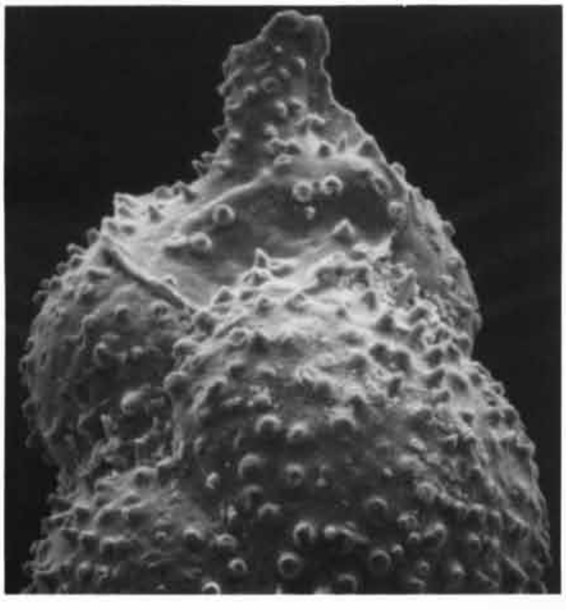
5b


3c

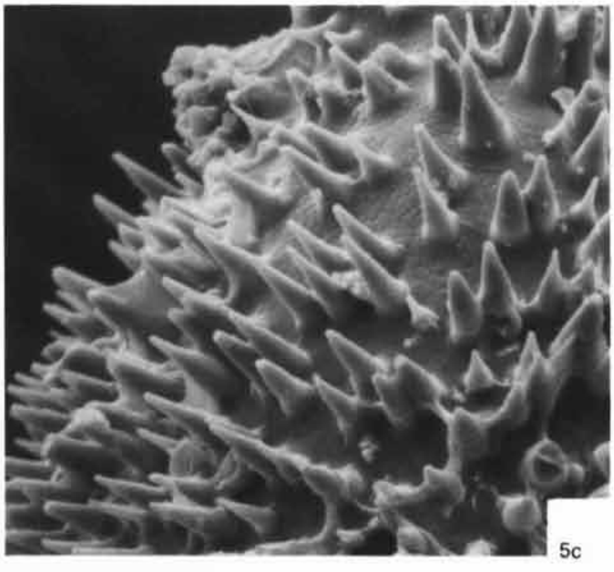

5c

Plate 3

UVIGERINA HISPIDA Schwager, 1866

Specimens from the California Seaboard Welch Well 1, northern San Joaquin Valley, California, from a depth of 4,179 feet in the Middle Eocene "transition zone" of Cushman and Simonson, 1944 (=Kreyenhagen Formation of authors).

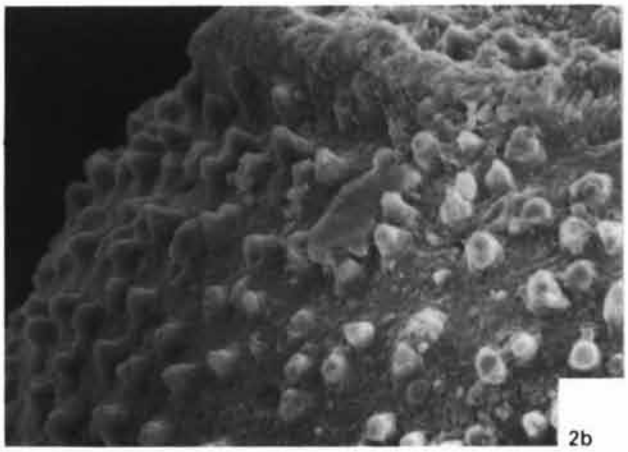
Fig. 1.—*1a.* Front view of megaspheric specimen showing apertural cleft, ×75.—*1b.* Enlarged view of same specimen, ×150.—*1c.* Magnified detail of test wall at sutural junction showing random distribution of thick spines and pores, ×750.

Fig. 2.—*2a.* Front view of megaspheric specimen showing apertural cleft and remnants of phialine lip, ×75.—*2b.* Detail of test wall showing spines, pores, and a ridge of broken last chamber, ×750.

Fig. 3.—*3a.* Side view of specimen with broken last chamber, ×150.—*3b.* Enlargement of sutural area showing well-defined pores and thick spines, ×750.


1a


2a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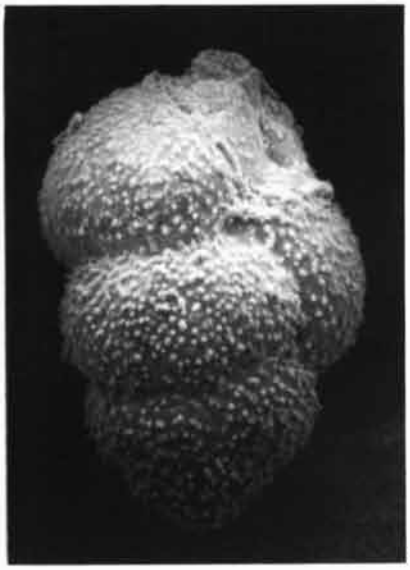
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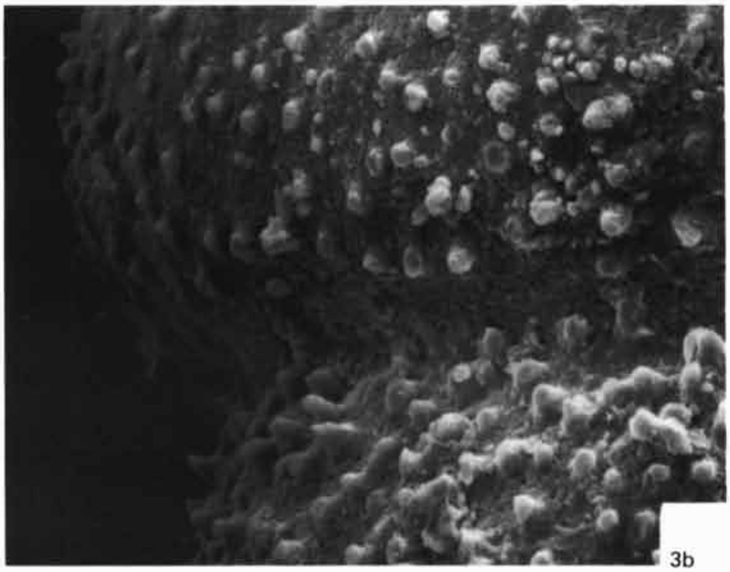

3b


1b

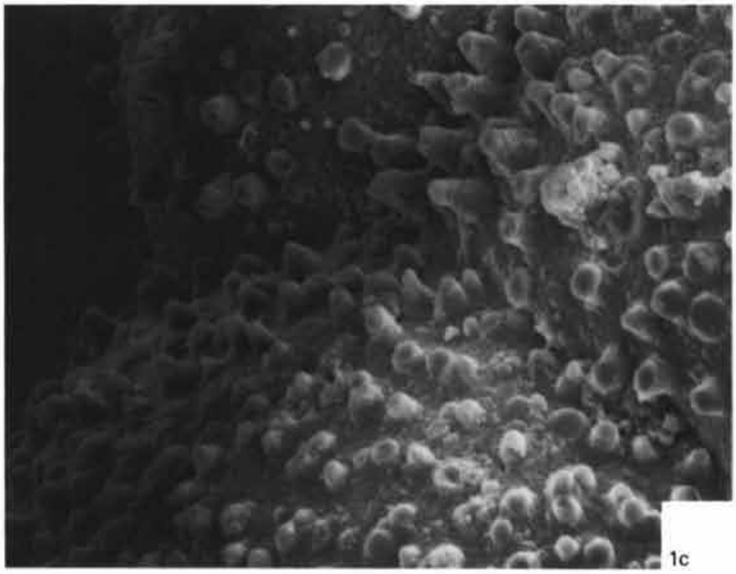

1c

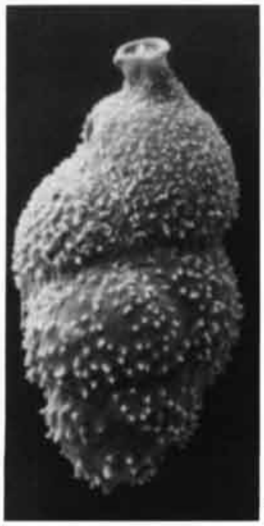
Plate 4

UVIGERINA AUBERIANA d'Orbigny, 1839

Specimens from the Middle Eocene of Mexico and Upper Eocene of Mississippi.

Figs. 1-4. Specimens from the Middle Eocene (*Globorotalia lehneri* Zone) Guayabal Formation of Mexico, described as *Uvigerina elongata* Cole, 1927.—*1a*. Side view of megaspheric specimen showing test surface covered by minute spines, ×150.—*1b*. Enlargement of apertural area showing short spinose neck and phialine lip. Spines are destroyed partially by calcification of the test, ×750.—*2a*. Front view of microspheric specimen showing apertural cleft, ×150.—*2b*. Magnified detail of sutural area showing random interspinal pores, ×300.—*3*. Front view of megaspheric specimen, ×150.—*4*. Megaspheric specimen, ×75.

Figs. 5,6. Specimens from the Upper Eocene (*Globorotalia cerroazulensis* Zone) Shubuta Member, Mississippi, described as *Uvigerina farinosa* Hantken by Howe and Wallace (1932).—*5*. Side view of megaspheric specimen showing spines on early chambers tending to coalesce into costae, ×150.—*6a*. Oblique frontal view of microspheric individual showing some coalescing of spines on early chambers, ×150.—*6b*. Enlargement of apertural area showing slender neck and well-defined apertural cleft with the penultimate chamber aperture typically only partially enclosed, ×750.


1a


2a


3


4


1b


5


6a


2b

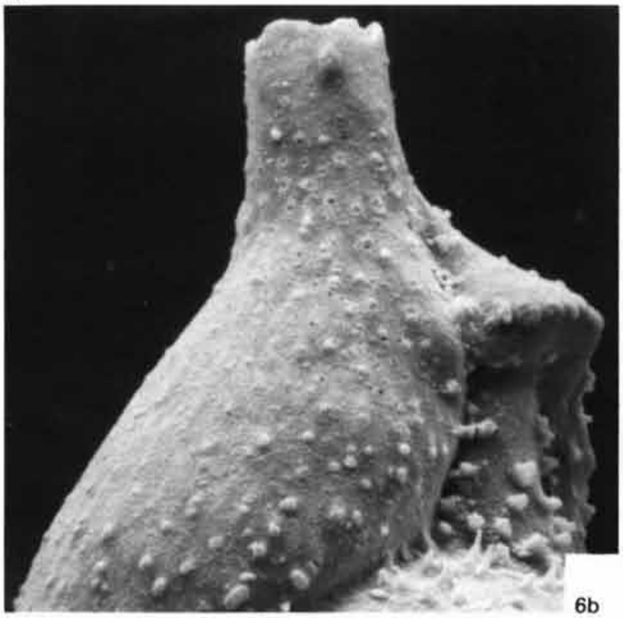

6b

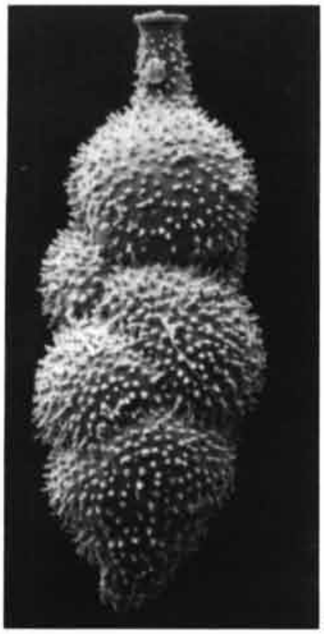
Plate 5

UVIGERINA PROBOSCIDEA Schwager, 1866

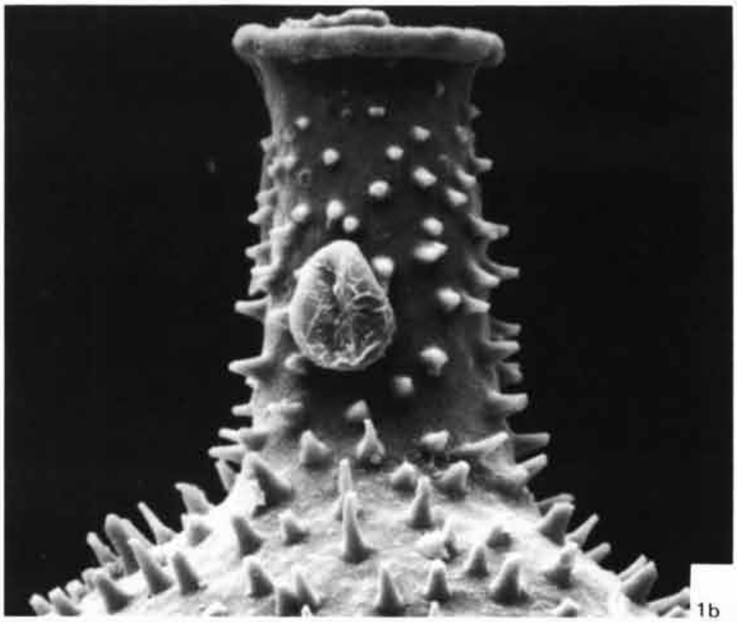
Topotype specimens from the Pliocene of Car Nicobar Island, northeastern Indian Ocean.

Fig. 1.—*1a.* Side view of microspheric specimen showing loosely coiled arrangement of later chambers and slender spinose neck with phialine lip, ×75.—*1b.* Enlargement of apertural area showing minute spines on neck, one of which has impaled a plant spore, ×750.

Fig. 2.—*2a.* Front view of microspheric individual having a weakly developed apertural cleft, ×75.—*2b.* Magnified test area showing heavily spinose neck, ×750.—*2c.* Enlargement showing slender spines and small interspine pores, ×750.—*2d.* Magnified detail of apiculate base, ×750.



1a



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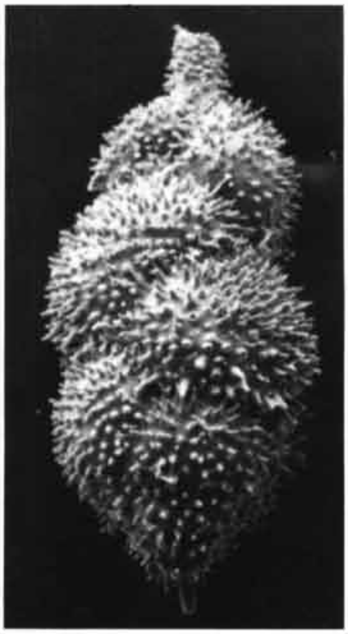

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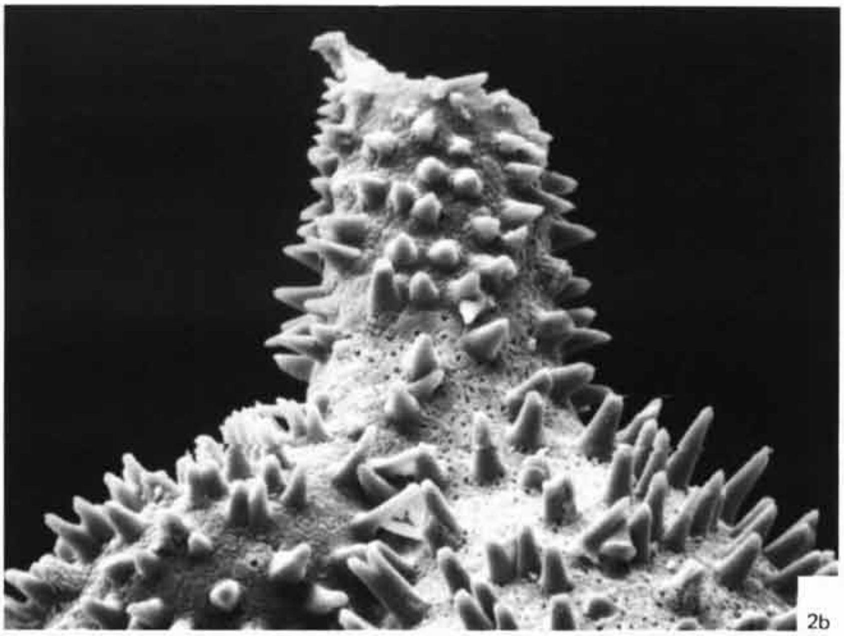

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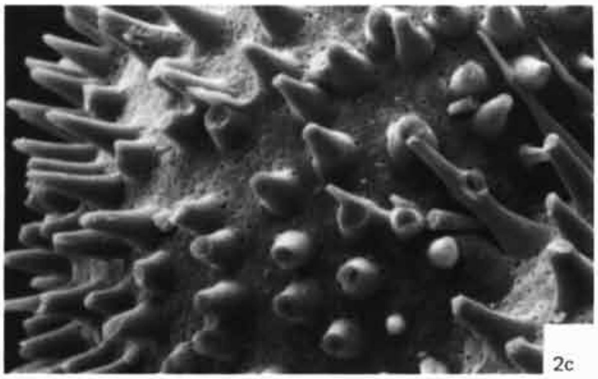

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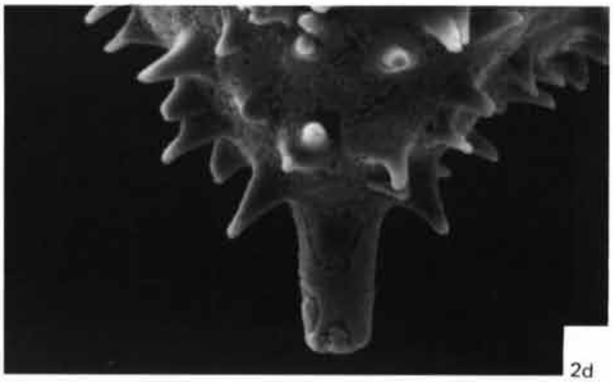


2d

Plate 6

UVIGERINA PROBOSCIDEA Schwager, 1866

Specimens from the Holocene of California and the Gulf of Mexico.

Fig. 1.—*1a.* Side view of microspheric specimen collected off Purisima Point, California, in 6,867 feet of water (Bandy, 1953), ×75.—*1b.* Magnified detail of test showing closely packed minute spines, ×750.

Fig. 2,3.—*2a, 3a.* Side views of megaspheric specimens collected in the Gulf of Mexico in 6,234 feet of water (locally referred to as *Uvigerina senticosa* Cushman), ×75.—*2b.* Enlargement of spinose neck with prominent lip, ×750.—*3b.* Magnified detail of test wall, ×750.

Fig. 4.—*4a.* Front view of morphological variant of *Uvigerina proboscidea* locally referred to as *Uvigerina ampullacea* Brady, ×75.—*4b.* Enlargement of the frontal face of last chamber showing poorly developed apertural cleft, ×750.

