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THREE INNER-NERITIC RECENT FORAMINIFERS FROM SOUTHERN CALIFORNIA

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ABSTRACT

Three new benthonic foraminifers (Bolivinitidae and Caucasinidae) are described from the inner-neritic zone of southern California and their relationship to associated Pacific coast shallow-water species is described.

INTRODUCTION

The analysis of living shallow-water foraminiferal populations in collections made off southern California in 1963 and 1964 and in subsequent laboratory cultures of representative species led to the recognition of previously undescribed species of the genera *Bolivina* and *Coryphostoma.*

Foraminifers inhabiting the coralline alga *Corallina officinalis* originally were collected from Malaga Cove, Santa Monica Bay, California, in February, 1963 (SLITER, 1965). Large assemblages of bolivinids were also obtained from clone and experimental cultures maintained at the University of California, Los Angeles, for more than three years (DOUGLAS & SLITER, 1965; SLITER, 1965, 1968). The specimens were studied under a stereoscopic microscope and a scanning electron microscope (a stereoscan of Cambridge Instruments, Ltd.). Illustrations of type specimens were prepared using a camera lucida.

Dr. RICHARD CIFELLI, U.S. National Museum, and Dr. IRENE MCCULLOCH, Allen Hancock Foundation at the University of Southern California, kindly loaned type material for use in the present analysis. Dr. ROBERT LANKFORD, Rice University, allowed examination of foraminiferal assemblages in many samples from the Pacific Coast and the Gulf of Mexico. I am indebted also to Dr. HELEN TAPPAN LOEBLICH, University of California, Los Angeles, and Dr. RUSSELL M. JEFFORDS, Esso Production Research Company, Houston, Texas, for their constructive suggestions during preparation of the manuscript, and to RALPH D. HOCKETT, JR., also of Esso Production Research Company, for his technical assistance in obtaining photographs by means of the scanning electron microscope. Field collection and laboratory culturing were done during tenure of an American Chemical Society Petroleum Research Fund Fellowship at the University of California, Los Angeles.

SYSTEMATIC DESCRIPTIONS

Order FORAMINIFERIDA

Superfamily BULIMINACEA Jones, 1875

Family BOLIVINITIDAE Cushman, 1927

Genus BOLIVINA d'Orbigny, 1839

Type species.—Bolivina plicata D'ORBIGNY, 1839.

BOLIVINA LEPIDA Sliter, n. sp.

Test free, small, strongly tapering, and slightly compressed; periphery broadly rounded. Chambers 10 to 14, broad, low, somewhat inflated; irregular lower margin of early chambers forming depressions around basal pores, margins of last-formed chamber broadly lobate. Sutures distinct, depressed, gently curved, initially crenulate, later gently sinuate. Wall calcareous, relatively smooth, translucent, radial in structure, coarsely perforate with pores restricted to basal half of chamber. Aperture a loop-shaped opening on inner face of final chamber, with tooth plate.

Length of holotype 0.23 mm., width 0.14 mm., thickness 0.09 mm. Length of paratypes range from 0.18 to 0.25 mm.

DISCUSSION.—*Bolivina lepida* SLITER, n. sp., is a consistent and relatively common species in shallow-water foraminiferal assemblages off southern California. Variations in overall test morphology (i.e., degree of test flaring, length, width and chamber shape) are relatively small. Morphologic dimorphism in the prolocular dimensions and the number of chambers produces two dimorphic groups; specimens having a prolocular diameter of 12 to 16 μ and 13 to 14 chambers and those having a prolocular diameter of 18 to 22 μ and 10 to 12 chambers. This species somewhat resembles *B. doniezi* CUSHMAN & WICKENDEN but is more robust and flaring, with a thicker test and has coarser perforations. *Bolivina lepida* differs from juvenile specimens of the larger, coarsely perforate *B. variabilis* (WILLIAMSON) in its more rapidly flaring test and characteristic pore distribution.

TYPES AND OCCURRENCE.—Holotype deposited in the foraminiferal type collection, Department of Geology, University of California, Los Angeles (no. 6842); paratypes deposited at the U.S. National Museum (no. 687463); all from 3 m. below low tide at Malaga Cove, southeast Santa Monica Bay, California (lat. 33°48′15″ N, long. 118°23′30″ W).

ILLUSTRATIONS.—Plate 1, figures 1-3.——1. Paratype; 1a, side view, ×450; 1b, central area of test showing pore pattern, ×900.——2. Holotype, side (2a) and apertural (2b) views, ×210.——3. Paratype; 3a, side view, ×450; 3b, central area of test showing pore pattern, ×900.

