19. CAMPANIAN LARGER FORAMINIFERA FROM SITE 98, LEG 11 OF THE DEEP SEA DRILLING PROJECT (NORTHWEST PROVIDENCE CHANNEL, BAHAMA ISLANDS)

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The following larger foraminifera were found in the Upper Cretaceous 272 to 318 meter interval (Cores 13, 14 and 15) of Site 98:

Core 13, core catcher:
Vaughanina barkeri, Ctenorbitoides cardwelli (1 specimen), *Sulcoperculina cf. globosa* (1 specimen).

Core 13, thin sections:
Torreina torrei (frequent), *Pseudorbitoides* sp., *Vaughanina barkeri*, *Sulcoperculina* cf. *globosa*, unidentified miliolid of *Raadshovenia* group, fragments of cuneolinids.

Core 14, 58-60 cm and core catcher:
Pseudorbitoides israelskyi (1 specimen), *Torreina* sp. (fragments), *Vaughanina barkeri, Aktinorbitoides* sp. (2 specimens), *Sulcoperculina dickersoni, S.* cf. *globosa, Coskinolina* sp. (1 specimen).

Center bit sample between Cores 14 and 15:
Orbitoides tissoti, Lepidorbitoides cf. *minor, Torreina torrei, Pseudorbitoides israelskyi, Vaughanina cubensis, Smoutina bermudezi* (1 oblique section), 1 specimen of an unidentified larger rotalid s.l., fragments of rudist shells, fish otoliths (2 specimens).

Core 15-1, thin section:
Coskinolina sp.
Preservation of the foraminiferal fauna is usually rather bad; The internal walls are coated with a thick layer of calcite crystals (see scanning electron microscope pictures on Plate 2). The material is therefore not well suited to elucidate questions of structural morphology.

The fauna as a whole corresponds very much to the Cuban Upper Cretaceous assemblages from the Habana group, Via Blanca formation (Palmer, 1934; Brönnimann and Rigassi, 1963), and to the assemblage collected by the *Glomar Challenger* on Leg 1, Site 4A (Sachs, 1969). The fauna of Leg 11, Site 98 differs from these by the predominance of orbitoids and in particular of *Torreina torrei* in the center bit sample between Cores 14 and 15.

The known stratigraphic distribution of the species mentioned here ties in quite well with the associated planktonic assemblages in the Cuban material (Brönnimann and Rigassi, 1963), and in Site 4A of Leg 1. In addition, *Orbitoides tissoti* can be correlated directly with the European type section of the Campanian stage.

REMARKS ON THE FIGURED FORAMINIFERA

Larger foraminifera from the Campanian level at Site 98 figured in Plates 1, 2 and 3 are briefly commented on below. The incomplete synonymy lists, preceding each comment, hint at the most important literature for identifying these species.