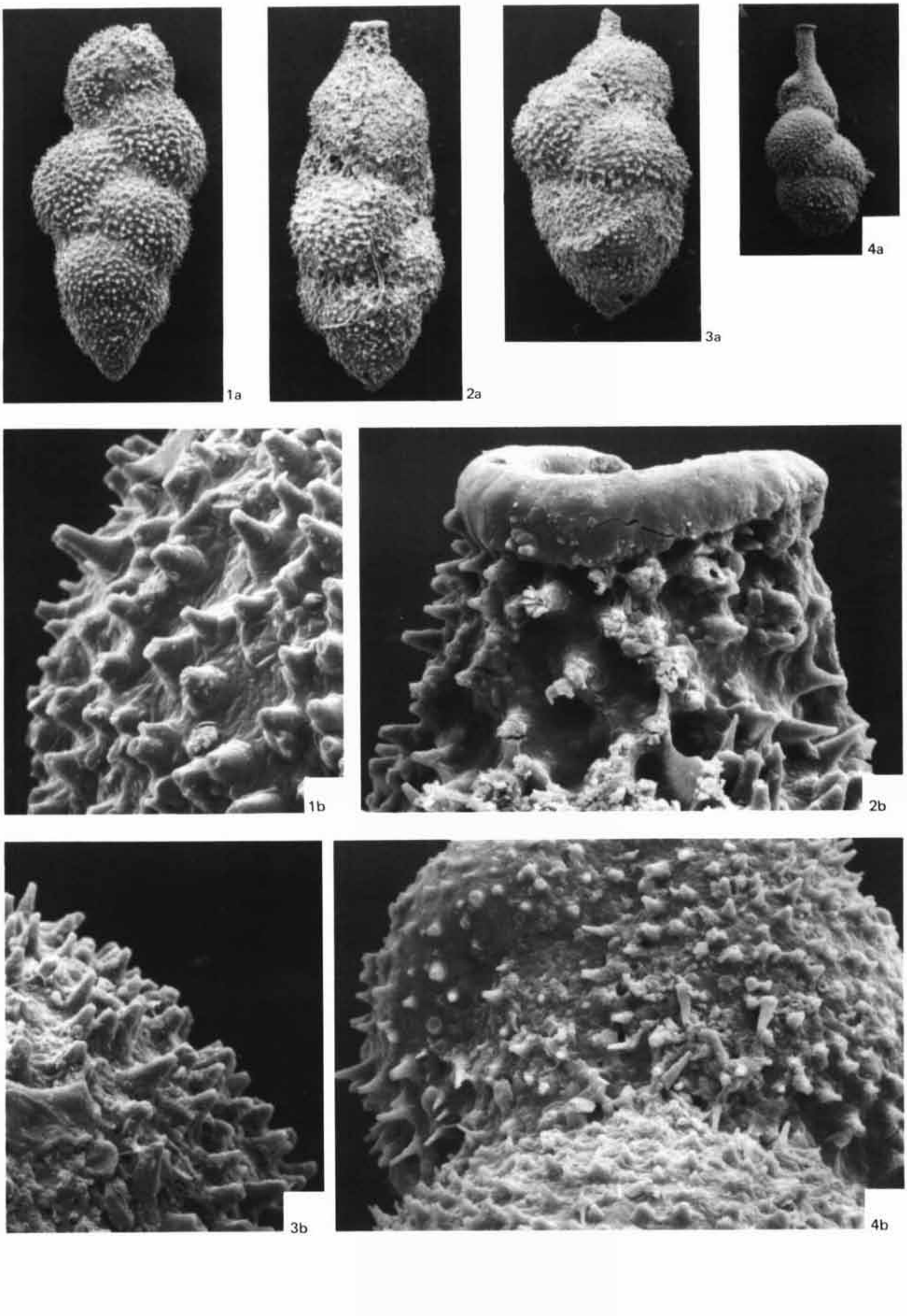

1a
2a
3a
4a
1b
2b
3b
4b

Plate 7

UVIGERINA RUSTICA
Cushman and Edwards, 1938

Specimens from the Miocene of Venezuela and Colombia and the Pliocene of Ecuador.

Fig. 1. Side view of megaspheric specimen from the Middle Miocene (*Globorotalia fohsi fohsi* Zone) Carapita Formation, Creole Chapapotal Well 3, eastern Venezuela, showing thick spines and loosely coiled later chambers, ×75.

Figs. 2,3. Specimens from the Middle Miocene (*Globorotalia peripheroronda* Zone) Flore Santo Formation, Sinu basin, coastal Colombia.—*2a.* Oblique frontal view of megaspheric specimen with a moderately developed apertural cleft, ×75.—*2b.* Magnified detail of sutural area with broken spine tips and small apertural cleft at upper right, ×3,000.—*3.* Microspheric specimen, ×75.

Figs. 4-6. Specimens from the Upper Pliocene (*Pulleniatina obliquiloculata* Zone) Punta Gorda Formation, Borbon basin, coastal Ecuador.—*4a.* Oblique view of loosely coiled microspheric individual with a deep apertural cleft, ×75.—*4b.* Enlargement of test surface showing broken spine bases and pores, ×1,500.—*5,6.* Side views of megaspheric specimens, ×75.


1


2a


3


4a


5


6


2b

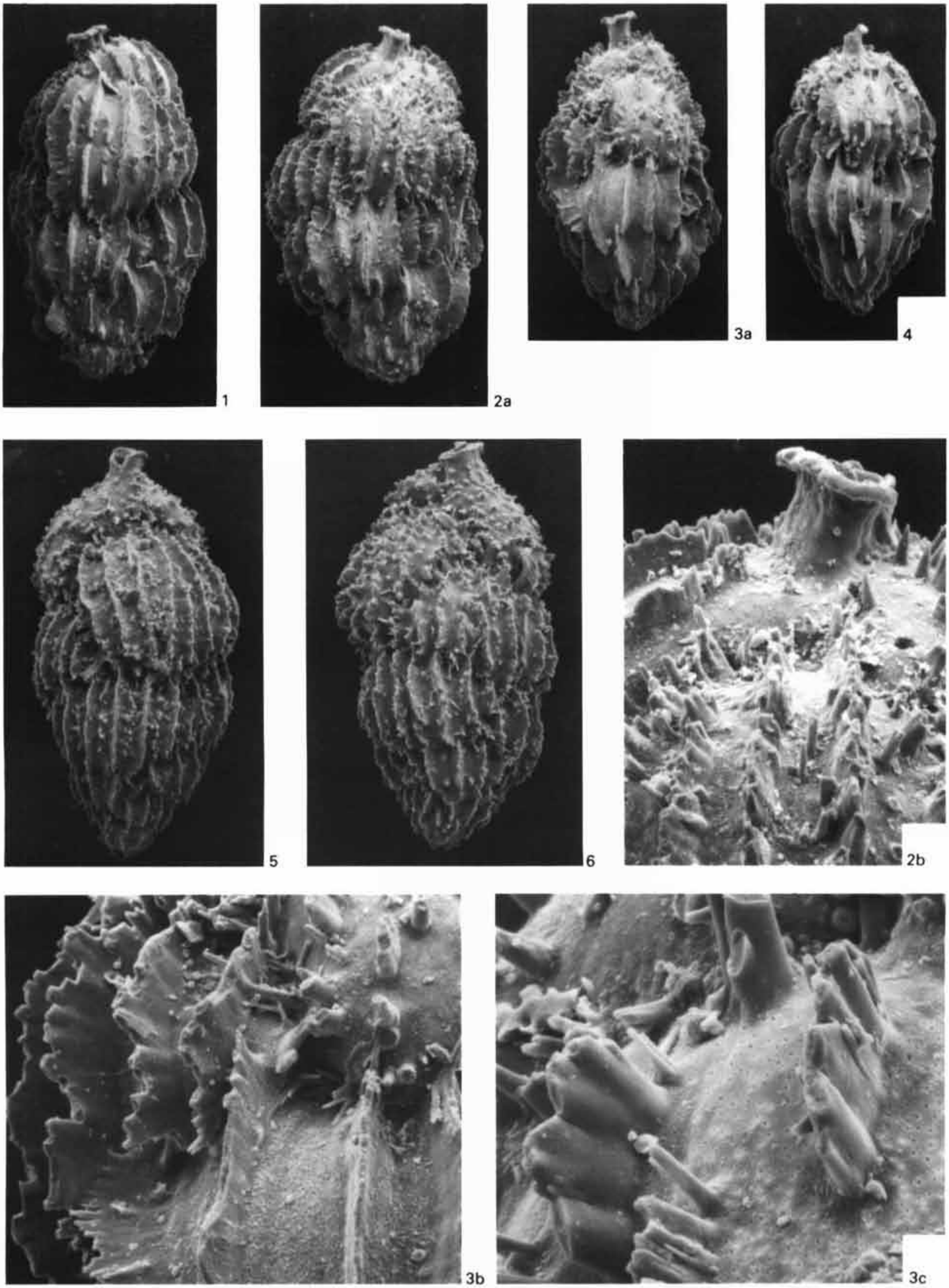

4b

Plate 8

UVIGERINA PEREGRINA Cushman, 1923

Specimens from the type locality of the Upper Eocene (*Globorotalia cerroazulensis* Zone) Shubuta Member of Mississippi.

Figs. 1-6. Specimens from near the type locality of *Uvigerina gardnerae* Cushman and Applin, 1926 (= *U. peregrina*).—*1, 2a, 3a, 4-6.* Typical specimens selected to illustrate varying degrees of spinosity, ×75.—*2b, 3b, 3c.* Magnified views of the test surface showing clearly that the imperforate serrate costae are essentially noncontinuous parallel rows of closely packed elongate calcite blades, whereas the spines are randomly oriented, individual calcite blades. Interspinal areas have numerous pores, ×750.


1
2a
3a
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5
6
2b
3b
3c

Plate 9

UVIGERINA PEREGRINA Cushman, 1923

Specimens from the Holocene of the Gulf of Mexico and North Atlantic Ocean.

Figs. 1-5. Specimens from a depth of 4,649 feet in the Gulf of Mexico.—*1a, 2, 3, 4a, 5a.* Specimens showing varying degrees of spinosity, ×75.—*1b, 4b, 5b.* Magnified details of test showing serrate costae and multiple fine pores, ×750.

Fig. 6. Megaspheric specimen taken in 5,948 feet of water southeast of Cape Cod in the North Atlantic Ocean near the type locality for the species, ×75.

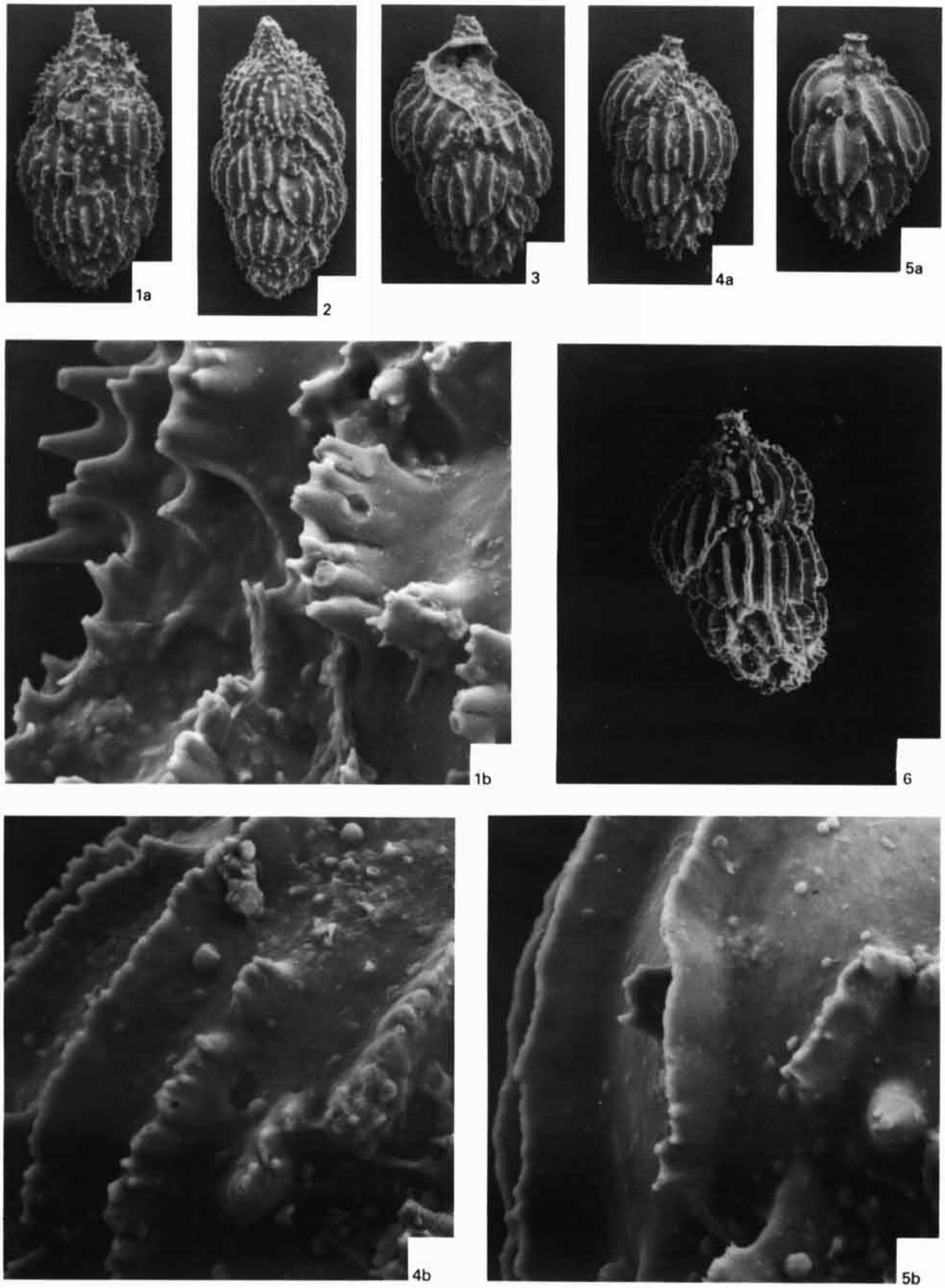

1a
2
3
4a
5a
1b
6
4b
5b

Plate 10

UVIGERINA SPINICOSTATA
Cushman and Jarvis, 1929

Topotype specimens from the middle Oligocene (*Globigerina ampliapertura* Zone) of the lower Cipero Marl of Trinidad.

Figs. 1-5. Megaspheric specimens *(1, 4a, 5a)* and microspheric specimens *(1, 2a, 3)* showing shape of test and arrangement of costae, ×75.—*4b*. Enlarged front view of apertural cleft, ×150.—*2b, 4c*. Enlarged top view showing costae swirling tangentially around aperture.—*5b*. Enlarged view of costae, ×150.—*5c*. Enlarged view of basal spines, ×750.—*4d*. Magnified segment of test surface with serrated costae, ×750.

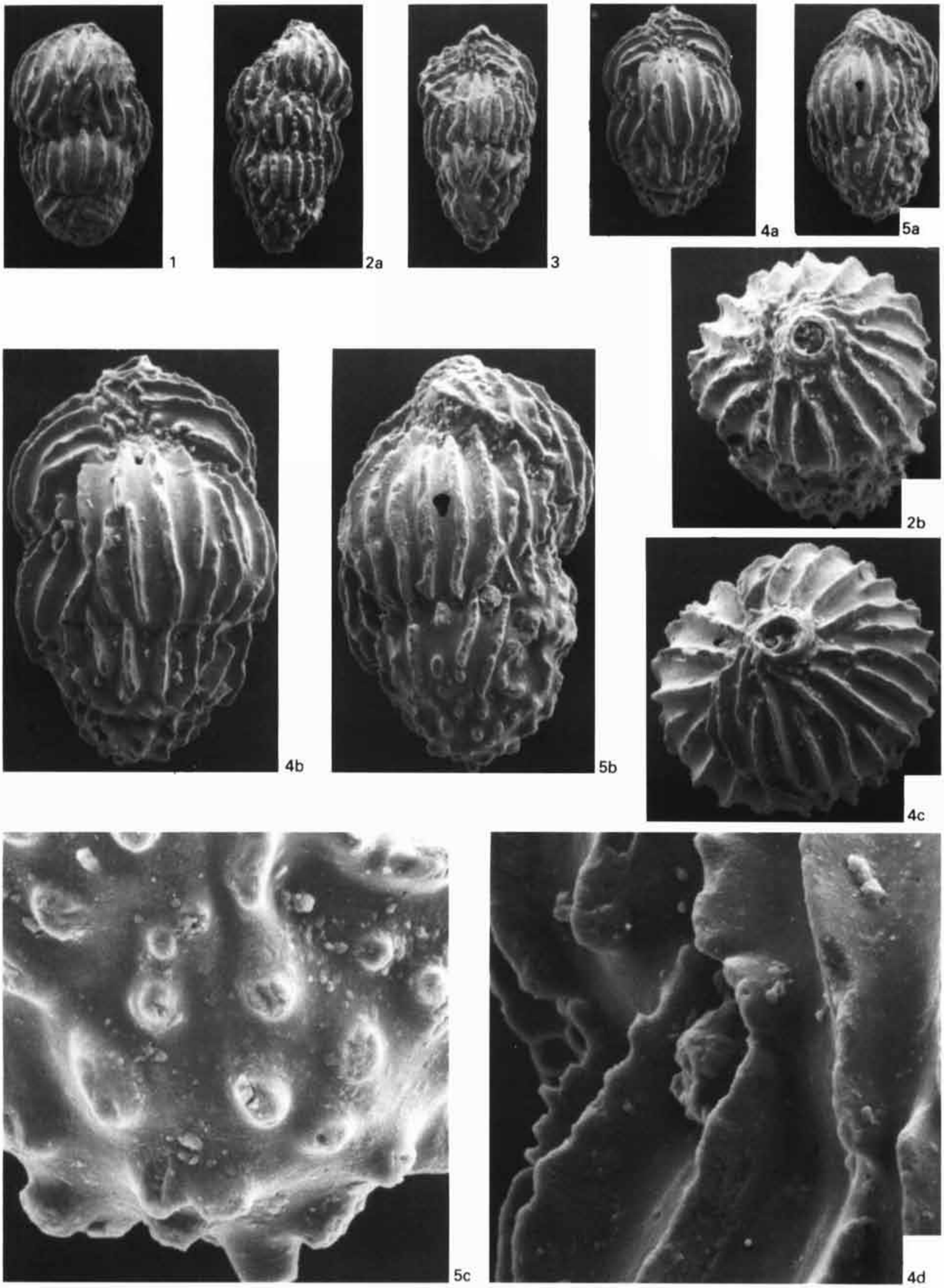

1
2a
3
4a
5a
2b
4b
5b
4c
5c
4d

Plate 11

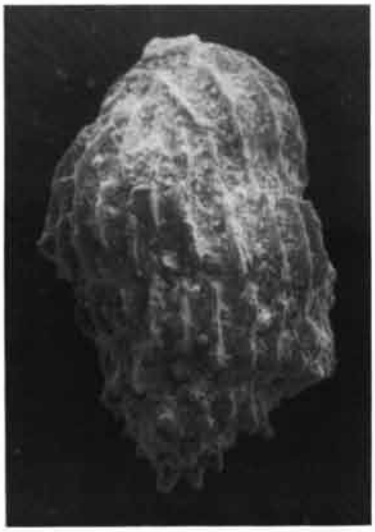
UVIGERINA SPINICOSTATA
Cushman and Jarvis, 1929

Specimens from the middle Oligocene (*Globigerina ampliapertura* Zone) of Venezuela and Cuba.

Figs. 1-3. Megaspheric specimens *(1, 3)* and microspheric specimen *(2)* from outcrop at Punta Tolete in the Gulf of Paria, Venezuela, ×150.

Figs. 4-8. Microspheric specimen *(4)* and megaspheric specimens *(5-8)* from Mantanzas, Cuba, exhibiting characteristic swirling of costae around aperture; *4-6,* ×150, *7, 8a,* ×75.—*8b.* Magnified portion of test surface with costae and pores, ×750.


1


2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7


8a

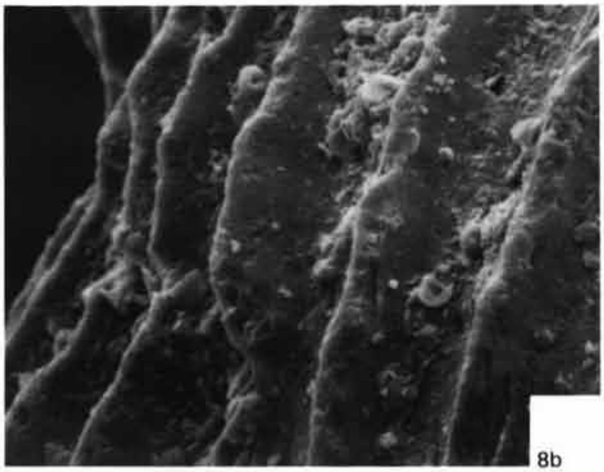

8b

Plate 12

UVIGERINA PRAEHUBBARDI
Lamb and Miller, new species

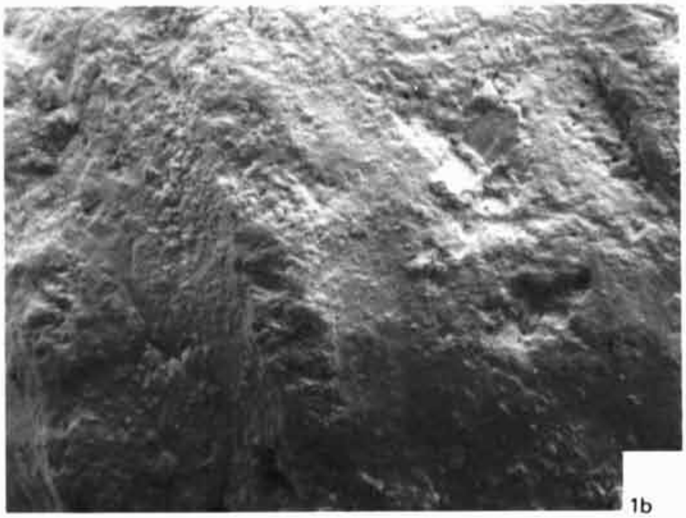
Specimens from the middle Oligocene Rices Mudstone Member of the San Lorenzo Formation, Santa Cruz Mountains, California.