BOLIVINA LUTEA Sliter, n. sp.

Test free, small, elongate, gradually tapering, compressed, with periphery initially subrounded, later subacute to acute. Chambers 12 to 15, increasing gradually in height; each with basal projection adjacent to depressed central axis of test, becoming more pronounced in middle chambers. Sutures distinct, gently curved to sinuate, initially limbate and flush, later depressed. Wall calcareous, radial in structure, perforations fine and unevenly distributed, surface rugose. Aperture loop-shaped, extending up from base of final chamber, with tooth plate.

Length of holotype 0.20 mm., width 0.10 mm., thickness 0.06 mm. Length of paratypes range from 0.14 to 0.20 mm.

DISCUSSION.—Living specimens of *Bolivina lutea* are distinguished readily from associated bolivinids by coloration and test characteristics. The initial chambers are pale yellow and commonly are slightly twisted, with a relatively smoother surface of thickened calcite (Pl. 4, fig. 1a,b). The middle chambers are reddish yellow, with prominent chamber projections and rugose surface ornamentation (Pl. 3, fig. 1a, 2). The final chambers are clear, semitranslucent, and thinner than the middle chambers and have a subacute periphery.

Test perforations in *Bolivina lutea* are irregular or patchy in distribution. Perforations on all but the ultimate chambers commonly are restricted to or occur adjacent to the raised, axial, chamber projections (Pl. 3, fig. 1a). In the ultimate chambers, perforations likewise are associated more commonly with the chamber projections but also occur in random patches on the chamber surface (Pl. 2, fig. 1b; Pl. 4, fig. 1c). Distinct necks formed by raised crystals surround each pore in the later chambers (Pl. 2, fig. 1c,d) whereas in earlier chambers, successive calcitic lamellae cover and obscure these necks so that the pores are flush with the test surface. The detailed examination of numerous specimens of this species, using a scanning electron microscope, shows these distinctive perforations are the only perforations of the test, and are indeed the test pores. Each specimen has the common association of perforations occurring with structural elements of the test, such as raised ridges and rugae.

Bolivina lutea varies considerably in amount of axial twisting and flaring of the test, shape of the final two chambers, and amount of surface irregularities. Prolocular dimorphism separates two groups of specimens whose average prolocular diameters are 9 and 16 μ, respectively. *Bolivina lutea* differs from *B. pseudoplicata* HERON-ALLEN & EARLAND which also has raised chamber irregularities in being smaller and less robust and in having a rugose surface with fine, irregular perforations.

TYPES AND OCCURRENCE.—Holotype deposited in the foraminiferal type collection, Department of Geology, University of California, Los Angeles (no. 6843); paratypes deposited at the U.S. National Museum (no.

687464); all from 3 m. below low tide at Malaga Cove, southeast Santa Monica Bay, California (lat. 33°48′15″ N, long. 118°23′30″ W).

Illustrations.—Plate 2, figure 1; Plate 3, figures 1-2; Plate 4, figures 1-3.——Pl. 2, fig. 1. Paratype; 1a, side view, ×500; 1b, perforations and surface rugae on ultimate chamber, ×2,200; 1c, enlarged view of central perforate area, ×11,000; 1d, further enlarged view showing pore necks and wall structure of rounded crystals, ×23,500.——Pl. 3, fig. 1. Paratype; 1a, central test area showing perforations on raised projections on axial chamber, ×2,200; 1b, enlarged view of perforations, ×11,000; 1c, further enlargement showing crystals that form pore necks and rugae, ×23,500.——Pl. 3, fig. 2. Paratype photographed at higher voltage to increase depth of field, ×500.——Pl. 4, fig. 1. Paratype; 1a, side view, ×200; 1b, axial half of test showing smooth areas characterized by successive calcitic lamellae, ×900; 1c, perforations on ultimate chamber, ×2,000.——Pl. 4, fig. 2. Holotype, ×210, side (2a) and apertural (2b) views. ——Pl. 4, fig. 3. Paratype; 3a, side view, ×200; 3b, perforations and rugae on final chamber, ×2,000.

Superfamily CASSIDULINACEA d'Orbigny, 1839

Family CAUCASINIDAE Bykova, 1959

Genus CORYPHOSTOMA Loeblich & Tappan, 1962

Type species.—Bolivina plaita Carsey, 1926.

Test free, elongate, narrow to tapering, may be axially twisted; periphery rounded to acute; chambers biserially arranged, later chambers commonly becoming cuneiform with tendency to become uniserial. Wall calcareous, finely perforate, granular in structure. Aperture loop-shaped in early stage, extending from base of final chamber, becoming terminal in adult, with internal tooth plate.

