24. LEG 9 SYNTHESIS, RADIOLARIA[1]

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ABSTRACT

The stratigraphic ranges of eighty Oligocene and Neogene Radiolaria in eight Leg 9 drilling sites are summarized and compared to foraminifera and nannofossils. Steroscan photomicrographs of all but nine of these species are provided. The zonation for Radiolaria is correlated to other zonal schemes and to European stages.

INTRODUCTION

With the exception of Site 76, well-preserved Radiolaria are present in all the Leg 9 drilling sites. Although siliceous fossils are rarely dominant in the chalks and volcanic sediments which we recovered, sufficiently large residues were obtained for biostratigraphic purposes. Radiolaria were generally of little value in providing basement ages because of their paucity in basal sediments. At Sites 77, 80, 81 and 82, where hydrothermal alteration of the basal sediments is manifested by limestone, calcareous mudstones and iron-rich clay (Line Islands Oceanic Formation), Radiolaria are not present for stratigraphic thicknesses of four to twenty-four meters above the basalt. At Sites 78 and 79, where hydrothermal alteration is limited to only a few centimeters of chalk above basalt, Radiolaria are present essentially to basement and are useful for age determination. Radiolaria are absent from the chalk breccia and chert overlying basement at Sites 83 and 84.

Three hiatuses are evident from Leg 9 recovery (Plate 88 and Figure 2). One is the obvious Pleistocene-Middle Miocene hiatus at the top of Site 78. At Sites 77 and 80, lesser hiatuses are indicated on the basis of Radiolaria and should be regarded as subject to interpretation. Portions of the *Hexaspyris papilio* Zone and *Lychnocanium bipes* Zone appear to be missing at Site 77 between Cores 34 and 36, because of the absence of *Clathrobursa clathrobursa* and the abrupt first appearances of seven species in Core 34. In Hole 80A, Core 2, a portion of the *Spongaster pentas* Zone appears to be absent on the basis of the simultaneous first appearance of *Clathrocircus stapedius, Nephrospyris renilla* and *Archicircus rhombus.* Studies of Site 77 and piston cores reveal that 1.3 million years lapse between the first appearances of these species.

[1] Lamont-Doherty Geological Observatory Contribution No. 1710.

ACKNOWLEDGEMENTS

I gratefully acknowledge the assistance of Tsunemasa Saito in the placement of stage boundaries for Plate 88. Sandra Meslow assisted with laboratory preparation and typing. A portion of the expenses of this work have been defrayed by DSDP. The major financial burden was borne by NSF Grant GA 17122.

SUMMARY OF RADIOLARIA ZONATION

With the exception of the Line Islands Oceanic Formation, Radiolaria are sufficiently abundant to provide ample material for biostratigraphic correlation. Figure 1 summarizes variations in zonal thicknesses with drilling sites arranged by longitude. Plate 88 (see pocket in back cover) compares the Radiolaria zonation to other zonations and geologic time. All sixteen zones which were used in this volume are present at Site 77. This composite zonation includes the Neogene zones proposed by Riedel and Sanfilippo (1970) and two Oligocene zones defined by Moore (in press). A brief discussion of each zone follows.

Thyrsocyrtis bromia Zone (Riedel and Sanfilippo, 1970)

Only the upper portion of this zone, above the first appearance of *Theocyrtis tuberosa,* was recovered on Leg 9. At Sites 77 and 78, the only sites where it is represented, the *Thyrsocyrtis bromia* Zone attains thicknesses of 24 and 16 meters, respectively. The Line Islands Formation and the lower portion of the Marquesas Oceanic Formation lie within the *T. bromia* Zone at these two sites.

The *Thyrsocyrtis bromia* Zone spans the Eocene-Oligocene boundary, and its upper limit lies within the *Coccolithus bisectus-Helicopontosphaera compacta* Subzone and the *Pseudohastigerina barbadoensis* Zone of this volume. Moreover, the top of the *T. bromia* Zone must lie within the *Cassigerinella chipolensis-Hastigerina micra* Zone of Bolli and the Rupelian-Lattorfian Stages.

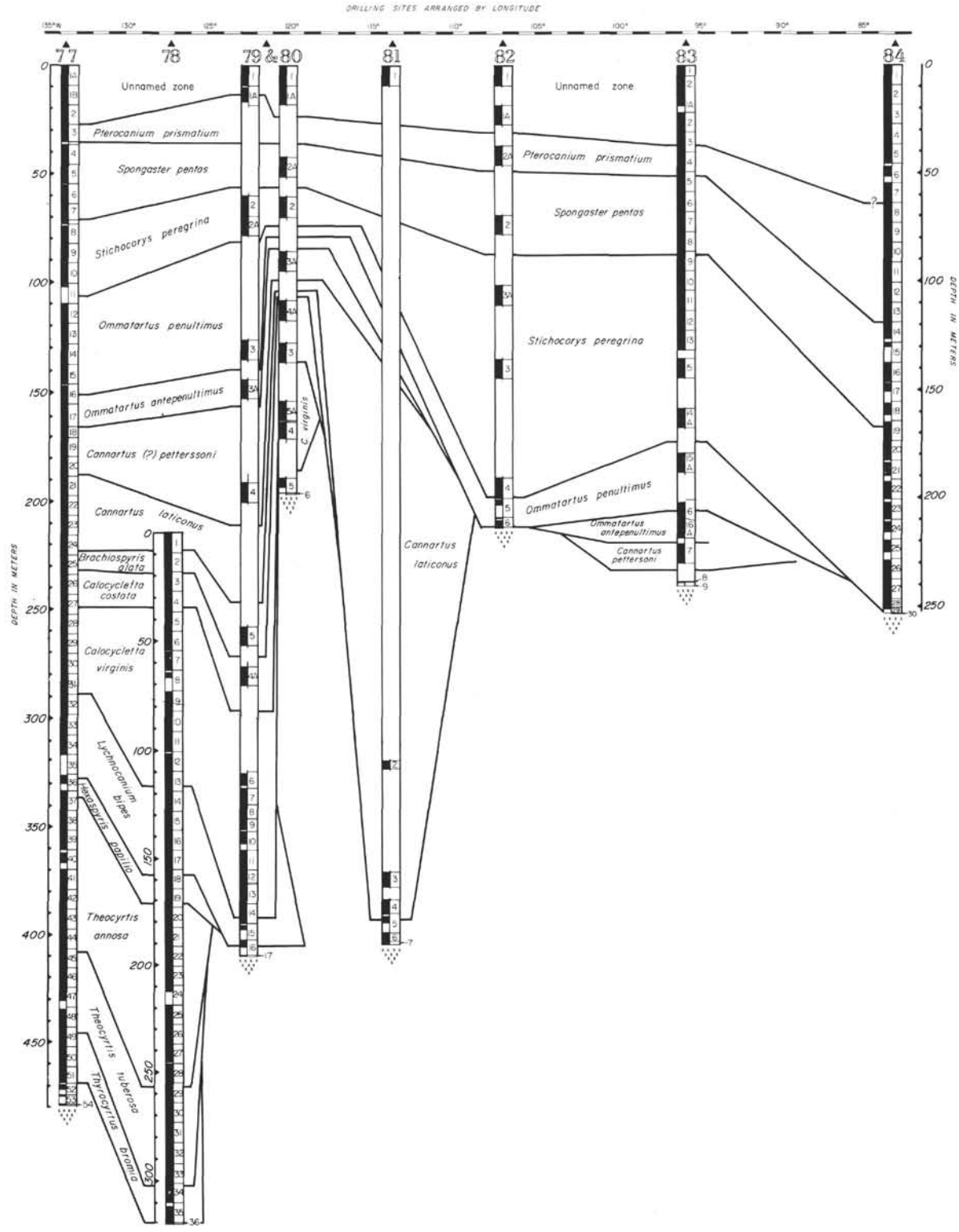


Figure 1. *Comparison of radiolarian zones at Sites 77 to 84. Drilling sites are arranged by longitude.*

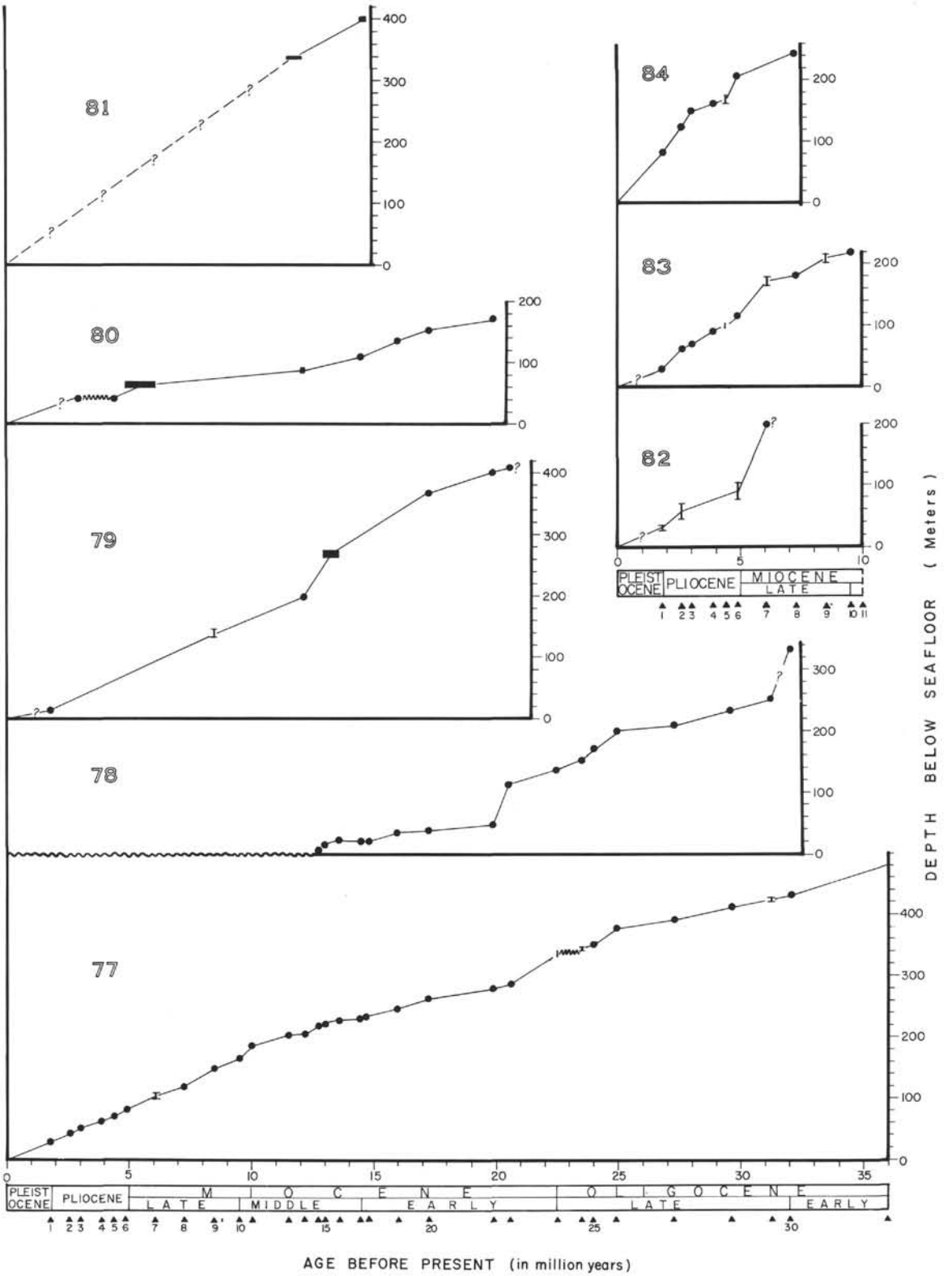


Figure 2. *Plots of sediment depth below sea floor vs. age inferred from biostratigraphic data. Arrows below horizontal scales are reference points which are explained in the text.*

Theocyrtis tuberosa **Zone**

Riedel and Sanfilippo, 1970, placed its base at the first appearance to *Lithocyclia angustum.* Moore (in press) emends its top as the first appearance of *Theocyrtis annosa.* Originally, this zone was established to directly underlie the *Lychnocanium bipes* Zone and include essentially all of the Oligocene Series. Recovery of thick Oligocene sections on Legs 8 and 9 require more detailed zonation. The usefulness of this zone is severely compromised by the erratic occurrence of *Lithocyclia angustum* in sediments recovered on both legs. Sediments referable to this zone were recovered only at Sites 77 and 78, where it is 38 and 45 meters thick, respectively. Sites 77 and 78 were the only Leg 9 sites where the *T. tuberosa* Zone was recovered. At these locations, the *T. tuberosa* Zone occupies a portion of the Marquesas Formation, and it is 38 and 45 meters thick, respectively.

The *Theocyrtis tuberosa* Zone spans the Lower-Upper Oligocene subseries boundary and Rupelian-Chattian stage boundary. The top of the *T. tuberosa* Zone conforms closely to the top of the *Coccolithus bisectus-Helicopontosphaera compacta* Subzone of this volume. Moreover, the top of the *T. tuberosa* Zone lies within the lower third of the *Globigerina ampliapertura* Zone of this volume and Bolli.

Theocyrtis annosa **Zone**

Moore (in press) proposes this zone such that its base is coincident with the first appearance of *Theocyrtis annosa* and its top is coincident with the first appearance of *Hexaspyris papilio.* Sediments referable to the *T. annosa* Zone were recovered only at Sites 77 and 78 on Leg 9. At Site 77, the *T. annosa* Zone consists of 70 meters of the Marquesas Formation. At Site 78, the *T. annosa* Zone consists of 83 meters of sediment from the varicolored unit of the Clipperton Oceanic Formation.

The top of the *Theocyrtis annosa* Zone correlates approximately with the top of the *Coccolithus bisectus* nannofossil zone of this volume. The *T. annosa* Zone is equivalent to the upper portion of the *Globigerina ampliapertura* Zone, all of the *Chiloguembelina cubensis* and *Globorotalia opima* Zones, and the lower part of the *Globigerina angulisuturalis* Zone based on foraminifera. The *T. annosa* Zone occupies much of the Chattian Stage, and its upper boundary lies within the *Globigerina ciperoensis ciperoensis* Zone of Bolli and Blow's N3 zone.

Hexaspyris papilio **Zone**

Moore (in press) defines this zone under the name *Dorcadospyris papilio.* The reader is referred to the systematics section for explanation of my choice of generic designation. The base of this zone is coincident with the first appearance of *Hexaspyris papilio*, and the top of the zone is coincident with the first appearance of *Lychnocanium bipes.* As was true of the three preceding zones, the *H. papilio* Zone was recovered only at Sites 77 and 78 of Leg 9. At Site 77, the *H. papilio* Zone consists of 9 meters of Marquesas Formation sediments; whereas, at Site 78 it consists of 15 meters of sediments from the varicolored unit of the Clipperton Formation. The complete absence of *Clathrobursa clathrobursa* at Site 77 suggests that the upper portion of the *H. papilio* Zone is mission there.

At Sites 77 and 78, the *Hexaspyris papalio* Zone is quite short compared to contiguous zones. It is equivalent to the lower third of the *Triquetrorhabdulus carinatus-Coccolithus abisectus* nannofossil subzone and the middle of the *Globigerina angulisuturalis* foraminiferal zone of this volume. Moreover, the *H. papilio* Zone must be equivalent to the medial *Globigerina ciperoensis ciperoensis* Zone of Bolli and the N3 zone of Blow.

Lychnocanium bipes **Zone**

Riedel and Sanfilippo (1970) defined this zone such that its base is coincident with the first appearance of *Lychnocanium bipes*, and its top is coincident with the first appearance of *Calocycletta virginis.* The *L. bipes* Zone was recovered at Sites 77, 78 and 79. Much of the lower portion of the *L. bipes* Zone is missing from Site 77 because of poor recovery. Moreover, the complete absence of *Clathrobursa clathrobursa* from this site suggests that a hiatus may have resulted in the loss of much of the lower *L. bipes* Zone. At Site 77, the *L. bipes* Zone consists of 41 meters of Marquesas Formation sediments. At Site 78, the *L. bipes* Zone appears to be complete and consists of 40 meters of sediment from both the varicolored and cyclic units of the Clipperton Formation. Only the upper portion of the *L. bipes* Zone was recovered from Site 79, where it consists of 11 meters of orange chalks of the Marquesas Formation.

Sites 79 and 80 were drilled on the same longitude in order to compare ages of basal sediments overlying basalt at places where the sedimentary section differed markedly in thickness. Although these basal sediments at Sites 79 and 80 belong to the same nannofossil and foraminiferal zones, the *Lychnocanium bipes* Zone was not presetn at Site 80. This apparent inconsistency is probably the result of poor opal preservation in the Line Islands Formation, which overlies basalt at Site 80. Radiolaria were not recovered for an interval of 25 meters above the basalt for this reason, and also because of spotty recovery.

The *Lychnocanium bipes* Zone spans the Chattian-Aquitanian stage boundary, and hence the Oligocene-Miocene series boundary. Moreover, the top of the

L. bipes Zone falls within the *Triquetrorhabdulus carinatus-Discoaster druggii* nannofossil subzone of this volume and the *Globorotalia kugleri* foraminiferal zone of this volume and Bolli.

Calocycletta virginis **Zone**

Riedel and Sanfilippo (1970) defined this zone such that its base is coincident with the first appearance of *Calocycletta virginis* and its top coincides with the first appearance of *Calocycletta costata.* Sediments referable to the *C. virginis* Zone are present in cores from Sites 77 through 80. Essential complete sections of the *C. virginis* Zone exist at Sites 77 and 78. At Site 77, the *C. virginis* Zone consists of 47 meters of Marquesas Formation sediments, whereas it is represented by 81 meters of sediments from the cyclic unit of the Clipperton Formation at Site 78. At Site 79, the top of the *C. virginis* Zone must lie within the uncored interval between Core 4A and 6. However, 68 meters of the lower *L. bipes* Zone was recovered and consists of Marquesas and San Blas Oceanic Formation sediments. Only a small portion of the upper *L. bipes* Zone is present in the cores from Site 80, because of the high percentage of uncored section and absence of opal in the basal sediments. Nonetheless, the *C. virginis* Zone must be at least 39 meters thick at Site 80.

The *Calocycletta virginis* Zone includes portions of both the Aquitanian and Burdigalian Stages and covers much of Early Miocene time. The top of the *C. virginis* Zone lies within the lower third of the *Triquetrorhabdulus carinatus-Sphenolithus heteromorphus* nannofossil subzone of this volume and below the *Globigerinoides bisphericus* Subzone of the *Globoquadrina venezuelana* foraminiferal zone of this volume. Moreover, the top of the *C. virginis* Zone must fall within the *Globigerinatella insueta* Zone of Bolli and N7 Zone of Blow.

Calocycletta costata **Zone**

Riedel and Sanfilippo (1970) defined the *Calocycletta costata* Zone such that its base coincides with the first appearance of *C. costata* and its top is coincident with the first appearance of *Brachiospyris alata.* The *C. costata* Zone was recognized at Sites 77 through 80 of Leg 9. Essentially complete sections of this zone were recovered from Site 77 and 78. At Site 77, the *C. costata* Zone consists of 20 meters of Marquesas Formation sediments, whereas it is represented by 15 meters of sediments from the cyclic unit of the Clipperton Formation at Site 78. At Site 79, the *C. costata* Zone is represented by one 9-meter core (4A) of San Blas Formation chalk. The top and bottom of the zone must lie in the uncored intervals above and below this core. The *C. costata* Zone reaches its maximum Leg 9 thickness at Site 80, where it is represented by two discontinuous cores (4A and 3). The minimum thickness for the zone is 26 meters, but the true thickness may be substantially greater because the top and base of the zone lie within superjacent and subjacent uncored intervals.

The *Calocycletta costata* Zone spans the Langhian-Burdigalian stage boundary and hence the Lower-Middle Miocene subseries boundary. The top of the *C. costata* Zone lies within the lower portion of the *Sphenolithus heteromorphus-Helicopontosphaera selli* nannofossil subzone of this volume. The top of the *C. costata* Zone is located above the *Praeorbulina glomerosa curva* Subzone of the *Globorotalia peripheroacuta* foraminiferal zone of this volume. Moreover, the top of the *C. costata* Zone must be close to the base of the *Globorotalia fohsi barisanensis* Zone of Bolli.

Brachiospyris alata **Zone**

Riedel and Sanfilippo (1970) defined this zone such that its base and top are coincident with the first and last appearance of *Brachiospyris alata.* They referred to the nominate species as *Dorcadospyris alata.* My preference for this older generic assignment is discussed in the systematics section. Use of this zone on Leg 9 was complicated by sporadic occurrences of the index species. The upper part of the stratigraphic range of *B. alata* is characterized by erratic occurrences in low specimen frequencies. Because this type of distribution may be the result of upward sediment reworking, I have placed the top of the *B. alata* Zone at the top of the continuous occurrence of the nominate species. Therefore, the thickness of this zone may be more constricted in this volume than elsewhere. On Leg 9, the *B. alata* Zone was recognized in Sites 77, 78 and 79. Essential complete sections of this zone, as it was here emended, are present at Sites 77 and 78. At Site 77, the *B. alata* Zone consists of 8 meters of Marquesas Formation sediments, whereas it consists of 11 meters of sediments from the cyclic unit of the Clipperton Formation at Site 78. At Site 79, the *B. alata* Zone is represented by one 9-meter core (Core 5) of San Blas Formation chalk. The top and base of the zone must lie in the uncored intervals above and below this core. At Site 80, the *B. alata* Zone must lie within the uncored interval between Cores 3A and 4A, or it is absent.

The top of the *Brachiospyris alata* Zone corresponds closely to the top of the Langhian Stage and to the top of the *Sphenolithus heteromorphus-Triquetrorhabdulus rugosus* nannofossil subzone of this volume. Moreover, the top of the *B. alata* Zone lies within the lower third of the *Globorotalia fohsi fohsi-Globorotalia peripheroacuta* foraminiferal zone of this volume.

Cannartus laticonus **Zone**

As it is used in this volume, the base of the *Cannartus laticonus* Zone is coincident with the top of the continuous range of *Brachiospyris alata.* Its top is coincident with the first appearance of *Cannartus* (?) *petterssoni.* The entire *C. laticonus* Zone was recovered only at Site 77, where it is represented by 34 meters of Marquesas Formation sediments.

The *C. laticonus* Zone is the youngest zone recovered at Site 78, where the base of the zone is only 8 meters below the sea floor. At Sites 79 and 80, the *C. laticonus* Zone is either absent or it is located in uncored intervals at both sites. The occurrence of the *C. laticonus* Zone at Site 81 is problematic. Radiolaria are absent or poorly preserved in the five meters of "baked" chalks overlying basalt at this site. From the lowest cores in which Radiolaria are present, the accessory fauna is much like that of the upper *Brachiospyris alata* Zone, although the nominate species has a very sporadic occurrence. Hence, the base of the *C. laticonus* Zone is placed at the first appearance of *C. laticonus.* Selective solution may have resulted in peculiar assemblages here, and the base of the *C. laticonus* Zone may be located in the lower part of Core 3, where six species have abrupt terminations. As the base is drawn here, the *C. laticonus* Zone has a minimum thickness of 78 meters.

The *Cannartus laticonus* Zone occupies much of the Serravallian Stage. The top of the *C. laticonus* Zone corresponds to the top of the *Globorotalia fohsi lobata* Zone of Bolli and this volume. The top of the *C. laticonus* Zone falls within the upper quarter of the *Discoaster exilis-Discoaster kugleri* nannofossil subzone of this volume.

Cannartus (?) *petterssoni* **Zone**

Riedel and Sanfilippo defined this zone such that its base is coincident with the first appearance of *Cannartus* (?) *petterssoni* and its top coincides with the first appearance of *Ommatartus antepenultimus.* The *C.* (?) *petterssoni* Zone was recovered at Sites 77, 79, 80 and 83. At Site 77, the entire zone is apparently present and consists of 23 meters of Marquesas Formation chalk. At both Sites 79 and 80, the *C.* (?) *petterssoni* Zone is represented by a single 9-meter core. The *C.* (?) *petterssoni* Zone is the oldest recognizable zone at Site 83, and only the uppermost 9 meters were recovered.