Figs. 1-3.—*1a, 2, 3a.* Side views of partially calcified specimens showing loosely coiled later chambers, nearly central apertures, lack of apertural clefts, and both continuous and discontinuous costae. Close inspection of figures *1a* and *2* reveals the presence of serrated costae and rare spines, ×75.—*1b, 3b.* Close-up of test surface showing a few pores visible though the calcified layer, ×750.—*1c.* Top view showing serrated costae breaking into spines, ×300.


1a


2


3a


1b


1c

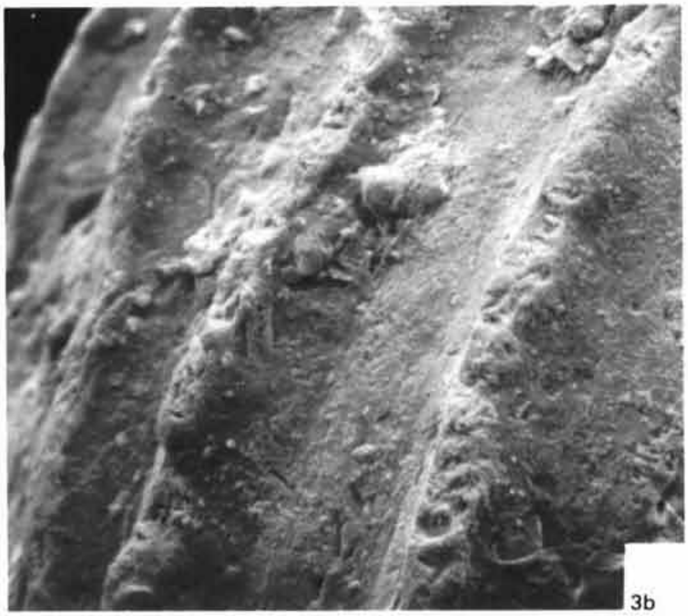

3b

Plate 13

RECTUVIGERINA HUBBARDI
(Galloway and Heminway), 1941

Specimens from the Miocene of Venezuela, Trinidad, and Colombia.

Fig. 1. Magaspheric specimen from the Lower Miocene (*Catapsydrax dissimilis* Zone) Carapita Formation of eastern Venezuela, with well-developed parallel continuous costae, ×75.

Figs. 2,3. Megaspheric specimens from the Middle Miocene (*Globorotalia fohsi fohsi* Zone) Cipero Formation, Nariva Quarry, Trinidad.—*2a*. Side view of slightly calcified specimen, ×75.—*2b*. Enlargement of apertural area showing costae breaking into spines, ×750.—*2c*. Enlargement of initial end, ×750.—*3a*. Megaspheric individual, ×75.—*3b*. Close-up of test surface with serrate costae, ×750.

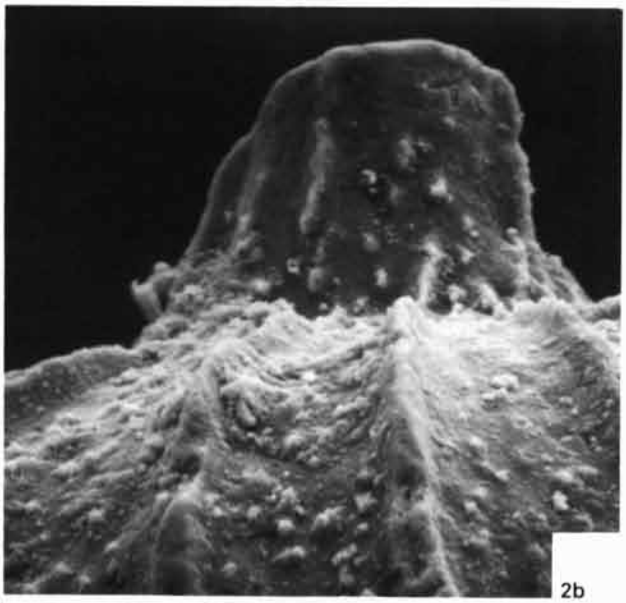
Fig. 4.—*4a*. Megaspheric specimen from the Middle Miocene (*Globorotalia fohsi peripheroronda* Zone) Flore Santo Formation, Sinu basin, Colombia, ×75.—*4b*. Close-up of test surface with serrate costae and fine pores, ×1,500.


1

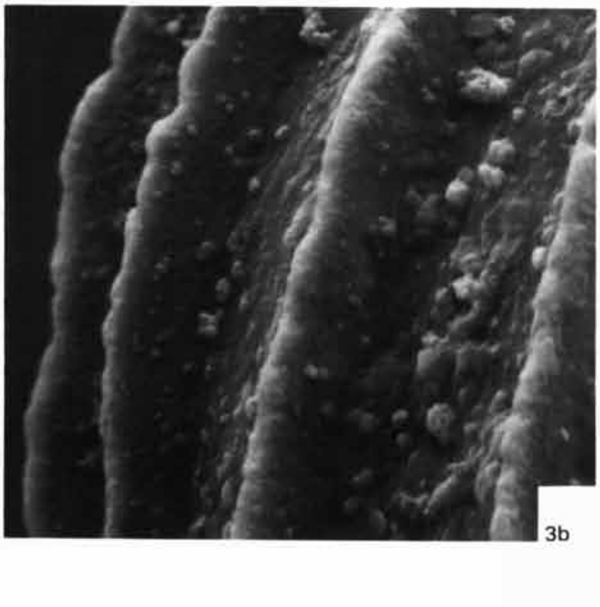

2a


3a


4a


2b


2c


3b

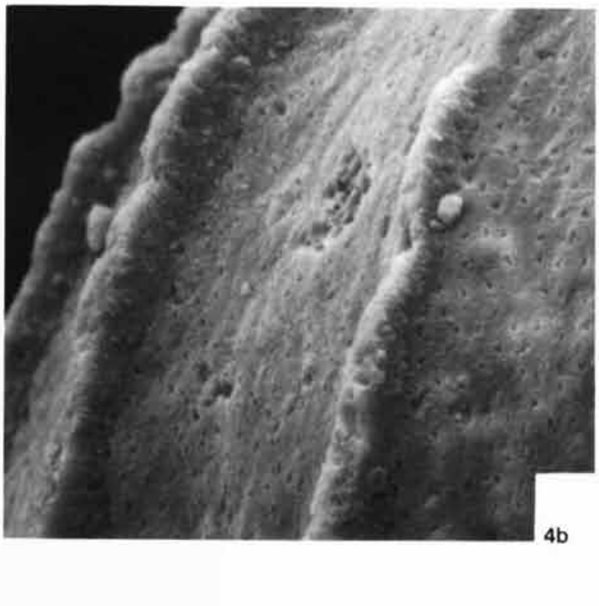

4b

Plate 14

RECTUVIGERINA MULTICOSTATA (Cushman and Jarvis), 1929

Specimens from the Miocene of Venezuela and Ecuador.

Fig. 1.—*1a.* Megaspheric specimen from the Lower Miocene (*Catapsydrax stainforthi* Zone) Carapita Formation of eastern Venezuela, with mostly discontinuous parallel costae, ×75.—*1b.* Magnified detail of apertural area showing serrated costae breaking into spines, ×300.—*1c.* Close-up of sutural area showing costae discontinuous at the sutures and intercostal pores, ×750.

Figs. 2,3. Megaspheric *(2)* and microspheric *(3)* specimens from the Lower Miocene (*Globigerinatella insueta* Zone) Viche Formation, Borbon basin, Ecuador.—*2a.* Individual with somewhat deformed last chamber, ×75.—*2b.* Enlarged detail of last chamber illustrating serrate costae breaking into spines, ×300.—*2c.* Magnified detail of apiculate base, ×300.—*3.* Typical specimen, ×75.

RECTUVIGERINA OPTIMA (Cushman), 1943

Specimens from the Miocene of Jamaica.

Figs. 4,5. Megaspheric *(4)* and microspheric *(5)* specimens from the Middle Miocene (*Globorotalia siakensis* Zone) Buff Bay Formation of Jamaica, ×75. Shown are the prominant necks with phialine lips, sharply overhanging costae at sutural junctions, and apiculate bases. Close inspection of *5* reveals serrate costae breaking into spines on final chambers.

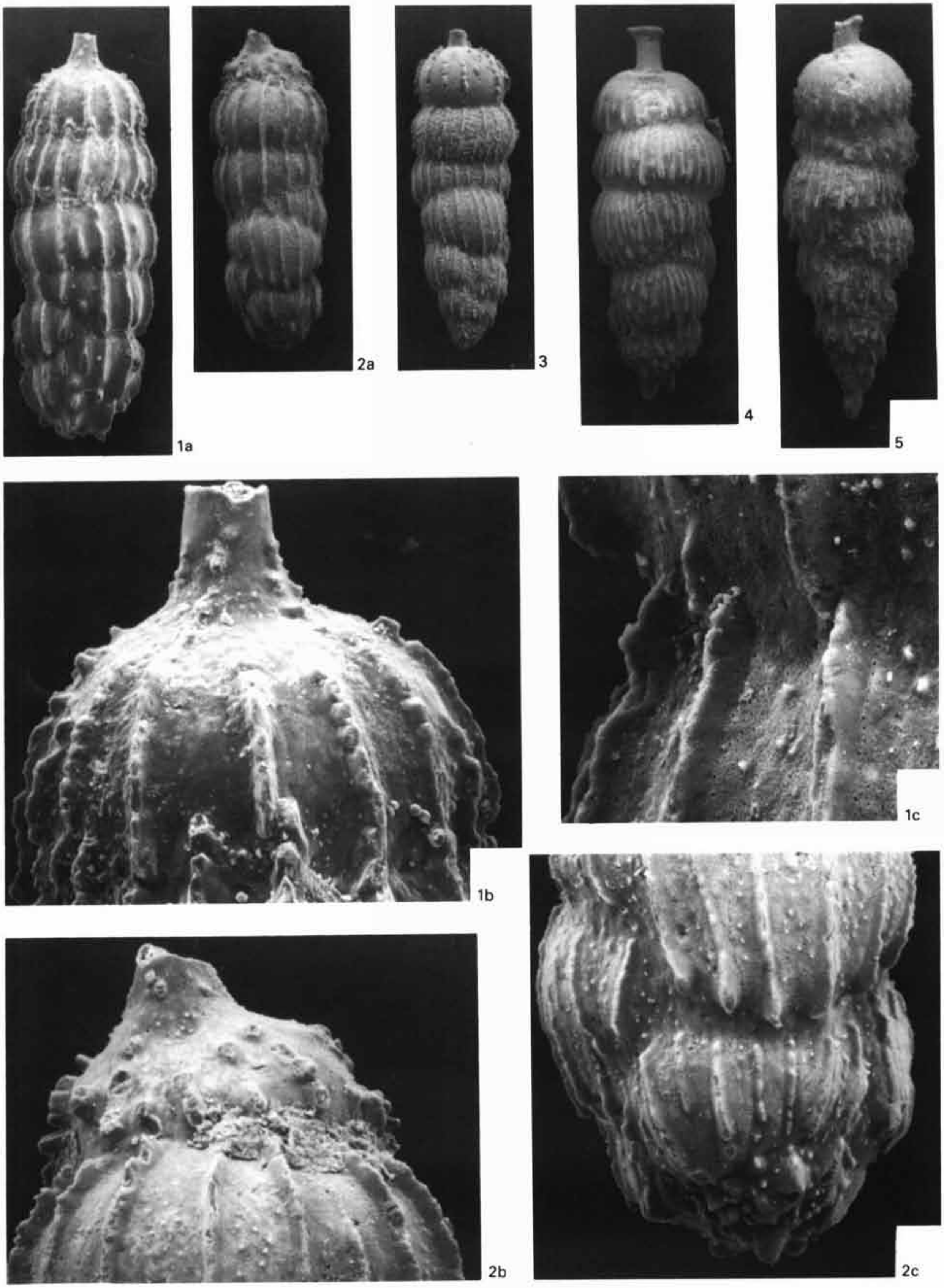

1a
2a
3
4
5
1b
1c
2b
2c

Plate 15

ESTORFFINA MAYI (Cushman and Parker), 1931

Specimens from the Miocene of the Atlantic slope and California.

Figs. 1-3.—*1a, 2a, 3.* Seemingly microspheric specimens from the Lower Miocene (*Globorotalia kugleri* Zone) Atlantic slope margin off Cape Fear, North Carolina, characterized by a slender test, overhang of costae at sutural juntions, and wide, short neck with phialine lip, ×75.—*1b.* Magnified detail of later chambers and broken aperture revealing an internal toothplate, ×300.—*2b.* Close-up of apertural area showing serrated costae composed of calcite blades, ×750.

Figs. 4,5.—*4a, 5a.* Partially calcified specimens from the Saucesian Stage (*Siphogenerina transversa* Zone of Lamb and Hickernell, 1972) of the San Joaquin Valley, California, ×75.—*4b.* Enlargement of broken chamber wall showing coarse pore arrangement, ×3,000.—*5b.* Magnified detail of sutural area showing coarse pore pattern, ×750.

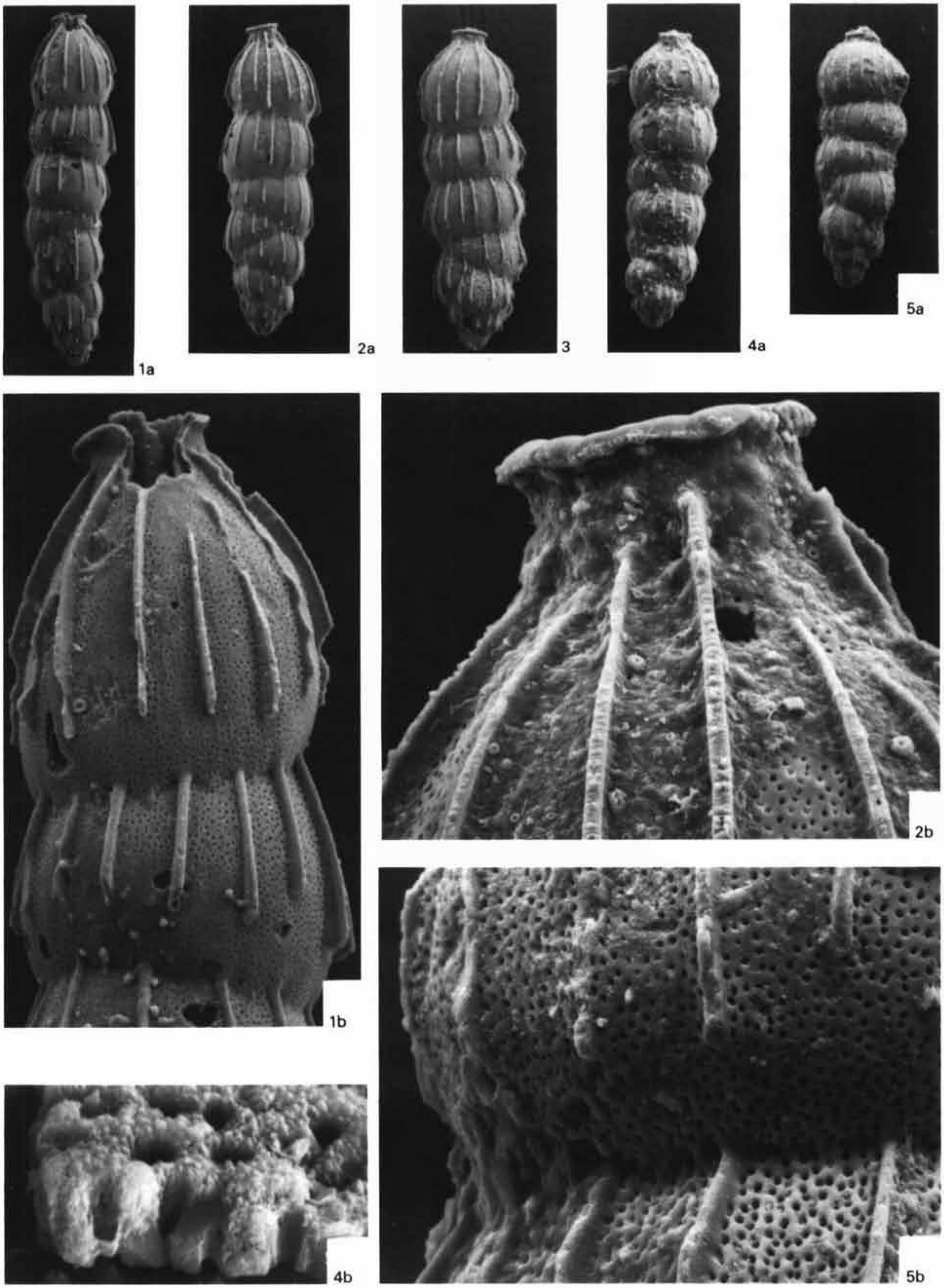

1a
2a
3
4a
5a
1b
2b
4b
5b

Plate 16

UVIGERINA JACKSONENSIS Cushman, 1925

Specimens from the Eocene of Alabama and the Oligocene of Mexico.

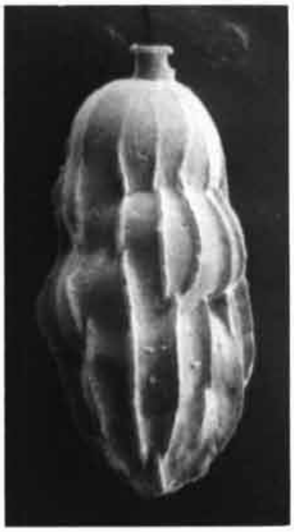
Figs. 1-3. Specimens from the Upper Eocene (*Globorotalia cerroazulensis* Zone) Cocoa Sand Member of Alabama.—*1, 2a.* Megaspheric specimens illustrating inflated chambers, costae that are either restricted to individual chambers or extend over several chambers, and apertural necks with phialine lips, ×75.—*2b.* Magnified view of test surface showing smooth plate-like costae and intercostal pores, ×750.—*3.* Microspheric specimen, ×75.

Figs. 4-6. Specimens from the middle Oligocene (upper *Globigerina ampliapertura* Zone) Palma Real Formation of Mexico.—*4a, 5, 6.* Megaspheric individuals with characteristics similar to those of specimens from the Eocene Cocoa Sand Member of Alabama, ×75.—*4b.* Magnified view of sutural junction showing terminations of some discontinuous costae, ×750.