Discussion.—The generic description of *Coryphostoma* given by Loeblich & Tappan (1964) here is emended as above to include the present species.

CORYPHOSTOMA SPISSUS Sliter, n. sp.

Test free, small, elongate, gradually tapering, biserial throughout, slightly twisted, periphery subacute to acute. Chambers broad, low; each with low knob forming rounded ridge on either side of depressed test axis. Sutures distinct, initially thickened and flush, later depressed. Wall calcareous, granular in structure with few coarse punctae on early chambers, more numerous and finer on later chambers. Surface generally smooth, with fine pits, commonly finely pustulose in median portion of test, wall of early chambers thickened by added lamellae as test enlarges. Aperture elongate, at base of final chamber, with lip and internal tooth plate.

Length of holotype 0.25 mm., width 0.14 mm., thickness 0.07 mm. Length of paratypes range from 0.20 to 0.25 mm.

Discussion.—This species is assigned to the genus *Coryphostoma* on the basis of its granular wall structure and biserial chamber arrangement. The wall structure clearly separates this species from the genus *Bolivina.* It somewhat resembles *Sigmavirgulina* in its acute peripheral margin and axial twisting but differs in lacking the diagnostic initial spiralled biserial or sigmoiline chamber arrangement and coarse perforations. *Coryphostoma spissus* is distinguished from associated biserial species by its axial twisting, thickened calcitic lamellae on the earlier chambers and the glossy, finely pitted surface (Pl. 6, fig. 1a,c). The process or agent producing these fine (2 to 3 μ) pits is unknown; they may represent sealed punctae or a residual effect related to calcification. It is less likely that these pits represent the product of some invasive organism. Like the pores, they are more strongly developed in the ultimate chambers and become progressively more obscured toward the test apex with its thickened calcitic lamellae (Pl. 5, fig. 1a,c), thus suggesting a relationship between the pits and the test perforation.

Specimens of *Coryphostoma spissus* differ morphologically in test width, amount of axial twisting, and presence or absence of peripheral lobation of the chambers.

Types and Occurrence.—Holotype deposited in the foraminiferal type collection, Department of Geology, University of California, Los Angeles (no. 6844); paratypes deposited at U.S. National Museum (no. 687465); all from 3 m. below low tide at Malaga Cove, southeast Santa Monica Bay, California (lat. 33°48′15″ N, long. 118°23′30″ W).

Illustrations.—Plate 5, figures 1-3; Plate 6, figure 1.——Pl. 5, fig. 1. Paratype; 1a, side view, ×450; 1b,c, enlarged views, ×900; 1d,e, views of surface pits, ×4,800. ——Pl. 5, fig. 2. Side view of paratype, ×450.——Pl. 5, fig. 3. Holotype, ×210, side (3a) and apertural (3b) views.——Pl. 6, fig. 1. Paratype; 1a, central test area,

PAPER 45, EXPLANATION OF PLATES

Plate 1, figures 1-3. *Bolivina lepida* Sliter, n. sp. (p. 1).

Plate 2, figure 1. *Bolivina lutea* Sliter, n. sp. (p. 2).

Plate 3, figures 1-2. *Bolivina lutea* Sliter, n. sp. (p. 2).

Plate 4, figures 1-3. *Bolivina lutea* Sliter, n. sp. (p. 2).

Plate 5, figures 1-3. *Coryphostoma spissus* Sliter, n. sp. (p. 3).

Plate 6, figure 1. *Coryphostoma spissus* Sliter, n. sp. (p. 3).

PAPER 46, EXPLANATION OF PLATES

Plate 1, figure 1. *Ammoglobigerinoides dehiscens* Frerichs, n. gen., n. sp. (p. 1).

Plate 1. figure 2. *Pseudotrochammina mexicana* Frerichs, n. gen., n. sp. (p. 2).

Plate 1, figure 3. *Pseudotrochammina triloba* Frerichs, n. gen., n. sp. (p. 2).

Plate 2, figure 1. *Ammoglobigerinoides dehiscens* Frerichs, n. gen., n. sp. (p. 1).

Plate 2, figure 2. *Pseudotrochammina mexicana* Frerichs, n. gen., n. sp. (p. 2).

Plate 2, figure 3. *Pseudotrochammina triloba* Frerichs, n. gen., n. sp. (p. 2).

×1,000; 1b,c, views of pores and surface pits, ×2,000; 1d, enlargement of pore and surface pits showing crystalline nature of surface, ×4,800.