The *Cannartus* (?) *petterssoni* Zone spans the Tortonian/Serravallian stage boundary and hence the Upper Miocene-Middle Miocene subseries boundary of conventional usage. For this volume, the Upper Miocene-Middle Miocene boundary is arbitrarily placed at the base of the *Ommatartus antepenultimus* Zone in order to conform with Leg 8. However, this assignment is above the boundary between the Seravallian and Tortonian Stages. A more precise subseries boundary could be placed at the first appearance of *Tholospyris infericosta* within the *C.* (?) *petterssoni* Zone. The top of the *C.* (?) *petterssoni* Zone is closely equivalent to the top of the *Discoaster variabilis-Discoaster hamatus* nannofossil subzone of this volume. The top of the *C.* (?) *petterssoni* Zone lies within the *Globoquadrina altispira* foraminiferal zone of this volume and the *Globorotalia acostaensis* Zone of Bolli.

Ommatartus antepenultimus **Zone**

Riedel and Sanfilippo (1970) defined this zone such that its base coincides with the first appearance of the nominate species and its top coincides with the first appearance of *Ommatartus penultimus.* This zone was recovered at Sites 77, 79 and 83. At Site 77, the *O. antepenultimus* Zone is apparently complete and consists of 13 meters of sediment from the Clipperton and Marquesas Formations. At Site 79, the *O. antepenultimus* Zone is represented by a single 9-meter core (Core 3) in a discontinuously cored interval. The base of the *O. antepenultimus* Zone must be located within the 4-meter unsampled interval between Cores 16A and 7 at Site 83, although the top is present in Core 6. Therefore, the thickness of the *O. antepenultimus* Zone must be between 12 and 16 meters at Site 83.

The base of the *Ommatartus antepenultimus* Zone has been used as the Upper Miocene-Middle Miocene boundary by Legs 8 and 9, although it falls above the base of the Tortonian Stage (see discussion of the *Cannartus* (?) *petterssoni* Zone). The top of the *O. antepenultimus* Zone lies within the *Discoaster variabilis-Discoaster neohamatus* Zone nannofossil subzone of this volume and coincides with the top of the *Globoquadrina altispira* Zone. Moreover, the top of the *O. antepenultimus* Zone probably conforms closely to the top of the N17 Zone of Blow and the *Globorotalia dutertrei-Globigerinoides obliquus extremus* Zone of Bolli.

Ommatartus penultimus **Zone**

Riedel and Sanfilippo (1970) defined this zone such that its base is coincident with the first appearance of *Ommatartus penultimus,* and its top is coincident with the first appearance of *Stichocorys peregrina.* On Leg 9, the *O. penultimus* Zone was recognized at Sites 77, 79, 82 and 83. All but the very top of this zone was recovered at Site 77, where it consists of 40 meters of sediments from the varicolored unit of the Clipperton Formation. The *O. penultimus* Zone is represented by one 9-meter core (Core 3) at Site 79. At Site 82, the *O. penultimus* Zone is the oldest zone above the basalt, and only the upper 13 meters of Line Islands Formation and San Blas Formation sediments were recovered.

Little of the *O. penultimus* Zone was found at Site 83, because of discontinuous coring. However, the base of the zone is present in Core 6, and its minimum thickness is 28 meters of San Blas Formation sediments.

The top of the *Ommatartus penultimus* Zone lies within the *Ceratolithus tricorniculata* nannofossil zone and the *Globorotalia plesiotumida* foraminiferal zone of this volume. Moreover, the top of the *Ommatartus penultimus* Zone lies within the *Globorotalia dutertrei-Globigerinoides obliquus extremus* Zone of Bolli and N17 of Blow.

Stichocorys peregrina **Zone**

Riedel and Sanfilippo (1970) defined this zone such that its base is coincident with the first appearance of the nominate species, and its top is coincident with the first appearance of *Pterocanium prismatium.* On Leg 9, the *S. peregrina* Zone was recognized at Sites 77, 79, 80, 82, 83 and 84. All but the very base of the zone is present at Site 77, where it consists of 30 meters of sediments from the varicolored unit of the Clipperton Formation. Discontinuous coring resulted in only partial recovery of the *S. peregrina* Zone at Sites 79 and 80, where it is represented by 18 meters and 9 meters, respectively, of sediment from the varicolored unit of the Clipperton Formation. Although the base of the *S. peregrina* Zone is present in Core 4, little of the remainder of the zone was recovered at Site 82 because of discontinuous coring. Nonetheless, the zone has a minimum thickness of 98 meters and consists of San Blas ooze and chalk ooze. It is strictly defined; the top of the *S. peregrina* becomes progressively younger at Sites 83 and 84 (see discussion of *Spongaster pentas* Zone for further details). At Site 83, the top of the zone was recovered, but its base must be located in the uncored interval between Cores 14A and 15A. Here, the *S. peregrina* Zone has a minimum thickness of 79 meters of San Blas Formation sediments. The *S. peregrina* Zone is the oldest zone recovered at Site 84, and its true base is not present. At this easternmost site, the *S. peregrina* Zone consists of 73 meters of San Blas sediments.

The top of the *Stichocorys peregrina* Zone lies within the Tabianian Stage and, at Site 77, closely corresponds to the top of the *Globorotalia tumida* foraminiferal zone and *Ceratolithus rugosus* nannofossil zone of this volume and Blow's N18 zone.

Spongaster pentas **Zone**

Riedel and Sanfilippo (1970) defined this zone such that its base is coincident with the first appearance of *Pterocanium prismatium* and its top is coincident with the last occurrence of *Stichocorys peregrina.* The *S. pentas* Zone was recovered at Sites 77, 80, 82, 83 and 84. At Site 77, the *S. pentas* Zone is essentially complete and consists of 34 meters of Clipperton Formation sediments. The *S. pentas* Zone is represented by one 9-meter core at each of Sites 80 and 82. Due to the erratic occurrence of *Pterocanium prismatium* at Sites 83 and 84, the base of the *S. pentas* Zone is diachronously younger there than at Site 77. Close scrutiny of the Biostratigraphic Charts in the Site Reports reveals that *P. prismatium* and *Archicircus rhombus* first appear at the same horizon at Site 77, whereas *P. prismatium* appears above the first appearance of *Nephrospyris renilla* at Sites 83 and 84. *Pterocanium prismatium* has a very sparse occurrence at Site 84. The top of the *S. pentas* Zone appears to be synchronous.

Regardless of these considerations, the *S. pentas* Zone reaches its maximum thickness east of the East Pacific Rise, where it consists of 34 meters of San Blas Formation at Site 83, and 47 meters of San Blas Formation at Site 84. The *Spongaster pentas* Zone spans the Astian-Tabianian stage boundary, and hence the Lower Pliocene-Upper Pliocene subseries boundary. The top of the *S. pentas* Zone is correlative to the lower portions of the *Discoaster brouweri-Cyclococcolithina leptopora* nannofossil subzone of this volume, and the N21 and *Globorotalia truncatulinoides tosaensis* Zones of Blow and Bolli, respectively.

Pterocanium prismatium **Zone**

Riedel and Sanfilippo (1970) defined this zone such that its base is coincident with the last appearance of *Stichocorys peregrina* and its top is coincident with the last appearance of the nominate species. On Leg 9, this zone was recovered at Sites 77, 79, 82, 83 and 84. At Site 77, the zone is essentially complete and consists of eight meters of Clipperton Formation sediments. Only short segments of the *P. prismatium* Zone were recovered at Sites 79 and 82, because of the high percentage of uncored intervals. The top of the *P. prismatium* Zone is diachronously older at Sites 83 and 84 than at Site 77. This relationship is illustrated in Figure 2, and is the result of the anomalous occurrence of the nominate species. At Site 77, *P. prismatium* disappears above the first appearance of *Thalospyris devexa* and at the base of the *Pulleniatina obliquiloculata* Zone. By strict definition, the top of the *P. prismatium* Zone is located below the base of the *P. obliquiloculata* Zone, and below the first appearance of *T. devexa* at Sites 83 and 84. In fact, the occurrence of *P. prismatium* is so sparse at Site 84 that the top of the zone was placed tentatively above the first appearance of *T. devexa.* Fourteen and 43 meters of San Blas sediments constitute the *P. prismatium* Zone at Sites 83 and 84.

At Sites 77 and 79, the top of the *Pterocanium prismatium* Zone conforms closely to the Calabrian-Astian stage boundary, and, hence, the Pliocene-Pleistocene series boundary. The top of the *P. prismatium* Zone is

essentially correlative to the top of the *Gephyrocapsa* spp.-*Coccolithus carteri* Subzone and *Globigerinoides fistulosus* Zone of this volume, and approximately correlates to the top of the N21 and *Globorotalia truncatulinoides tosaensis* Zone of Blow and Bolli, respectively.

Unnamed Zone

This zone overlies the *Pterocanium prismatium* Zone and includes Pleistocene sediments above the extinction of *P. prismatium*. This zone was recovered at Sites 77 and 79 through 84. The base of the unnamed zone is recognized only at Sites 77, 79, 83 and 84. At Sites 77 and 79, the zone consists of 27 meters and 12 meters, respectively, of Clipperton Formation sediments. The mechanics of deep sea drilling are such that the absolute surface sediments may be lost. Therefore, the thickness of the unnamed zone is subject to considerable error. The base of the unnamed zone is older at Sites 83 and 84 than at Sites 77 and 79 (see discussion of *P. prismatium* Zone). At these sites east of the East Pacific Rise, the unnamed zone consists of 37 meters and 64 meters of Clipperton Formation and San Blas Formation sediments at Sites 83 and 84, respectively.

SYSTEMATIC PALEONTOLOGY

The cores collected on Leg 9 are of great value for biostratigraphic studies. Four sites were continuously cored, essentially, in this tropical region of rich organic production. Leg 9 cores are of particular importance to the study of Radiolaria because they offer an opportunity to compare stratigraphic ranges to those of the calcareous microfossils. Hence, it is possible to correlate Radiolaria to established global biostratigraphic zonations and Tertiary stages.

Efforts to achieve these ends were somewhat compromised by calcite solution and disturbed recovery. Many of the index taxa for the foraminiferal zonations of Blow and Bolli were absent from our cores because of neritic endemism or selective solution. For this reason, Leg 9 foraminifera specialists chose to present an alternate zonation which can be correlated to existing zonal schemes only tentatively. In the main, sediments recovered on Leg 9 were soft and fluid, and bedding was highly disturbed. However, this disturbance appears to be limited to short stratigraphic distances, and the ranges of microfossils have not been seriously influenced.

Because of the importance of comparing the stratigraphic ranges of Radiolaria to foraminifera and nannofossils, I have attempted to compile a synthesis of species range and zonation data from the Site Reports onto a single chart (Plate 88, in pocket attached to inside back cover). Site 84 was omitted from this synthesis because fossil assemblages exhibited such a high degree of reworking that all of the biostratigraphy is suspect. Indeed, there is much discord in the three sets of zonal assignments at Site 84. Plate 88 is based largely on Sites 77, 78 and 83, and includes all eighty Radiolaria from the Site Reports. Only common and biostratigraphically important foraminifera are included, and discontinuous or questionable ranges are not illustrated. Planktonic foraminifera serve as the standard for Plate 88 because they are the primary means of correlation to series and stage boundaries. Ranges and zones for Radiolaria and nannofossils are distorted to conform to the foraminiferal data. Correlation to the zonal schemes of Bolli and Blow is taken from Jenkins and Orr (this volume). Correlation to European stage nomenclature was facilitated by the work of Saito and Funnel (1970, Figure 1).

As should be expected, there are minor variations in the biostratigraphic data at each site, and the stratigraphic ranges presented on Plate 88 reflect a limited amount of subjectivity. It is hoped that Plate 88 will serve as a useful extraction of Leg 9 biostratigraphic data. I must bear the responsibility for all errors.

A total of eighty Radiolaria are reported in this volume. Of course, this represents but a minute fraction of the immensely diverse faunas occurring in Leg 9 cores. This study includes forty-four species of Trissocyclidae, of which 17 are not part of the assemblage revised by Goll (1968 and 1969). The remaining thirty-six species are either Theoperidae or established taxa of biostratigraphic importance. All the species are listed alphabetically with references to their original description or most recent revision.

Acrobotrys tritubus Riedel, 1957a

Acrocubus octopylus Haeckel, 1887

Androspyris anthropiscus Haeckel, 1887

Archicircus rhombus Haeckel, 1887

Artophormis gracilis Riedel, 1959

Brachiospyris alata Riedel, 1959

Brachiospyris simplex Riedel, 1959

Calocycletta costata Riedel and Sanfilippo, 1970

Calocycletta virginis Riedel and Sanfilippo, 1970

Cannartus laticonus Riedel, 1959

Cannartus mammiferus Riedel, 1959

Cannartus (?) *petterssoni* Riedel and Sanfilippo, 1970

Cannartus prismaticus Riedel, 1959

Cannartus tubarius Riedel, 1959

Cannartus violina Riedel, 1959

Cantharospyris ateuthus Riedel, 1959

Ceratospyris hyperborea Jorgensen, 1905

Clathrobursa clathrobursa Campbell, 1954

Clathrocircus stapedius Haeckel, 1887

Cyclampterium (?) *brachythorax* Sanfilippo and Riedel, 1970

Cyclampterium (?) *leptetrum* Sanfilippo and Riedel, 1970

Cyclampterium (?) *neatum* Sanfilippo and Riedel, 1970

Cyclampterium (?) *pegetrum* Sanfilippo and Riedel, 1970

Cyclampterium (?) *tanythorax* Sanfilippo and Riedel, 1970

Cyrtocapsella cornuta Sanfilippo and Riedel, 1970

Cyrtocapsella elongata Sanfilippo and Riedel, 1970

Cyrtocapsella japonica Sanfilippo and Riedel, 1970

Cyrtocapsella tetrapera Sanfilippo and Riedel, 1970

Dendrospyris anthocyrtoides Goll, 1968

Dendrospyris binapertonis Goll, 1968

Dendrospyris damaecornis Goll, 1968

Dendrospyris pannosa Goll, 1968

Dendrospyris pododendros Goll, 1968

Dipodospyris forcipata Riedel, 1959

Dorcadospyris costatescens Goll, 1969

Dorcadospyris dentata Goll, 1969

Dorcadospyris pentagona Goll, 1969

Gamospyris circulus Goll, 1969

Giraffospyris angulata Goll, 1969

Giraffospyris annulispina Goll, 1969

Giraffospyris laterispina Goll, 1969

Giraffospyris toxaria Goll, 1969

Gorgospyris schizopodia Haeckel, 1887

Hexaspyris papilio Riedel, 1959

Lampospyris huxleyi Haeckel, 1887

Liriospyris elevata Goll, 1968

Liriospyris globosa Goll, 1968

Liriospyris longicorcuta Goll, 1968

Liriospyris mutuaria Goll, 1968

Liriospyris ovalis Goll, 1968

Liriospyris reticulata Goll, 1968

Liriospyris stauropora Goll, 1968

Lithocyclia angustum Riedel and Sanfilippo, 1970

Lithopera bacca Sanfilippo and Riedel, 1970

Lithopera baueri Sanfilippo and Riedel, 1970

Lithopera neotera Sanfilippo and Riedel, 1970

Lithopera renzae Sanfilippo and Riedel, 1970

Lithopera thornburgi Sanfilippo and Riedel, 1970

Lychnocanium bipes Riedel, 1959

Nephrospyris renilla Haeckel, 1887

Ommatartus antepenultimus Riedel and Sanfilippo, 1970

Ommatartus hughesi Riedel and Sanfilippo, 1970

Ommatartus penultimus Riedel and Sanfilippo, 1970

Panartus tetrathalamus Haeckel, 1887

Pterocanium prismatium Riedel, 1957a

Stichocorys delmontense Sanfilippo and Riedel, 1970

Stichocorys diploconus Sanfilippo and Riedel, 1970

Stichocorys peregrina Sanfilippo and Riedel, 1970

Theocyrtis annosa Riedel and Sanfilippo, 1970

Theocyrtis tuberosa Riedel, 1959

Tholospyris anthopora Goll, 1969

Tholospyris cortinisca Goll, 1969

Tholospyris devexa Goll, 1969

Tholospyris infericosta Goll, 1969

Tholospyris mammilaris Goll, 1969

Tholospyris procera Goll, 1969

Tholospyris scaphipes Goll, 1969

Tricolospyris leibnitziana Haeckel, 1887

Tristylospyris palmipes Haeckel, 1887

Tympanidium binoctonum Riedel, 1957a

Suborder SPUMELLARIA Ehrenberg, 1875

Family ACTINOMMIDAE Haeckel, 1862

Cannartus laticonus
(Plate 1, Figures 1 and 2)

Cannartus laticonus Riedel and Sanfilippo, 1970, p. 520 (synonymy).

Remarks: Incomplete tuberculate specimens of *Cannartus* (on which polar caps are missing) are present in the upper cores at Site 78. These individuals cannot be identified to species, but may belong to *C. laticonus*. Other specimens are common which appear to be transitional between *C. laticonus* and *O. antepenultimus*, and I experienced difficulty in defining the upper limit of the range of *C. laticonus*.

Occurrences:

Site 77—Top of the *Calocycletta costata* Zone to middle of the *Ommatartus antepenultimus* Zone.

Site 78—Lower *Cannartus laticonus* Zone.

Site 80—*C. costata* Zone to *Cannartus* (?) *pettersoni* Zone.

Site 81—*C. laticonus* Zone.

Site 83—*C.* (?) *petterssoni* to lower *Ommatartus penultimus*.

Stratigraphic Range: *Calocycletta costata* Zone to *Ommatartus antepenultimus* Zone; Middle Miocene to Upper Miocene.

Cannartus mammiferus

Cannartus mammiferus (Haeckel) Riedel and Sanfilippo 1970, p. 520 (synonymy).

Occurrences:

Site 77–Top of the *Calocycletta virginis* Zone to base of *Cannartus laticonus* Zone.
Site 78–Base of *Calocycletta costata* Zone to *C. laticonus* Zone.
Site 79–*C. costata* Zone to *Brachiospyris alata* Zone.
Site 80–Top of the *C. virginis* Zone to *C. costata* Zone.
Site 81–*C. laticonus* Zone.

Stratigraphic Range: *Calocycletta virginis* Zone to *Cannartus laticonus* Zone; Lower Miocene to Middle Miocene.

Cannartus (?) *petterssoni*
(Plate 2, Figures 1-4)

Cannartus (?) *petterssoni* Riedel and Sanfilippo, 1970 pp. 520-521, Pl. 14, fig. 3.

Occurrences:

Site 77–Base of *Cannartus* (?) *petterssoni* Zone to lower *Ommatartus penultimus* Zone.
Site 79–*C.* (?) *petterssoni* Zone to *Ommatartus antepenultimus* Zone.
Site 80–*C.* (?) *petterssoni* Zone.
Site 83–*C.* (?) *petterssoni* Zone to *O. antepenultimus* Zone.

Stratigraphic Range: *Cannartus* (?) *petterssoni* Zone to *Ommatartus penultimus* Zone; Middle Miocene to Upper Miocene.

Cannartus prismaticus
(Plate 3, Figures 1-3; Plate 4, Figures 1 and 2)

Cannartus prismaticus (Haeckel) Riedel and Sanfilippo, 1970, p. 520 (synonymy).

Remarks: Specimens similar to *C. prismaticus* are common in cores from the Upper and Lower Oligocene at Sites 77 and 78. However, the interior lattice shells are missing, and they cannot be assigned to this species. Possibly, these specimens are incomplete due to solution of the more delicate structures.

Occurrences:

Site 77–Upper *Theocyrtis annosa* to middle *Calocycletta costata* Zone.
Site 78–Middle *T. annosa* Zone to top of *Calocycletta virginis* Zone.
Site 79–*Lychnocanium bipes* Zone to *C. virginis* Zone.
Site 80–*C. virginis* Zone to base of *C. costata* Zone.

Stratigraphic Range: *Theocyrtis annosa* Zone to *Calocycletta costata* Zone; Upper Oligocene to Lower Miocene.

Cannartus tubarius
(Plate 5, Figures 1 and 2)

Cannartus tubarius (Haeckel) Riedel and Sanfilippo, 1970, p. 520 (synonymy).

Occurrences:

Site 77–Middle of *Lychnocanium bipes* Zone to base of *Cannartus laticonus* Zone.
Site 78–Base of *L. bipes* Zone to *C. laticonus* Zone.
Site 80–*Calocycletta virginis* Zone to *Calocycletta costata* Zone.

Stratigraphic Range: *Lychnocanium bipes* Zone to *Cannartus tubarius* Zone; Upper Oligocene to Middle Miocene.

Cannartus violina
(Plate 6, Figures 1-3)

Cannartus violina (Haeckel) Riedel and Sanfilippo, 1970, p. 520 (synonymy).

Occurrences:

Site 77–Upper *Calocycletta virginis* Zone to base of the *Cannartus laticonus* Zone.
Site 78–Upper *C. virginis* Zone to top of *Calocycletta costata* Zone.
Site 79–Middle of *C. virginis* Zone to *C. costata* Zone.
Site 80–*C. virginis* Zone to lower *C. costata* Zone.
Site 81–Lower *C. laticonus* Zone.

Stratigraphic Range: *Calocycletta virginis* Zone to *Cannartus laticonus* Zone; Upper Oligocene to Middle Miocene.

Ommatartus antepenultimus
(Plate 7, Figure 2)

Ommatartus antepenultimus Riedel and Sanfilippo 1970, p. 521, Pl. 14, fig. 4.

Occurrences:

Site 77–Base of *Ommatartus antepenultimus* Zone to upper *Ommatartus penultimus* Zone.
Site 79–*O. antepenultimus* Zone to *O. penultimus* Zone.
Site 80–*Stichocorys peregrina* Zone.
Site 83–Base of *O. antepenultimus* to *O. penultimus* Zone.

Stratigraphic Range: *Ommatartus antepenultimus* Zone to *Ommatartus penultimus* Zone; Upper Miocene.

Ommatartus hughesi
(Plate 8, Figures 1-3; Plate 9, Figure 1)

Ommatartus hughesi (Campbell and Clark) Riedel and Sanfilippo, 1970, p. 521 (synonymy).

Occurrences:
Site 77–Top of *Cannartus* (?) *petterssoni* Zone to middle of *Ommatartus penultimus* Zone.
Site 79–*Ommatartus antepenultimus* Zone to *O. penultimus* Zone.
Site 83–*C.* (?) *petterssoni* Zone to *O. penultimus* Zone.

Stratigraphic Range: *Ommatartus antepenultimus* Zone to *Ommatartus penultimus* Zone; Upper Miocene.

Ommatartus penultimus
(Plate 9, Figures 2 and 3; Plate 10, Figures 2 and 3)

Ommatartus penultimus (Riedel) Riedel and Sanfilippo, 1970, p. 521.

Occurrences:
Site 77–Base of *Ommatartus penultimus* Zone to upper *Stichocorys peregrina* Zone.
Site 79–*O. penultimus* Zone to *S. peregrina* Zone.
Site 80–*S. peregrina* Zone.
Site 82–*O. penultimus* Zone to *S. peregrina* Zone.
Site 83–Base of *O. penultimus* Zone to middle of *Spongaster pentas* Zone.
Site 84–*S. peregrina* Zone.

Stratigraphic Range: *Ommatartus penultimus* Zone to *Stichocorys peregrina* Zone; Upper Miocene to Lower Pliocene.

Pannartus tetrathalamus
(Plate 10, Figure 1)

Pannartus tetrathalamus Haeckel, 1887, p. 378, Pl. 40, fig. 3.

Remarks: The base of the range of *P. tetrathalamus* in Leg 9 sites is much lower than Hays *et al.* (1969) found from piston cores.