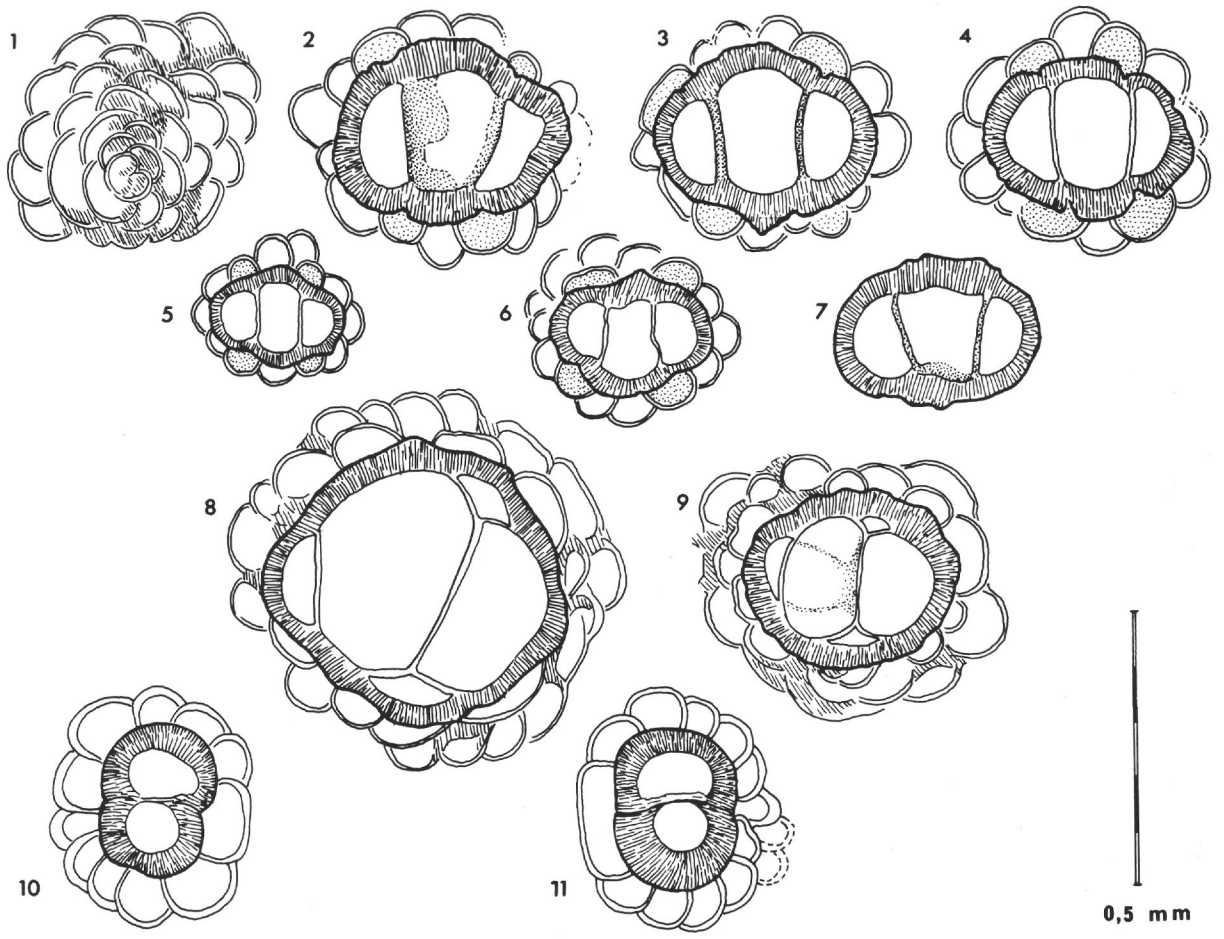
Orbitoides tissoti Schlumberger, 1902
(Plate 1, Figures 2 and 3; Text-figures 1-7.)

1902 *Orbitoides tissoti* Schlumberger. B. Soc. géol. France (Paris). 4, *2*, p. 259, pl. 8, fig. 21-25.
1930 *Orbitoides palmeri* Gravell J. Paleont. (Tulsa). *4*, 3, p. 269, pl. 22, fig. 1-10.
1954 *Orbitoides tissoti* Schlumberger. Küpper K. Contr. Cushm. Found. Foram. Res. V. 2, p. 66, pl. 12, fig. 1,2; text fig. 2 12-15.
1966 *Orbitoides tissoti* (?) Schlumberger. Van Hinte, J. E. K. Nederl Akad. Wetensch. (Amsterdam). B. *69*, 1, p. 100, pl. I, FR 821.

Small, thickly-lenticular species with a three-chambered megalospheric embryo; largest diameter of embryo: 0.25-0.4 millimeter. Four auxiliary chambers; one microspheric specimen with at least 6 biserial early chambers (Text-Figure 1).

Remarks:

O. tissoti is the only larger foraminifer providing direct correlation with the type Campanian. The preservation and the number of available specimens does not allow the quantitative methods of determination suggested by Van Hinte (1966) to be used, but determination on a typological basis seems to be secure enough to correlate the orbitoids of the *tissoti* group with the lowest morphological unit found by Van Hinte (1966) in the type section of the Campanian stage in the 526 to 821 meter interval.