DISCUSSION

Species of the foraminiferal family Bolivinitidae have figured prominently in surveys of Recent foraminiferal distributions and in bathymetric zonations, especially in such intensively studied areas as the Gulf of Mexico and off the coast of southern California. The main taxonomic emphasis on species from middle neritic to bathyal depths has resulted, however, in a proliferation of specific names.

Some described species are quite distinct but others seemingly represent parts of phenotypically plastic stocks differing morphologically in response to environmental changes (Lutze, 1964; Smith, 1954). Inner-neritic species, on the other hand, generally are referred to a few, presumably highly variable taxa such as *Brizalina lowmani* (Phleger & Parker), *B. quadrata* (Cushman & McCulloch), and *Bolivina vaughani* Natland (Walton, 1955; Bandy & Arnal, 1957; Uchio, 1960; Cooper, 1961; Watkins, 1961; Bandy, 1963; Bandy, Ingle, & Resig, 1964; Smith, 1964a,b). Problems in identification doubtlessly result from the relative rarity of these forms in shallow water as compared to their abundance in deeper water and from the small size and morphologic similarity of smooth-walled species, especially juvenile specimens of related taxa. For example, none of the sampled assemblages contain specimens resembling the commonly identified species *Bolivina vaughani* and *Brizalina quadrata,* in spite of the fact that samples subsequently were collected at several times during the year from Malibu Creek, Malaga Cove, and Point Loma in California and from Punta Banda in Baja California, Mexico. Both species, therefore, seem to be restricted to water depths below those of the innermost neritic zone along the coast of southern California.

Species of Bolivinitidae Included in Samples

Bolivina doniezi Cushman & Wickenden

Bolivina pseudoplicata Heron-Allen & Earland

Bolivina subexcavata Cushman & Wickenden

Bolivina torqueata Cushman & McCulloch

Bolivina variabilis (Williamson)

Brizalina lowmani (Phleger & Parker)

Brizalina pacifica (Cushman & McCulloch)

Brizalina striatula (Cushman)

The addition to the taxa here proposed for already numerous shallow-water bolivinids seems justified by the need for increasingly precise ecologic descriptions of populations from an environment where many of the physical limiting factors can be reproduced in the laboratory. The present taxonomic distinctions, moreover, are justified by studies of both large and widespread natural populations and clone cultures of bolivinids. The latter were maintained at several controlled eco-

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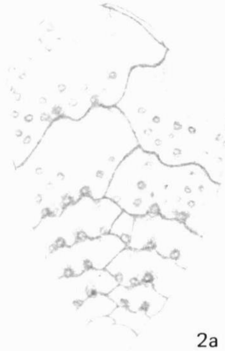
2b

3a



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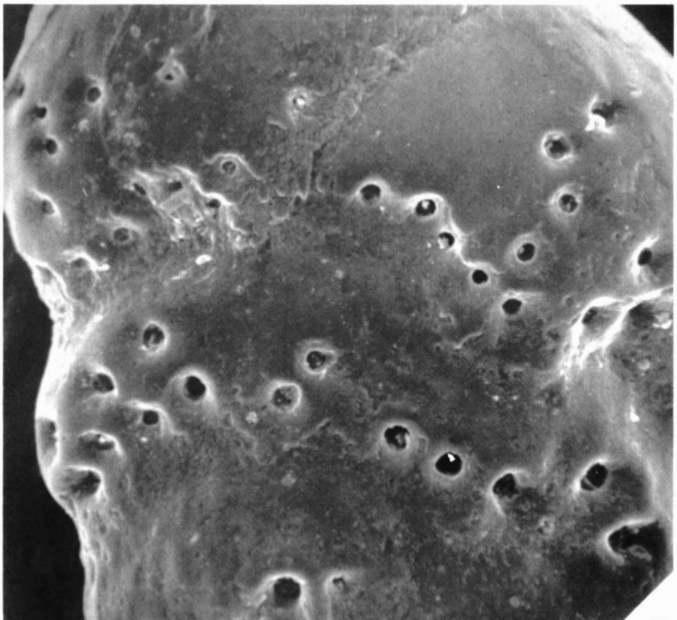

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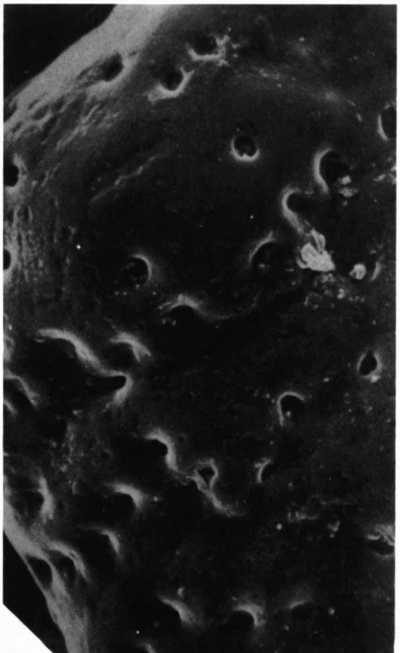