1

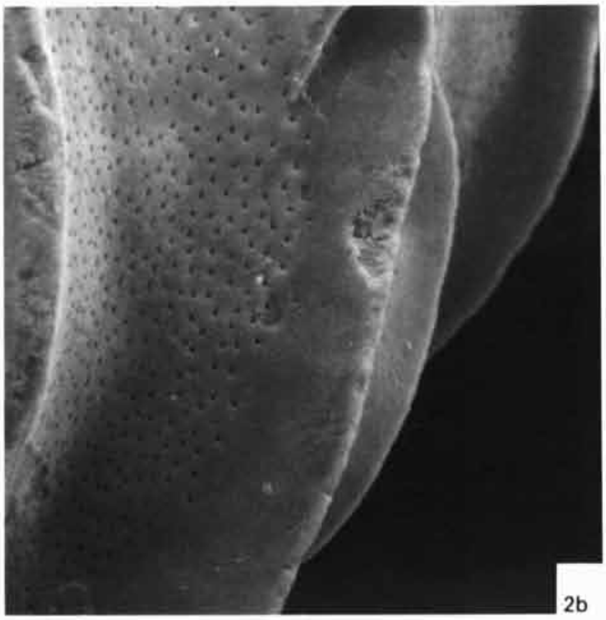

2a


3


4a


5


6


2b

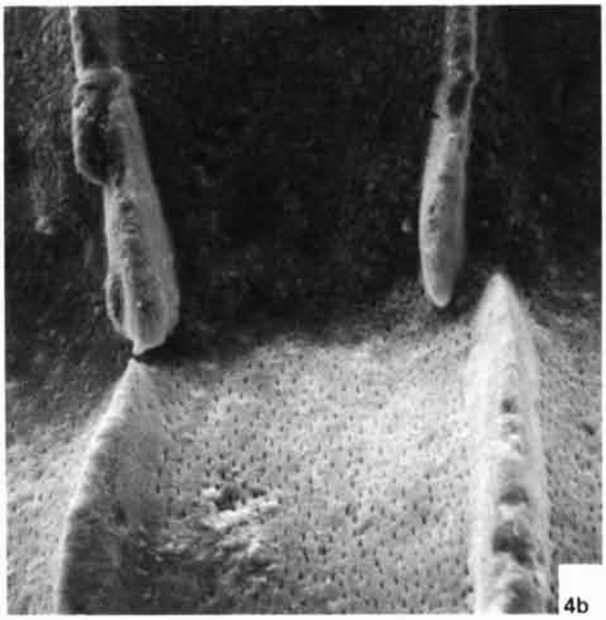

4b

Plate 17

UVIGERINA TUMEYENSIS Lamb, 1964

Specimens from the Oligocene of Mexico and the Sable Island region, Nova Scotia.

Figs. 1-4. Specimens from the middle Oligocene (upper *Globigerina ampliapertura* Zone) Palma Real Formation of Mexico. Megaspheric specimen *(1)* and microspheric specimens *(2, 3a, 4)* with high, platelike costae, mostly continuous but fading on last chamber and often anastomosing, and necks with phialine lips in slight depressions, ×75.—*3b.* Enlarged view of test surface showing smooth platelike costae and highly perforate wall, ×750.

Figs. 5,6. Specimens from the middle Oligocene (lower *Globorotalia opima opima* Zone) in Mobile Well C-67, Sable Island region, Nova Scotia.—*5, 6a.* Microspheric individuals, ×75.—*6b.* Enlarged view of test surface, ×750.


1

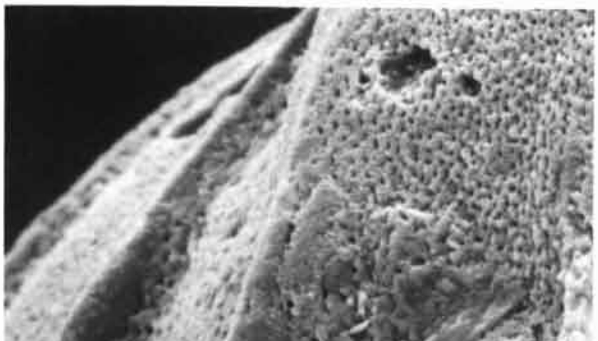

2


3a


4


5


6a


3b

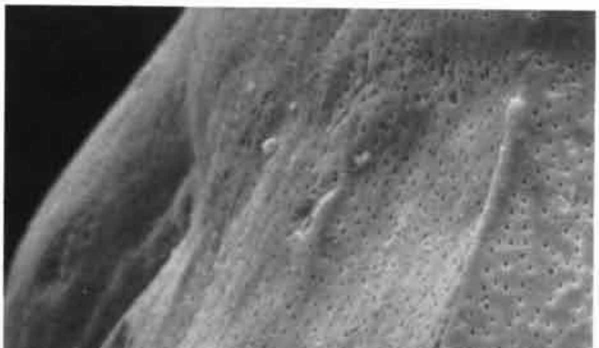

6b

Plate 18

UVIGERINA TUMEYENSIS Lamb, 1964

Specimens from the middle Oligocene of California and Venezuela.

Figs. 1,2. Specimens from the middle Oligocene (*Uvigerina tumeyensis* Range-zone) upper part of the Rices Mudstone Member of the San Lorenzo Formation, Santa Cruz Mountains, California (sample B4364 of Fairchild, Wesendunk, and Weaver, 1969), ×75.

Figs. 3-6. Topotype specimens from the middle Oligocene (*Uvigerina tumeyensis* Range-zone) within core at 8,704–8,787 feet, lower part of the Pleito Formation, in Richfield Oil Company's San Emigdio Well E-1, Kern County, California, ×75.

Figs. 7-9. Specimens from the middle Oligocene (lower *Globorotalia opima opima* Zone) Pecaya Formation, in the T.O.V. Well 57, core at 2,116 feet, Falcón, Venezuela, ×75.

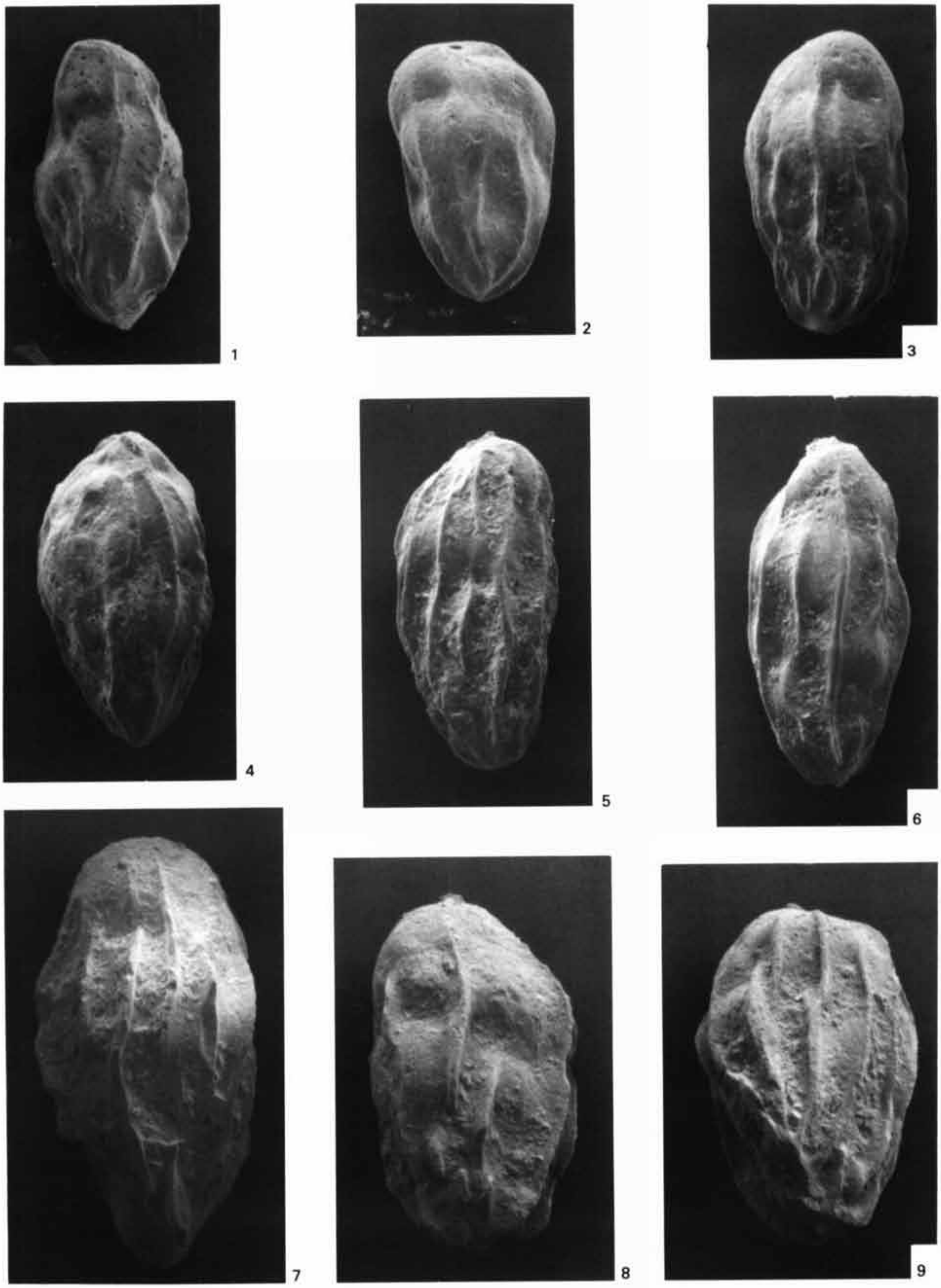

1
2
3
4
5
6
7
8
9

Plate 19

UVIGERINA ADELINENSIS
Palmer and Bermúdez, 1949

Specimens from the Oligocene of Mexico and Cuba.

Figs. 1,2. Specimens from the middle Oligocene (upper *Globigerina ampliapertura* Zone) Palma Real Formation of Mexico.—*1a, 2.* Specimens exhibiting high platelike trialate costae that dominate the surface ornamentaion and the short neck with phialine lip set in a slight depression, ×75.—*1b.* Enlarged view of test surface showing smooth platelike costae and highly perforate wall, ×750.

Figs. 3-6. Topotype specimens from the middle Oligocene (lower *Globorotalia opima opima* Zone) Adelina Marl of Cuba.—*3-5, 6a.* Specimens showing typical strong trialation of the costae, ×75.—*6b.* Enlarged view of test surface, ×1,500.

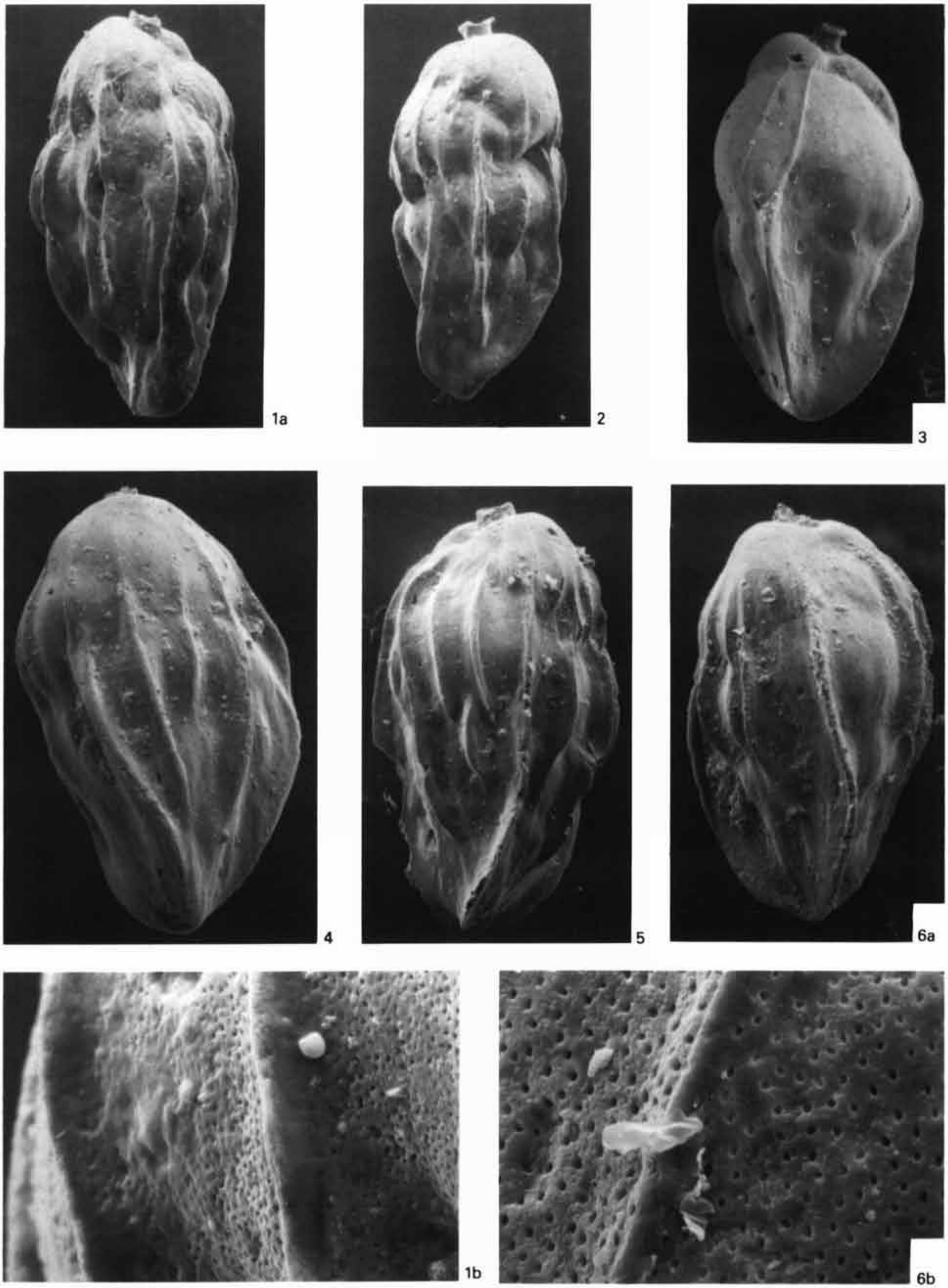

1a
2
3
4
5
6a
1b
6b

Plate 20

TIPTONINA NODIFERA
(Cushman and Kleinpell), 1934

Specimens from the middle to upper Oligocene of California and the upper Oligocene of Ecuador and Venezuela.

Figs. 1,2. Megaspheric *(1)* and microspheric *(2)* specimens from the upper Oligocene (*Globigerina ciperoensis* Zone) upper Areo Formation of eastern Venezuela showing development of continuous, high, platelike, parallel costae, loosely coiled later chambers, and an aperture centrally positioned on the last chamber, ×75.

Figs. 3-7. Megaspheric specimens *(3-6)* and microspheric specimen *(7)* from the upper Oligocene (*Globigerina ciperoensis* Zone) Las Canas Formation in the Las Canas Well 1, at a depth of 1,715 feet, Progresso basin, Ecuador, ×75. Note incipient sutural arches on specimen in *7*.

Figs. 8,9. Topotype megaspheric calcified specimens from the upper Oligocene (*Tiptonina nodifera* Range-zone) Lower Santos Shale, 90 to 100 feet below Agua Sandstone, Chico Martinez Creek, California, ×75.

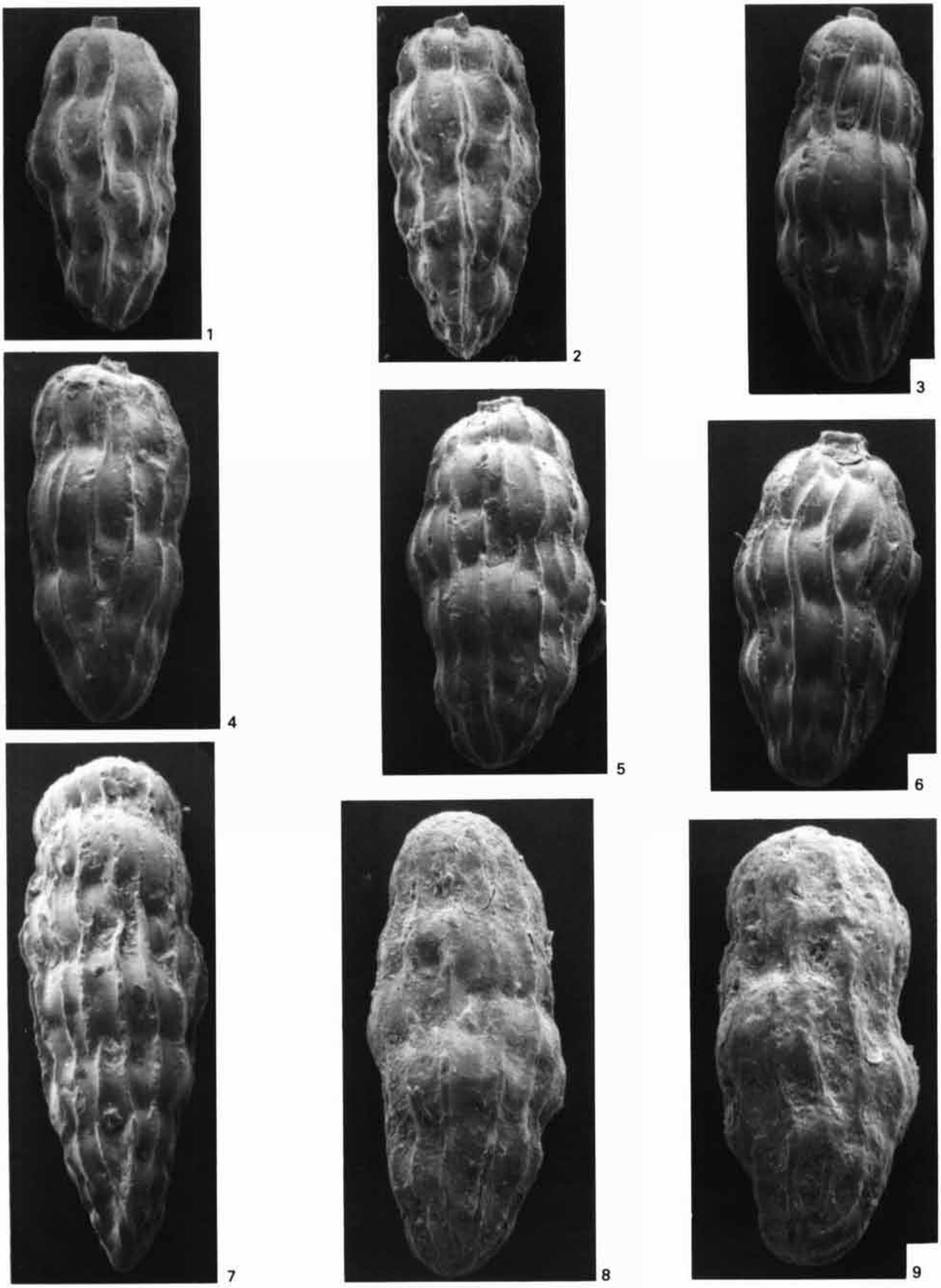
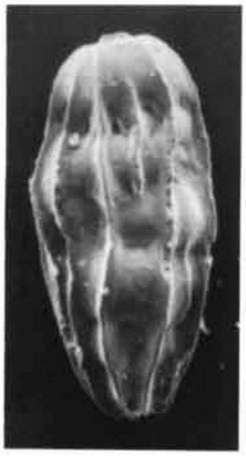


Plate 21

TIPTONINA NODIFERA
(Cushman and Kleinpell), 1934

Specimens from the upper Oligocene (*Globigerina ciperoensis* Zone) subsurface Anahuac Formation in Matagorda County, Texas.

Figs. 1-6.—*1-4, 5a, 6a.* Megaspheric specimens with continuous, high, platelike, parallel costae, loosely coiled later chambers, and aperture centrally positioned on the last chamber, ×75.—*5b.* Enlarged view of test surface, ×750.—*6b.* Magnified view of a broken last chamber showing slightly recessed aperture, smooth, platelike costae, and intercostal pores, ×300.