Occurrences:
Site 77–Middle of *Ommatartus penultimus* Zone to top of unnamed zone.
Site 79–*Stichocorys peregrina* Zone to top of unnamed zone.
Site 80–*S. peregrina* Zone to top of unnamed zone.
Site 81–Unnamed zone.
Site 82–Middle of *S. peregrina* Zone to top of unnamed zone.
Site 83–Middle of *S. peregrina* Zone to top of unnamed zone.
Site 84–*S. peregrina* Zone to top of unnamed zone.

Stratigraphic Range: *Ommatartus penultimus* Zone to unnamed zone; Upper Miocene to Pleistocene.

Family COCCODISCIDAE Haeckel, 1862

Lithocyclia angustum
(Plate 11, Figure 1)

Lithocyclia angustum (Riedel) Riedel and Sanfilippo 1970, p. 522 (synonymy).

Remarks: *Lithocyclia angustum* has a sporadic occurrence in the top of the *Theocyrtis tuberosa* Zone at Site 77.

Occurrences:
Site 77–Base of *Theocyrtis tuberosa* Zone to base of *Theocyrtis annosa* Zone.
Site 78–Base of *T. tuberosa* Zone to middle of *T. annosa* Zone.

Stratigraphic Range: *Theocyrtis tuberosa* Zone to *Theocyrtis annosa* Zone; Lower Miocene to Middle Miocene.

Suborder NASSELLARIA Ehrenberg, 1875

Family CANNOBOTRYIDAE Haeckel, 1881

Acrobotrys tritubus
(Plate 12, Figures 1-4; Plate 13, Figures 1-3)

Acrobotrys tritubus Riedel 1957, p. 80, Pl. 1, fig. 5.

Occurrences:
Site 77–Middle of the *Ommatartus penultimus* Zone to lower *Stichocorys peregrina* Zone.
Site 79–*Ommatartus penultimus* Zone.
Site 82–*Ommatartus penultimus* Zone to lower *Stichocorys peregrina* Zone.
Site 83–Middle of the *Ommatartus penultimus* Zone to lower *Stichocorys peregrina* Zone.

Stratigraphic Range: *Ommatartus penultimus* Zone to *Stichocorys peregrina* Zone; Upper Miocene.

Family PTEROCORYIDAE Haeckel, 1881

Calocycletta costata
(Plate 14, Figure 2)

Calocycletta costata (Riedel) Riedel and Sanfilippo 1970, p. 535 (synonymy).

Remarks: *C. costata* has a discontinuous range at Site 77.

Occurrences:
Site 77–Base of the *Calocycletta costata* Zone to lower *Brachiospyris alata* Zone.
Site 78–Base of the *Calocycletta costata* Zone to lower *Brachiospyris alata* Zone.
Site 79–*C. costata* Zone.
Site 80–*C. costata* Zone.
Site 81–?? lower *Cannartus laticonus* Zone.

Stratigraphic Range: *Calocycletta costata* Zone to *Brachiospyris alata* Zone; Lower Miocene to Middle Miocene.

Calocycletta virginis
(Plate 14, Figure 1)

Calocycletta virginis (Haeckel) Riedel and Sanfilippo, 1970, p. 535 (synonymy).

Remarks: No attempt was made to distinguish *C. virginis* from *Calocycletta robusta*, a new species proposed by Moore (in press).

Occurrences:
Site 77–Base of *Calocycletta virginis* Zone to lower *Cannartus laticonus* Zone.
Site 78–Base of *C. virginis* Zone to *C. laticonus* Zone.
Site 79–Base of *C. virginis* Zone to *Brachiospyris alata* Zone.
Site 80–*C. virginis* Zone to *Calocycletta costata* Zone.

Stratigraphic Range: *Calocycletta virginis* Zone to *Cannartus laticonus* Zone; Lower Miocene to Middle Miocene.

Theocyrtis annosa
(Plate 17, Figure 1; Plate 18, Figures 1 and 2)

Theocyrtis annosa (Riedel) Riedel and Sanfilippo, 1970, p. 535 (synonymy).

Occurrences:
Site 77–Base of *Theocyrtis annosa* Zone to top of *Lychnocanium bipes* Zone.
Site 78–Base of *T. annosa* Zone to base of *Calocycletta virginis* Zone.

Stratigraphic Range: *Theocyrtis annosa* Zone to *Lychnocanium bipes* Zone; Upper Oligocene to Lower Miocene.

Theocyrtis tuberosa
(Plate 19, Figure 1)

Theocyrtis tuberosa Riedel, 1959, p. 295, Pl. 2, fig. 7.

Occurrences:
Site 77–*Thyrocyrtis bromia* Zone to upper *Theocyrtis tuberosa* Zone.
Site 78–*Thyrocyrtis bromia* Zone to lower *T. tuberosa* Zone.

Stratigraphic Range: *Thyrocyrtis bromia* Zone to *Theocyrtis tuberosa* Zone; Eocene to Upper Oligocene.

Family THEOPERIDAE Haeckel, 1881

Artophormis gracilis

Artophormis gracilis Riedel, 1959, p. 300, Pl. 2, figs. 12-13.

Remarks: Incomplete speciemsn which may belong to *A. gracilis* are numerous in the Lower Oligocene, and its true stratigraphic range may extend much lower than the *Thyrocyrtis bromia* Zone.

Occurrences:
Site 77–Lower *Thyrocyrtis bromia* Zone to top of the *Theocyrtis annosa* Zone.
Site 78–Lower *Thyrocyrtis bromia* Zone to middle of the *Lychnocanium bipes* Zone.

Stratigraphic Range: *Thyrocyrtis bromia* Zone to *Lychnocanium bipes* Zone; Lower Oligocene to Upper Oligocene.

Cyclampterium (?) *brachythorax*
(Plate 20, Figures 1-3; Plate 21, Figures 1-3)

Cyclampterium (?) *brachythorax* Sanfilippo and Riedel, 1970, p. 457, Pl. 2, figs. 15-16.

Occurrences:
Site 77–Lower *Cannartus laticonus* Zone to middle of *Ommatartus antepenultimus* Zone.
Site 79–*Cannartus* (?) *petterssoni* Zone to *Ommatartus penultimus* Zone.
Site 80–*C.* (?) *petterssoni* Zone.
Site 81–*C. laticonus* Zone.

Stratigraphic Range: *Cannartus laticonus* Zone to *Ommatartus antepenultimus* Zone; Middle Miocene to Upper Miocene.

Cyclampterium leptetrum
(Plate 22, Figure 1)

Cyclampterium (?) *leptetrum* Sanfilippo and Riedel, 1970, p. 456, Pl. 2, figs. 11-12.

Occurrences:
Site 77–Middle of *Calocycletta virginis* Zone to base of *Brachiospyris alata* Zone.
Site 78–Middle of *C. virginis* Zone to base of *B. alata* Zone.
Site 79–Lower *C. virginis* Zone to *B. alata* Zone.
Site 80–*C. virginis* Zone to *Calocycletta costata* Zone.
Site 81–*Cannartus laticonus* Zone.

Stratigraphic Range: *Calocycletta virginis* Zone to *Brachiospyris alata* Zone; Lower Miocene to Middle Miocene.

Cyclampterium (?) *neatum*
(Plate 23, Figures 1-3)

Cyclampterium (?) *neatum* Sanfilippo and Riedel 1970, p. 457, Pl. 2, figs. 171-8.

Remarks: Possibly, *C.* (?) *neatum* is indigenous to the western Pacific Ocean, as it was only observed at Site 77. The sporadic occurrences of *C.* (?) *neatum* above the *Stichocorys peregrina* Zone are regarded as the result of reworking.

Occurrence:
Site 77–Lower *Ommatartus penultimus* Zone to upper *Pterocanium prismatium* Zone.

Stratigraphic Range: *Ommatartus penultimus* Zone to *Stichocorys peregrina* Zone; Upper Miocene to Lower Pliocene.

Cyclampterium (?) *pegetrum*
(Plate 24, Figures 1-4; Plate 25, Figures 1-3)

Cyclampterium (?) *pegetrum* Sanfilippo and Riedel, 1970, Pl. 2, figs. 8-10.

Remarks: Specimens much like *C.* (?) *pegetrum,* but lacking a closed basal chamber of the lattice shell, are common in the Lower Oligocene of Sites 77 and 78.

Occurrences:
Site 77–Upper *Theocyrtis tuberosa* Zone to middle of *Calocycletta virginis* Zone.
Site 78–Base of *Theocyrtis annosa* Zone to middle of *C. virginis* Zone.
Site 79–*C. virginis* Zone.
Site 80–*C. virginis* Zone.

Stratigraphic Range: *Theocyrtis tuberosa* Zone to *Calocycletta virginis* Zone; Upper Oligocene to Lower Miocene.

Cyclampterium (?) *tanythorax*
(Plate 26, Figures 1-4)

Cyclampterium (?) *tanythorax* Sanfilippo and Riedel, 1970, p. 457, Pl. 2, figs. 13-14.

Occurrences:
Site 77–Middle of *Calocycletta costata* Zone to base of *Cannartus* (?) *petterssoni* Zone.
Site 78–Base of *Brachiospyris alata* Zone to *C. laticonus* Zone.
Site 79–*C. costata* Zone to *B. alata* Zone.
Site 80–Upper *C. costata* Zone.

Stratigraphic Range: *Calocycletta costata* Zone to *Cannartus laticonus* Zone; Lower Miocene to Middle Miocene.

Cyrtocapsella cornuta
(Plate 27, Figures 1-3; Plate 28, Figures 2 and 3)

Cyrtocapsella cornuta (Haeckel) Sanfilippo and Riedel, 1970, Pl. 1, figs. 19-20.

Occurrences:
Site 77–Middle of *Lychnocanium bipes* Zone to base of *Cannartus* (?) *petterssoni* Zone.
Site 78–Top of *L. bipes* Zone to *Cannartus laticonus* Zone.
Site 79–*L. bipes* Zone to *Brachiospyris alata* Zone.
Site 80–*Calocycletta virginis* Zone to *C.* (?) *petterssoni* Zone.
Site 81–*C. laticonus* Zone.

Stratigraphic Range: *Lychnocanium bipes* Zone to *Cannartus laticonus* Zone; Lower Miocene to Middle Miocene.

Cyrtocapsella elongata

Cyrtocapsella elongata (Nakaseko) Sanfilippo and Riedel, 1970, p. 452, Pl. 1, figs. 11-12.

Occurrences:
Site 77–Middle of *Calocycletta virginis* Zone to lower *Calocycletta costata* Zone.
Site 78–Middle to top of *C. virginis* Zone.
Site 79–*C. virginis* Zone.

Stratigraphic Range: *Calocycletta virginis* Zone to *Calocycletta costata* Zone; Lower Miocene.

Cyrtocapsella japonica

Cyrtocapsella japonica (Nakaseko) Sanfilippo and Riedel, 1970, p. 452, Pl. 1, figs. 13-15.

Occurrences:
Site 77–*Cannartus* (?) *petterssoni* Zone.
Site 79–*Cannartus* (?) *petterssoni* Zone.
Site 80–*C.* (?) *petterssoni* Zone.

Stratigraphic Range: *Cannartus* (?) *petterssoni* Zone; Upper Miocene.

Cyrtocapsella tetrapera
(Plate 29, Figures 1-4)

Cyrtocapsella tetrapera (Haeckel), Sanfilippo and Riedel, 1970, p. 453, Pl. 1, figs. 16-18.

Remarks: There appears to be little taxonomic or biostratigraphic merit in subdividing *C. tetrapera* from *Cyrtocapsella cornuta.*

Occurrences:
Site 77–Middle of *Lychnocanium bipes* Zone to base of *Cannartus* (?) *petterssoni* Zone.
Site 78–Upper *L. bipes* Zone to *Cannartus laticonus* Zone.
Site 79–*L. bipes* Zone to *Brachiospyris alata* Zone.
Site 80–*Calocycletta virginis* Zone to *C.* (?) *petterssoni* Zone.
Site 81–*C. laticonus* Zone.

Stratigraphic Range: *Lychnocanium bipes* Zone to *Cannartus laticonus* Zone; Lower to Middle Miocene.

Lithopera bacca
(Plate 30, Figures 1-3; Plate 31, Figures 1-3)

Lithopera bacca Ehrenberg- Sanfilippo and Riedel, 1970, p. 455, Pl. 1, fig. 29 (synonymy).

Occurrences:
Site 77–Lower *Ommatartus antepenultimus* Zone to middle of *Stichocorys peregrina* Zone.
Site 79–*O. antepenultimus* Zone to lower unnamed zone.
Site 80–*Spongaster pentas* Zone.
Site 82–*Ommatartus penultimus* Zone to *Pterocanium prismatium* Zone.
Site 83–*Cannartus* (?) *petterssoni* Zone to upper *Stichocorys peregrina* Zone.

Stratigraphic Range: *Ommatartus antepenultimus* Zone to *Pterocanium prismatium* Zone; Upper Miocene to Upper Pliocene.

Lithopera baueri
(Plate 32, Figures 1 and 2)

Lithopera baueri Sanfilippo and Riedel, 1970, p. 455, Pl. 2, figs. 1-2.

Occurrence:
Site 77–Middle of *Cannartus laticonus* Zone.

Stratigraphic Range: *Cannartus laticonus* Zone; Middle Miocene.

Lithopera neotera
(Plate 28, Figure 1)

Lithopera neotera Sanfilippo and Riedel, 1970, p. 454, Pl. 1, figs. 24-26, 28.

Occurrences:
Site 77–Upper *Cannartus laticonus* Zone to lower *Ommatartus antepenultimus* Zone.
Site 79–*Cannartus* (?) *petterssoni* Zone to *O. antepenultimus* Zone.
Site 80–*C.* (?) *petterssoni* Zone.

Stratigraphic Range: *Cannartus laticonus* Zone to *Ommatartus antepenultimus* Zone; Middle Miocene to Upper Miocene.

Lithopera renzae

Lithopera renzae Sanfilippo and Riedel, 1970, p. 454, Pl. 1, figs. 21-23, 27.

Occurrences:
Site 77–Middle of *Calocycletta costata* Zone to upper *Cannartus laticonus* Zone.
Site 78–Top of *Brachiospyris alata* Zone to *Cannartus laticonus* Zone.
Site 79–*C. costata* Zone to *B. alata* Zone.
Site 80–*Cannartus* (?) *petterssoni* Zone.
Site 81–*C. laticonus* Zone.

Stratigraphic Range: *Calocycletta costata* Zone to *Cannartus laticonus* Zone; Lower Miocene to Middle Miocene.

Lithopera thornburgi
(Plate 32, Figures 3 and 4)

Lithopera thornburgi Sanfilippo and Riedel, 1970, pp. 455-456, Pl. 2, figs. 4-6.

Occurrences:
Site 77–Middle of *Cannartus laticonus* Zone to top of *Cannartus* (?) *petterssoni* Zone.
Site 80–*Cannartus* (?) *petterssoni* Zone.

Stratigraphic Range: *Cannartus laticonus* Zone to *Cannartus* (?) *petterssoni* Zone; Middle Miocene.

Lychnocanium bipes
(Plate 15, Figure 1; Plate 16, Figure 1; Plate 17, Figure 2)

Lychnocanium bipes Riedel, 1959, p. 294, Pl. 2, figs. 5-6.

Occurrences:
Site 77–Base of *Lychnocanium bipes* Zone to top of *Calocycletta virginis* Zone.
Site 78–Base of *L. bipes* Zone to lower *Calocycletta costata* Zone.
Site 79–*L. bipes* Zone to *C. virginis* Zone.
Site 80–*C. virginis* Zone.

Stratigraphic Range: *Lychnocanium bipes* Zone to *Calocycletta costata* Zone; Upper Oligocene to Lower Miocene.

Pterocanium prismatium
(Plate 33, Figure 1)

Pterocanium prismatium Riedel, 1957, p. 87, Pl. 3, figs. 4-5.

Remarks: This species is apparently indigenous to the western Pacific Ocean. East of Site 79, *P. prismatium* has a constricted range, and its occurrence is quite sporadic at Site 84.

Occurrences:
Site 77–Base of *Spongaster pentas* Zone to top of *Pterocanium prismatium* Zone.
Site 79–*P. prismatium* Zone.
Site 80–*S. pentas* Zone.
Site 82–*S. pentas* Zone to *P. prismatium* Zone.
Site 83–Base of *S. pentas* Zone to top of *P. prismatium* Zone.
Site 84–Base of *S. pentas* Zone to middle of *P. prismatium* Zone.

Stratigraphic Range: *Spongaster pentas* Zone to *Pterocanium prismatium* Zone; Lower Pliocene to Upper Pliocene.

Stichocorys delmontense
(Plate 34, Figures 1-3; Plate 35, Figure 1)

Stichocorys delmontensis (Campbell and Clark) Sanfilippo and Riedel, 1970, p. 451, Pl. 1, fig. 9 (synonymy).

Occurrences:
Site 77–Middle of *Calocycletta virginis* Zone to lower *Stichocorys peregrina* Zone.
Site 78–Middle of *C. virginis* Zone to *Cannartus laticonus* Zone.
Site 79–*C. virginis* Zone to *Ommatartus penultimus* Zone.
Site 80–*C. virginis* Zone to *S. peregrina* Zone.
Site 81–*C. laticonus* Zone.
Site 82–*Ommatartus penultimus* Zone to *S. peregrina* Zone.
Site 83–*Cannartus* (?) *petterssoni* Zone to upper *S. peregrina* Zone.

Stratigraphic Range: *Calocycletta virginis* Zone to *Stichocorys peregrina* Zone; Lower Miocene to Lower Pliocene.

Stichocorys diploconus
(Plate 35, Figures 2-4)

Stichocorys diploconus (Haeckel) Sanfilippo and Riedel, 1970, p. 451, Pl. 1, figs. 31-32.

Occurrences:
- Site 77–Middle of *Calocycletta virginis* Zone to lower *Ommatartus penultimus* Zone.
- Site 78–Middle of *C. virginis* Zone to *Cannartus laticonus* Zone.
- Site 79–*C. virginis* Zone to *Brachiospyris alata* Zone.
- Site 80–*C. virginis* Zone to *Cannartus* (?) *petterssoni* Zone.
- Site 81–*C. laticonus* Zone.

Stratigraphic Range: *Calocycletta virginis* Zone to *Ommatartus penultimus* Zone; Lower Miocene to Upper Miocene.

Stichocorys peregrina
(Plate 36, Figures 1-3)

Stichocorys peregrina (Riedel) Sanfilippo and Riedel, 1970, p. 451, Pl. 1, fig. 10 (synonymy).

Occurrences:
- Site 77–Base of *Stichocorys peregrina* Zone to top of *Spongaster pentas* Zone.
- Site 79–*S. peregrina* Zone.
- Site 80–*S. peregrina* Zone to *S. pentas* Zone.
- Site 82–*S. peregrina* Zone to *S. pentas* Zone.
- Site 83–Base of *S. peregrina* Zone to top of *Spongaster pentas* Zone.
- Site 84–*S. peregrina* Zone to top of *S. pentas* Zone.

Stratigraphic Range: *Stichocorys peregrina* Zone to *Spongaster pentas* Zone; Upper Miocene to Lower Pliocene.

Family TRISSOCYCLIDAE

Acrocubus octopylus
(Plate 37, Figures 1-3)

Acrocubus octopylus Haeckel, 1887, p. 993, Pl. 82, fig. 9.

Remarks: This species is included here because of its limited stratigraphic range. The original binomen is retained until the species evolution can be deciphered. *A. octopylus* resembles *Tholospyris toxaria, Liriospyris longicornuta* and *Liriospyris stauropora.* It differs from *T. toxaria* by lacking basal spines, and the lattice shell does not extend above the sagittal ring. It differs from the latter species by lacking secondary lateral bars.

Occurrences:
- Site 77–Base of the *Calocycletta costata* Zone to lower *Cannartus laticonus* Zone.
- Site 78–Middle of the *Calocycletta costata* Zone to *Cannartus laticonus* Zone.
- Site 79–*Calocycletta costata* Zone to *Cannartus laticonus* Zone.
- Site 80–Upper *Calocycletta costata* Zone.
- Site 81–Lower *Cannartus laticonus* Zone.

Stratigraphic Range: Base of *Calocycletta costata* to lower *Cannartus laticonus* Zone; Lower Miocene to Middle Miocene.

Androspyris anthropiscus
(Plate 38, Figure 1; Plate 39, Figure 1)

Androspyris anthropiscus Haeckel, 1887, p. 1093, Pl. 83, fig. 8.

Remarks: This species is included here because its short stratigraphic range spans the Pliocene-Pleistocene boundary. Further study is necessary before the taxonomy can be revised. *A. anthropiscus* differs from *Tholospyris cortinisca* by having basal spines of equal length. It differs from *Tristylospyris palmipes,* its probable precursor, by having a lattice shell surrounding the sagittal ring. It differs from *Lamprospyris huxleyi* in having four connector bars supporting the upper portion of the lattice shell.

Occurrences:
- Site 77–Lower unnamed zone.
- Site 79–Upper *Pterocanium prismatium* Zone to lower unnamed zone.
- Site 80–Unnamed zone.
- Site 81–Unnamed zone.
- Site 82–Upper *Pterocanium prismatium* Zone.
- Site 83–Upper *Pterocanium prismatium* Zone to lower unnamed zone.

Stratigraphic Range: Upper *Pterocanium prismatium* Zone to lower unnamed zone; upper Pliocene to lower Pleistocene.

Archicircus rhombus

Archicircus rhombus Haeckel, 1887, p. 942, Pl. 81, fig. 7.

Remarks: A manuscript is in preparation in which the generic assignment of this species is revised. The first appearance of *A. rhombus* coincides with the top of the "C" event of the Gilbert paleomagnetic epoch, which has been dated at 4.4 m.y.a. (Hays *et al.,* 1969, Pl. 1).

The apparent increasing age of the first appearance of *A. rhombus* toward the east in Leg 9 sites is due to the diachronous nature of the *Spongaster pentas* Zone.

Occurrences:
- Site 77–Base of *Spongaster pentas* Zone to top of unnamed zone.
- Site 79–*Pterocanium prismatium* Zone to unnamed zone.
- Site 80–*Spongaster pentas* Zone to top of unnamed zone.
- Site 81–Unnamed zone.
- Site 82–*Spongaster pentas* Zone to top of unnamed zone.

Site 83—Upper *Stichocorys peregrina* Zone to top of unnamed zone.

Site 84—Upper *Stichocorys peregrina* Zone to top of unnamed zone.

Stratigraphic Range: *Spongaster pentas* Zone to unnamed zone; Lower Pliocene to Pleistocene. The first appearance of *Archicircus rhombus* is approximately synchronous with the first appearances of *Ceratolithus cristatus* and *Sphaeroidinella dehiscens.*

Brachiospyris alata
(Plate 40, Figures 1-3; Plate 41, Figures 1-3)

Brachiospyris alata Riedel, 1959, p. 293, Pl. 1, figs. 5, 11-12.

Remarks: Several authors recently have assigned this species to *Dorcadospyris.* However, specimens of *B. alata* possess sternal bars; a structure alien to the revised definition of *Dorcadospyris*, Goll (1969).

The sporadic occurrence of *B. alata* in the *Cannartus laticonus* Zone is thought to be the result of reworking.

Occurrences:

Site 77—Base of the *Brachiospyris alata* Zone to middle of the *Cannartus laticonus* Zone.

Site 78—*Brachiospyris alata* Zone.

Site 79—*Brachiospyris alata* Zone.

Site 81—Lower *Cannartus laticonus* Zone.

Stratigraphic Range: *Brachiospyris alata* Zone; Middle Miocene. The top of the continuous range of *B. alata* is approximately synchronous with the first appearance of *Discoaster exilis, Globorotalia peripheroacuta,* and *Globorotalia fohsi fohsi.*

Brachiospyris simplex
(Plate 42, Figures 2 and 3)

Brachiospyris simplex Riedel, 1959, p. 293, Pl. 1, fig. 10.