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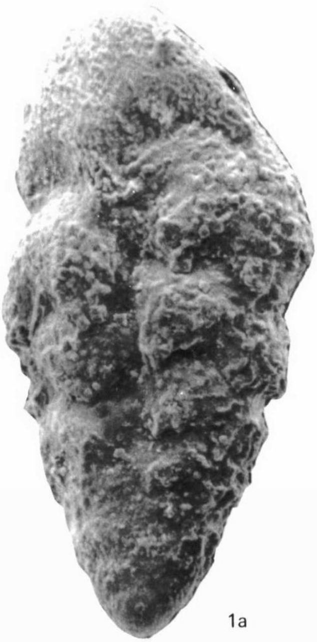

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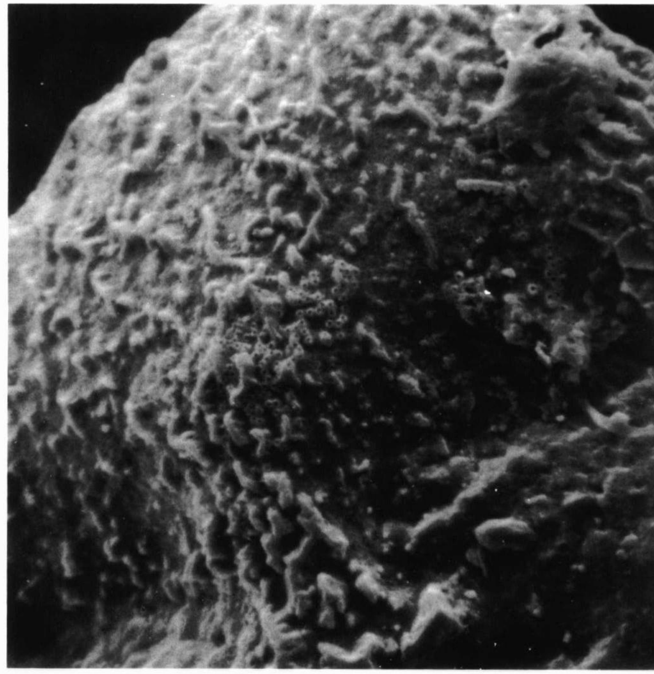

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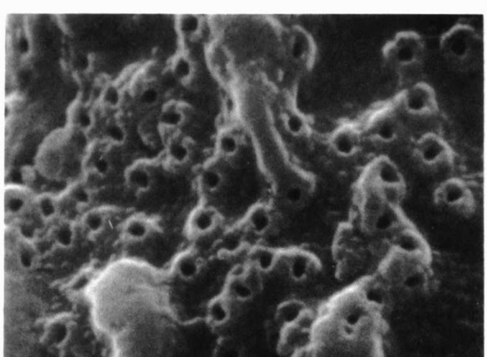

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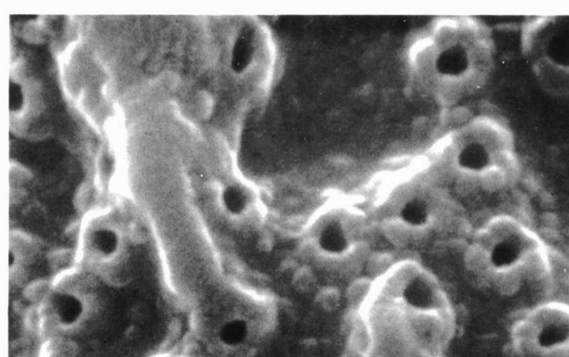