1

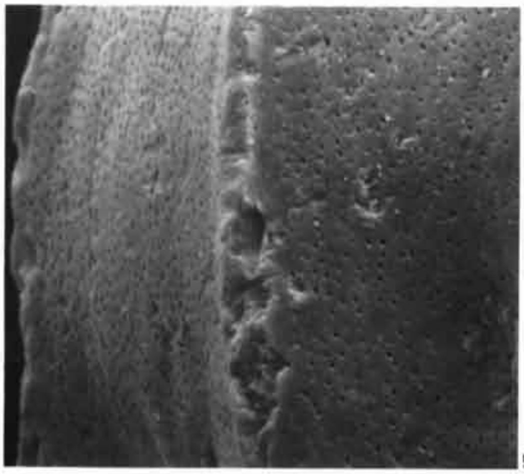

2


3


4


5a


6a


5b

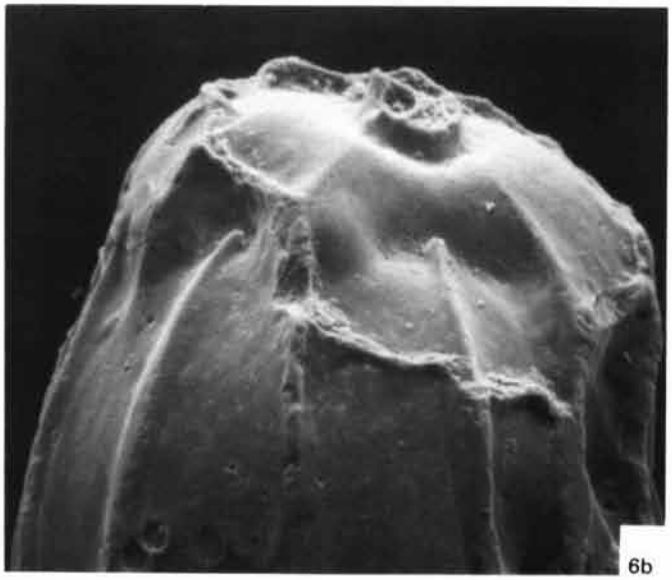

6b

Plate 22

TIPTONINA NODIFERA
(Cushman and Kleinpell), 1934

Specimens from the upper Oligocene (*Globigerina ciperoensis* Zone) of Texas and Brazil.

Figs. 1,2. Megaspheric specimens from the subsurface Anahuac Formation of Matagorda County, Texas, ×75.

Figs. 3-9. Megaspheric specimens *(3-7)* and microspheric specimens *(8, 9)* from the subsurface of the Santos basin, offshore Brazil, ×75.

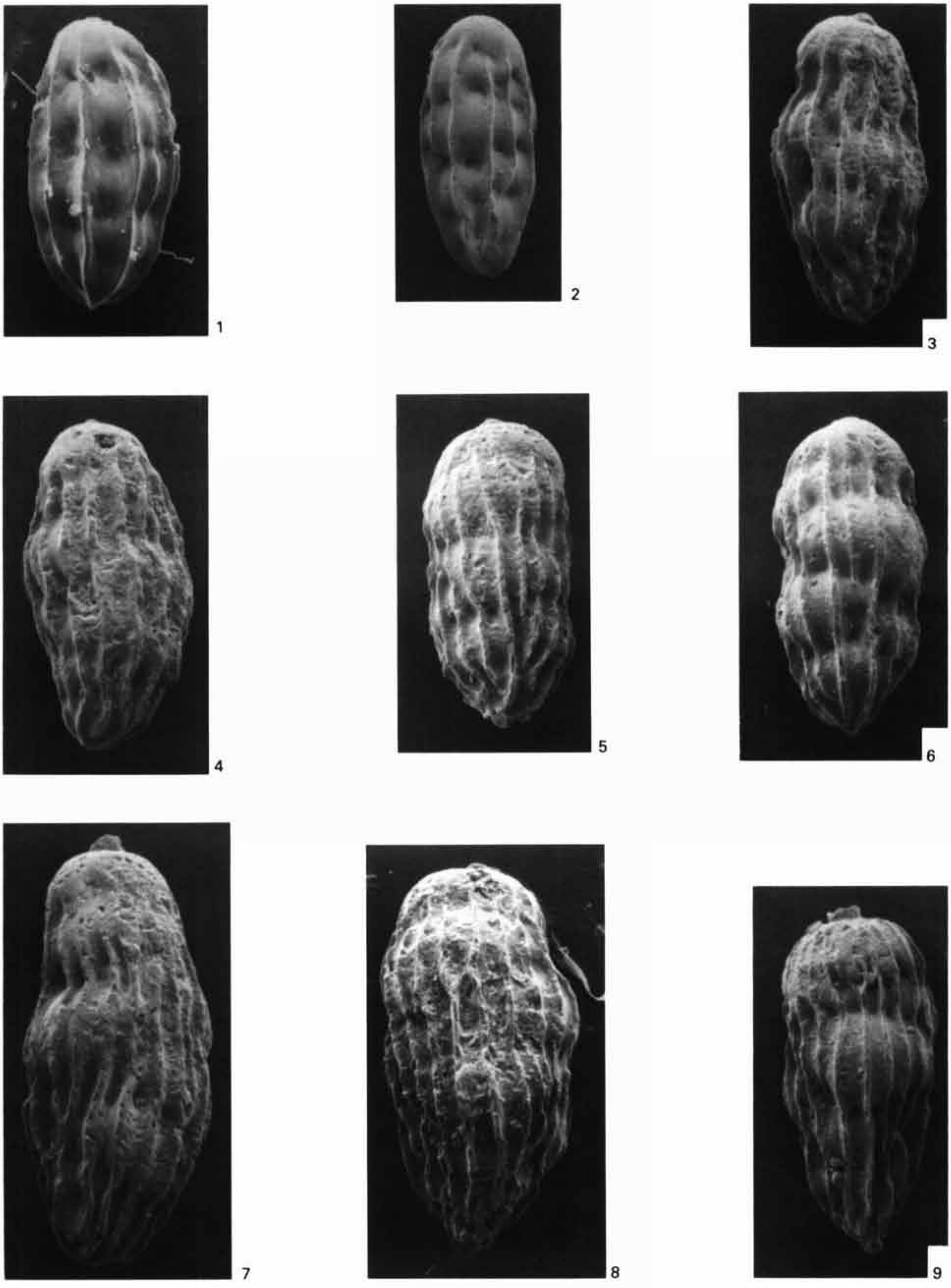

1
2
3
4
5
6
7
8
9

Plate 23

TRANSVERSIGERINA TRANSVERSA (Cushman), 1918

Specimens from the Lower Miocene (*Catapsydrax stainforthi* Zone) lower Carapita Formation, in J.G.E. Well 27 at a depth of 4,284 feet, northern Monagas, eastern Venezuela.

Figs. 1-6. Microspheric specimens *(1, 2a, 5, 6a)* and megaspheric specimens *(3a, 4)* showing early triserial chambers followied by a long series of uniserial chambers, high, platelike parallel costae, and development of arched sutures reflecting the scalloped nature of the chamber base, ×75.—*2b.* Enlarged view of the smooth platelike costae, intercostal pores, and the interior of an arched suture, ×750.—*3b.* Close-up of the smooth, platelike costae and intercostal pores, ×750.—*6b.* Close-up of base of test showing confluence of costae, ×200.

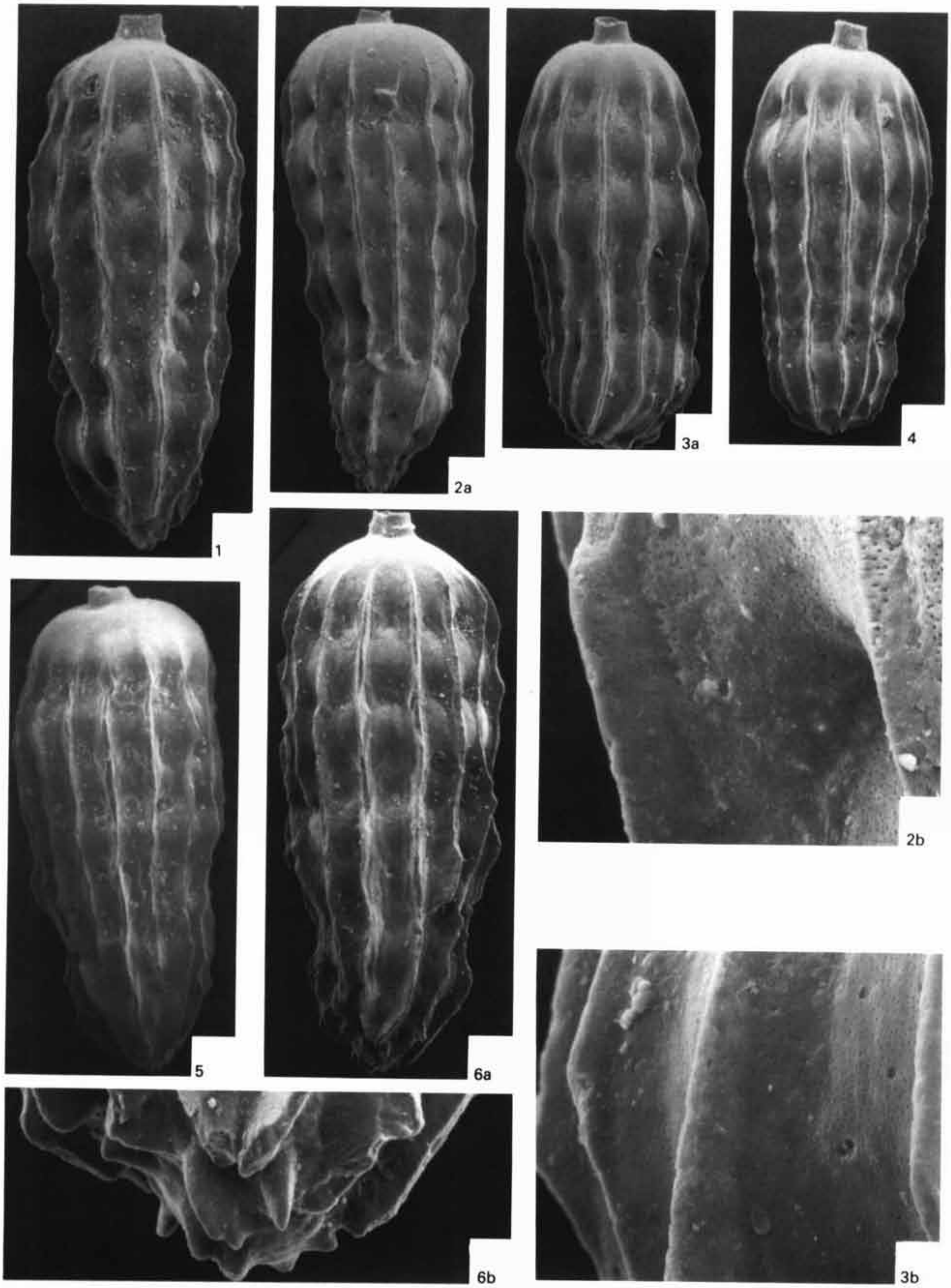

1
2a
3a
4
2b
5
6a
6b
3b

Plate 24

TRANSVERSIGERINA TRANSVERSA (Cushman), 1918

Specimens from the Lower Miocene of Brazil and California.

Figs. 1-3. Moderately weathered megaspheric specimens *(1, 2a)* and microspheric specimen *(3a)* from the Lower Miocene (*Globigerinatella insueta* Zone) subsurface of the Santos basin, offshore Brazil, ×75.—*2b.* Close-up of weathered test surface, ×750.—*3b.* Close-up of test surface at junction of chambers, showing arched suture, ×750.

Figs. 4,5. Microspheric *(4)* and megaspheric *(5)* specimens from the Lower Miocene (*Transversigerina transversa* Range-zone) Jewett Silts, in the ROCO Boston Well 1, east side San Joaquin Valley of California, ×75.—*5b.* Close-up of test surface at junction of chambers showing arched suture, ×750.

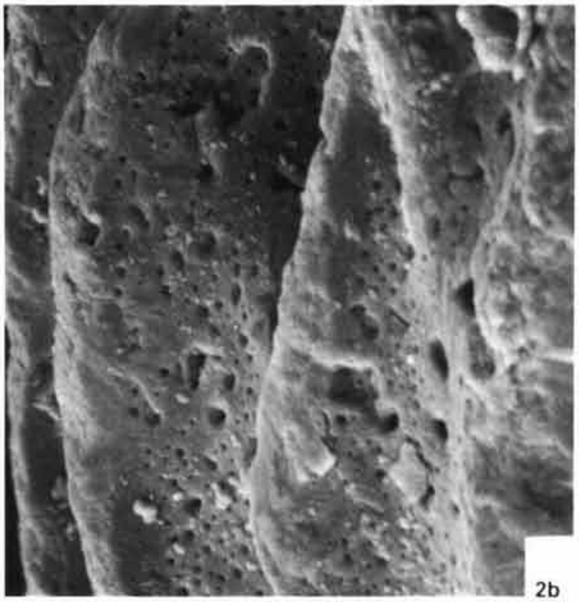
1

2a

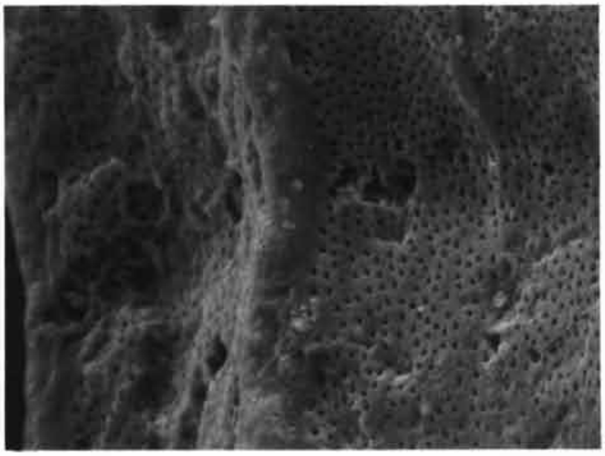
3a

4

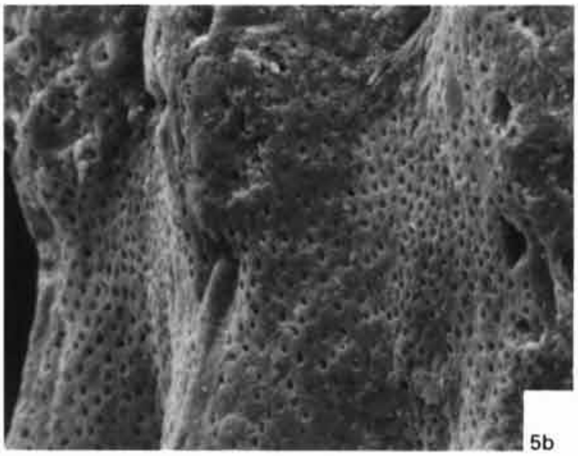
5a



2b



3b



5b

Plate 25

TRANSVERSIGERINA COLLOMI (Cushman), 1925

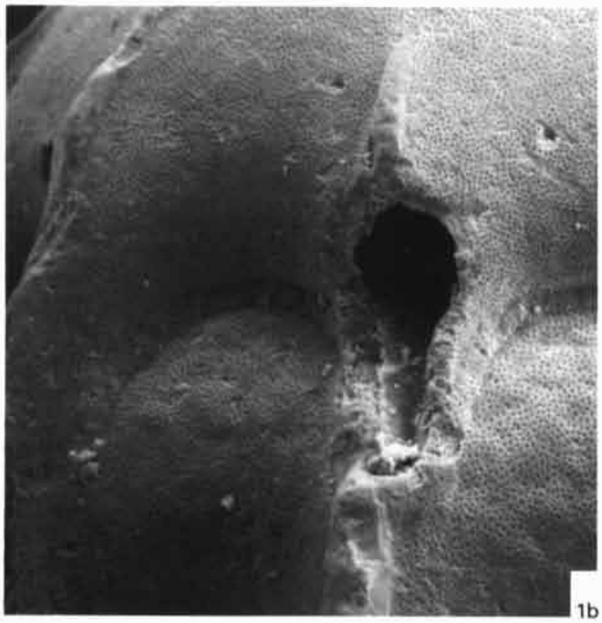
Specimens from the Middle Miocene (*Praeorbulina glomerosa* Zone) Carapita Formation of northern Monagas, Venezuela.

Figs. 1-3. Microspheric specimen *(1a)* illustrating a very short triserial stage followed by an extensive uniserial stage, and megaspheric specimens *(2, 3a)* having essentially a complete uniserial development, ×75.—*1b, 3b.* Close-up of the junction of two chambers, showing well-developed arched suture and coarse wall perforations. Note how the costa has become an extension of the perforate chamber wall, here overlain with an imperforate calcite ridge, ×300.

1a

2

3a



1b

3b

Plate 26

TRANSVERSIGERINA COLLOMI
(Cushman), 1925

Specimens from the Middle Miocene of California and Venezuela.

Figs. 1-3. Slightly calcified megaspheric specimens *(1, 2)* and microspheric specimen *(3)* from the subsurface Middle Miocene (Luisian Stage) of the Tejon Ranch region, San Joaquin Valley, California, ×75.

Figs. 4,5. Microspheric *(4)* and megaspheric *(5)* specimens from the Middle Miocene (*Globorotalia fohsi fohsi* Zone) Carapita Formation of northern Monagas, Venezuela, ×75.—*4b.* Close-up of the junction of two chambers showing arched sutures and the smooth imperforate costal ridge, ×300.—*5b.* Magnified view of test surface and smooth, platelike costae, ×300.

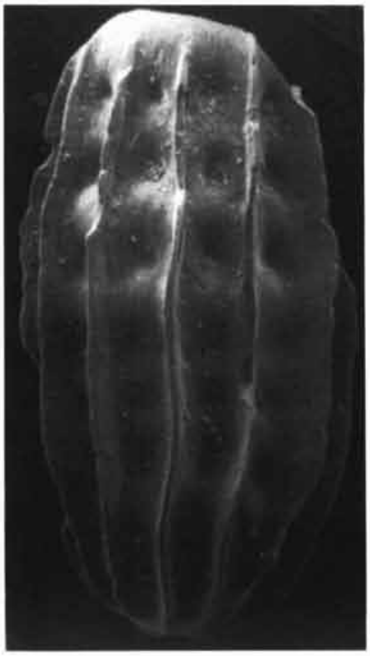
1

2

3

4b

4a



5a

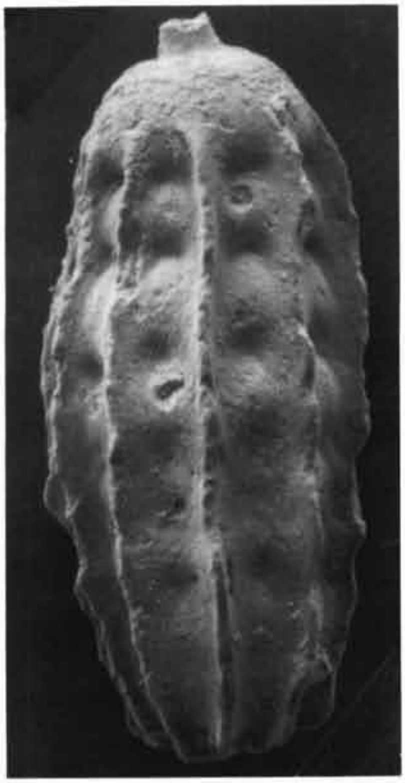
5b

Plate 27

TRANSVERSIGERINA COLLOMI
(Cushman), 1925

Specimens from the Middle Miocene (*Praeorbulina glomerosa* Zone) of the Darien basin, eastern Panama.

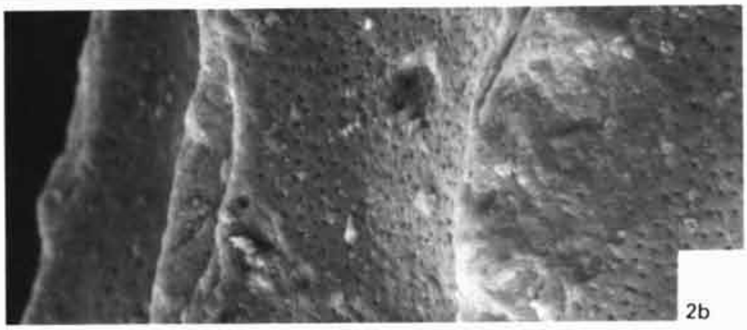
Figs. 1-4. Megaspheric specimens *(1a, 2a, 3)* and microspheric specimen *(4)* showing typical development of arched sutures, high platelike costae, and seemingly completely uniserial megaspheric adult specimens, ×75.—*1b, 2b.* Magnified views of test surface and arched sutures, ×750.