Figures 1-11. *Orbitoidal embryos in equatorial sections, from station 98, center bit sample between B1 14 and 15.*

Figure 1. Orbitoides tissoti *Schlumberger, microspheric form.*
Figures 2-7. Orbitoides tissoti *Schlumberger, megalospheric forms. Auxiliary chambers dotted.*
Figures 8, 9. Torreina torrei *Palmer.*
Figures 10, 11. Lepidorbitoides *cf.* minor *Schlumberger.*

According to Van Hinte (1965 and 1967), *O. tissoti* occurs there together with a planktonic assemblage comprising *Globotruncana arca, G. cretacea, G. fornicata, G. linneiana,* and *G. marginata.* The benthonic smaller foraminifera *Bolivinoides decoratus* and *B. miliaris* also occur.

Lepidorbitoides cf. *minor* (Schlumberger), 1902
(Plate 1, Figure 1; Text-Figures 10 and 11)

Two specimens which differ from *L. minor* by the more isolepidine shape of the embryo and by their longer, and more asymmetric initial spirals were found. They differ from *L. palmerae* Thiadens, 1937, by having much thicker embryonic walls and much smaller chambers in the main layer. *L. macgillavryi* Thiadens, 1937, has an embryo about half the size of that of *L.* cf. *minor*. Preservation and scarceness of specimens do not allow a detailed comparison with *L. minor* of the European type Maestrichtian. All *Lepidorbitoides* species need revision before they can be used for detailed biostratigraphic correlation.

Torreina torrei Palmer, 1934
(Plate 1, Figures 6-8, Text-Figures 8 and 9)

1934 *Torreina torrei* Palmer. Soc. Cubana Hist. Nat. (Havana). *8*, p. 237, pl. 12, fig. 1,4.
1962 *Torreina torrei* Palmer. Hanzawa S., Micropaleontology. (New York) *8*, 2, p. 133, pl. 1, fig. 45, 53-55.

Spherical, gypsina-like foraminifera with an orbitoidal embryo. Largest diameter 0.55 millimeter. Auxiliary

chambers not restricted to equatorial plane. No equatorial layer of main chambers. The system of intercameral communication in the radially arranged chambers, and the arrangement of auxiliary chambers around the spherical embryo are not yet understood.

Pseudorbitoids

Pseudorbitoids seem to be closely related to *Sulcoperculina*, a rotalid which develops marginal exits from the intraseptal canal system. They differ from European Cretaceous orbitoidal rotalids (*Orbitokathina* etc.; Hottinger, 1966) by their imperforate periphery which admits to the large apertures of the canal system, and by their tendency toward planispiral involute growth. The generic and specific definitions in *Pseudorbitoides, Vaughanina* and related genera will have to be revised when sufficiently well-preserved material is available.

Pseudorbitoides israelskyi Vaughan and Cole, 1932
(Plate 1, Figures 4 and 5; Plate 3, Figure 6)

1943 *P. israelskyi* Vaughan and Cole. Vaughan T. W. and Cole W. S., J. Paleont. (Menasha, Wisc.) *17*,1, p. 98; pl. 17, fig. 1,2.

Spiral embryo composed of 8 to 9 chambers. Diameter of proloculus 0.1 millimeter (Plate 3, Figure 3). Megalospheric *P. trechmanni* Douvillé (Brönnimann 1955) has two prime auxiliary chambers.

The European *P. longispiralis* Papp and Küpper (1953) occurs at a similar stratigraphic level associated with *O. tissoti* but shows a much longer embryonic spiral (16 to 20 spiral chambers). The generic assignment is doubtful, as structural details cannot be recognized in the single published picture. Material from Switzerland, also rather poor (Hottinger, 1967), does not show radial structures in the equatorial main layer.