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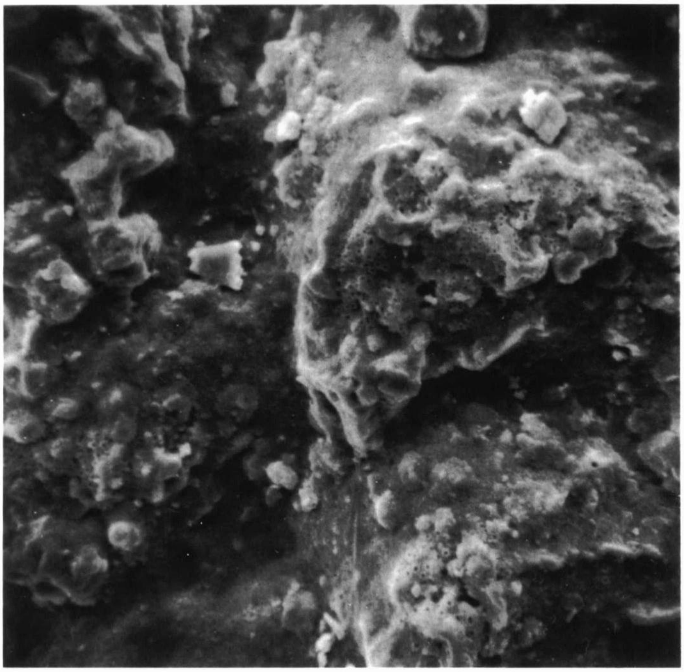

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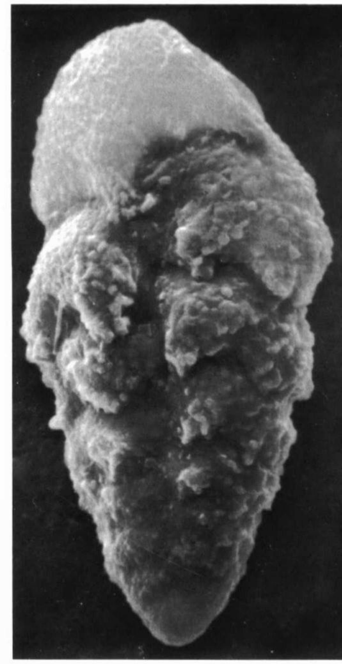

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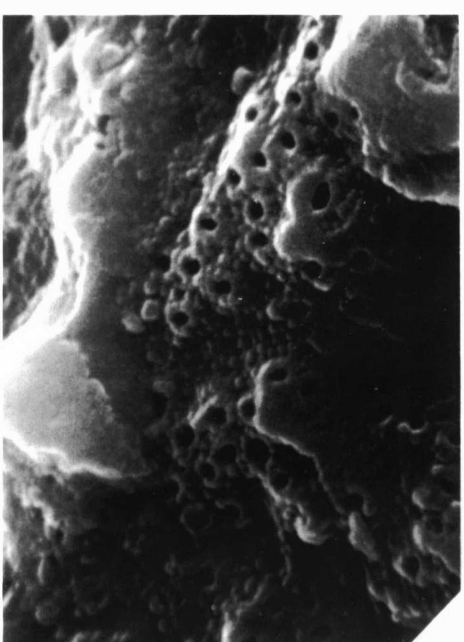

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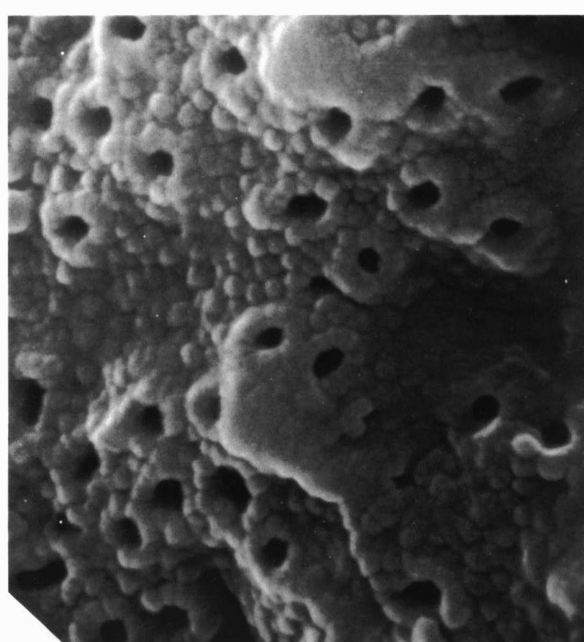