Remarks: Because of difficulties experienced with the placement of *Brachiospyris alata* and *Hexaspyris papilio* in the genus *Dorcadospyris*, the taxonomy of *Brachiospyris simplex* has not been revised until further investigation is possible.

Occurrence:

Site 77—Middle of the *Lychnocanium bipes* Zone to middle of the *Calocycletta virginis* Zone.

Site 78—Middle of the *Lychnocanium bipes* Zone to upper *Calocycletta virginis* Zone.

Site 79—*Lychnocanium bipes* Zone to middle of *Calocycletta virginis* Zone.

Site 80—*Calocycletta virginis* Zone.

Stratigraphic Range: *Lychnocanium bipes* Zone to *Calocycletta virginis* Zone; Lower Miocene. The first appearance of *Brachiospyris simplex* is approximately synchronous with the first appearances of *Globorotalia kugleri* and *Globoquadrina dehiscens,* and the last occurrence of *Coccolithus abisectus.*

Cantharospyris ateuchus
(Plate 44, Figures 1 and 2; Plate 45, Figures 1 and 2)

Cantharospyris ateuchus (Ehrenberg)-Riedel, 1959, p. 294, Pl. 22, figs. 3-4 (synonymy).

Remarks: Because of difficulties arising from the placement of *Brachiospyris alata* and *Hexaspyris papilio* in the genus *Dorcadospyris*, the taxonomy of *Cantharospyris ateuchus* has not been revised until further investigation is possible.

Occurrence:

Site 77—Lower *Theocyrtis tuberosa* Zone to middle *Lychnocanium bipes* Zone.

Site 78—Middle *T. tuberosa* Zone to middle *L. bipes* Zone.

Stratigraphic Range: *Theocyrtis tuberosa* Zone to *Lychnocanium bipes* Zone; Upper Oligocene to Lower Miocene. The first appearance of *Cantharospyris ateuchus* coincides approximately with the brief occurrence of *Globigerina rohri* in the *Pseudohastigerina barbadoensis* Zone.

Ceratospyris hyperborea

Ceratospyris hyperborea Jørgensen, 1905, pp. 130-131, Pl. 13, fig. 49.

Remarks: Goll and Bjørklund (in press) use the modern sedimentary distribution of this species as an indicator of western boundary currents in the Atlantic Ocean. *Ceratospyris hyperborea* was observed sporadically in cores from the sites west of Site 83, but its stratigraphic occurrences there were not recorded.

Ceratospyris hyperborea is a homeomorph of *Dorcadospyris pentagona,* from which it can be distinguished by the absence of tri-bladed lattice bars on the lateral portions of the lattice shell.

Occurrences:

Site 83—Upper *Spongaster pentas* Zone to top of unnamed zone.

Site 84—Middle *Pterocanium prismatium* Zone to top of unnamed zone.

Stratigraphic Range: *Spongaster pentas* Zone to unnamed zone; Pliocene to Pleistocene.

Clathrobursa clathrobursa
(Plate 46, Figures 1-3)

Clathrobursa clathrobursa (Haeckel) Campbell, 1954, p. D112 (synonymy).

Remarks: The short range of *Clathrobursa clathrobursa* can be utilized for biostratigraphic studies. The absence of this species at Site 77 indicates that a hiatus may have occupied its range at this site.

Clathrobursa clathrobursa is distinguished by two long basal spines at the positions of the primary lateral bars and no frontal spine. The lattice shell extends above the sagittal ring.

Occurrence:

Site 78–Top of *Hexaspyris papilio* Zone to lower *Lychnocanium bipes* Zone.

Stratigraphic Range: *Hexaspyris papilio* Zone to *Lychnocanium bipes* Zone; Upper Oligocene. The extinction of *Clathrobursa clathrobursa* is approximately synchronous with the first appearance of *Globorotalia kugleri* and *Discoaster serratus.*

Clathrocircus stapedius
(Plate 51, Figure 3)

Clathrocircus stapedius Haeckel, 1887, p. 962, Pl. 92, fig. 8.

Remarks: A manuscript is presently in preparation in which the first appearance of *Clathrocircus stapedius* is shown to coincide with the top of the lowest normal event of the Gauss paleomagnetic epoch, which can be dated at 3 m.y.a. (Hays, 1969, Pl. 1).

Clathrocircus stapedius was referred to by Goll (1968) as "De2" and has *Dendrospyris damaecornis* as its ancestor.

Occurrences:

Site 77–Middle of *Spongaster pentas* Zone to top of unnamed zone.
Site 79–*Pterocanium prismatium* Zone to unnamed zone.
Site 80–*S. pentas* Zone and unnamed zone.
Site 81–Unnamed zone.
Site 82–*P. prismatium* Zone to unnamed zone.
Site 83–Middle of *S. pentas* Zone to top of unnamed zone.
Site 84–Middle of *S. pentas* Zone to top of unnamed zone.

Stratigraphic Range: *Spongaster pentas* Zone to unnamed zone; Pliocene to Pleistocene.

Dendrospyris anthocyrtoides
(Plate 47, Figures 1, 2 and 4)

Dendrospyris anthocyrtoides (Bütschli) Goll, 1968, pp. 1419-1420, Pl. 174, figs. 11-14 (synonymy).

Remarks: *Dendrospyris anthocyrtoides* is the oldest species whose specimens have been observed to bear a small sculptured axial tubercule on the base of the sagittal ring.

Occurrences:

Site 77–*Thyrocyrtis bromia* Zone to middle of *Theocyrtis annosa* Zone.
Site 78–*T. bromia* Zone to middle of *T. annosa* Zone.

Stratigraphic Range: *Thyrsocyrtis bromia* Zone to *Theocyrtis annosa* Zone; Lower Oligocene to Upper Oligocene. The true base of the stratigraphic range of this species is unknown. The last occurrence of *D. anthocyrtoides* is approximately synchronous with the last occurrences of *Globorotalia opima* and *Sphenolithus distentus.*

Dendrospyris binapertonis
(Plate 49, Figures 1 and 2)

Dendrospyris binapertonis Goll, 1968, p. 1420, Pl. 173, figs. 5-6, 10-11.

Remarks: Specimens of *Dendrospyris binapertonis* bear a small sculptured axial tubercule at the base of the sagittal ring. This species has a similar appearing modern descendant, and the top of the stratigraphic range of *D. binapertonis* is difficult to determine. *Dendrospyris binapertonis* is a very long ranging species with little biostratigraphic significance.

Occurrences:

Site 77–Lower *Brachiospyris alata* Zone to top of *Pterocanium prismatium* Zone.
Site 79–*Cannartus* (?) *petterssoni* Zone to *Stichocorys peregrina* Zone.
Site 80–*C.* (?) *petterssoni* Zone to *Spongaster pentas* Zone.
Site 81–*Cannartus laticonus* Zone to unnamed zone.
Site 82–*Ommatartus penultimus* Zone to *S. pentas* Zone.
Site 83–*Cannartus* (?) *petterssoni* Zone to top of *S. pentas* Zone.
Site 84–Lower *Stichocorys peregrina* Zone to middle unnamed zone.

Stratigraphic Range: *Brachiospyris alata* Zone to *Pterocanium prismatium* Zone; Middle Miocene to Upper Pliocene.

Dendrospyris damaecornis
(Plate 50, Figures 1-4; Plate 51, Figures 1 and 2)

Dendrospyris damaecornis (Haeckel) Goll, 1968, p. 1420-1421, Pl. 173, figs. 1-4 (synonymy).

Occurrences:

Site 77–Lower *Calocycletta virginis* Zone to top of unnamed zone.
Site 78–Lower *C. virginis* Zone to *Cannartus laticonus* Zone.
Site 79–Top of *Lychnocanium bipes* to top of unnamed zone.
Site 80–Top of *C. virginis* Zone to top of unnamed zone.
Site 81–Unnamed zone.
Site 83–*Cannartus* (?) *petterssoni* Zone to top of unnamed zone.
Site 84–*Stichocorys peregrina* Zone to top of unnamed zone.

Stratigraphic Range: *Calocycletta virginis* Zone to unnamed zone; Lower Miocene to Pleistocene.

Dendrospyris pannosa
(Plate 52, Figures 1-3; Plate 53, Figures 1-4)

Dendrospyris pannosa Goll, 1968, pp. 1421-22, Pl. 173, figs. 13-15, 19.

Occurrences:
Site 77—Base of *Lychnocanium bipes* Zone to lower *Calocycletta virginis* Zone.
Site 78—Base of *Hexaspyris papilio* Zone to middle of *Calocycletta* Zone.
Site 79—*L. bipes* to lower *C. virginis* Zone.

Stratigraphic Range: *Lychnocanium bipes* Zone to *Calocycletta virginis* Zone; Upper Oligocene to Lower Miocene.

Dendrospyris pododendros
(Plate 47, Figure 3; Plate 48, Figures 1-3)

Dendrospyris pododendros (Carnevale) Goll, 1968, p. 1422, Pl. 174, figs. 1-4.

Remarks: Taxonomic subdivision is necessary before this long ranging species can be useful biostratigraphically. The oldest representatives have six irregular basal spines. Eventually, an arrangement of four basal spines is noted, and specimens at the top of the stratigraphic range have no basal spines.

Occurrences:
Site 77—*Thyrocyrtis bromia* Zone to lower *Cannartus* (?) *petterssoni* Zone.
Site 78—*Thyrocyrtis bromia* Zone to *Cannartus laticonus.*
Site 79—*Lychnocanium bipes* Zone to *Brachiospyris alata* Zone.
Site 80—*Calocycletta virginis* Zone to *Calocycletta costata* Zone.
Site 81—*C. laticonus* Zone.

Stratigraphic Range: *Thyrocyrtis bromia* Zone to *Cannartus* (?) *petterssoni* Zone; Upper Eocene (?) to Middle Miocene. The true base of the stratigraphic range of this species is unknown.

Dipodospyris forcipata
(Plate 54, Figures 1 and 2)

Dipodospyris forcipata Haeckel-Riedel 1959, p. 293, Pl. 1, fig. 9.

Remarks: Recently, other specialists have assigned *D. forcipata* to another genus. I have retained this earlier generic placement until this complex of species is deciphered.

Occurrences:
Site 77—Upper *Lychnocanium bipes* Zone to top of *Calocycletta costata* Zone.
Site 78—Upper *L. bipes* Zone to top of *C. costata* Zone.
Site 79—*L. bipes* Zone to *Calocycletta virginis* Zone.
Site 80—*C. virginis* Zone to *C. costata* Zone.

Stratigraphic Range: *Lychnocanium bipes* Zone to *Calocycletta virginis* Zone; Lower Miocene to Middle Miocene.

Dorcadospyris costatescens
(Plate 55, Figures 2 and 3)

Dorcadospyris costatescens Goll, 1969, p. 337-38, Pl. 57, figs. 1-4.

Occurrences:
Site 77—*Thyrocyrtis bromia* Zone to middle of *Theocyrtis annosa* Zone.
Site 78—*T. bromia* Zone to middle of *T. annosa* Zone.

Stratigraphic Range: *Thyrocyrtis bromia* Zone to *Theocyrtis annosa* Zone; Lower to Upper Oligocene. If the first appearance of *D. costatescens* at Site 77 is the true base of its range, then *D. costatescens* can be used as an approximate marker for the Eocene-Oligocene boundary.

Dorcadospyris dentata
(Plate 56, Figures 1-3; Plate 57, Figures 1-3)

Dorcadospyris dentata (Haeckel) Goll, 1969, p. 338, Pl. 60, figs. 8, 10-13 (synonymy).

Occurrences:
Site 77—Upper *Calocycletta virginis* Zone to upper *Calocycletta costata* Zone.
Site 78—Top of *C. virginis* Zone to lower *Brachiospyris alata* Zone.
Site 79—*C. virginis* Zone to *C. costata* Zone.
Site 80—Top of *C. virginis* Zone to *C. costata* Zone.

Stratigraphic Range: *Calocycletta virginis* Zone to *Calocycletta costata* Zone; Lower Miocene. The range of *D. dentata* at Site 77 is regarded as correct. Its younger occurrence at Site 78 may be the result of reworking at the top of the section. The extinction of *D. dentata* is approximately synchronous with the first appearance of *Praeorbulina glomerosa curva* and, thus, the Lower Miocene-Middle Miocene boundary.

Dorcadospyris pentagona
(Plate 58, Figures 1-3)

Dorcadospyris pentagona (Ehrenberg) Goll, 1969, p. 338-39, Pl. 59, figs. 8, 10-12 (synonymy).

Remarks: *Dorcadospyris pentagona* is part of a very successful lineage of similar appearing forms which span much of the Tertiary. *D. pentagona* can be distinguished from its ancestors by the possession of tri-bladed lattice bars covering the entire lattice shell.

Occurrences:
Site 77—Top of *Calocycletta virginis* Zone to top of unnamed zone.
Site 78—Top of *C. virginis* Zone to *Cannartus laticonus* Zone.

Site 79—*Calocycletta costata* Zone to top of unnamed zone.
Site 80—Base of *C. costata* Zone to top of unnamed zone.
Site 81—*Cannartus laticonus* Zone to top of unnamed zone.
Site 82—*Ommatartus penultimus* Zone to top of unnamed zone.
Site 83—*Cannartus* (?) *petterssoni* Zone to top of unnamed zone.
Site 84—*Stichocorys peregrina* Zone to top of unnamed zone.

Stratigraphic Range: *Calocycletta virginis* Zone to unnamed zone; Lower Miocene to Pleistocene. The first appearance of *D. pentagona* is approximately synchronous with the first appearance of *Reticulofenestra pseudoumbilica, Cyclococcolithina leptopora, Dictyocha ausonia.*

Gamospyris circulus
(Plate 59, Figure 1; Plate 60, Figures 1-3; Plate 61, Figure 1; Plate 62, Figures 1-3)

Gamospyris circulus Haeckel, 1887, p. 1042, Pl. 83, fig. 19.

Remarks: Specimens of *G. circulus* do not bear a sternal bar, and the species may be referable to *Dorcadospyris.* This older generic assignment has been retained here until further study is possible.

Occurrences:
Site 77—Lower *Theocyrtis tuberosa* Zone to upper *Theocyrtis annosa* Zone.
Site 78—Middle of *T. tuberosa* Zone to upper *T. annosa* Zone.

Stratigraphic Range: *Theocyrtis tuberosa* Zone to *Theocyrtis annosa* Zone; Lower Oligocene to Upper Oligocene. The extinction of *G. circulus* is approximately synchronous with the extinction of *Sphenolithus distentus.*

Giraffospyris angulata
(Plate 63, Figures 1-4)

Giraffospyris angulata (Haeckel) Goll, 1969, p. 331, Pl. 59, figs. 4, 6-7, 9 (synonymy).

Occurrences:
Site 77—Upper *Ommatartus antepenultimus* Zone to top of unnamed zone.
Site 79—*Ommatartus penultimus* Zone to top of unnamed zone.
Site 80—*Stichocorys peregrina* Zone to top of unnamed zone.
Site 81—Unnamed zone.
Site 82—*O. penultimus* Zone to top of unnamed zone.
Site 83—Base of *O. penultimus* Zone to top of unnamed zone.
Site 84—*S. peregrina* Zone to top of unnamed zone.

Stratigraphic Range: *Ommatartus antepenultimus* Zone to unnamed zone; Upper Miocene to Pleistocene.

Giraffospyris annulispina
(Plate 64, Figures 1-5)

Giraffospyris annulispina Goll, 1969, p. 331-332, Pl. 57, figs. 11-12, 15-17.

Remarks: The extinction of *G. annulispina* is marked by the loss of the sternal bar and pare. *Giraffospyris annulispina* gives rise to several undescribed species with which it is easily confused. The extinction of *G. annulispina* apparently is progressively younger to the east. The cause for this phenomenon is unknown, but its range at Site 77 is regarded as conservative and probably correct.

Occurrences:
Site 77—Upper *Calocycletta virginis* Zone to lower *Ommatartus antepenultimus* Zone.
Site 78—Middle of *C. virginis* Zone to *Cannartus laticonus* Zone.
Site 79—Upper *C. virginis* Zone to *Ommatartus penultimus* Zone.
Site 80—*C. virginis* Zone to *Cannartus* (?) *petterssoni* Zone.
Site 81—*C. laticonus* Zone.
Site 83—*C.* (?) *petterssoni* Zone to upper *O. penultimus* Zone.

Stratigraphic Range: *Calocycletta virginis* Zone to *Ommatartus antepenultimus* Zone; Lower to Middle Miocene.

Giraffospyris laterispina
(Plate 65, Figures 1 and 2; Plate 66, Figures 1-4)

Giraffospyris laterispina Goll, 1969, pp. 334-35, Pl. 58, figs. 15-16, 20-21.

Occurrences:
Site 77—Lower *Ommatartus penultimus* to top of unnamed zone.
Site 79—*Stichocorys peregrina* Zone to lower unnamed zone.
Site 80—*S. peregrina* to top of unnamed zone.
Site 81—Unnamed zone.
Site 82—*O. penultimus* Zone to top of unnamed zone.
Site 83—Middle of *S. peregrina* to top of unnamed zone.
Site 84—Middle of *S. peregrina* to top of unnamed zone.

Stratigraphic Range: *Ommatartus penultimus* Zone to unnamed zone; Upper Miocene to Recent.

Giraffospyris toxaria
(Plate 55, Figure 1)

Giraffospyris toxaria (Haeckel) Goll, 1969, p. 335, Pl. 56, figs. 1-2, 4, 7 (synonymy).

Occurrences:

Site 77—Middle of *Calocycletta costata* Zone to base of *Cannartus* (?) *petterssoni* Zone.

Site 78—Middle of *C. costata* Zone to *Cannartus laticonus* Zone.

Site 79—*C. costata* Zone to *Brachiospyris alata* Zone.

Site 80—*C. costata* Zone to *C.* (?) *petterssoni* Zone.

Site 81—*C. laticonus* Zone.

Stratigraphic Range: *Calocycletta costata* Zone to *Cannartus* (?) *petterssoni* Zone; Lower Miocene to Middle Miocene.

Gorgospyris schizpodia
(Plate 67, Figures 1-3)

Gorgospyris schizopodia Haeckel, 1887, p. 1071, Pl. 87, fig. 4.

Remarks: *Gorgospyris schizopodia* has biostratigraphic significance because of its short range. *Gorgospyris schizopodia* can be distinguished from *Dendrospyris pannosa*, its probable precursor, by the presence of regular flat-bladed basal spines. Commonly, a lattice pare is present beneath the lattice bar extending as a loop above the sagittal ring.

Occurrences:

Site 77—Middle to top of *Calocycletta virginis* Zone.

Site 78—Middle of *C. virginis* Zone to lower *Calocycletta costata* Zone.

Site 79—*C. virginis* Zone.

Stratigraphic Range: *Calocycletta virginis* Zone to *Calocycletta costata* Zone; Lower Miocene.

Hexaspyris papilio
(Plate 42, Figure 3; Plate 43, Figures 1 and 2)

Hexaspyris papilio Riedel 1959, p. 294, Pl. 2, figs. 1-2.

Remarks: Specimens of *H. papilio* bear a sternal bar, and therefore the species cannot be assigned to *Dorcadospyris.*

Occurrences:

Site 77—Base of *Hexaspyris papilio* Zone to base of *Lychnocanium bipes* Zone.

Site 78—Base of *H. papilio* Zone to lower *L. bipes* Zone.

Site 79—*L. bipes* Zone.

Stratigraphic Range: *Hexaspyris papilio* Zone to *Lychnocanium bipes* Zone; Upper Oligocene. The last occurrence of *H. papilio* is approximately synchronous with the first appearance of *Globorotalia kugleri.*

Lamprospyris huxleyi

Lamprospyris huxleyi Haeckel, 1887, p. 1094, Pl. 89, fig. 14.

Remarks:„*Lamprospyris huxleyi* is included in this study because of its morphological similarity with *Androspyris anthropiscus*, to which it is apparently related. *L. Huxleyi* can be distinguished from the latter by the possession of only 3 lattice connector bars joining the upper portion of the lattice shell to the sagittal ring.

Occurrence:

Site 84—Upper unnamed zone.

Stratigraphic Range: Unnamed zone; Pleistocene.

Liriospyris elevata
(Plate 68, Figures 3 and 4)

Liriospyris elevata Goll 1968, pp. 1426-1427, Pl. 175, figs. 4-5, 8-9.

Occurrences:

Site 77—Base of *Cannartus* (?) *petterssoni* Zone to middle of *Ommatartus antepenultimus* Zone.

Site 79—*C.* (?) *petterssoni* Zone to *O. antepenultimus* Zone.

Site 80—*C.* (?) *petterssoni* Zone.

Stratigraphic Range: *Cannartus* (?) *petterssoni* Zone to *Ommatartus antepenultimus* Zone; Middle Miocene to Upper Miocene.

Liriospyris globosa
(Plate 68, Figures 1 and 2)

Liriospyris globosa Goll, 1968, pp. 1427-1428, Pl. 176, figs. 1-3, 5.

Remarks: ‚A short stratigraphic range assures the biostratigraphic value of this species. The Site 77 data confirms *L. globosa* as an intermediate form between *Liriospyris mutuaria* and *Liriospyris reticulata.*

Occurrences:

Site 77—Top of *Calocycletta virginis* Zone to base of *Calocycletta costata* Zone.

Site 78—Top of *C. virginis* Zone to top of *C. costata* Zone.

Site 80—Lower *C. costata* Zone.

Stratigraphic Range: *Calocycletta virginis* Zone to *Calocycletta costata* Zone; Lower Miocene.

Liriospyris longicornuta
(Plate 69, Figures 1-3; Plate 70, Figures 1 and 2)

Liriospyris longicornuta Goll, 1968, p. 1428, Pl. 176, figs. 8, 10, 12.

Remarks: A remarkable homeomorph of *L. longicornuta* was observed lower in the *Theocyrtis annosa* Zone.

Occurrences:

Site 77—Upper *Theocyrtis annosa* Zone to base of *Lychnocanium bipes* Zone.

Site 78—Upper *T. annosa* Zone to middle *L. bipes* Zone.

Stratigraphic Range: *Theocyrtis annosa* to *Lychnocanium bipes* Zone; Upper Oligocene to Lower Miocene.

Liriospyris mutuaria
(Plate 71, Figure 2)

Liriospyris mutuaria Goll, 1968, pp. 1428-1429, Pl. 175, figs. 6, 10-11, 14.

Occurrences:
Site 77–Middle of *Lychnocanium bipes* Zone to base of *Cannartus* (?) *petterssoni* Zone.
Site 78–Upper *Lychnocanium bipes* Zone to *Cannartus laticonus* Zone.
Site 79–*L. bipes* Zone to *C.* (?) *petterssoni* Zone.
Site 80–*Calocycletta virginis* Zone to *C.* (?) *petterssoni* Zone.
Site 81–*Cannartus laticonus.*

Stratigraphic Range: *Lychnocanium bipes* Zone to *Cannartus* (?) *petterssoni* Zone; Lower Miocene to Middle Miocene.

Liriospyris ovalis

Liriospyris ovalis Goll, 1968, Pl. 176, figs. 4, 6-7.

Remarks: Near the top of its range, incomplete specimens are common and cause difficulties in identification. *Liriospyris ovalis* has little biostratigraphic significance unless the species can be subdivided.

Occurrences:
Site 77–Top of *Cannartus* (?) *petterssoni* Zone to top of *Ommatartus penultimus* Zone.
Site 79–*Ommatartus antepenultimus* Zone to lower unnamed zone.
Site 80–*O. penultimus* Zone to middle of *Stichocorys peregrina* Zone.
Site 83–*Cannartus* (?) *petterssoni* Zone to middle of *Spongaster pentas* Zone.

Stratigraphic Range: *Cannartus* (?) *petterssoni* Zone to *Spongaster pentas* Zone; Middle Miocene to Lower Pliocene.