Vaughanina cubensis Palmer, 1934
(Plate 1, Figure 9; Plate 3, Figure 5)

1943 *V. cubensis* Palmer. Vaughan T. W. and Cole W. S., J. Paleont. (Menasha, Wisc.) *17*,1, p. 98; pl. 17, fig. 3,4; pl. 18, fig. 1-10.

1954 *V. cubensis* Palmer. Brönnimann. Contr. Cushm. Found. Foram. Res. *5*,3, p. 91, pl. 16,. fig. 1-11; pl. 17, fig. 1-6; pl. 18, fig. 4-10; text fig. 1-9.

Spiral embryo composed of 13 rotaloid chambers. Diameter of proloculus 0.08 - 0.01 millimeter. The first lateral chambers connect directly with the intraseptal canal system.

Vaughanina barkeri Brönnimann, 1954
(Plate 1, Figures 10 and 11; Plate 2, Figures 3 and 4; Plate 3, Figures 1 and 2)

1954 *V. barkeri* Brönnimann. Contr. Cushm. Found. Foram. Res. *5*,3, p. 103; pl. 18, fig. 1-3; text fig. 10.

Tightly coiled, juvenile stage composed of about 30 chambers. Diameter of megalosphere 0.03 millimeter. The particular canal system pointed out by Brönnimann, 1954 has not been observed in our rather badly preserved material. Scanning microscope pictures show the minute perforation in the vertical walls separating lateral chambers (Plate 2, Figure 4).

Aktinorbitoides sp.
(Plate 2, Figure 2)

1958 *A. browni* Brönnimann. Micropaleontology. *4*,2, 167, pl. 1, fig. 1-9; pl. 2, fig. 1-10; text fig. 2-6.

Two badly preserved specimens generically recognizable by their spines. The specimens have not been cut and, therefore, can not be determined specifically.

Ctenorbitoides cardwelli Brönnimann, 1958
(Plate 2, Figure 1; Plate 3, Figure 3)

1958 *C. cardwelli* Brönnimann. Micropaleontology. *4*,2, 171, pl. 3, fig. 1-6; plate 4, fig. 1-7; pl. 5, fig. 1-4, 6-8, 10-13; plate 7, fig. 1-4; text fig. 7-9.

One rather nicely preserved specimen which was photographed in the scanning microscope first (Plate 2, Figure 1) and cut in an axial direction afterwards (Plate 3, Figure 3).

Sulcoperculina cf. *globosa* de Cizancourt, 1949
Plate 2, Figures 6 and 7; Plate 3, Figure 4

1967 *Sulcoperculina globosa* de Cizancourt. Butterlin J., Rev. Micropal. (Paris). *10*,1, pl. 61; pl. 1, fig. 11

This sulcoperculinid is probably a new clearly trochospiral species of the *S. globosa - obesa* group which are defined by their thickened shells with very little or no external ornamentation. There are not only marginal but also a few umbilical openings of the intraseptal canal system suggesting a rotaloid origin of *Sulcoperculina*. The same trochoid species occurs in strata of Campanian age associated with the hippuritids *Barrettia* and *Torreites* and with *Pseudorbitoides trechmanni* in Jamaica (Jung, 1970; see also Butterlin, 1956) and in Haiti (Butterlin, 1967). This form might represent an ancestor of the more or less planispiral Maestrichtian *S. globosa* and will be described elsewhere in detail.

Sulcoperculina dickersoni (Palmer), 1934
(Plate 2, Figure 5)

1934 ?*Camerina dickersoni* Palmer. Mem. Soc. Cuban Hist. Nat. *8*,4; p. 243; pl. 14, fig. 1, 2, 4, 6, 8; text fig. 4, 5.

Few specimens showing the badly preserved ornamentation on the lateral surface of the shell and the typical shape and number of main chambers.