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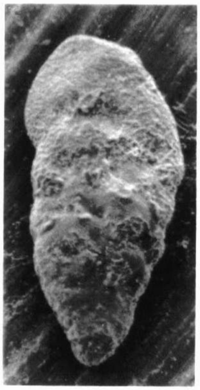
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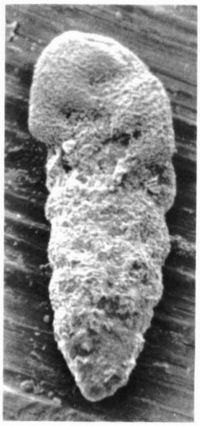
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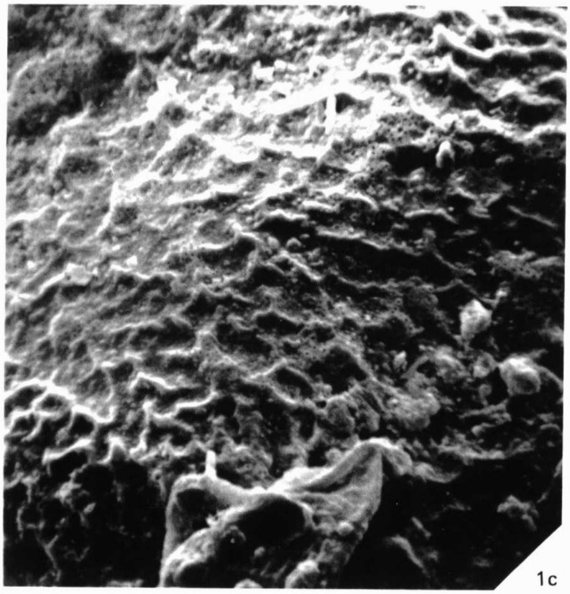
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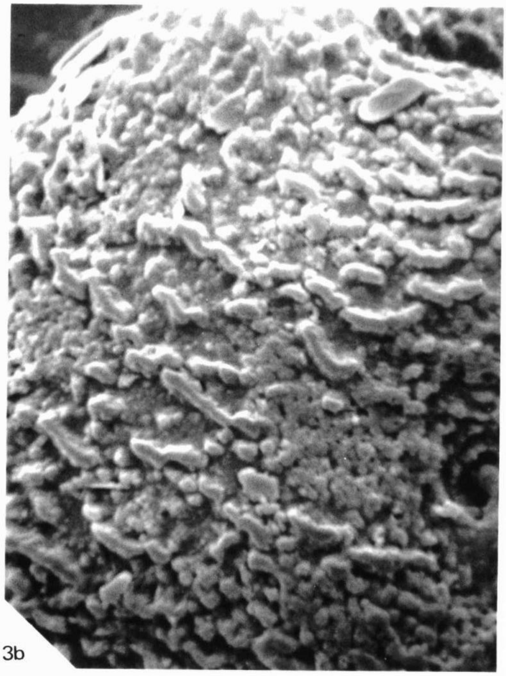
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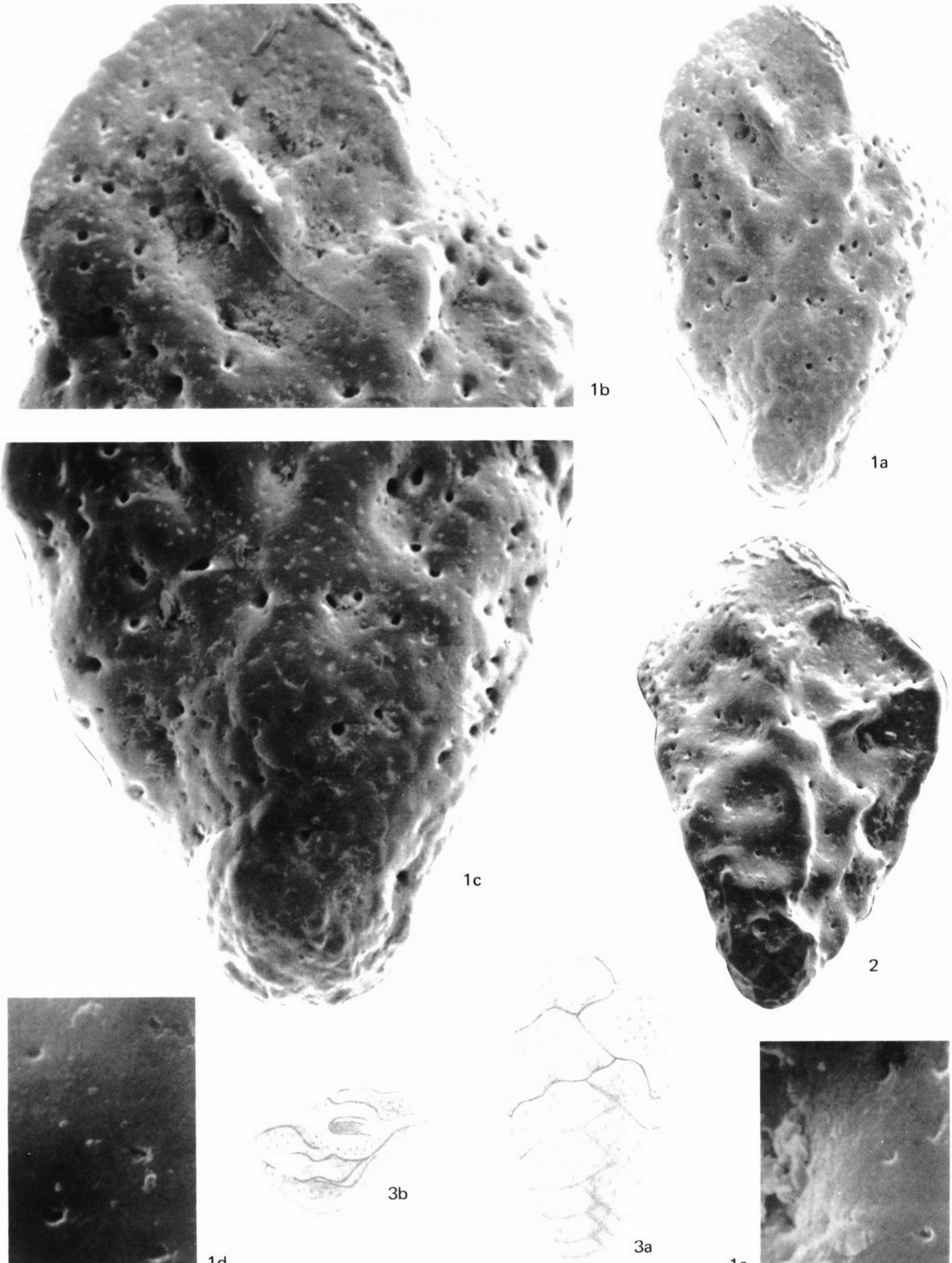
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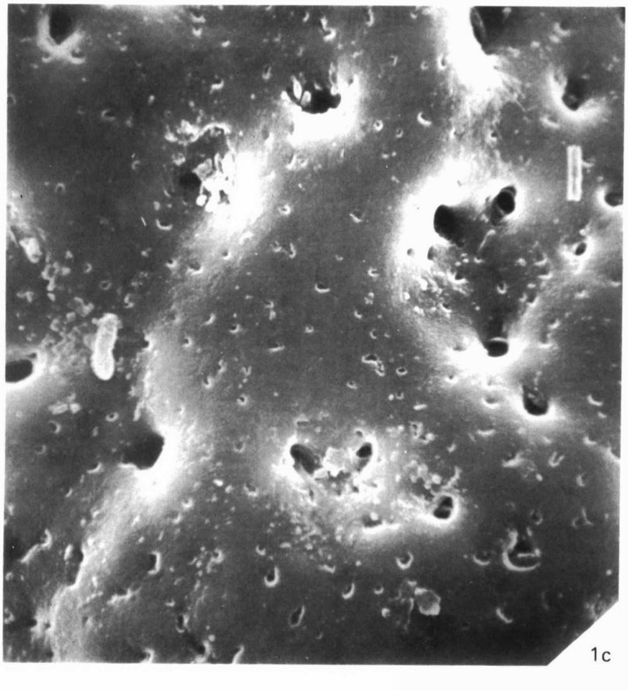