1a

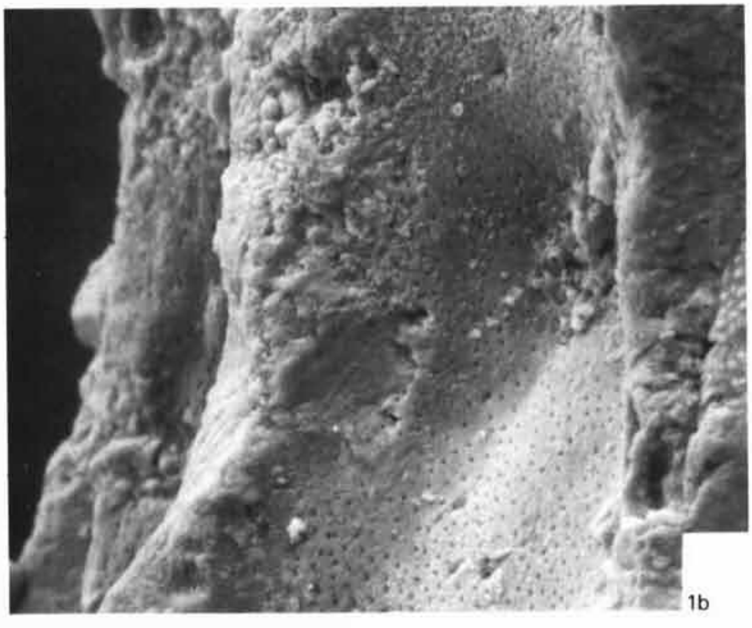
2a

3



2b

4



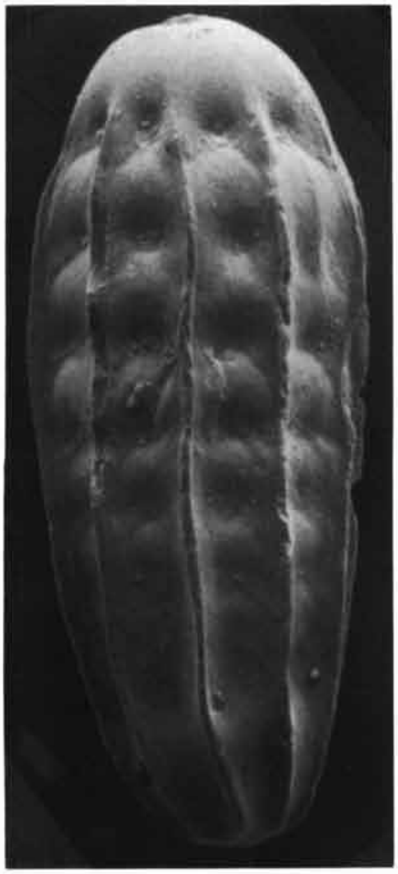
1b

Plate 28

TRANSVERSIGERINA COLLOMI (Cushman), 1925

Specimens from the Middle Miocene (*Praeorbulina glomerosa* Zone) of the Darien basin, eastern Panama.

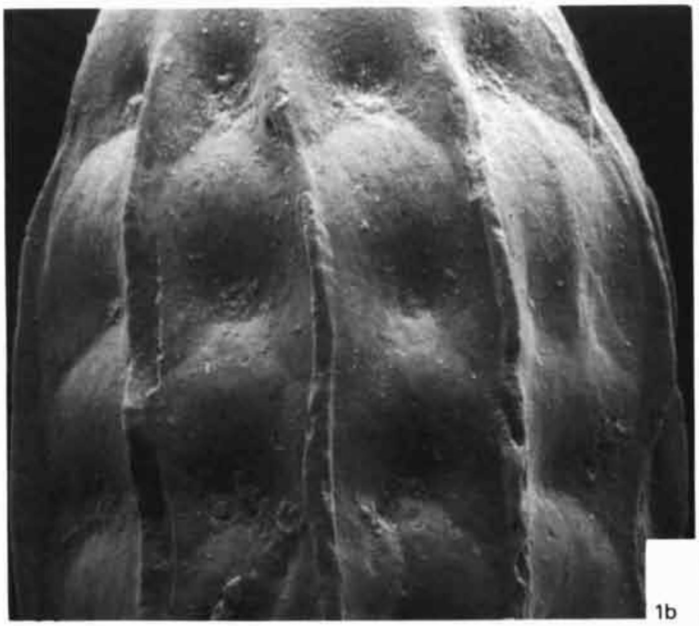
Figs. 1-3. Megaspheric specimens *(1a, 3)* and microspheric specimens *(2a)* showing development of sutural arches, high, platelike costae, and seemingly completely uniserial megaspheric adult specimens, ×75.—*1b, 2b.* Magnified detail of test surfaces and sutural arches, ×150 and ×300, respectively.



1a

2a

3



1b

2b

Plate 29

TRANSVERSIGERINA ACUTA (Bermúdez), 1949

Specimens from the Middle and Lower Miocene of Barbados and Ecuador.

Figs. 1-3. Microspheric specimens *(1, 3)* and megaspheric specimen *(2)* from the Middle Miocene (*Praeorbulina glomerosa* Zone) Bissex Hill Formation of Barbados exhibiting typical low height-to-width ratio, pronounced sutural arches, and high, thin, platelike costae, ×75.

Figs. 4-6. Megaspheric specimen *(4)* and microspheric specimens *(5, 6)* from the Lower Miocene (*Globigerinatella insueta* Zone) Viche Formation of the Borbon basin of coastal Ecuador, ×75.

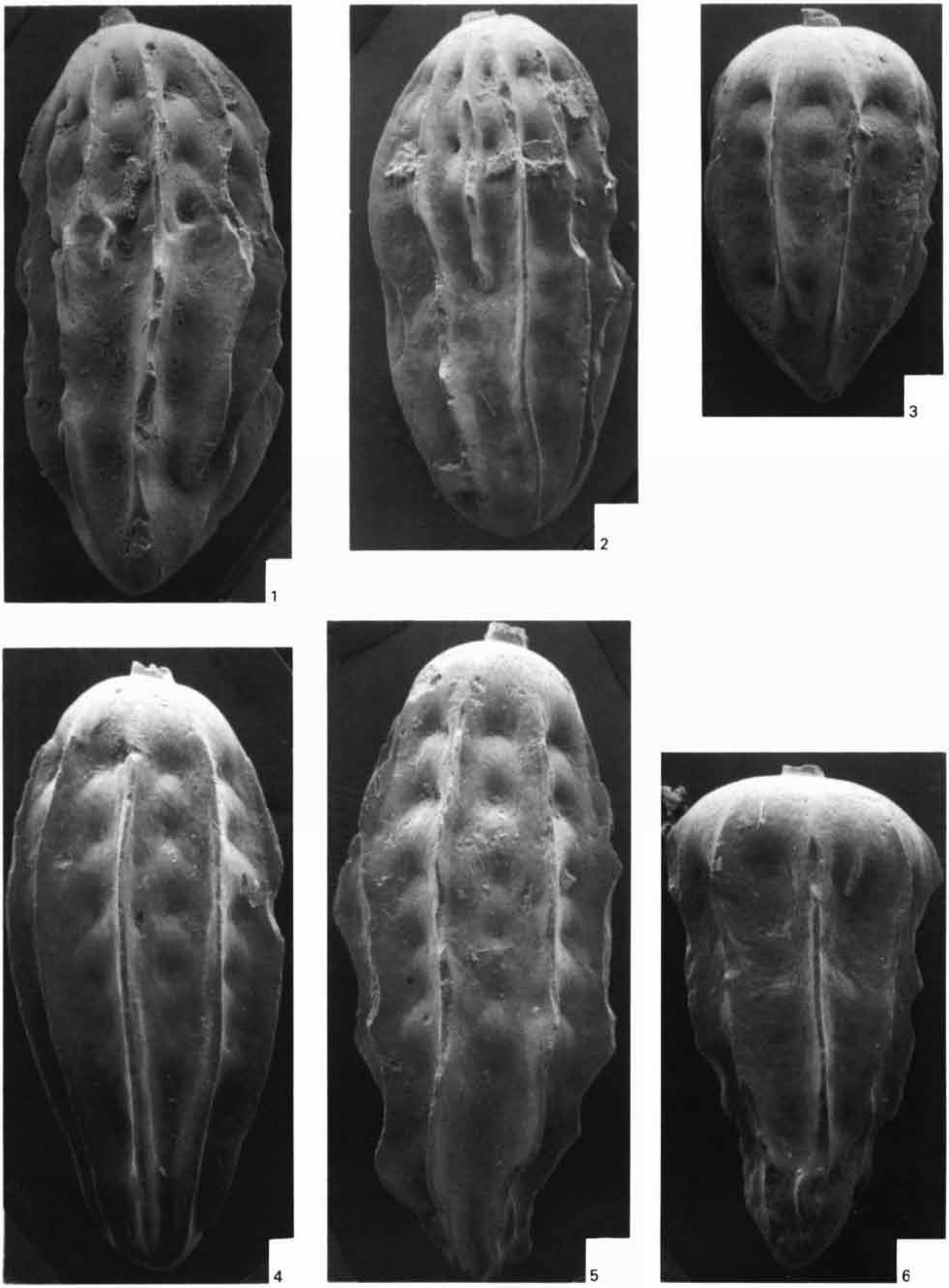


Plate 30

TRANSVERSIGERINA ACUTA (Bermúdez), 1949

Specimens from the Middle Miocene (*Praeorbulina glomerosa* Zone) Bissex Hill Formation of the island of Barbados.

Figs. 1,2.—*1a, 2a.* Typical, short, squat megaspheric specimens, ×75.—*1b.* Magnified view of initial end showing confluence of costae, ×300.—*1c, 2c.* Close-up at junction of two chambers showing sutural arches, ×300 and ×750, respectively.—*2b.* Magnified view of broken last chamber with vivid outline of sutural arches, ×300.

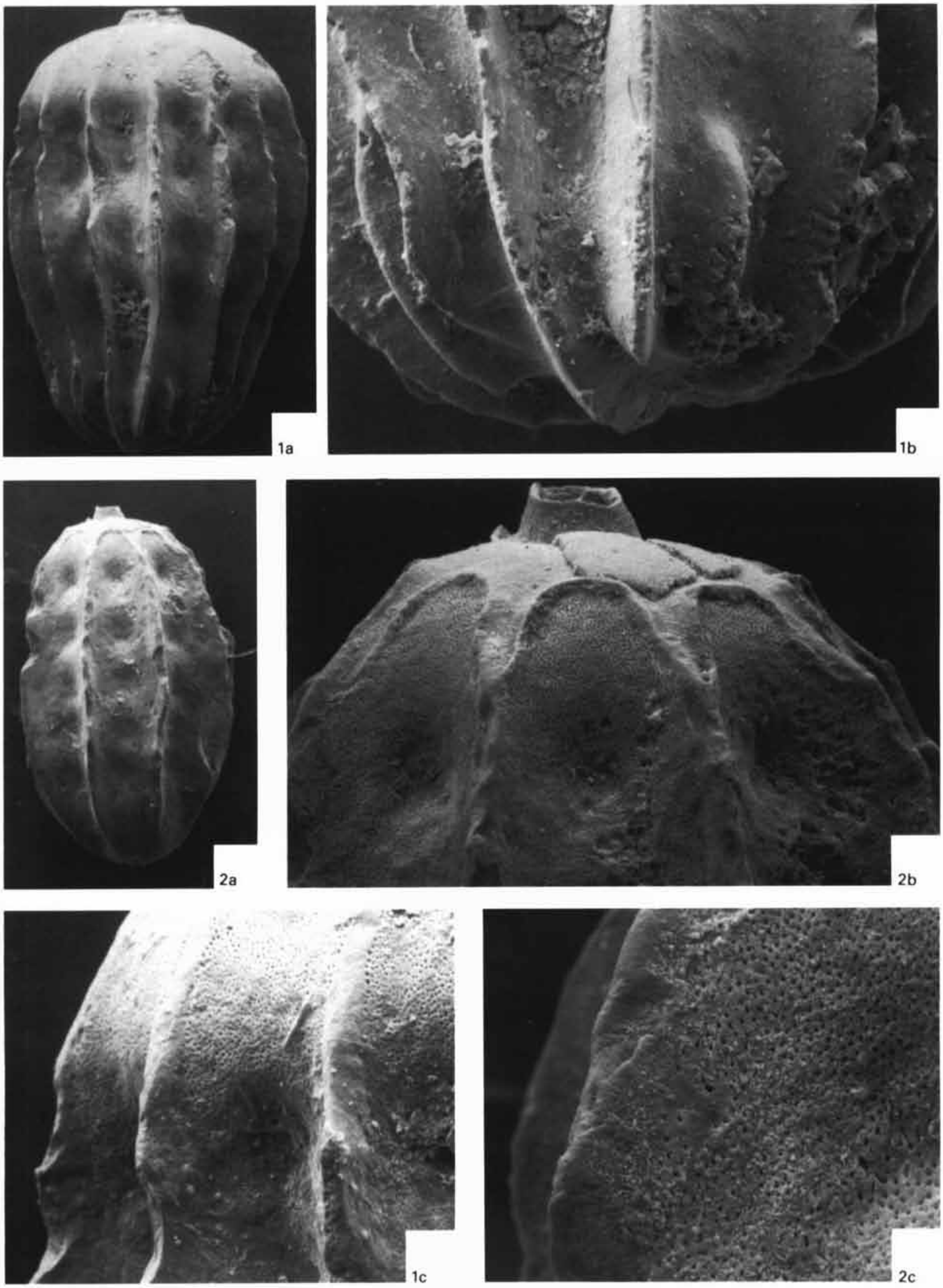

1a
1b
2a
2b
1c
2c

Plate 31

TRANSVERSIGERINA LAMELLATA (Cushman), 1918

Specimens from the Miocene of Ecuador and Venezuela.

Figs. 1,2,5. Megaspheric specimens *(1, 2a)* and microspheric specimen *(5)* from the late Middle Miocene (*Globorotalia menardii* Zone) Onzole Formation of the Borbon basin in coastal Ecuador exhibiting typical slender fusiform tests, moderate costae count, sutural arches, and seemingly completely uniserial megaspheric adults, ×75.—*2b*. Close-up at junction of two chambers showing smooth, imperforate calcite costae and area of intercostal pores, ×750.

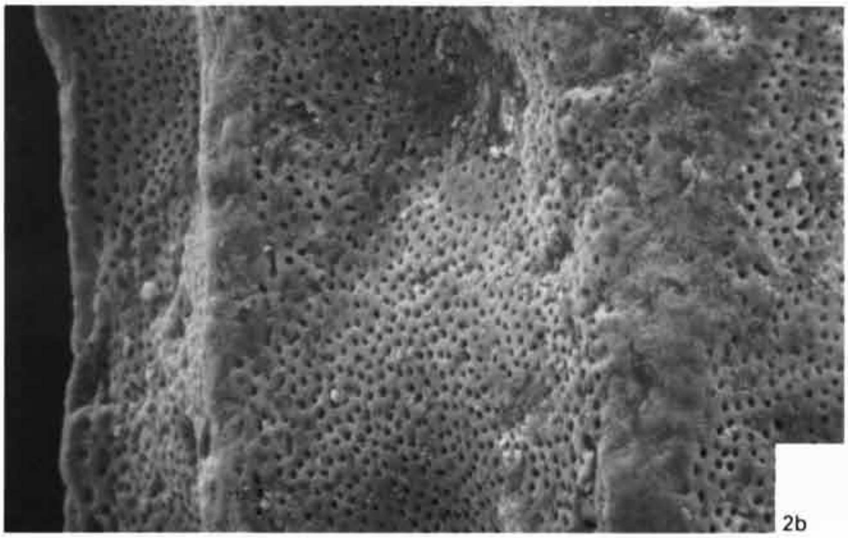
Figs. 3,4. Microspheric specimen *(3a)* and megaspheric specimen *(4)* from the Middle Miocene (*Globorotalia fohsi lobata-robusta* Zone) Carapita Formation of northern Monagas, Venezuela, ×75.—*3b*. Enlarged view of test surface, ×750.

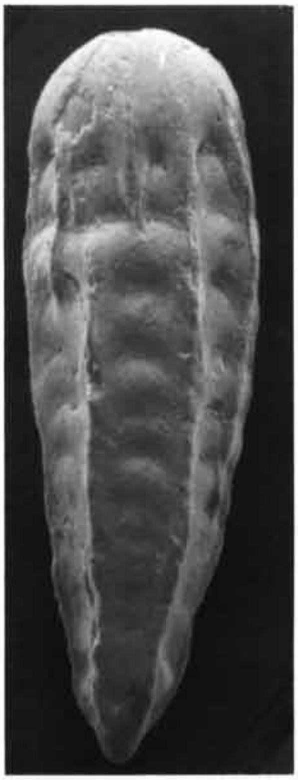

1


2a


3a


4


2b


5

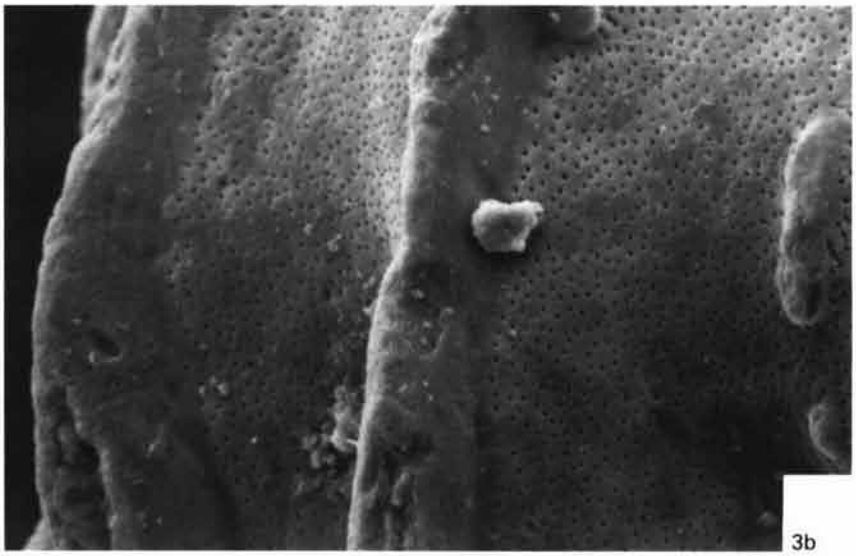

3b

Plate 32

TRANSVERSIGERINA LAMELLATA (Cushman), 1918

Specimens from the Middle Miocene (*Globorotalia fohsi fohsi* Zone) Viche Formation of the Borbon basin in coastal Colombia.

Figs. 1-5. Megaspheric specimens *(1, 3, 4)* and microspheric specimens *(2a, 5a)* illustrating the slender tests, sparse high lamellate costae, prominent sutural arches, and seemingly completely uniserial adult megaspheric specimens, ×75.—*2b, 5b.* Magnified views at the junctions of two chambers showing prominent sutural arches, smooth imperforate calcite costae, and areas of intercostal pores, ×750.