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PLATE 1
Campanian Larger Foraminifera from Site 98

Figure 1	*Lepidorbitoides* cf. *minor* Schlumberger, equatorial section, X20
Figure 2	*Orbitoides tissoti* Schlumberger, axial section of particularly thick, conical specimen, X20.
Figure 3	*Orbitoides tissoti* Schlumberger, equatorial section, X20.
Figures 4, 5	*Pseudorbitoides israelskyi* Vaughan and Cole, slightly oblique equatorial sections, X20.
Figures 6-8	*Torreina torrei* Palmer, centered sections. Figure 7 shows a twinned specimen; Figure 8 shows a not quite centered section. X20.
Figure 9	*Vaughanina cubensis* Palmer, equatorial section, X20.
Figure 10	*Vaughanina barkeri* Brönnimann, axial section, X50.
Figure 11	*Vaughanina barkeri* Brönnimann, euqatorial section, X50.
Figures 1-9	From Site 98, center bit sample between Cores 14 and 15.
Figures 10-11	From Site 98, Core 14.

PLATE 1

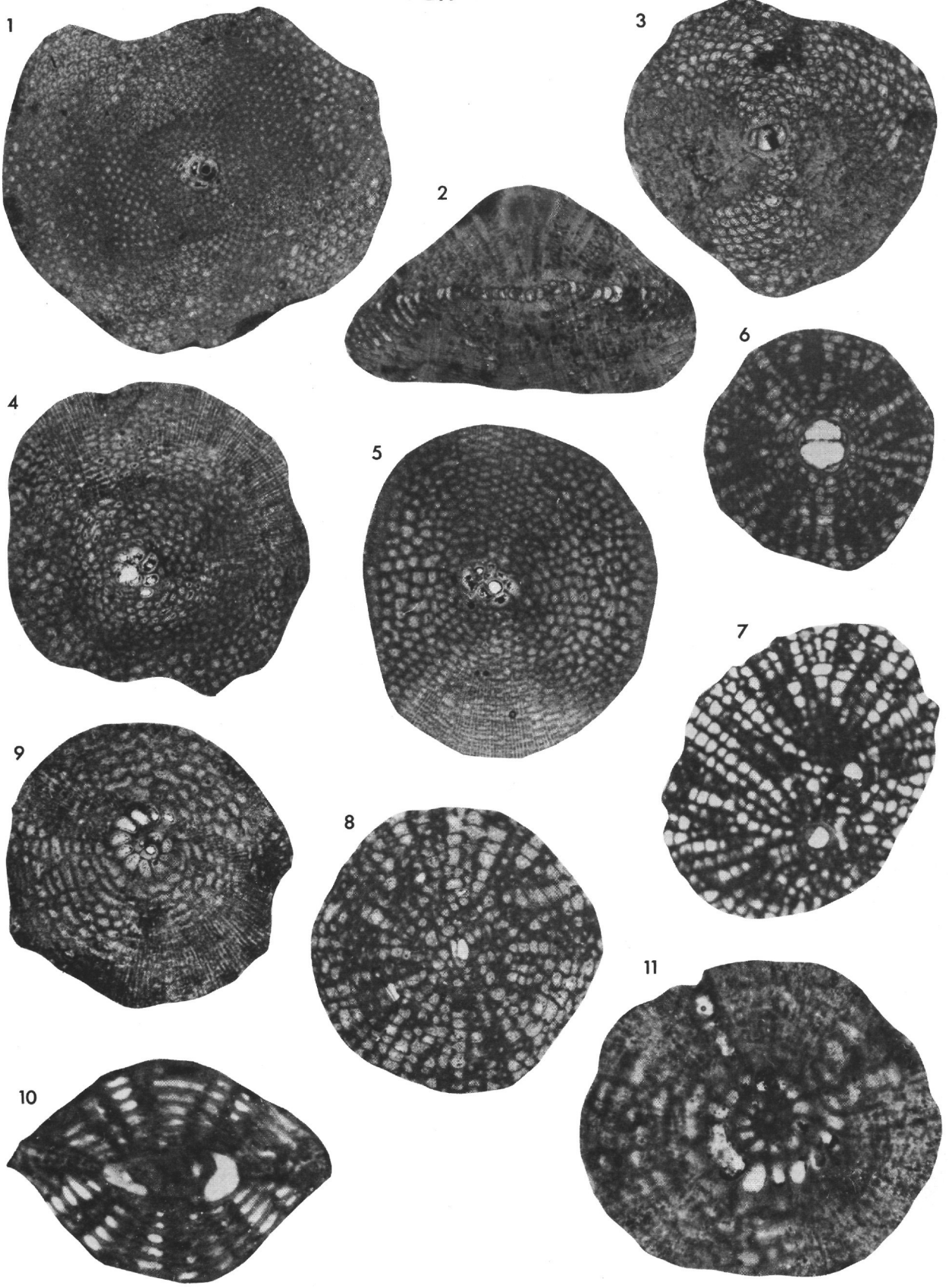


PLATE 2

Scanning Electron Micrographs of Pseudorbitoids and *Sulcoperculina* showing the State of Preservation