Liriospyris reticulata
(Plate 71, Figure 1)

Liriospyris reticulata (Ehrenberg) Goll, 1968, pp. 1429-1430, Pl. 176, figs. 9, 11, 13 (synonymy).

Occurrences:
Site 77–Top of *Calocycletta virginis* Zone to top of unnamed zone.
Site 79–*Calocycletta costata* Zone to top of unnamed zone.
Site 80–Top of *C. virginis* Zone to top of unnamed zone.
Site 81–Unnamed zone.
Site 82–*Ommatartus penultimus* Zone to top of unnamed zone.
Site 83–*Cannartus* (?) *petterssoni* Zone to top of unnamed zone.
Site 84–Upper *Pterocanium prismatium* Zone to top of unnamed zone.

Stratigraphic Range: *Calocycletta virginis* Zone to unnamed zone; Lower Miocene to Pleistocene.

Liriospyris stauropora
(Plate 70, Figure 3)

Liriospyris stauropora (Haeckel) Goll, 1968, pp. 1431-1432, Pl. 175, figs. 1-3, 7.

Occurrences:
Site 77–Upper *Calocycletta virginis* Zone to lower *Cannartus laticonus* Zone.
Site 78–Upper *C. virginis* Zone to *Cannartus laticonus* Zone.
Site 79–*C. virginis* Zone to *Brachiospyris alata* Zone.
Site 80–Top of *C. virginis* Zone to *Calocycletta costata* Zone.
Site 81–*C. laticonus* Zone.

Stratigraphic Range: *Calocycletta virginis* Zone to *Cannartus laticonus* Zone; Lower Miocene to Middle Miocene.

Nephrospyris renilla
(Plate 72, Figures 1-3)

Nephrospyris renilla Haeckel, 1887, p. 1101, Pl. 90, figs. 9-10.

Remarks: This large and easily recognized species is probably a descendant of *Tristylospyris palmipes. Nephrospyris renilla* is most common in the eastern equatorial Pacific Ocean. Its apparently older first appearance in Sites 83 and 84 is a result of the diachronous nature of the zonal scheme. A manuscript is now in preparation in which the first appearance of *N. renilla* is shown to coincide with the top of the "a" event in the Gilbert paleomagnetic epoch, which can be dated at 3.9 m.y.a.

Occurrences:
Site 77–Lower *Spongaster pentas* Zone to top of unnamed zone.
Site 79–*Pterocanium prismatium* Zone to top of unnamed zone.
Site 80–*S. pentas* Zone to top of unnamed zone.
Site 81–Unnamed zone.
Site 82–*S. pentas* Zone to top of unnamed zone.
Site 83–*Stichocorys peregrina* Zone to top of unnamed zone.
Site 84–Upper *S. peregrina* Zone to top of unnamed zone.

Stratigraphic Range: *Spongaster pentas* Zone to unnamed zone; Lower Pliocene to Pleistocene.

Tholospyris anthopora
(Plate 73, Figures 1 and 2; Plate 74, Figures 1-3)

Tholospyris anthopora (Haeckel) Goll, 1969, pp. 324-325, Pl. 55, figs. 1-4.

Remarks: The top of the range of *T. anthopora* is difficult to determine, and the species has little biostratigraphic value.

Occurrences:

Site 77–Base of *Theocyrtis annosa* Zone to middle of *Brachiospyris alata* Zone.
Site 78–Lower *T. annosa* Zone to *Cannartus laticonus* Zone.
Site 79–*Lychnocanium bipes* Zone to *Brachiospyris alata* Zone.
Site 80–*Calocycletta virginis* Zone to *Cannartus* (?) *petterssoni* Zone.
Site 81–*C. laticonus* Zone.

Stratigraphic Range: *Theocyrtis annosa* Zone to *Brachiospyris alata* Zone; Upper Oligocene to Middle Miocene.

Tholospyris cortinisca
(Plate 75, Figures 1-4)

Tholospyris cortinisca (Haeckel) Goll, 1969, pp. 325-326, Pl. 56, figs. 3, 5, 6, 8 (synonymy).

Occurrences:

Site 77–Middle of *Cannartus laticonus* Zone to upper *Pterocanium prismatium* Zone.
Site 79–*Ommatartus antepenultimus* Zone to *Stichocorys peregrina* Zone.
Site 80–*Cannartus* (?) *petterssoni* Zone to *Spongaster pentas* Zone.
Site 82–*Ommatartus penultimus* Zone to *S. pentas* Zone.
Site 83–*C.* (?) *petterssoni* Zone to upper *S. pentas* Zone.
Site 84–*S. peregrina* Zone to upper *S. pentas* Zone.

Stratigraphic Range: *Cannartus laticonus* Zone to *Pterocanium prismatium* Zone; Middle Miocene to Upper Pliocene.

Tholospyris devexa
(Plate 76, Figures 1-3; Plate 77, Figures 1-4)

Tholospyris devexa Goll, 1969, p. 326, Pl. 57, figs. 9-10, 13-14.

Occurrences:

Site 77–Lower *Pterocanium prismatium* Zone to top of unnamed zone.
Site 79–*P. prismatium* Zone to unnamed zone.
Site 80–Unnamed zone.
Site 81–Unnamed zone.
Site 82–*P. prismatium* Zone to top of unnamed zone.
Site 83–Top of *P. prismatium* Zone to top of unnamed zone.
Site 84–Top of *P. prismatium* Zone to top of unnamed zone.

Stratigraphic Range: *Pterocanium prismatium* Zone to unnamed zone; Upper Pliocene to Pleistocene.

Tholospyris infericosta
(Plate 78, Figures 1-3; Plate 79, Figures 1-4)

Tholospyris infericosta Goll, 1969, pp. 326-327, Pl. 55, figs. 7, 10-12.

Remarks: This species first appears at the approximate position of the Serravalian-Tortonian stage boundary, and can serve as a more precise marker for the Middle Miocene-Upper Miocene boundary than *Ommatartus antepenultimus.* Both *Tholospyris infericosta* and *Tricolospyris leibnitziana* have tri-bladed lattice bars and are otherwise morphologically similar. *Tholospyris infericosta* can be distinguished from the latter species by its possession of lattice spines on the apical portion of the lattice shell.

Occurrences:

Site 77–Middle of *Cannartus* (?) *petterssoni* Zone to lower *Ommatartus penultimus* Zone.
Site 80–*C.* (?) *petterssoni* Zone.
Site 83–*C.* (?) *petterssoni* Zone to *Ommatartus antepenultimus.*

Stratigraphic Range: *Cannartus* (?) *petterssoni* Zone to *Ommatartus penultimus* Zone; Middle Miocene to Upper Miocene.

Tholospyris mammalaris
(Plate 80, Figures 1-4)

Tholospyris mammalaris (Haeckel) Goll, 1969, pp. 327-328, Pl. 55, figs. 5-6, 8-9 (synonymy).

Occurrences:

Site 77–Middle of *Lychnocanium bipes* Zone to top of *Calocycletta costata* Zone.
Site 78–Upper *L. bipes* Zone to top of *C. costata* Zone.
Site 79–*Calocycletta virginis* Zone to *C. costata* Zone.
Site 80–*C. virginis* Zone to lower *C. costata* Zone.

Stratigraphic Range: *Lychnocanium bipes* Zone to *Calocycletta costata* Zone; Lower Miocene to Middle Miocene.

Tholospyris procera
(Plate 81, Figures 1-4)

Tholospyris procera Goll, 1969, p. 328, Pl. 59, figs. 8, 10-12.

Remarks: The sporadic occurrence of *T. procera* in the *Ommatartus penultimus* Zone of Site 77 is regarded as anomalous. The oldest members of this species are difficult to distinguish from its precursor, and *T. procera* has little biostratigraphic merit.

Occurrences:

Site 77–*Ommatartus penultimus* Zone to top of unnamed zone.
Site 79–*Stichocorys peregrina* Zone to top of unnamed zone.

Site 80—*S. peregrina* Zone to top of unnamed zone.
Site 82—Upper *S. peregrina* Zone to top of unnamed zone.
Site 83—Middle of *S. peregrina* Zone to top of unnamed zone.

Stratigraphic Range: *Stichocorys peregrina* Zone to unnamed zone; Upper Miocene to Pleistocene.

Tholospyris scaphipes
(Plate 82, Figures 1-4; Plate 83, Figure 1)

Tholospyris scaphipes (Haeckel) Goll, 1969, pp. 328-329, Pl. 58, figs. 1-8, 13-14 (synonymy).

Occurrences:
Site 77—Top of *Cannartus laticonus* Zone to top of unnamed zone.
Site 79—*Cannartus* (?) *petterssoni* Zone to top of unnamed zone.
Site 80—*C.* (?) *petterssoni* Zone to top of unnamed zone.
Site 81—Unnamed zone.
Site 82—*Ommatartus penultimus* Zone to top of unnamed zone.
Site 83—*C.* (?) *petterssoni* Zone to top of unnamed zone.
Site 84—*Stichocorys peregrina* Zone to top of unnamed zone.

Stratigraphic Range: *Cannartus laticonus* Zone to unnamed zone; Middle Miocene to Pleistocene.

Tricolospyris leibnitziana
(Plate 84, Figures 1-4; Plate 85, Figures 1-3)

Tricolospyris leibnitziana Haeckel, 1887, p. 1098, Pl. 88, fig. 9.

Remarks: A manuscript is in preparation in which the extinction of *T. leibnitziana* is shown to occur in the upper normal event of the Gauss paleomagnetic epoch. Unlike *Tholospyris infericosta*, the apical spine of specimens of *T. leibnitziana* is small and does not extend above the lattice shell.

Occurrences:
Site 77—Middle of *Ommatartus antepenultimus* Zone to lower *Pterocanium prismatium* Zone.
Site 79—*O. antepenultimus* Zone to *Stichocorys peregrina* Zone.
Site 80—*S. peregrina* Zone to *Spongaster pentas* Zone.
Site 82—*Ommatartus penultimus* to *S. pentas* Zone.
Site 83—*Cannartus* (?) *petterssoni* Zone to upper *S. pentas* Zone.
Site 84—*S. peregrina* Zone to upper *S. pentas* Zone.

Stratigraphic Range: *Ommatartus antepenultimus* Zone to *Pterocanium prismatium* Zone; Upper Miocene to Upper Pliocene.

Tristylospyris palmipes
(Plate 83, Figure 2)

Tristylospyris palmipes Haeckel, 1887, p. 1033, Pl. 84, fig. 14.

Remarks: This species is indigenous to the western Pacific Ocean and was not observed east of Site 80. Its range at Site 80 is constricted and indicates a brief invasion into this region. *Tristylospyris palmipes* is an important precursor to species such as *Nephrospyris renilla* and *Androspyris anthropiscus.* Specimens of *T. palmipes* can be distinguished from *Tholospyris cortinisca* by the possession of three basal spines of equal length and the absence of tribladed lattice bars.

Occurrences:
Site 77—Upper *Ommatartus penultimus* Zone to top of unnamed zone.
Site 79—*Stichocorys peregrina* Zone to top of unnamed zone.
Site 80—*S. peregrina* Zone to *Spongaster pentas* Zone.

Stratigraphic Range: *Ommatartus penultimus* Zone to unnamed zone; Upper Miocene to Pleistocene.

Typanidium binoctonum
(Plate 86, Figures 1 and 2; Plate 87, Figures 1 and 2)

Tympanidium binoctonum Haeckel-Riedel 1957, pp. 78-79, Pl. 1, fig. 2.

Remarks: *Tympanidium binoctonum* is a massive species characterized by the absence of lattice spines, and the apical and vertical spines are not visible beneath the thick lattice bars. The primary lateral bars are replaced by short spines.

Occurrences:
Site 77—Lower *Lychnocanium bipes* Zone to top of *Calocycletta costata* Zone.
Site 78—Upper *L. bipes* Zone to top of *C. costata* Zone.
Site 79—*L. bipes* Zone to *Calocycletta virginis* Zone.
Site 80—*C. virginis* Zone to *C. costata* Zone.

Stratigraphic Range: *Lychnocanium bipes* Zone to *Calocycletta costata* Zone; Upper Oligocene to Middle Miocene.

AGE RELATIONSHIPS OF LEG 9 SITES

The biostratigraphic data compiled in Figure 1 can be used to plot age versus sediment thickness for each of the drilling sites (Figure 2). Calculations for rates of sediment accumulation have been presented elsewhere in this volume (Site Reports and Synthesis), and it is not my intention to duplicate these findings here. Figure 2 provides a more detailed visual presentation of sediment accumulation fluctuations. Higher rates of accumulation are represented by steeper portions of

each curve. Arrows beneath the horizontal scales are biostratigraphic reference points which have been extracted from Plate 88. In part, these arrows indicate ages for series and subseries boundaries which have been discussed in the Preliminary Explanation chapter. Three of the arrows mark first appearances of Radiolaria whose ages are established from paleomagnetic studies. The remaining 22 arrows are subjective interpolations based on Plate 88. Identifications for the arrows are listed below:

1 – Base of *Pulleniatina obliquiloculata* Zone; 1.85 m.y.a.

2 – Base of *Cyclococcolithina leptopora* Zone.

3 – First appearance of *Clathrocircus stapedius;* 3.0 m.y.a.

4 – First appearance of *Nephrospyris renilla;* 3.9 m.y.a.

5 – Base of *Sphaeroidinella dehiscens* Zone and first appearance of *Archicircus rhombus;* 4.4 m.y.a.

6 – Base of *Globorotalia tumida* Zone.

7 – Base of *Stichocorys peregrina* Zone.

8 – Base of *Ceratolithus tricorniculatus* Zone.

9 – Bases of *Globorotalia plesiotumida* Zone and *Ommatartus penultimus* Zone.

10 – Base of *Ommatartus antepenultimus* Zone; 9.5 m.y.a.

11 – Bases of *Globoquadrina altispira* Zone and *Cannartus* (?) *petterssoni* Zone.

12 – Bases of *Globorotalia fohsi lobata* Zone.

13 – Base of *Discoaster exilis-Discoaster kugleri* Subzone.

14 – Base of *Cannartus laticonus* Zone.

15 – Base of *Globorotalia fohsi fohsi-Globorotalia peripheroacuta* Zone.

16 – Base of *Brachiospyris alata* Zone.

17 – Base of *Praeorbulina glomerosa curva* Zone.

18 – Base of *Sphenolithus heteromorphus-Helicopontosphaera selli* Subzone.

19 – Base of *Calocycletta costata* Zone.

20 – Base of *Globoquadrina venezuelana* Zone.

21 – Base of *Globigerinita dissimilis* Zone.

22 – Base of *Calocycletta virginis* Zone.

23 – Base of *Globorotalia kugleri* Zone.

24 – Base of *Lychnocanium bipes* Zone.

25 – Base of *Hexaspyris papilio* Zone.

26 – Base of *Globigerina angulisuturalis* Zone.

27 – Base of *Globorotalia opima* Zone.

28 – Base of *Chiluguembelina cubensis* Zone.

29 – Bases of *Theocyrtis annosa* Zone and *Coccolithus bisectus-Sphenolithus distentus* Subzone.

30 – Base of *Globigerina ampliapertura* Zone.

31 – Base of *Cyclococcolithina formosa-Sphenolithus predistentus* Subzone.

Examination of the plot for Site 77 suggests that these interpolated reference arrows are approximately correct. With the exception of the Upper Oligocene-Lower Miocene, the section at Site 77 shows remarkably uniform accumulation. In contrast, Site 78 is characterized by extremes of high and low rates of sediment accumulation, although hiatuses below the Middle Miocene are not evident. In terms of overall accumulation, Site 80 has the lowest rate, while Site 81 has the highest accumulation rate of all the Leg 9 sites. Sites 82, 83 and 84 have abnormally high accumulation rates during Late Miocene time; whereas, the same phenomenon occurs during Middle Miocene time at Site 79 and Early Miocene time for Sites 77 and 78. These observations suggest that the northward movement of the Pacific plate under the equatorial high production belt occurred at progressively later times towards the east.

REFERENCES

Goll, R. M., 1968. Classification and phylogeny of Cenozoic Trissocyclidae (Radiolaria) in the Pacific and Caribbean basins, part I. *J. Paleont.* **42**, 1409.

_____, 1969. Classification and phylogeny of Cenozoic Trissocyclidae (Radiolaria) in the Pacific and Caribbean basins, part II. *J. Paleont.* **43**, 322.

Goll, R. M. and Bjørklund, K. R. (in press). Radiolaria in surface sediments of the North Atlantic Ocean. *Micropaleontology.*

Haeckel, E., 1887. Report of the Radiolaria collected by H.M.S. *Challenger* during the years 1873-1876. *Rept. Voyage Challenger, Zool.* **18.**

Hays, J. D. *et al.,* 1969. Pliocene-Pleistocene sediments of the equatorial Pacific: their paleomagnetic, biostratigraphic, and climatic record. *Bull. Geol. Soc. Am.* **80**, 1481.

Jorgensen, E., 1905. The protist plankton and the diatoms in bottom samples. *Bergens Museum Skrifer (1905).* 114.

Moore, T. C. (in press). Radiolaria. **In** Tracey, J. *et al.,* 1971. *Initial Reports of the Deep Sea Drilling Project, Volume VIII.* Washington (U. S. Government Printing Office).

Riedel, W. R., 1957. Radiolaria: a preliminary stratigraphy. *Repts. Swedish Deep-Sea Exped.* **6**, 59.

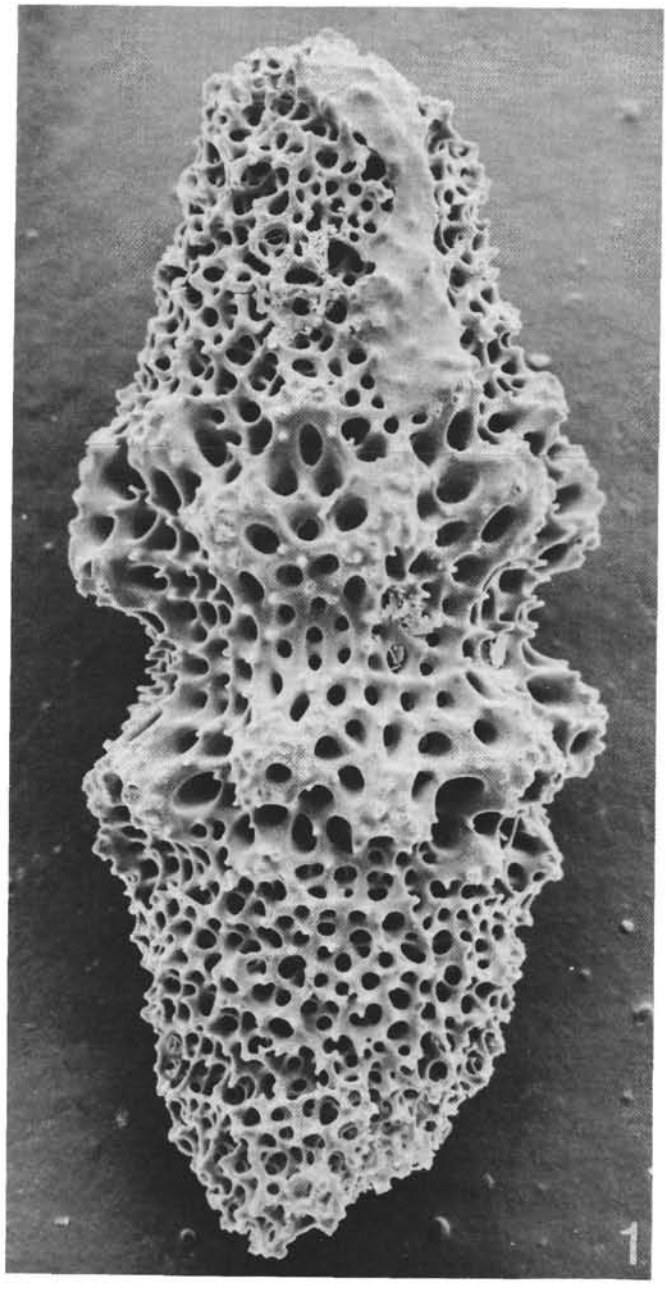
_____, 1959. Oligocene and Lower Miocene Radiolaria in tropical Pacific sediments. *Micropaleontology.* **5**, 285.

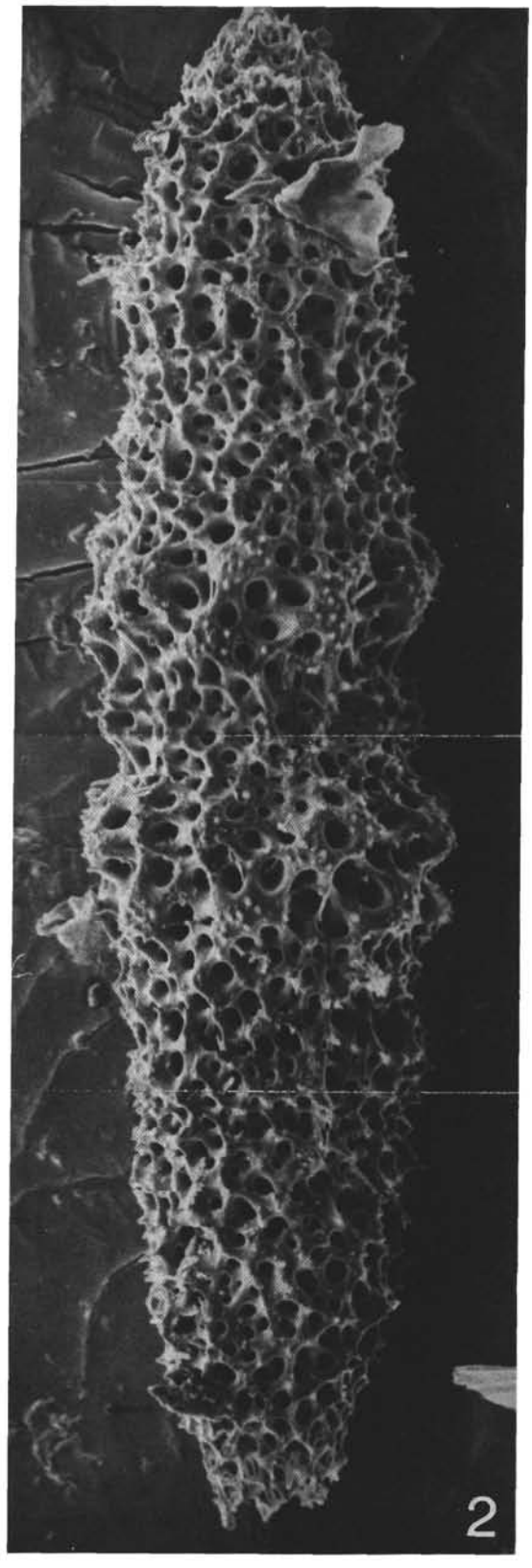
Riedel, W. R. and Sanfilippo, A., 1970. Radiolaria. **In** Bader, R. G. *et al.,* 1970. *Initial Reports of the Deep*

Sea Drilling Project, Volume IV. Washington (U. S. Government Printing Office), 504.