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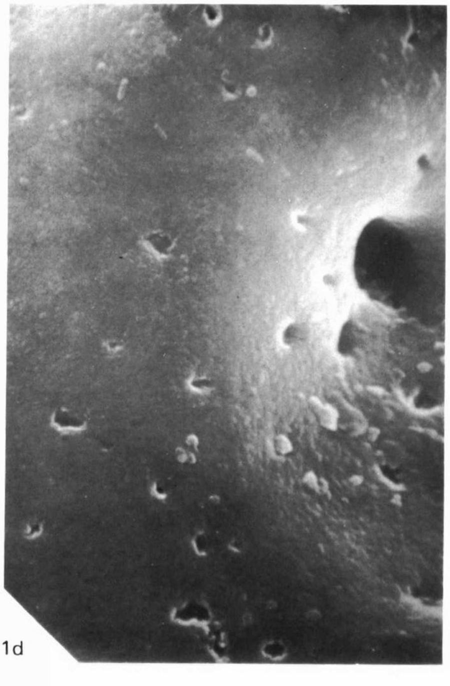

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logical conditions to determine the range of intra- and infraspecific variation, as well as morphologic dimorphism related to their reproductive cycle (the latter aspect is discussed in a report presently in preparation).

These observations and the identification of two new bolivinid species indicate that additional re-examination of the systematics of Recent inner-neritic Bolivinitidae is desirable.

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