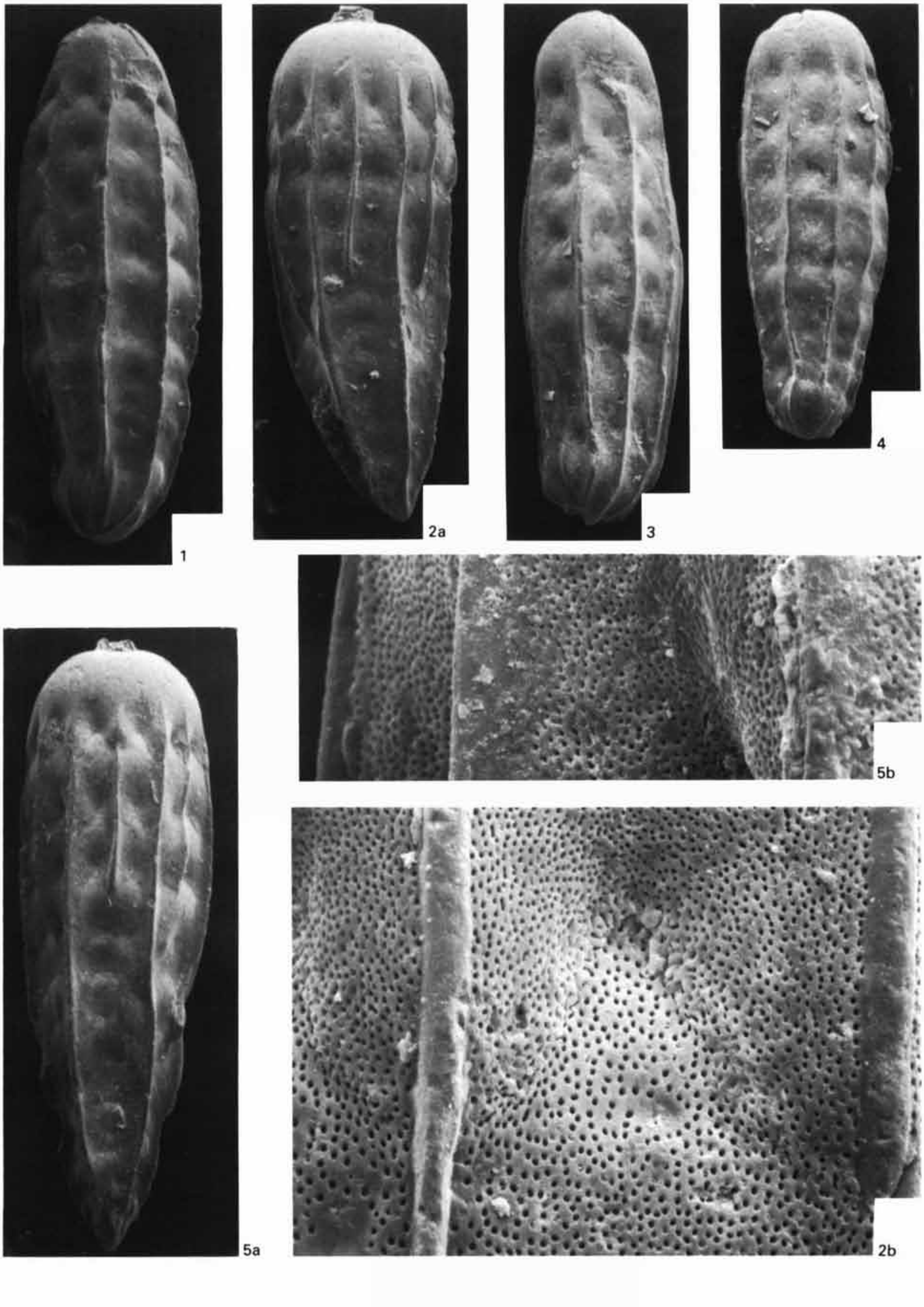

1
2a
3
4
5b
5a
2b

Plate 33

TRANSVERSIGERINA TENUA (Cushman and Kleinpell), 1934

Specimens from the upper Oligocene and Lower Miocene of California and the Lower Miocene of the Atlantic Slope province.

Figs. 1-4.—*1, 2a.* Microspheric specimens from the lower Saucesian Stage (*Siphogenerina transversa* Zone of Lamb and Hickernell, 1972) of the San Joaquin Valley, California, showing tapered test and intermediate costae inserted on later chambers, ×50.—*3a, 4.* Megaspheric specimens showing test with essentially uniserial chambers, parallel sides, and arched sutures, ×75.—*2b, 3b.* Magnified views of test surface showing fine perforations and arched sutures, ×75 and ×300 respectively.

Fig. 5. Specimen from the Lower Miocene (*Globorotalia kugleri* Zone) Atlantic slope margin off Cape Fear, North Carolina.—*5a.* Megaspheric adult showing the essentially uniserial chambers and arched sutures, ×75.—*5b.* Enlarged view of test showing finely perforate wall and arched sutures, ×300.

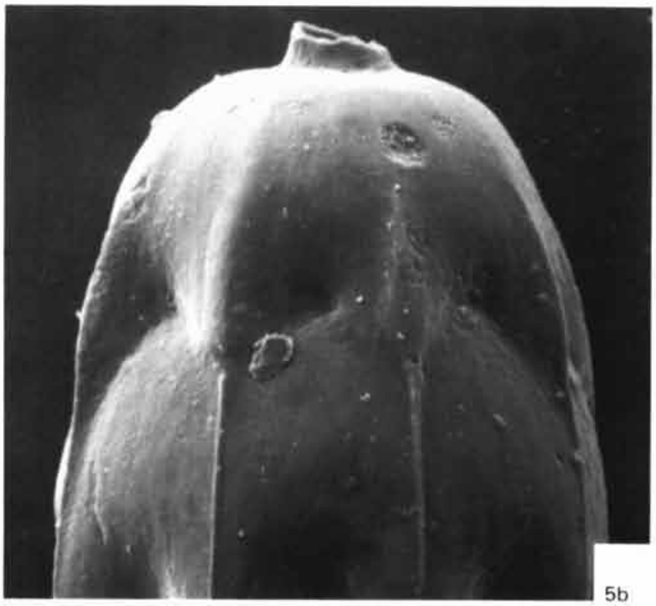

1

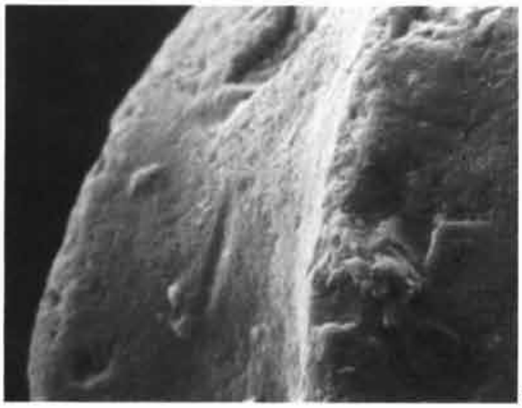

2a


3a


4


5a


5b


3b

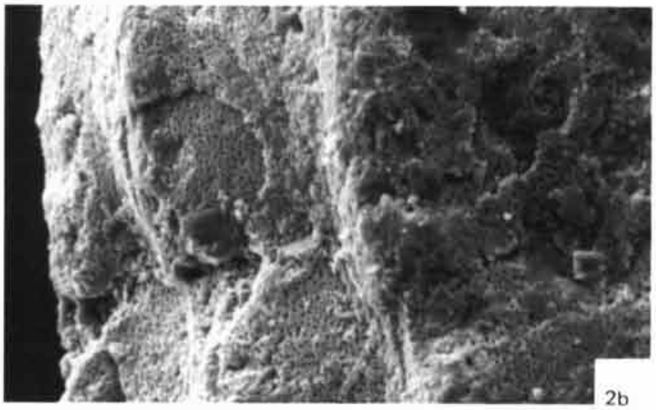

2b

Plate 34

UVIGERINA MEXICANA Nuttall, 1932

Specimens from the Oligocene of Mexico and Miocene of Venezuela.

Figs. 1,2. Megaspheric *(1)* and microspheric *(2)* specimens from the Lower Miocene (*Catapsydrax dissimilis* Zone) Carapita Formation of eastern Venezuela, showing inflated chambers, nearly parallel, sometimes anastomosing costae, and recessed neck, ×75.

Figs. 3-8. Specimens from near the type locality for the species, middle Oligocene (*Globorotalia opima opima* Zone) Alazan Formation of Mexico. Megaspheric specimens *(3, 4a)* and microspheric specimen *(5a)*, ×75.—*4b, 6, 7a, 8.* Megaspheric specimens, ×150.—*5b.* Enlargement of initial chamber showing spinelike projection, ×750.—*7b.* Enlargement of apertural chamber surface showing costae as essentially a continuation of the porous surface of the chamber wall, ×1,500.

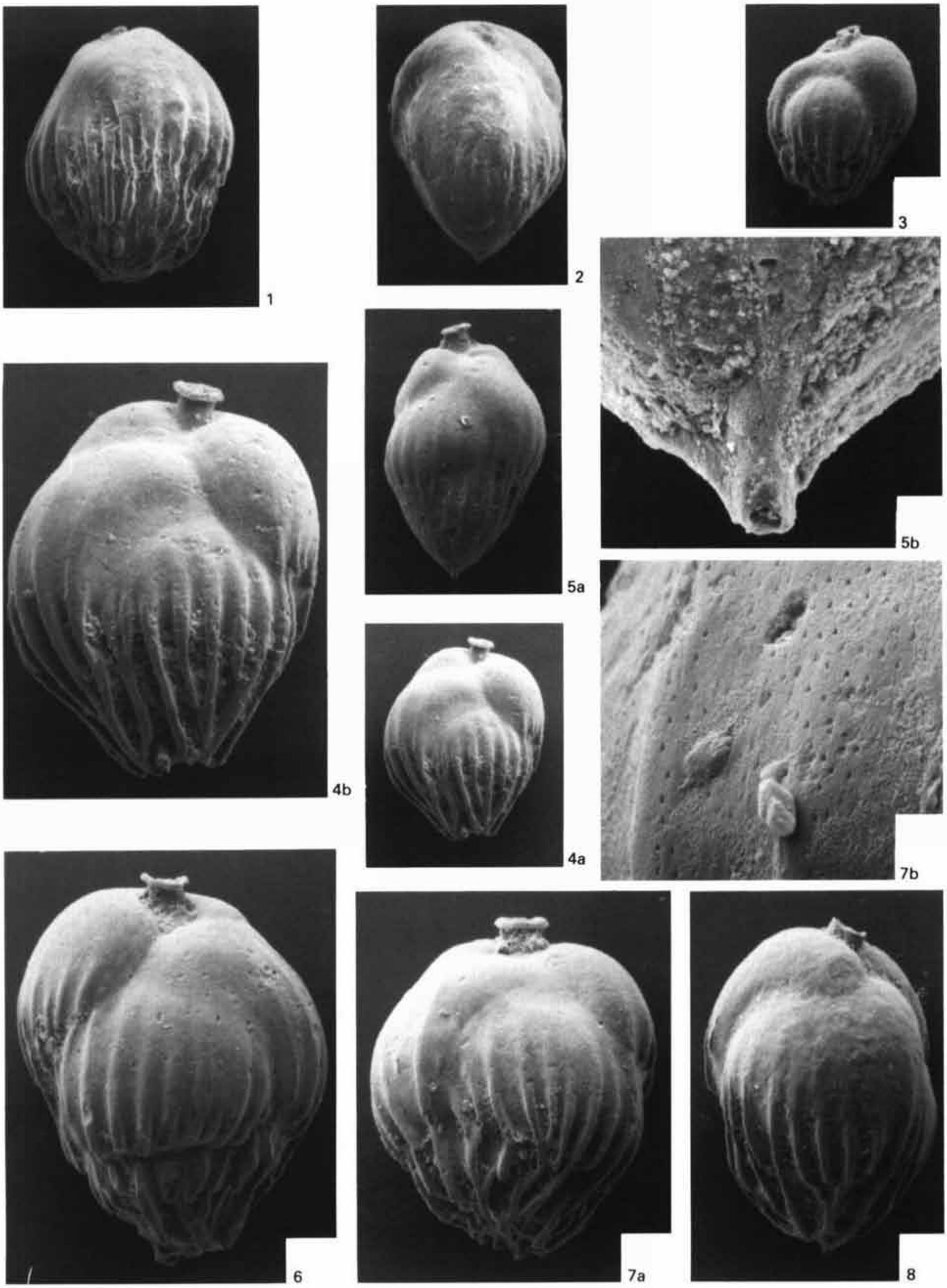

1
2
3
5b
4b
5a
4a
7b
6
7a
8

Plate 35

UVIGERINA GALLOWAYI Cushman, 1929

Specimens from the Miocene of Ecuador and Trinidad.

Figs. 1-4. Specimens from near the type locality for the species, Middle Miocene (*Globorotalia fohsi fohsi* Zone) Manta Shale of Ecuador.—*1, 4a.* Megaspheric specimens with both continuous and discontinuous, undercut, platy costae, ×75.—*4b.* Enlargement of the initial chamber surface focusing on the undercut costae and a few spinelike projections, ×300.—*4c.* Close-up of apertural chamber surface with view of the smooth imperforate costae and intercostal pores, ×750.

Figs. 5,7. Light micrographs of actual paratype megaspheric specimens from Manta, Ecuador (USNM, Cushman Collection 12315), ×105.

Fig. 6. Light micrograph of paratype specimen described as *Siphogenerina basispinata* Cushman and Jarvis, 1929, from the Middle Miocene Sagrina beds of Trinidad (USNM Cushman Collection 10054), ×105. Note that there are no sutural arches as in *Transversigerina.*

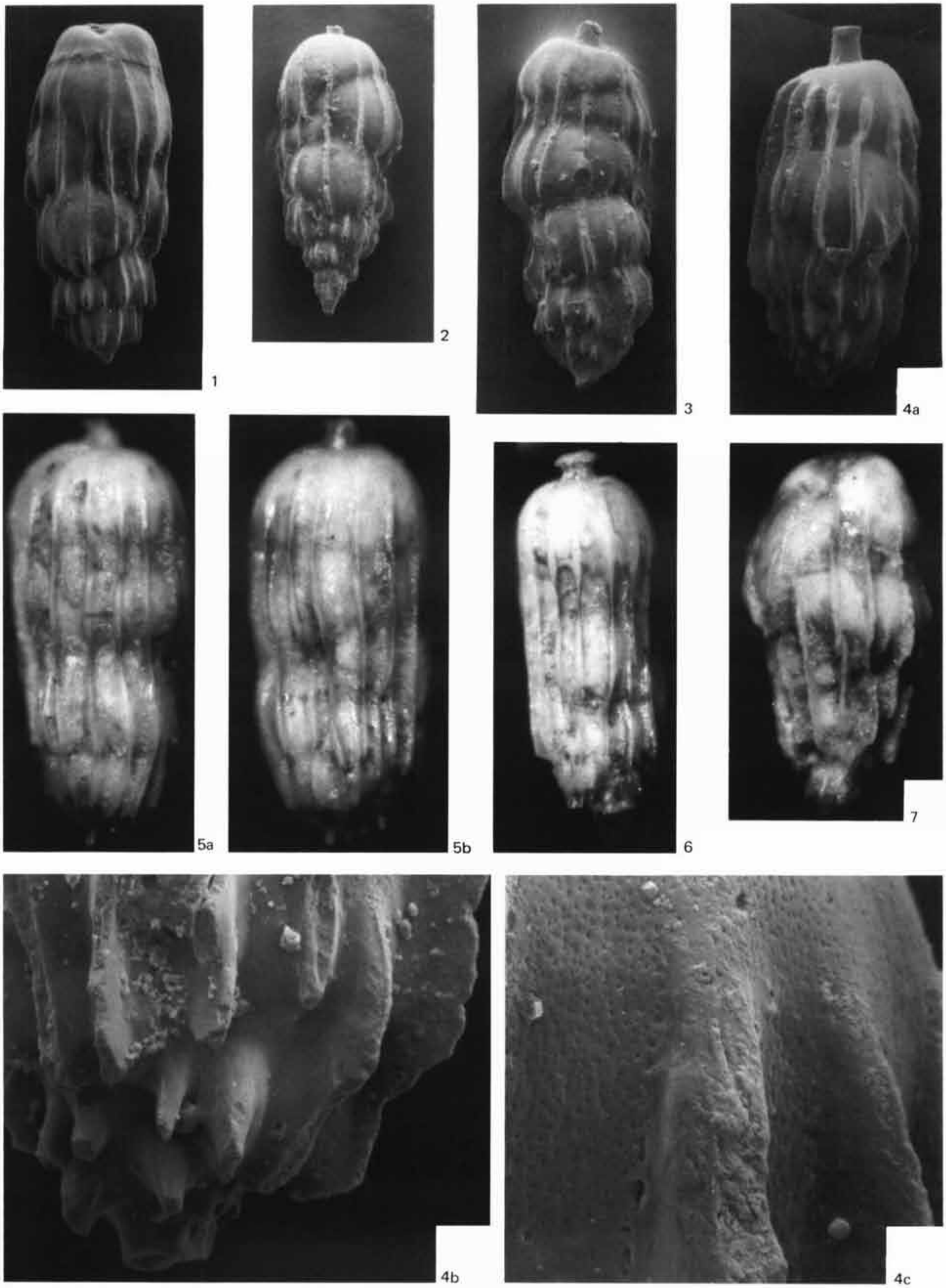

1
2
3
4a
5a
5b
6
7
4b
4c

Plate 36

UVIGERINA SCHWAGERI Brady, 1884

Specimens from the Miocene of Ecuador and Colombia.

Figs. 1-3. Microspheric specimens *(1, 2a, 3)* from the Lower Miocene (*Globigerinatella insueta* Zone) Viche Formation of the Borbon basin of coastal Ecuador showing inflated chambers and heavy platelike costae continuous over several chambers, ×75.—*2b.* Enlargement of test surface showing costae as essentially a continuation of the finely perforate chamber wall, ×750.

Figs. 4,5. Megaspheric specimens *(4a, 4b)* and microspheric specimen *(5a)* from the Middle Miocene (*Globorotalia fohsi peripheroronda* Zone) Flore Santo Formation of the Sinu basin of coastal Colombia, ×75.—*5b.* Enlargement of upper chamber surface showing wall pores and perforate costae, which may have a narrow imperforate calcite ridge, ×750.

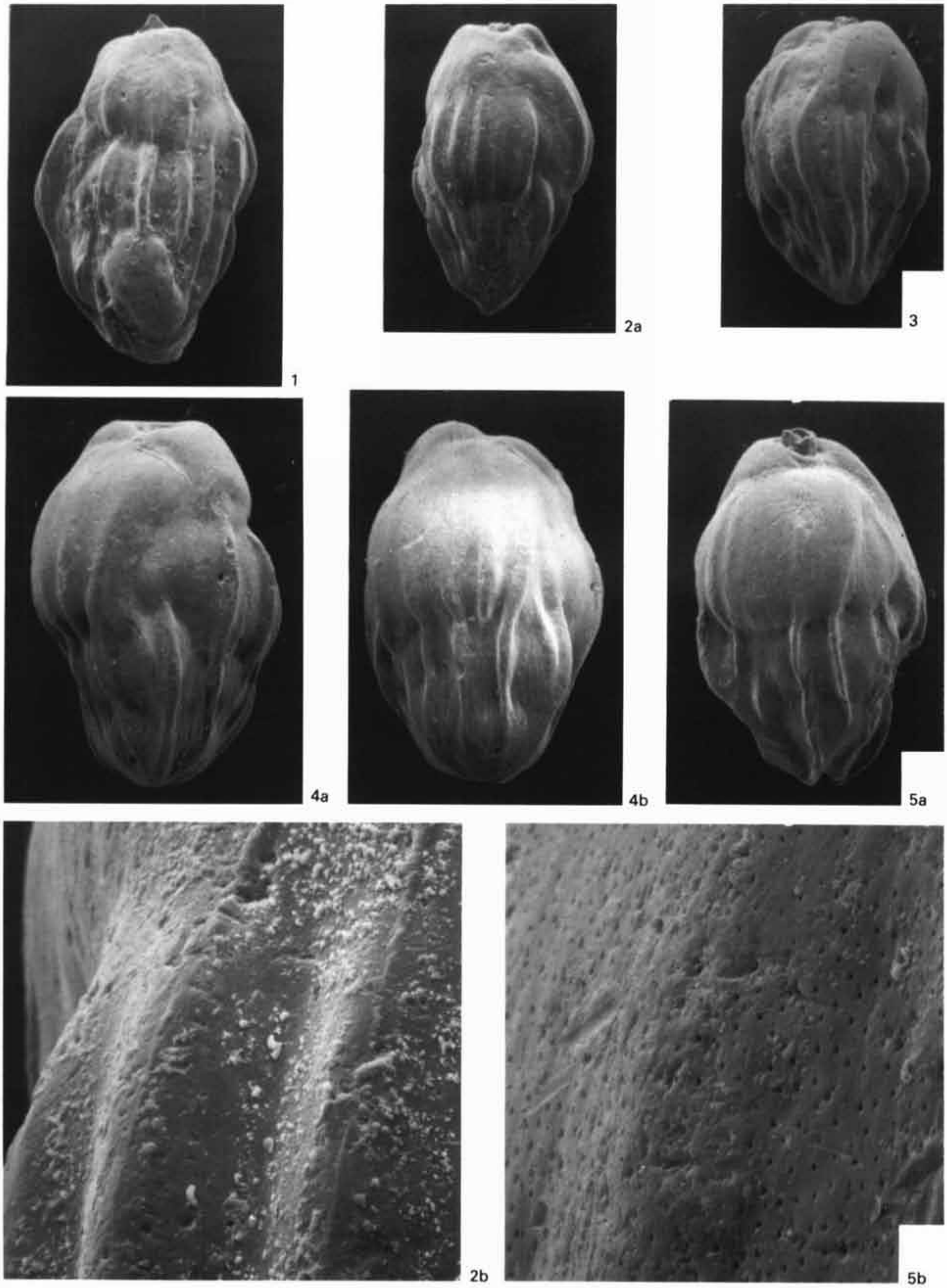

1
2a
3
4a
4b
5a
2b
5b

Plate 37

UVIGERINA DUMBLEI
Cushman and Applin, 1926

Specimen from the Upper Eocene of Mississippi.