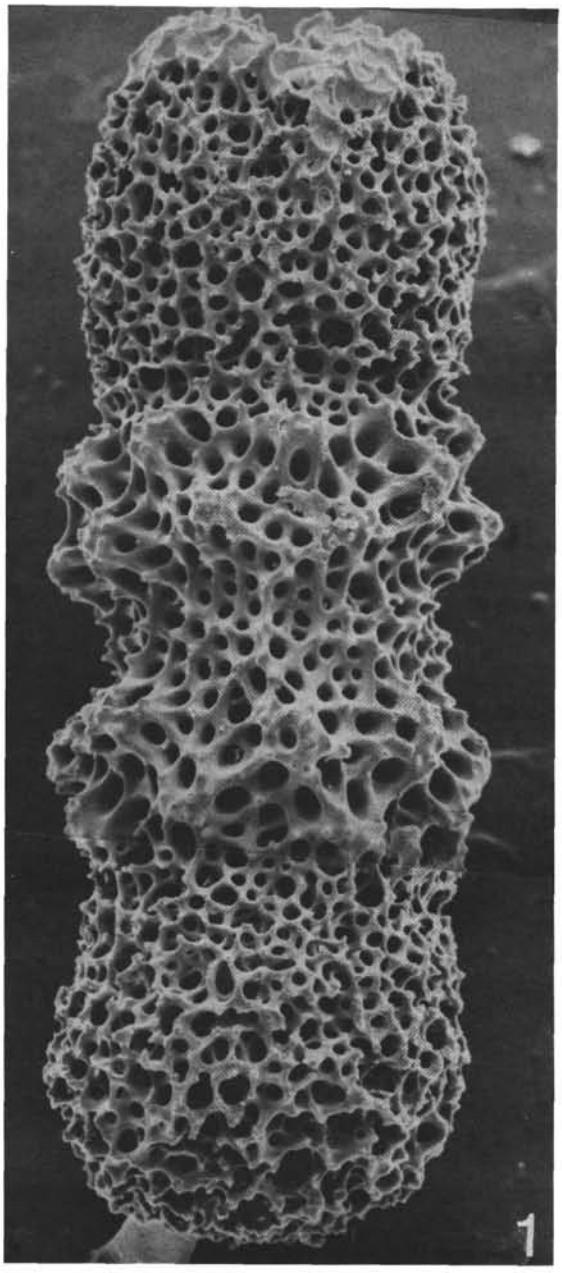
Saito, T. and Funnell, B. M., 1970. Pre-Quaternary sediments and microfossils in the oceans. **In** *The Sea*. Maxwell, A. E. (Ed.), New York (Inter-science), **4** (1), 183.

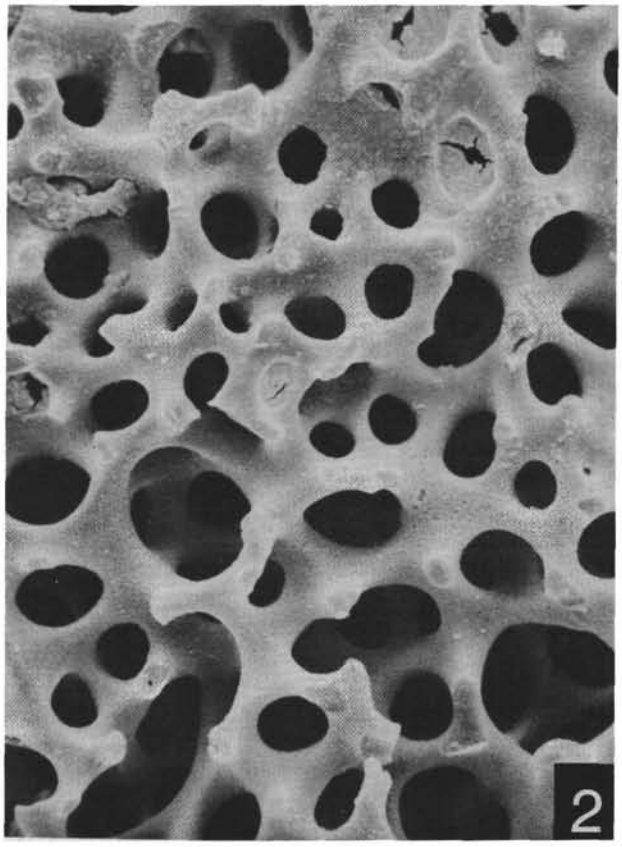
Sanfilippo, A. and Riedel, W. R., 1970. Post-Eocene "closed" theoperid radiolarians. *Micropaleontology*. **16**, 446.

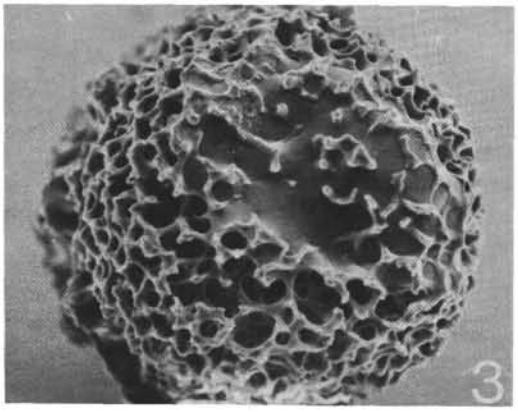


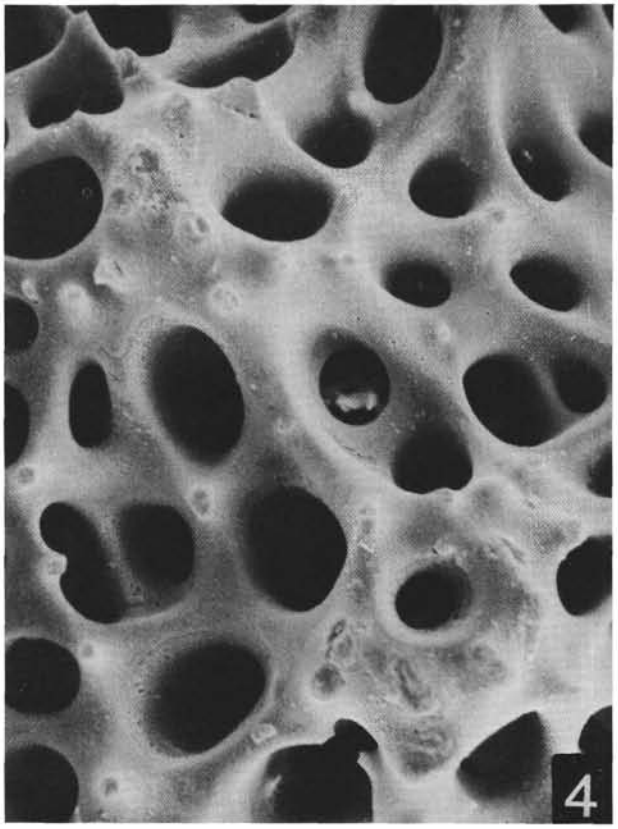


Figures 1, 2 *Cannartus laticonus.*
1: Hole 77B, Core 8, Section 3, 0-2 cm; ×550.
2: Hole 80A, Core 3, Section 4, 17-19 cm; ×500.

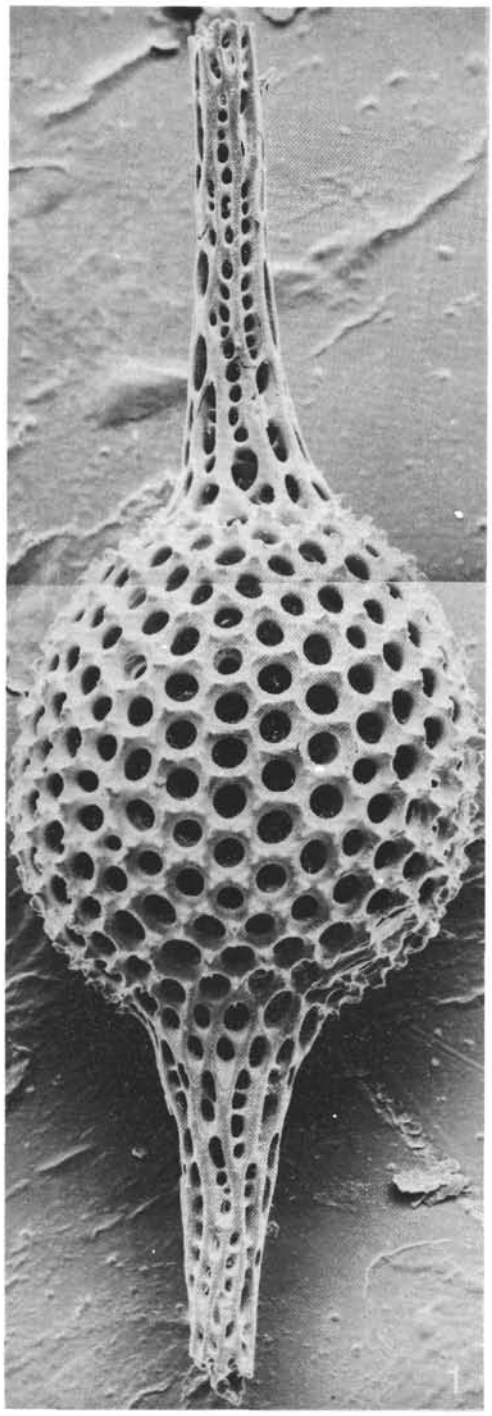


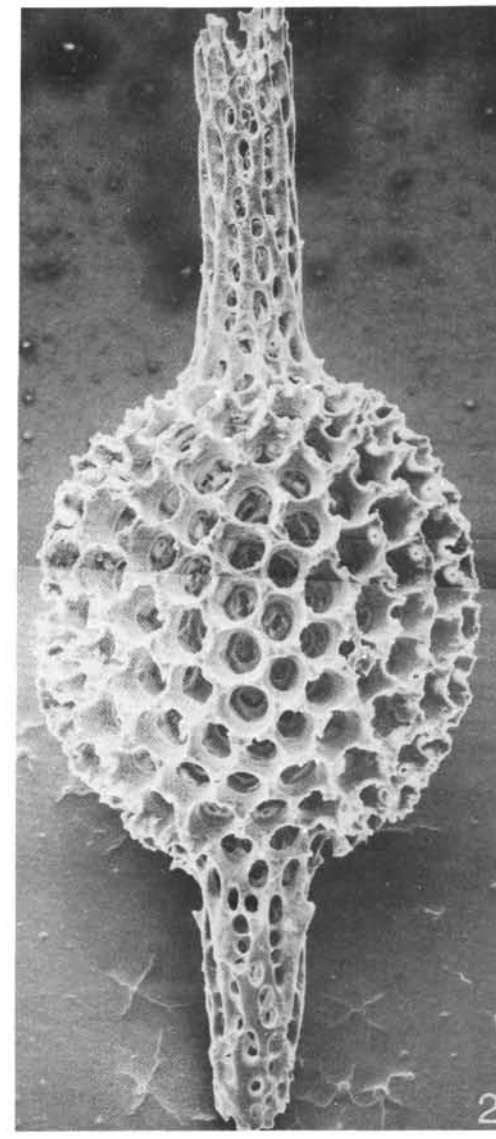


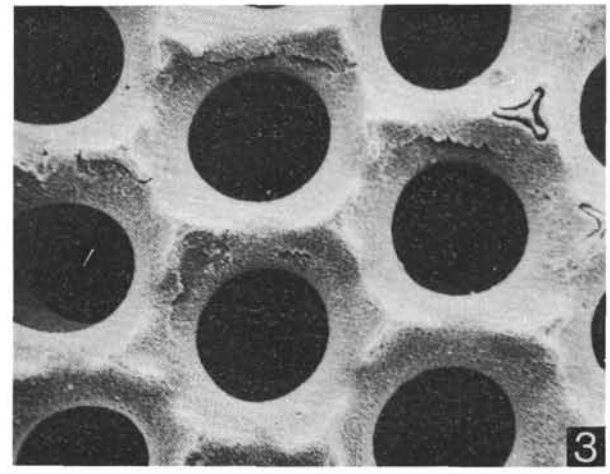




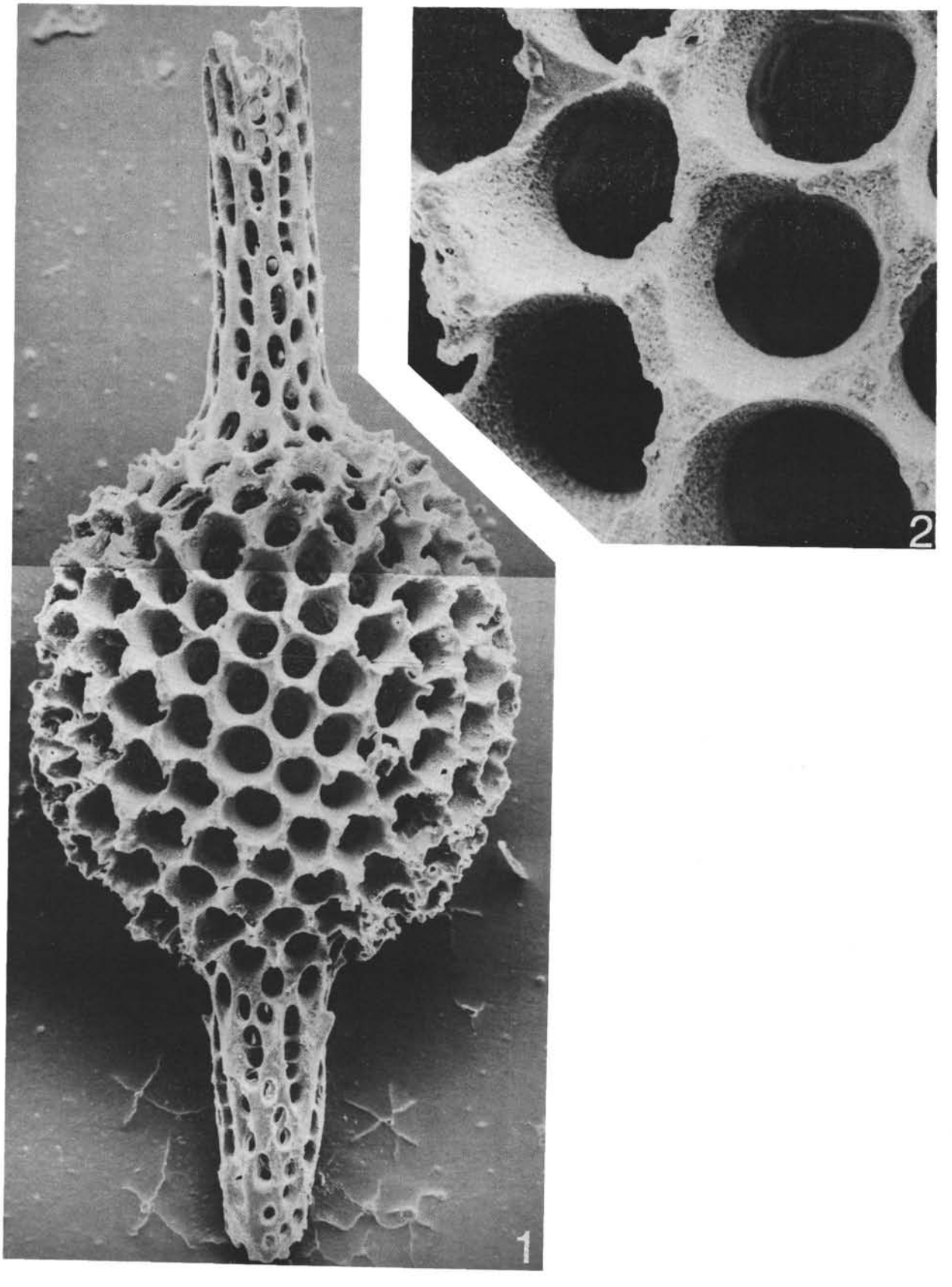
Figures 1-4 *Cannartus (?) petterssoni.* Hole 80A, Core 3, Section 4, 17-19 cm.
1: Side view; X500.
2: Detail of polar column; X2000.
3: End view of polar column; X500
4: Detail of cortical twin-shell; X2000.



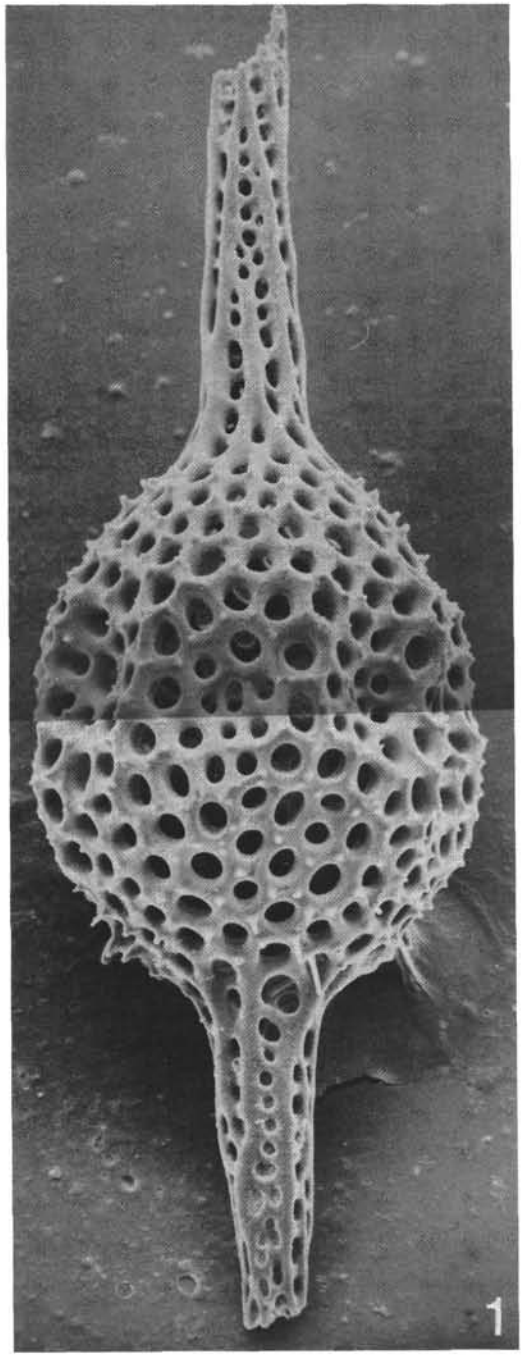


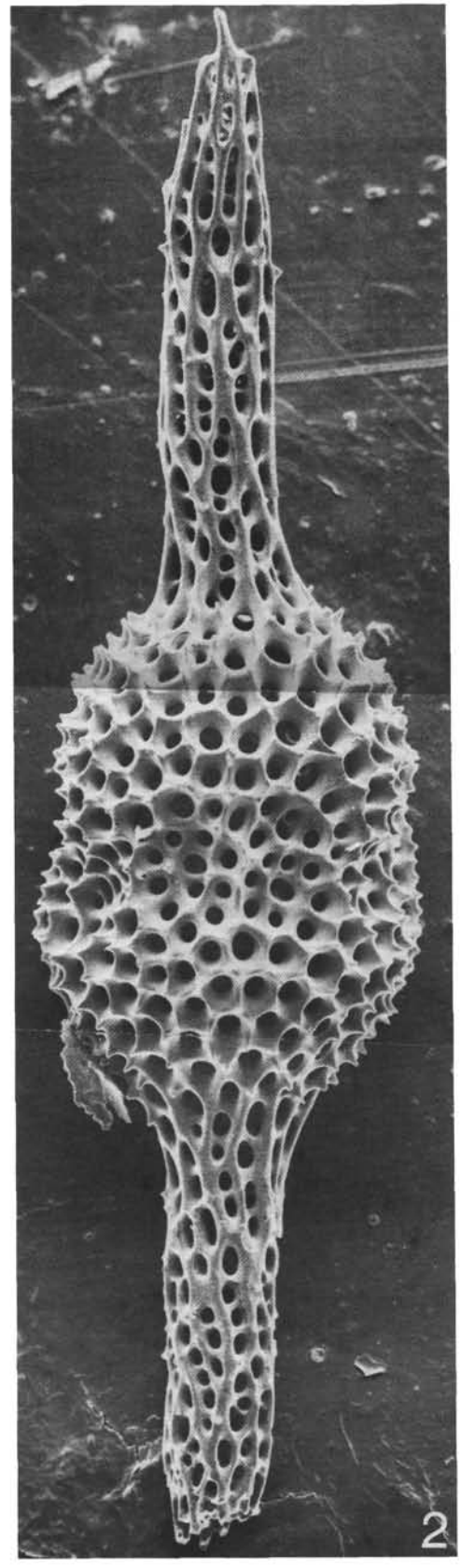


Figures 1-3 *Cannartus prismaticus.*
1 and 3: Hole 78, Core 28, core catcher; X360 and X1440, respectively.
2: Hole 78, Core 24, core catcher; X360.

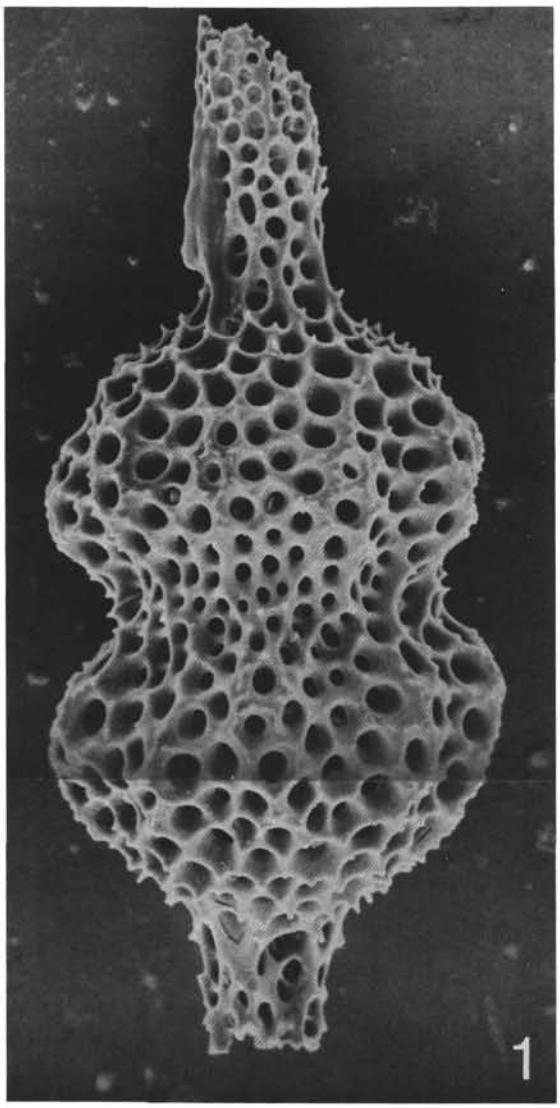


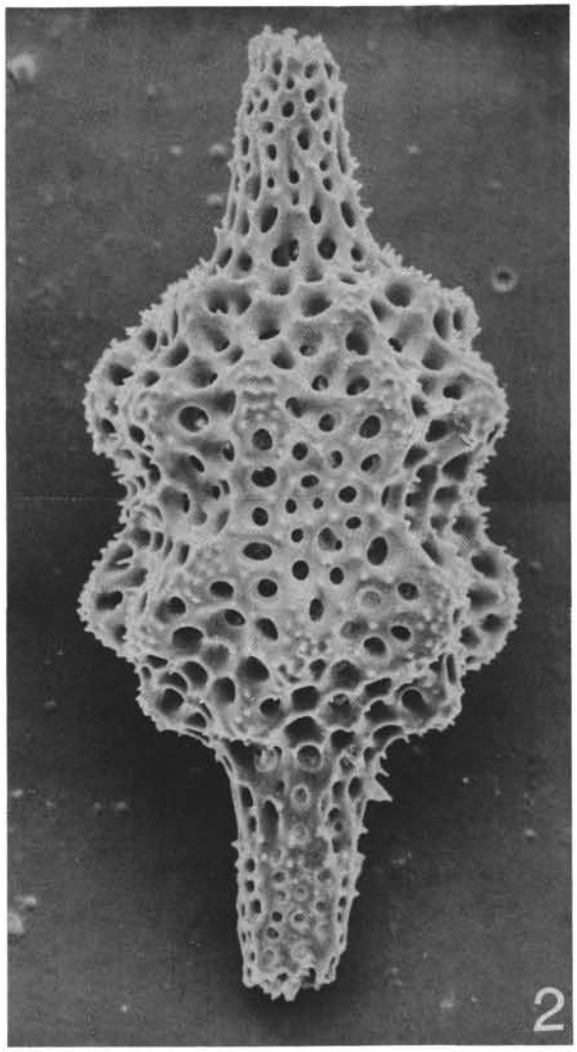
Figures 1, 2 *Cannartus prismaticus.*
Hole 78, Core 17, Section 4, 20-22 cm; X510 and X2050, respectively.