Figure 1 — *Ctenorbitoides cardwelli* Brönnimann, external view, ×50. From Site 98, Core 13.

Figure 2 — *Aktinorbitoides* sp., external view showing spines, ×45. From Site 98, Core 14.

Figure 3 — *Vaughanina barkeri* Brönnimann, external view, ×50. From Site 98, Core 14.

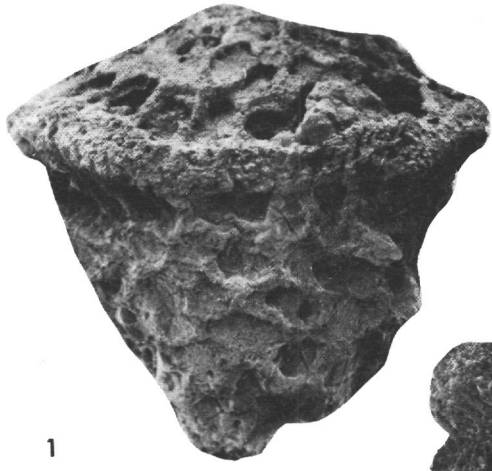
Figure 4 — *Vaughanina barkeri* Brönnimann, lateral chamber broken up, showing perforation of chamber floor and chamber walls. ×450. From Site 98, Core 14.

Figure 5 — *Sulcoperculina dickersoni* (Palmer), lateral view showing ornamentation, ×50. From Site 98, Core 14.

Figure 6 — *Sulcoperculina* cf. *globosa* de Cizancourt, erodet specimen, ×100, from Site 98, Core 14.

Figure 7 — *Sulcoperculina* cf. *globosa* de Cizancourt, detail, ×200. From Site 98, Core 14. C: chamber cavity. L: ventral, lateral wall with coarse perforations. M: marginal apertures of intraseptal canal system. S: septum.

PLATE 2



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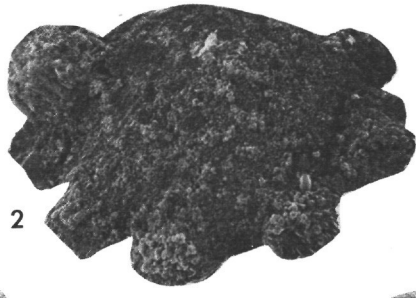

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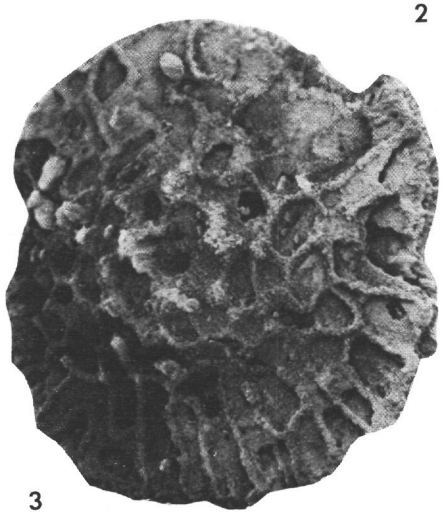