Fig. 1. Megaspheric specimen *(1a)* from the Upper Eocene (*Globorotalia cerroazulensis* Zone) type Shubata Member of Mississippi showing inflated chambers and reticulate network of costae, ×75—*1b.* Enlarged detail of test surface showing low imperforate costae and intercostal pores, ×300.—*1c.* Enlarged detail of neck, ×300.

UVIGERINA CONTINUOSA Lamb, 1964

Specimens from the Upper Eocene of Mississippi.

Figs. 2,3. Megaspheric specimens *(2, 3a)* from the Upper Eocene (*Globorotalia cerroazulensis* Zone) type Shubata Member of Mississippi illustrating slender test and characteristic, mostly continuous costae, ×75.—*3b.* Enlargement of upper test surface showing perforate wall and imperforate costae, ×750.

UVIGERINA CHURCHI
Cushman and Siegfus, 1939

Specimens from the Middle Eocene of California.

Figs. 4,5. Probable microspheric specimens from the upper Middle Eocene transition zone in Seaboard Welch Well 1, San Joaquin Valley, California, illustrating very irregular development of the costae, ×150.—*5b.* Close-up of test surface and aperture, showing juncture of longitudinal and horizontal costae. Upon close inspection, the costae seem to be serrated and composed of calcite plates, ×750.

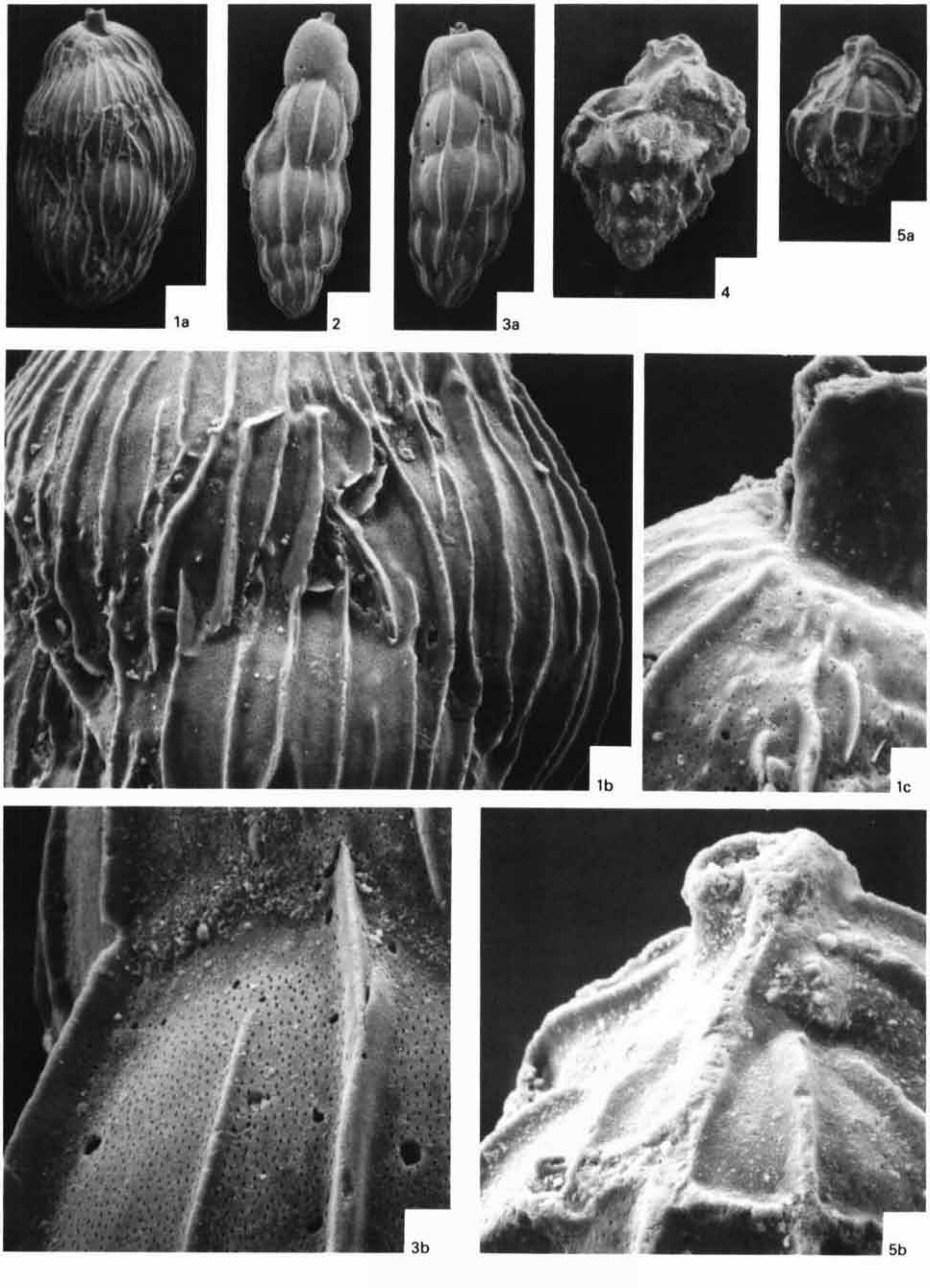

1a
2
3a
4
5a
1b
1c
3b
5b

Plate 38

UVIGERINA ATWILLI
Cushman and Simonson, 1944

Specimens from the middle Oligocene (Refugian Stage) Tumey Formation, in the Seaboard Welch Well 1 (core at 3,585 feet), San Joaquin Valley, California.

Figs. 1-3. Probable megaspheric specimens *(1a, 2a, 3a)* showing highly inflated chambers and costae mostly restricted to the lower portion of the test, ×75.—*1b.* Enlargement of a broken chamber showing the highly perforate wall, ×750.—*2b.* Enlargement of wall surface showing densely packed pores, ×750.—*3b, 3c.* Close-up of slightly calcified wall surface showing pores, ×750.

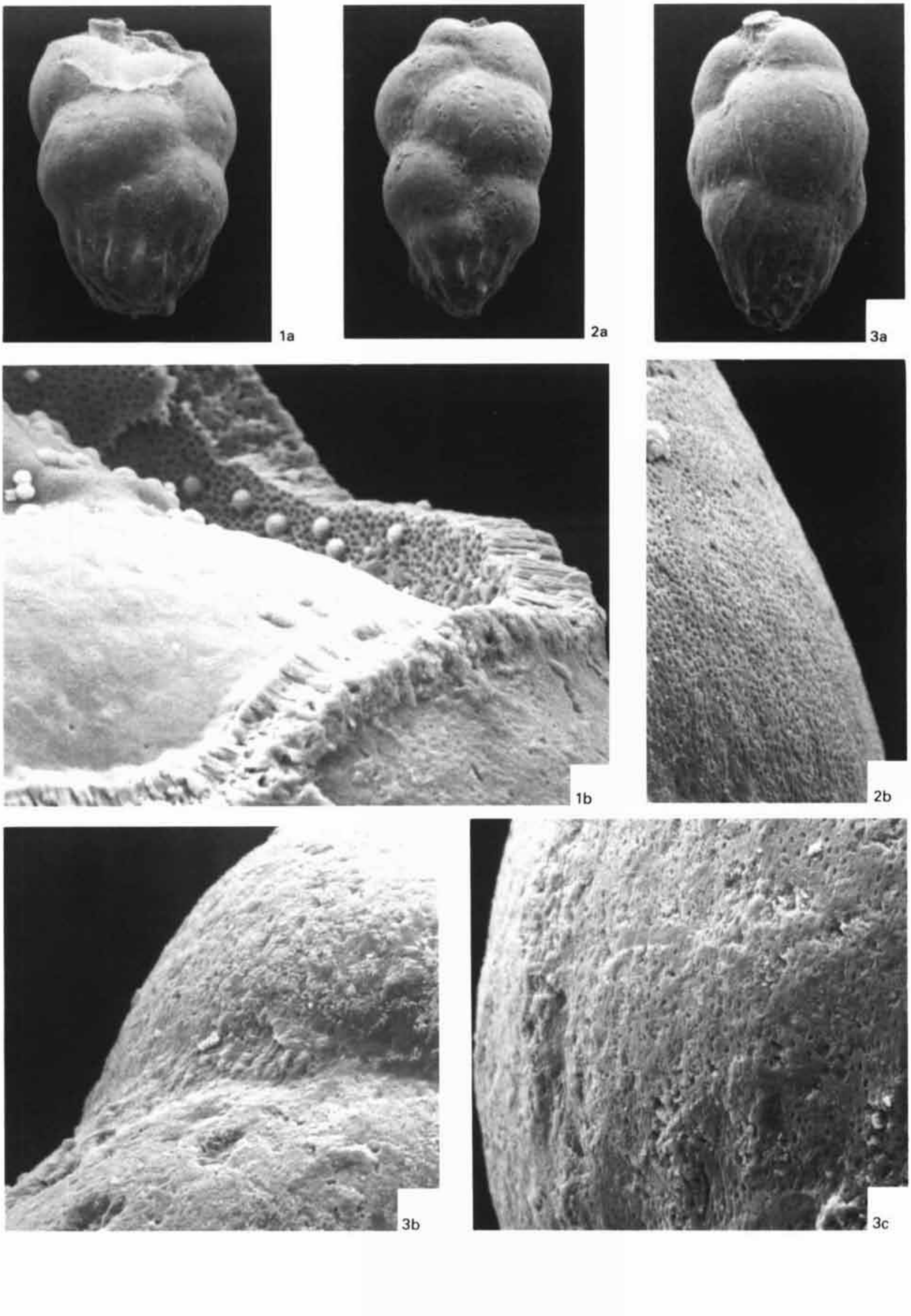

1a
2a
3a
1b
2b
3b
3c

Plate 39

UVIGERINA CARAPITANA Hedberg, 1937

Specimens from the Miocene of Ecuador and Panama.

Figs. 1-3. Megaspheric specimens *(1, 2, 3a)* from the Upper Miocene (*Globorotalia acostaensis* Zone) Onzole Formation of Ecuador showing inflated chambers and finely striated test, ×75.—*3b.* Enlargement of wall surface with striae, ×300.

Figs. 4,5. Megaspheric specimens *(4a, 5a)* from the Middle Miocene (*Globorotalia lobata-robusta* Zone) Darien Basin of eastern Panama, ×75.—*4b.* Enlargement of sutural area showing nearly flush surfaces of the chambers, ×750.—*5b.* Close-up of test wall showing pores, ×750.

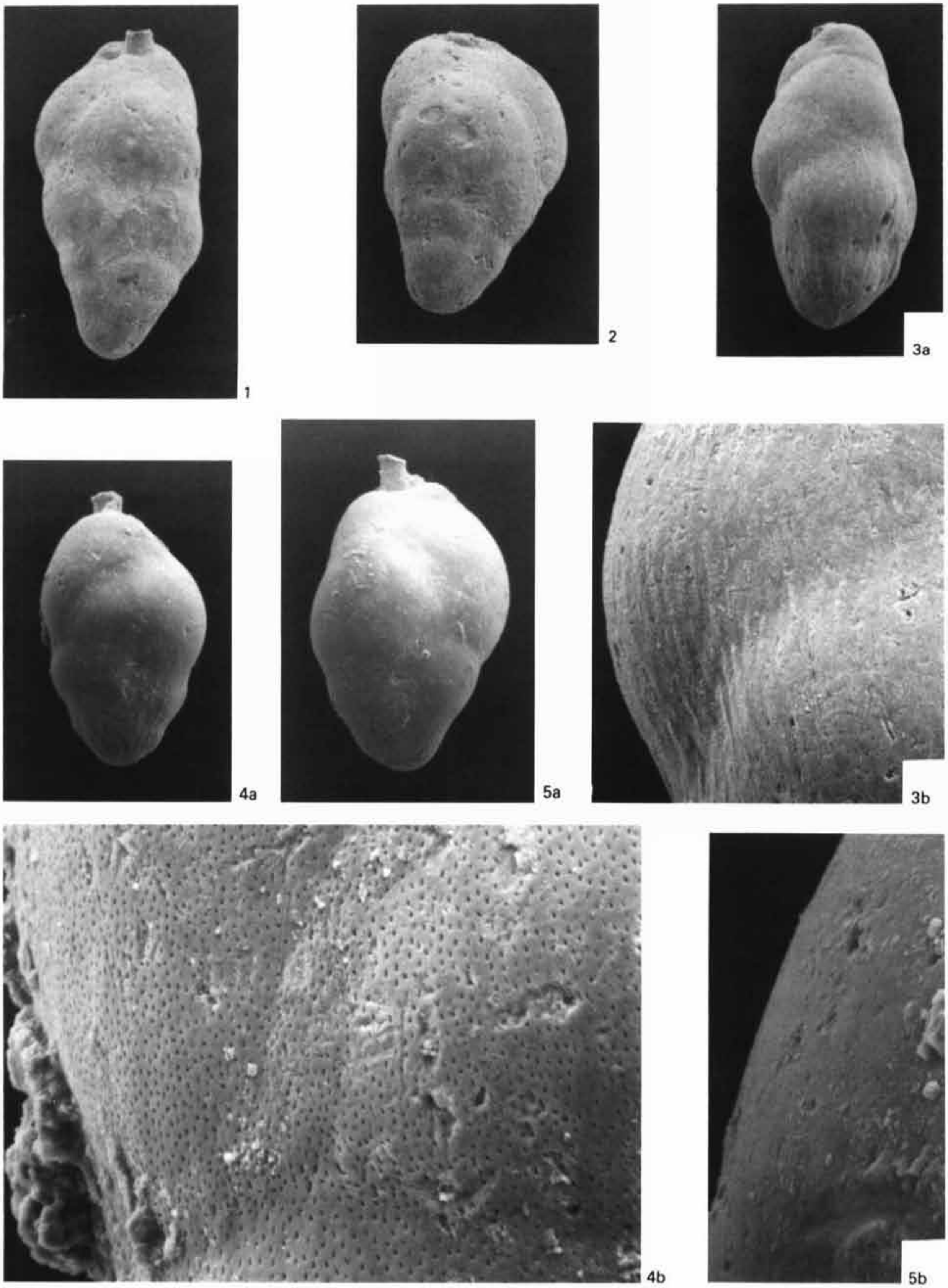
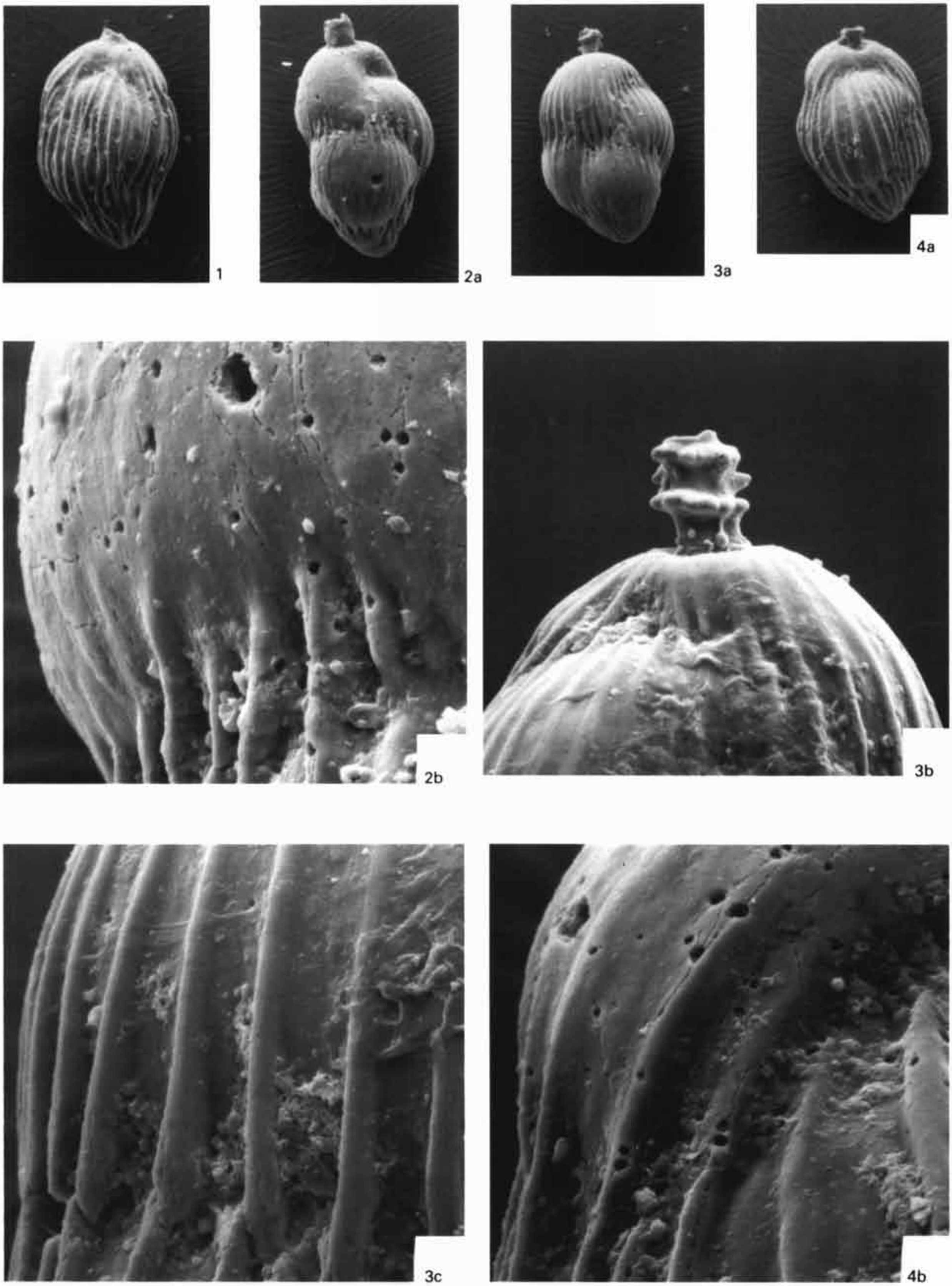

1
2
3a
4a
5a
3b
4b
5b

Plate 40

UVIGERINA FLINTII Cushman, 1923

Specimens from the Holocene of the Gulf of Mexico at a depth of 505 feet.

Figs. 1-4. Megaspheric specimens *(1, 2a, 3a, 4a)* showing slightly inflated chambers and thin, continuous, longitudinal costae, ×75.—*2b, 3c, 4b.* Enlargements of chamber junctions showing costae bridging the sutures, ×750.—*3b.* View of aperture with ring-like plates encircling the neck, ×300.


1
2a
3a
4a
2b
3b
3c
4b