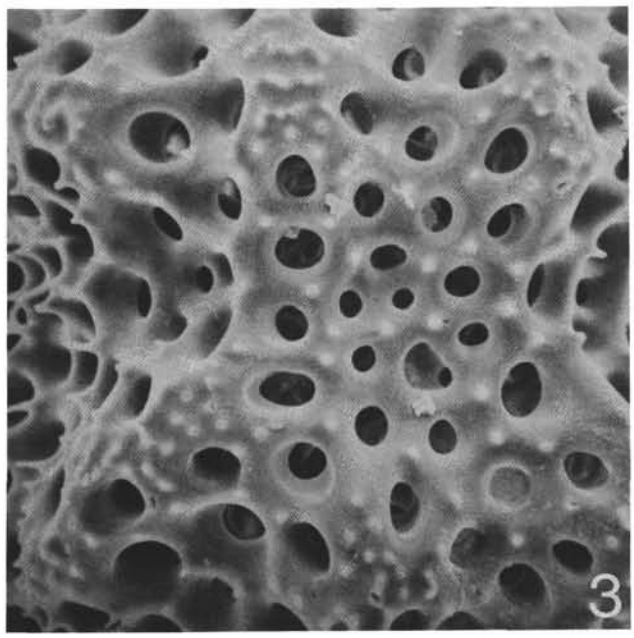




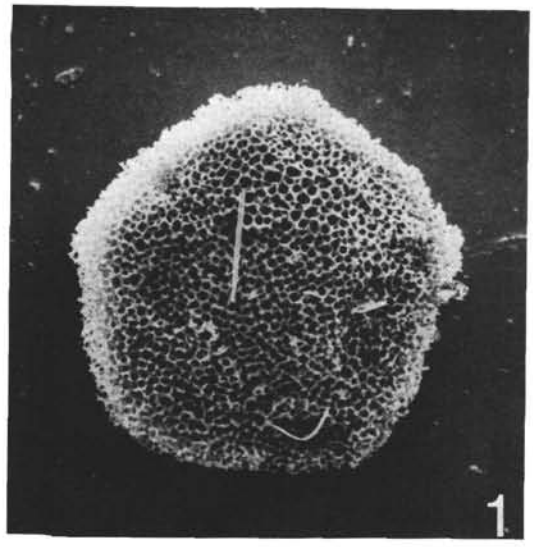
Figures 1, 2 *Cannartus tubarius.*
1: Hole 77B, Core 27, Section 6, 74-76 cm; X450.
2: Hole 78, Core 7, Section 4, 13-15 cm; X475.

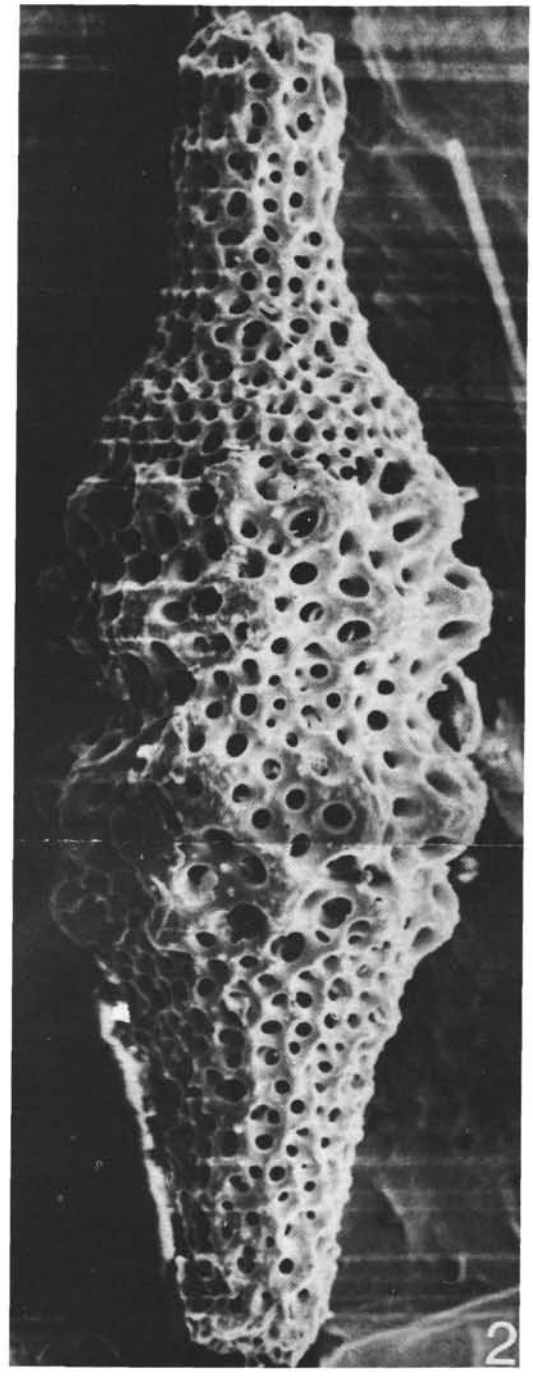


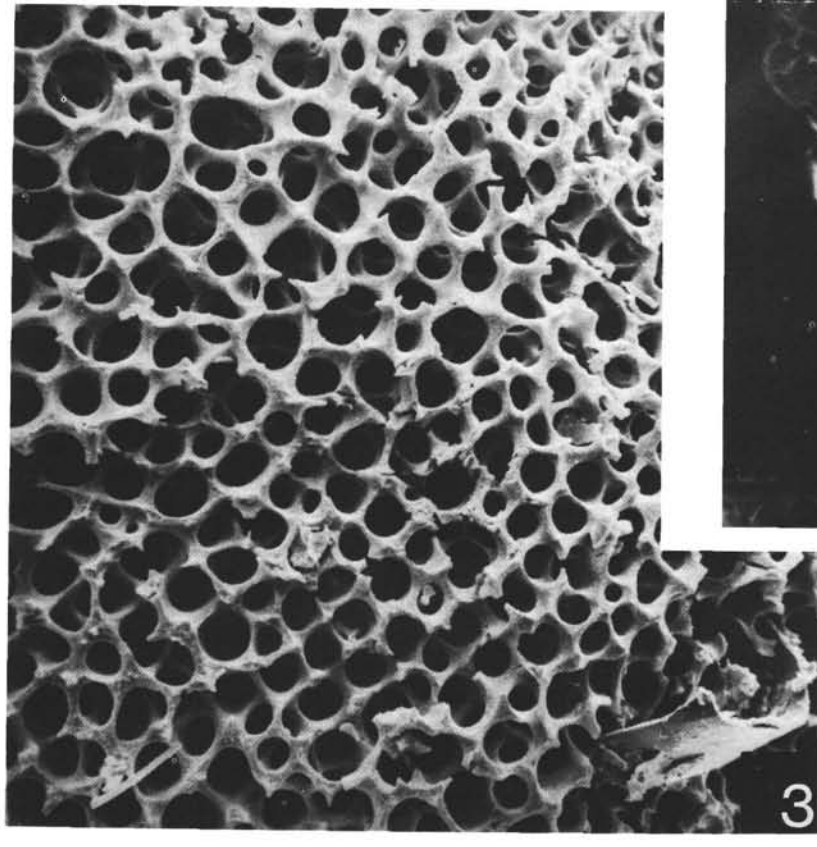




Figures 1-3 *Cannartus violina.*
1: Hole 77B, Core 27, Section 6, 74-76 cm; X500.
2 and 3: Hole 77B, Core 27, Section 6, 74-76 cm; X500 and X1000, respectively.

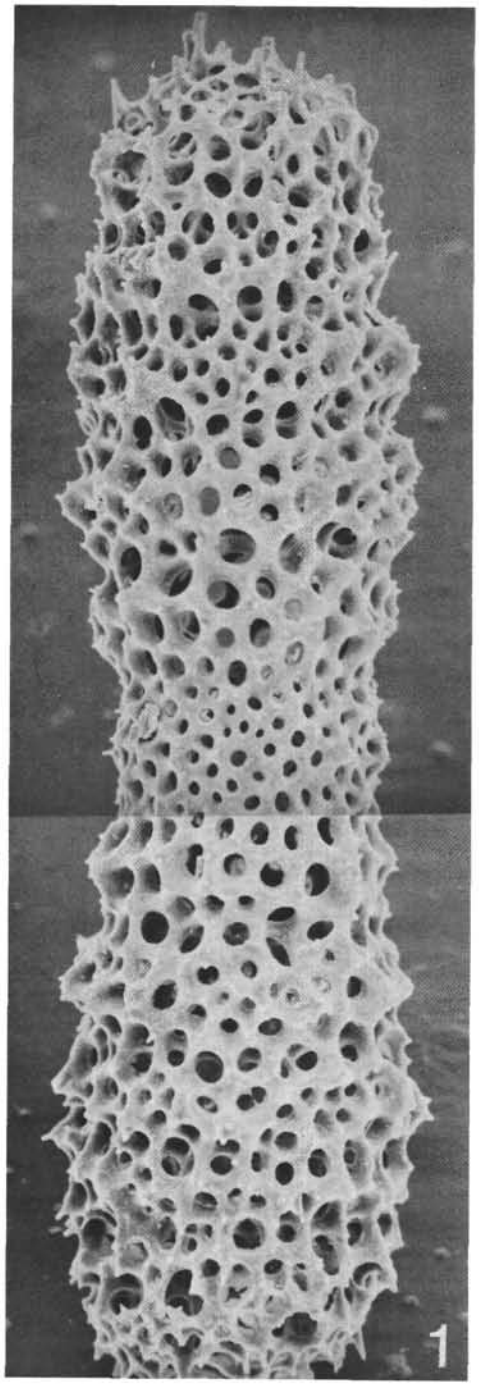


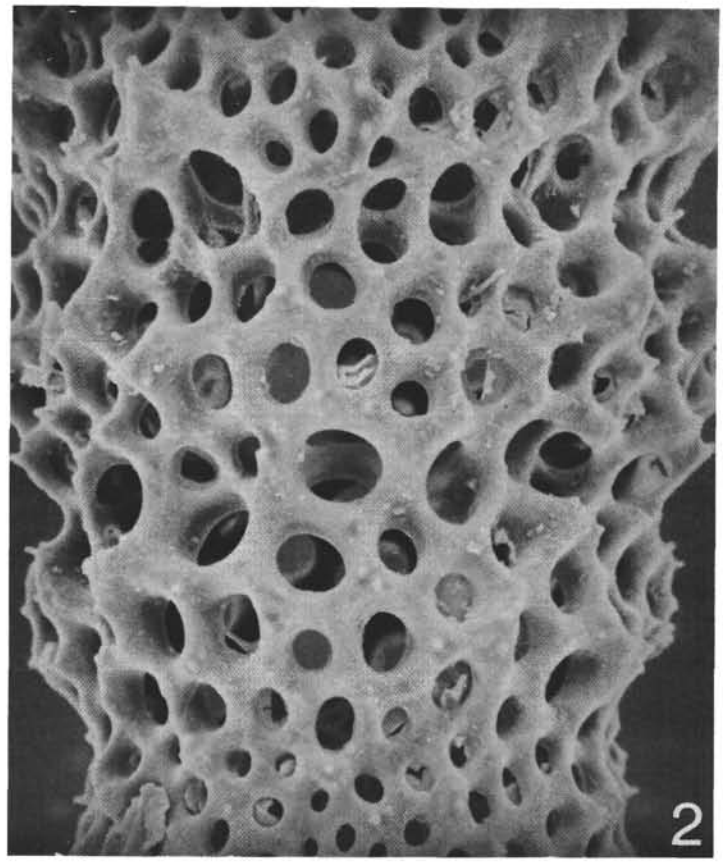


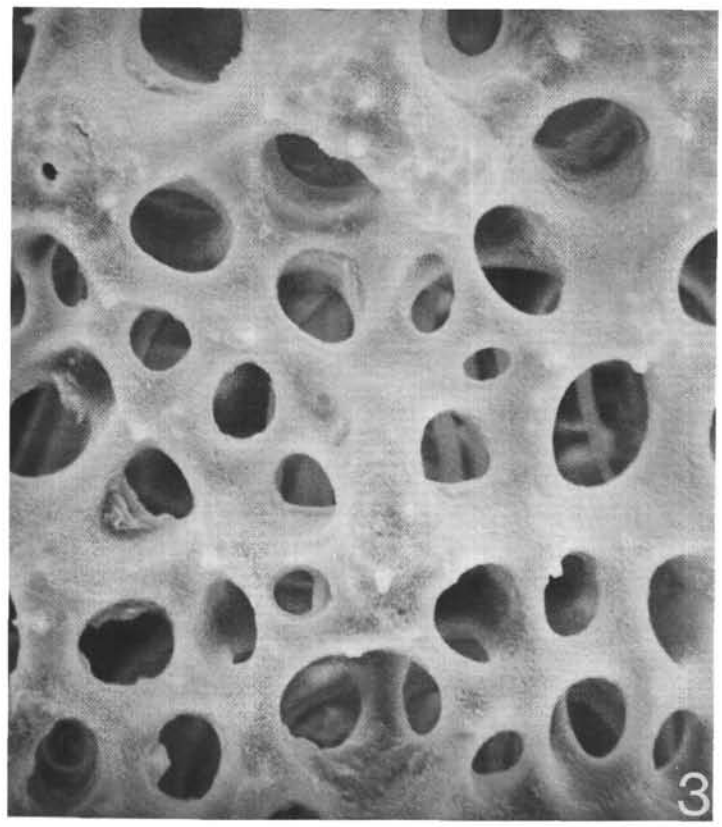


Figures 1,3 *Spongaster pentas.*
Hole 80A, Core 2, Section 4, 75-77 cm; X205 and X1000, respectively.

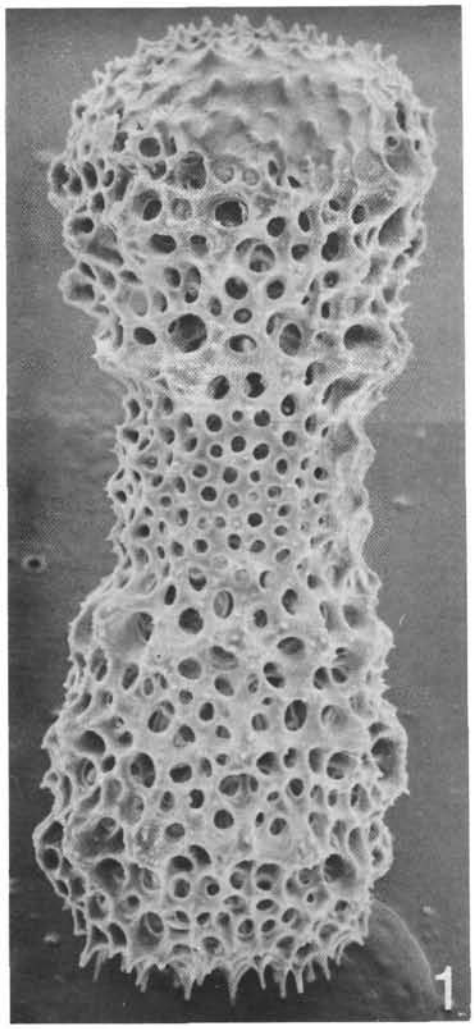
Figure 2 *Ommatartus antepenultimus.*
Hole 77B, Core 8, Section 3, 0-2 cm; X550.

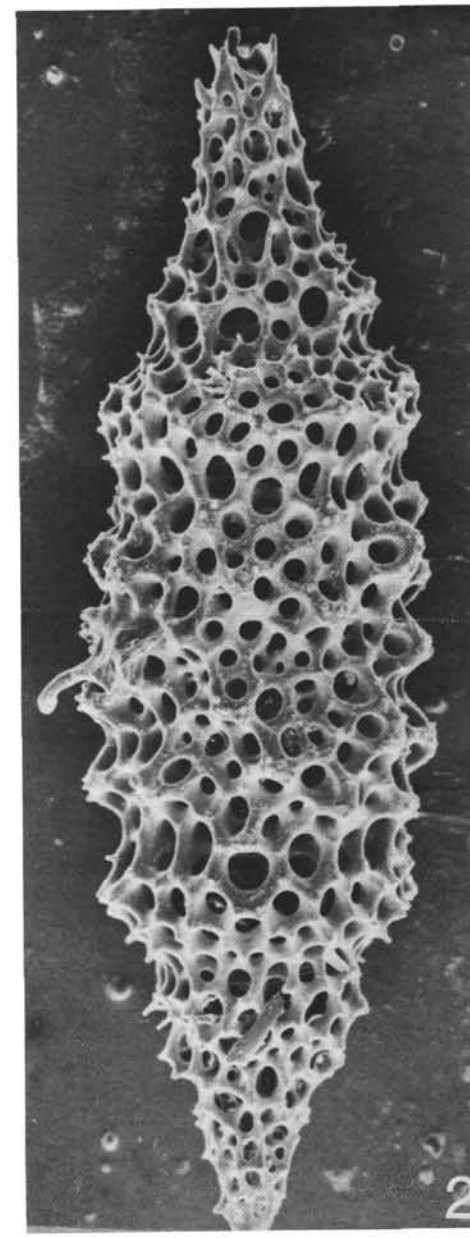






Figures 1, 3 *Ommatartus hughesi.*
Hole 77B, Core 15, Section 4, 0-2 cm; ×1000 and ×2000, respectively.





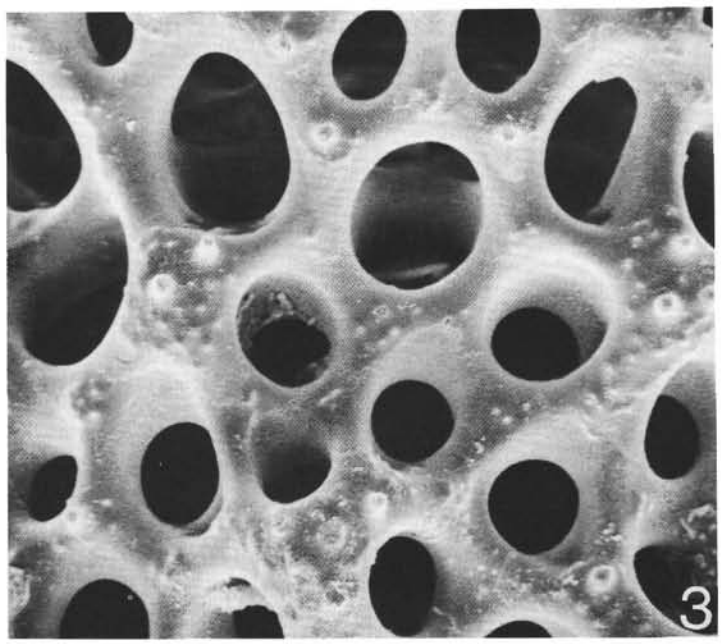
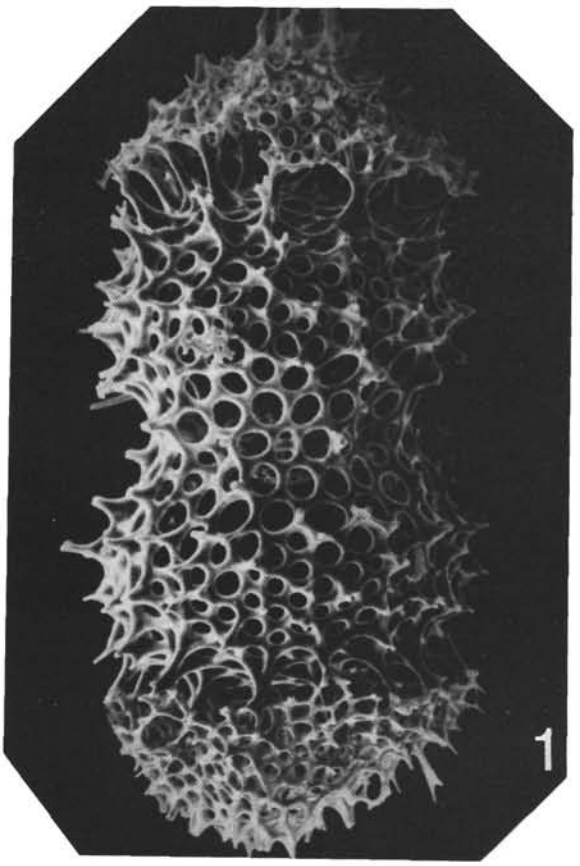
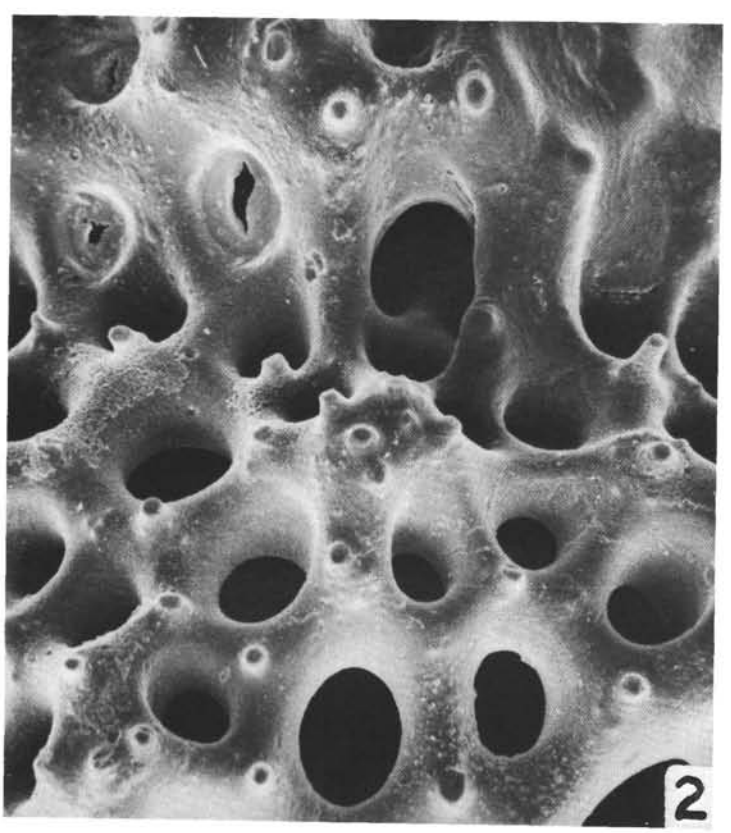


Figure 1 *Ommatartus hughesi.*
Hole 77B, Core 15, Section 4, 0-2 cm; X500.

Figures 2, 3 *Ommatartus penultimus.*
Hole 79, Core 2, Section 4, 1-3 cm; X510 and X2050, respectively.

PLATE 10





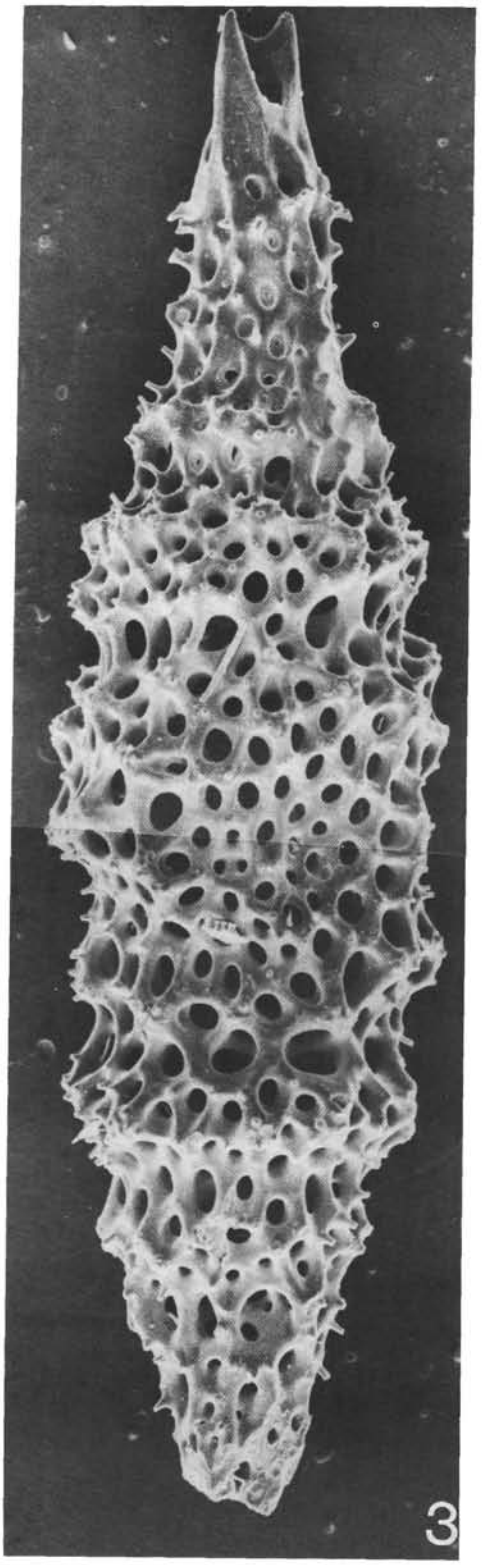


Figure 1 *Panartus tetrathalamus.*
Hole 77B, Core 2, Section 5, 0-2 cm; X480.