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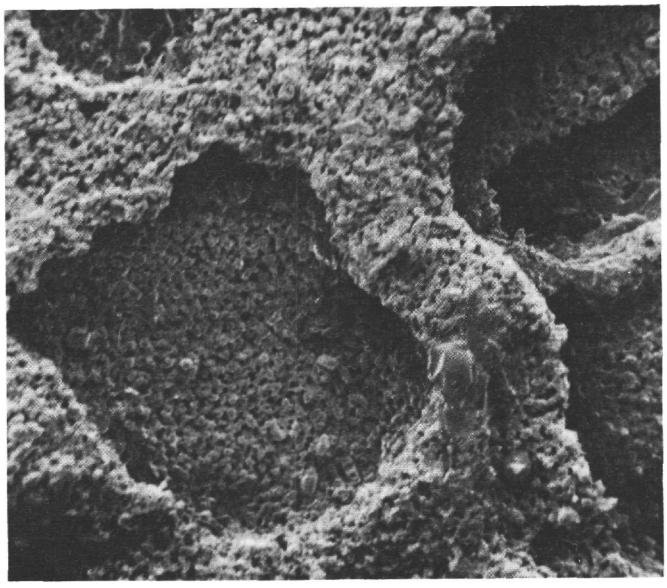

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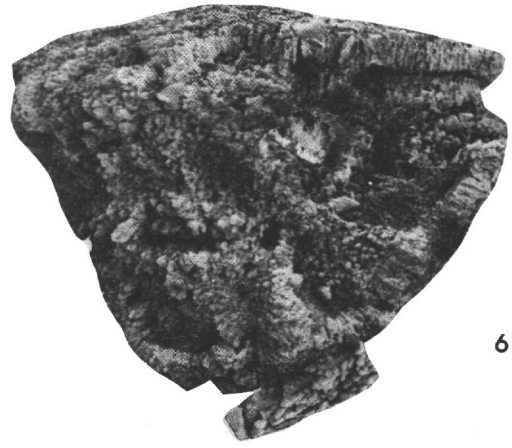

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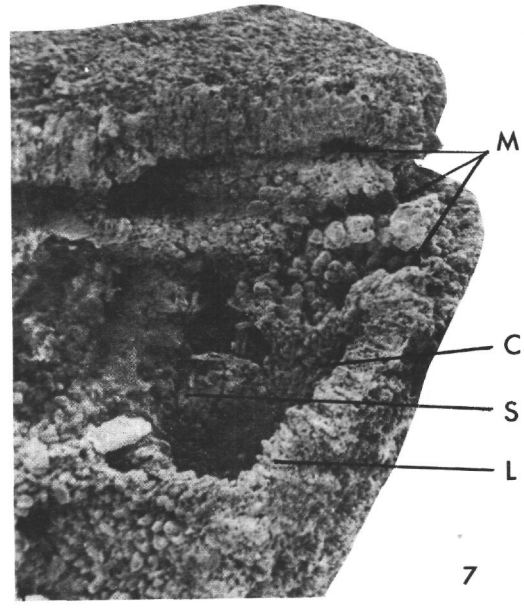

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PLATE 3

Neanic and First Adult Stages of Pseudorbitoids Compared to *Sulcoperculina*, all X34, from Leg 11, Site 98.

Figure 1 — *Vaughanina barkeri* Brönnimann, equatorial section. From Core 14.

Figure 2 — *Vaughanina barkeri* Brönnimann, axial section, not quite centered. From Core 14.

Figure 3 — *Ctenorbitoides cardwelli* Brönnimann, axial section. From Core 13.

Figure 4 — *Sulcoperculina* cf. *globosa* de Cizancourt, axial section, entire specimen, From Core 14.

Figure 5 — *Vaughanina cubensis* Palmer, equatorial section. From Core 14.

Figure 6 — *Pseudorbitoides israelskyi* Vaughan and Cole, equatorial section. From center bit sample between Cores 14 and 15.

PLATE 3