Figure 2, 3 *Ommatartus penultimus.*
Hole 79, Core 2, Section 4, 1-3 cm; X2000 and X500, respectively.

PLATE 11

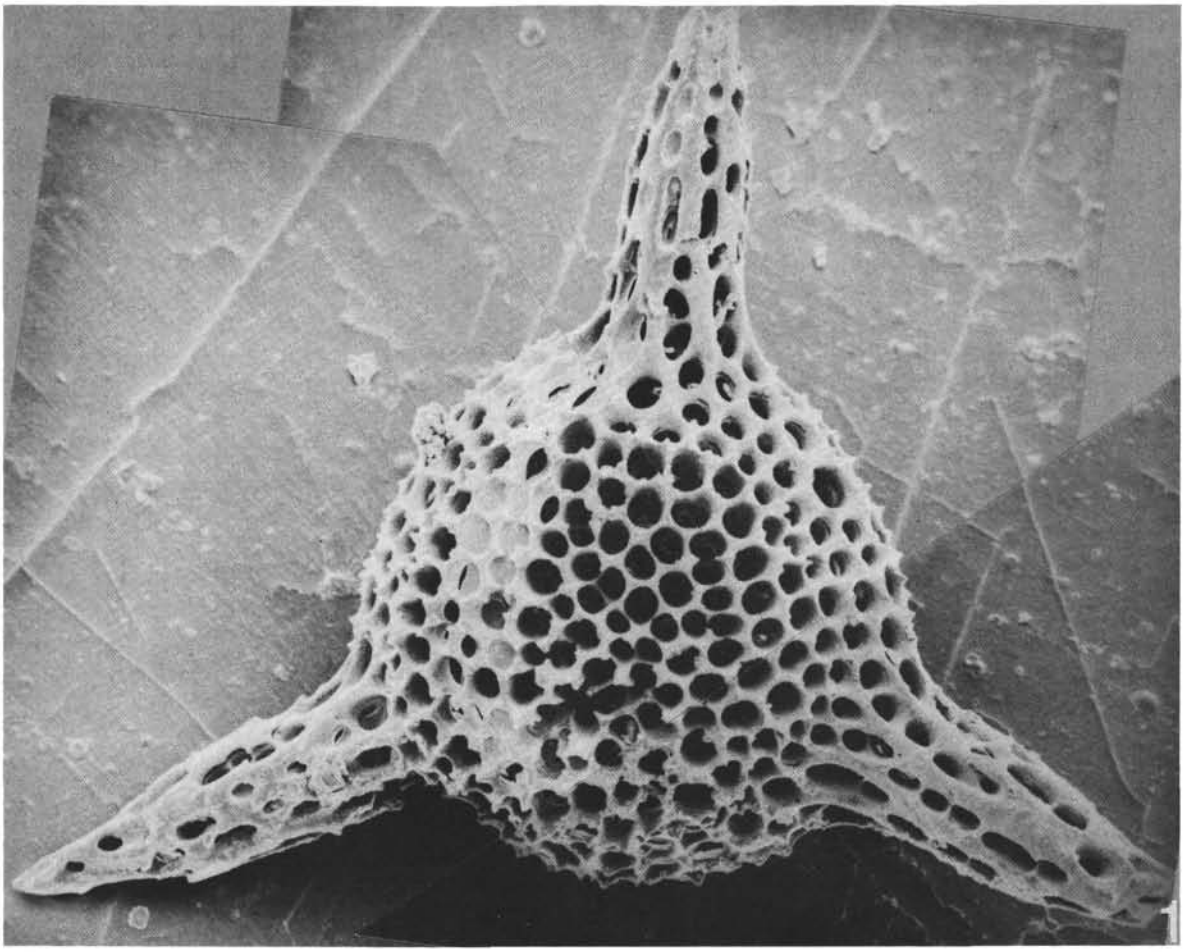
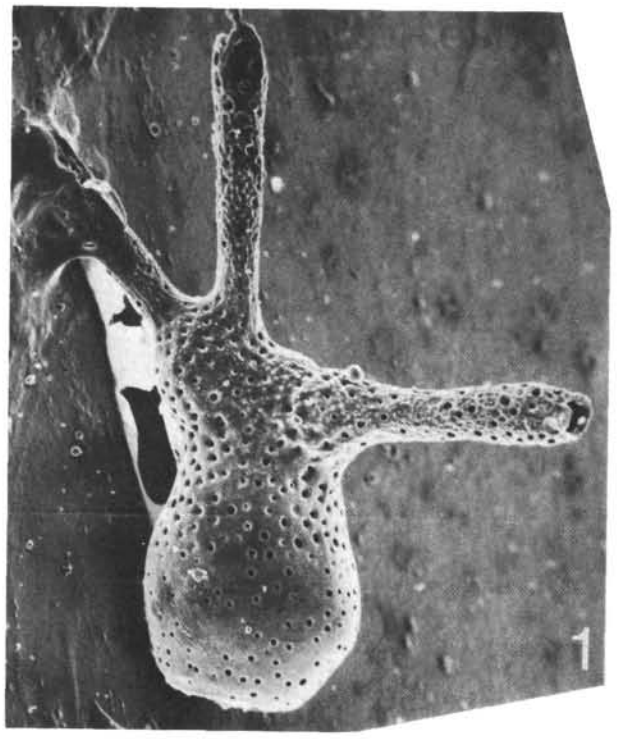
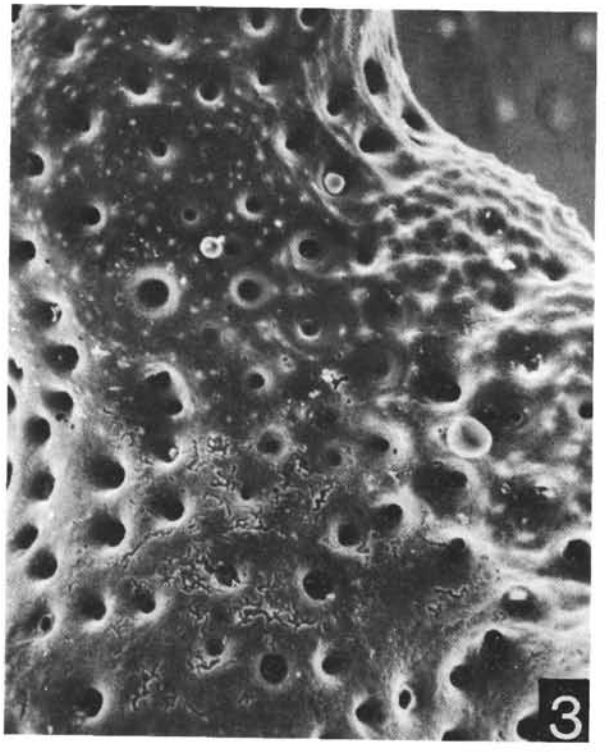
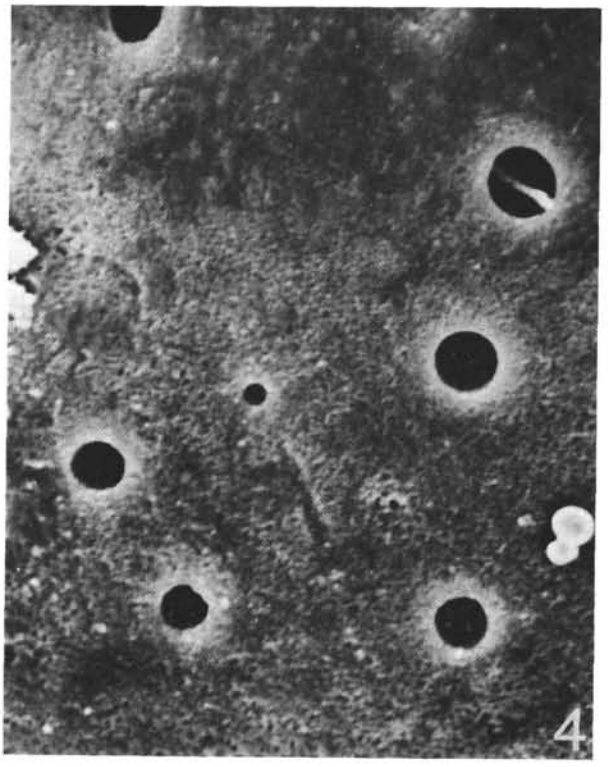


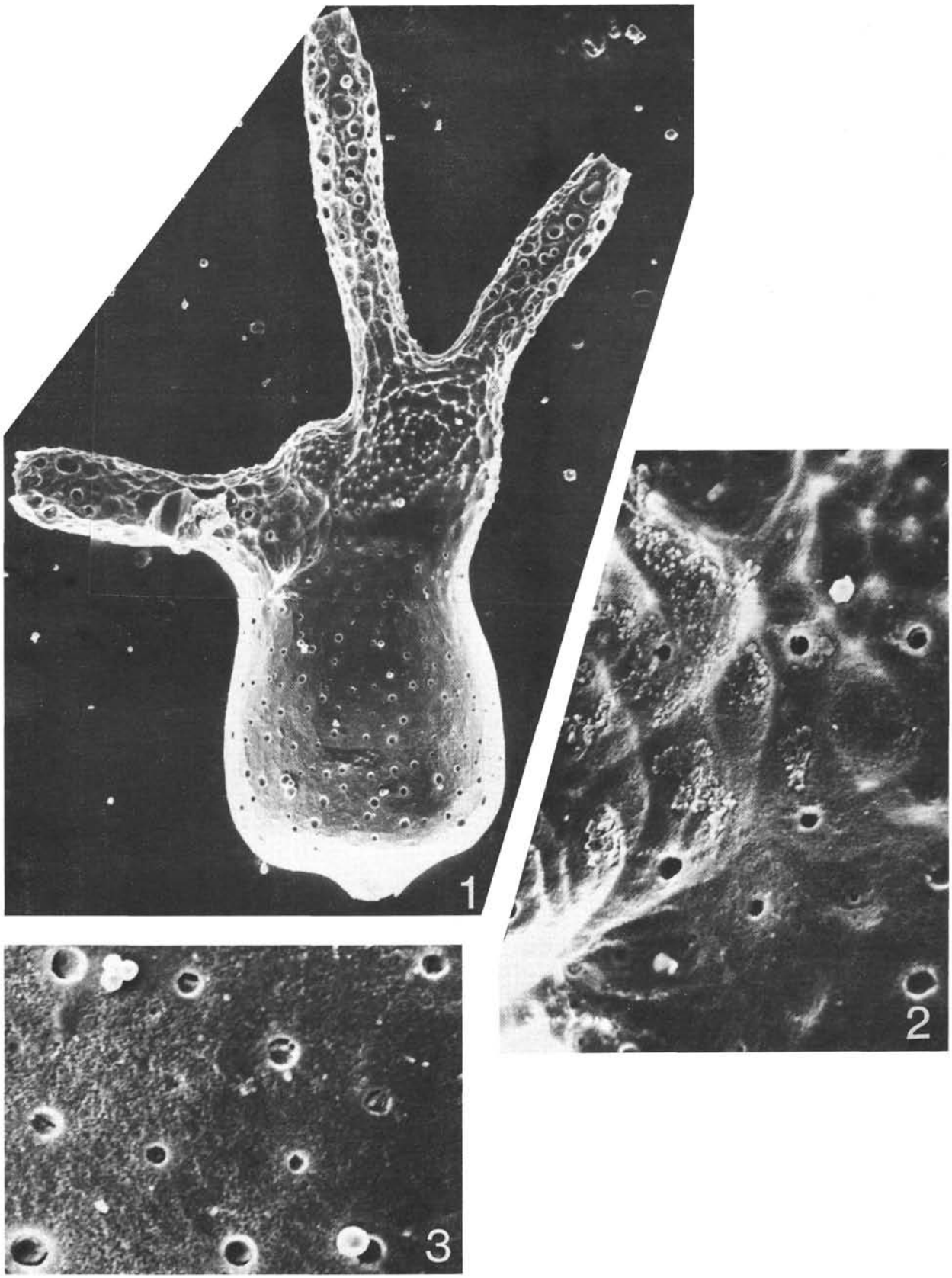
Figure 1 *Lithocyclia angustum.*
Hole 78, Core 28, core catcher; X490.



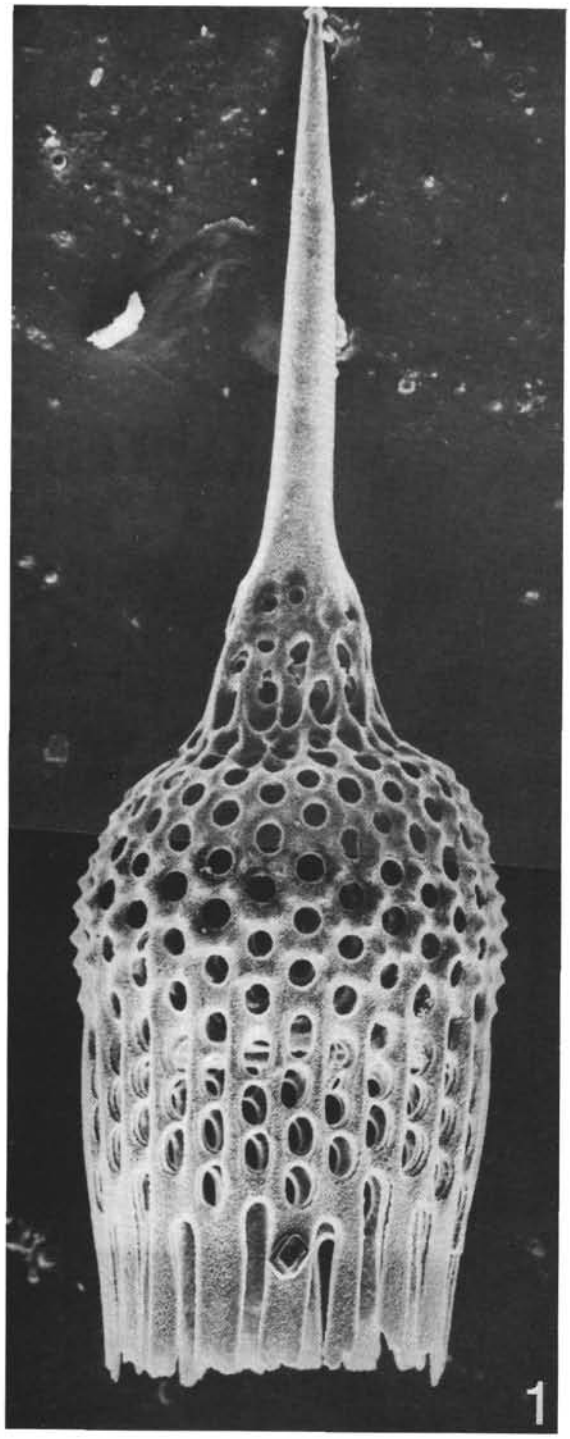


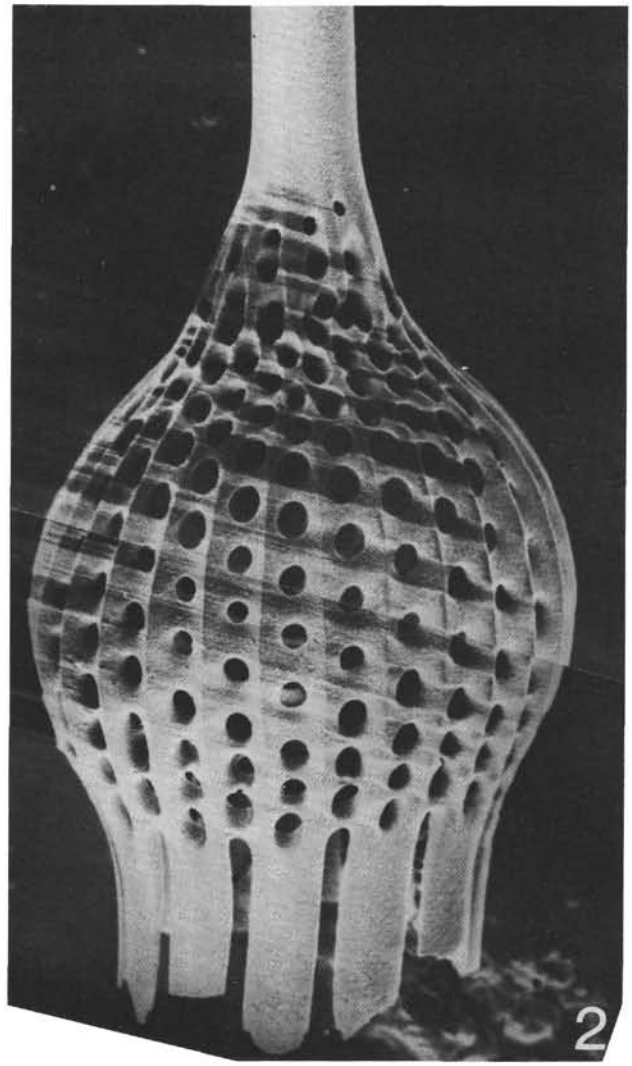


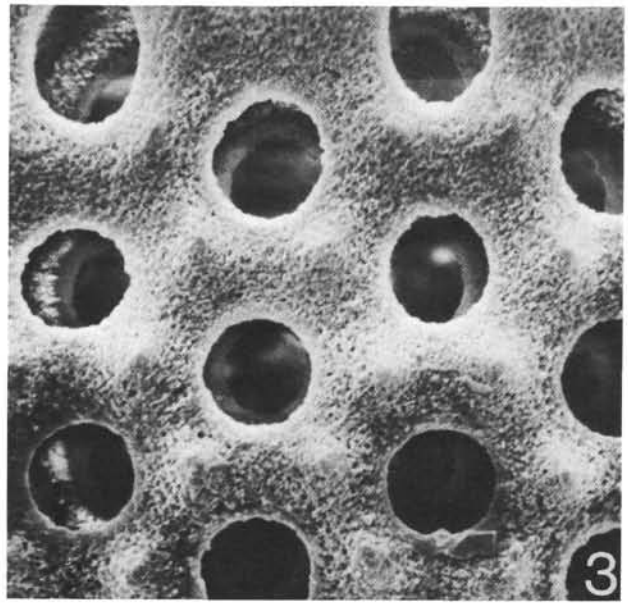
Figures 1-4 *Acrobotrys tritubus;*
Hole 77B, Core 14, Section 3, 0-2 cm; X500, X5000, X5000 and X5000, respectively.



Figures 1-3 *Acrobotrys tritubus.*
Hole 77B, Core 12, Section 6, 17-19 cm; X500, X5000 and X5000, respectively.







Figures 1, 3 *Calocycletta virginis.*
Hole 78, Core 3, Section 4, 13-15 cm; X510 and X2050, respectively.

Figure 2 *Calocycletta costata.*
Hole 78, Core 3, Section 4, 13-15 cm; X510.

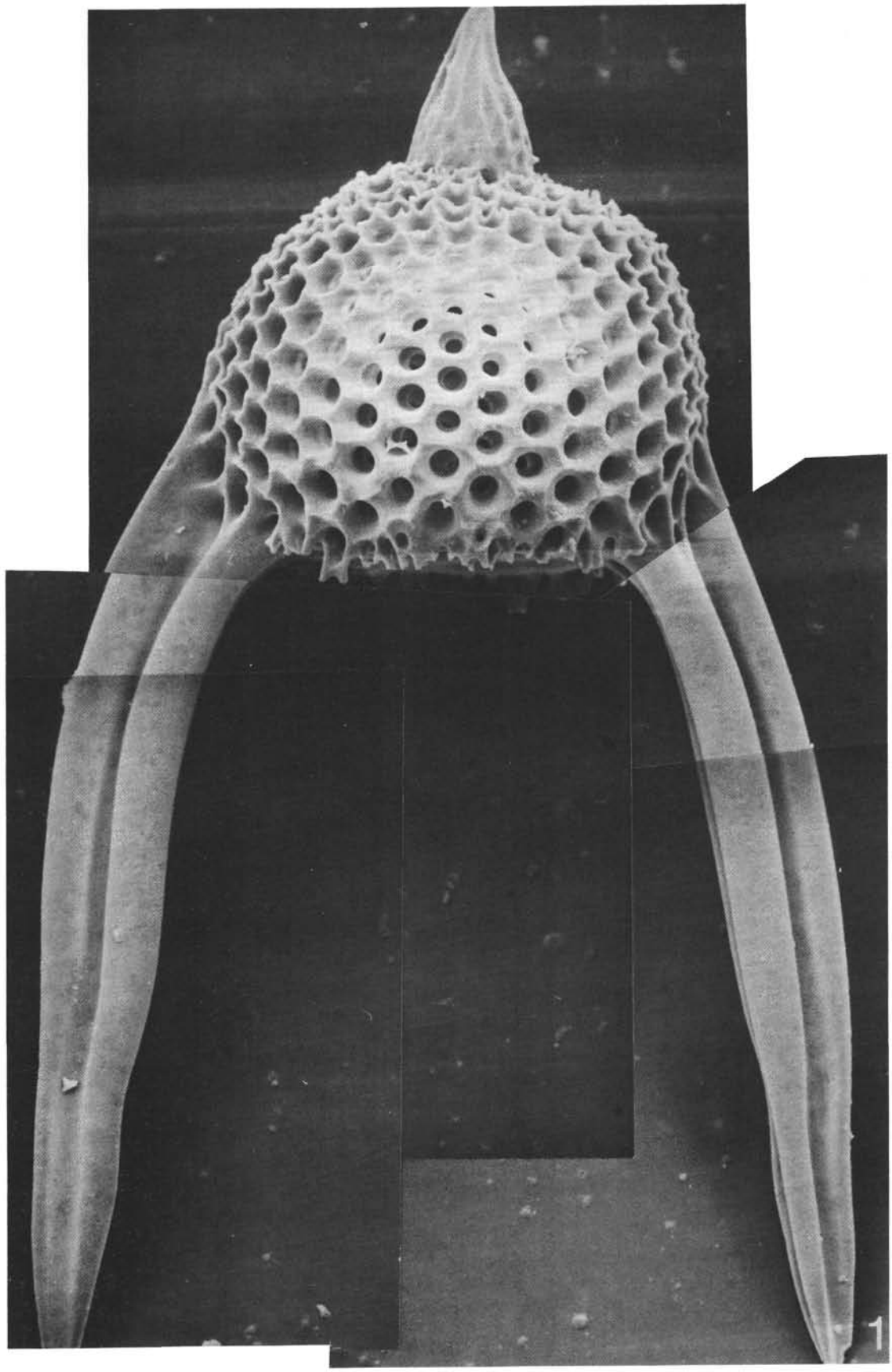


Figure 1 *Lychnocanium bipes.*
Hole 77B, Core 29, core catcher; ×500.

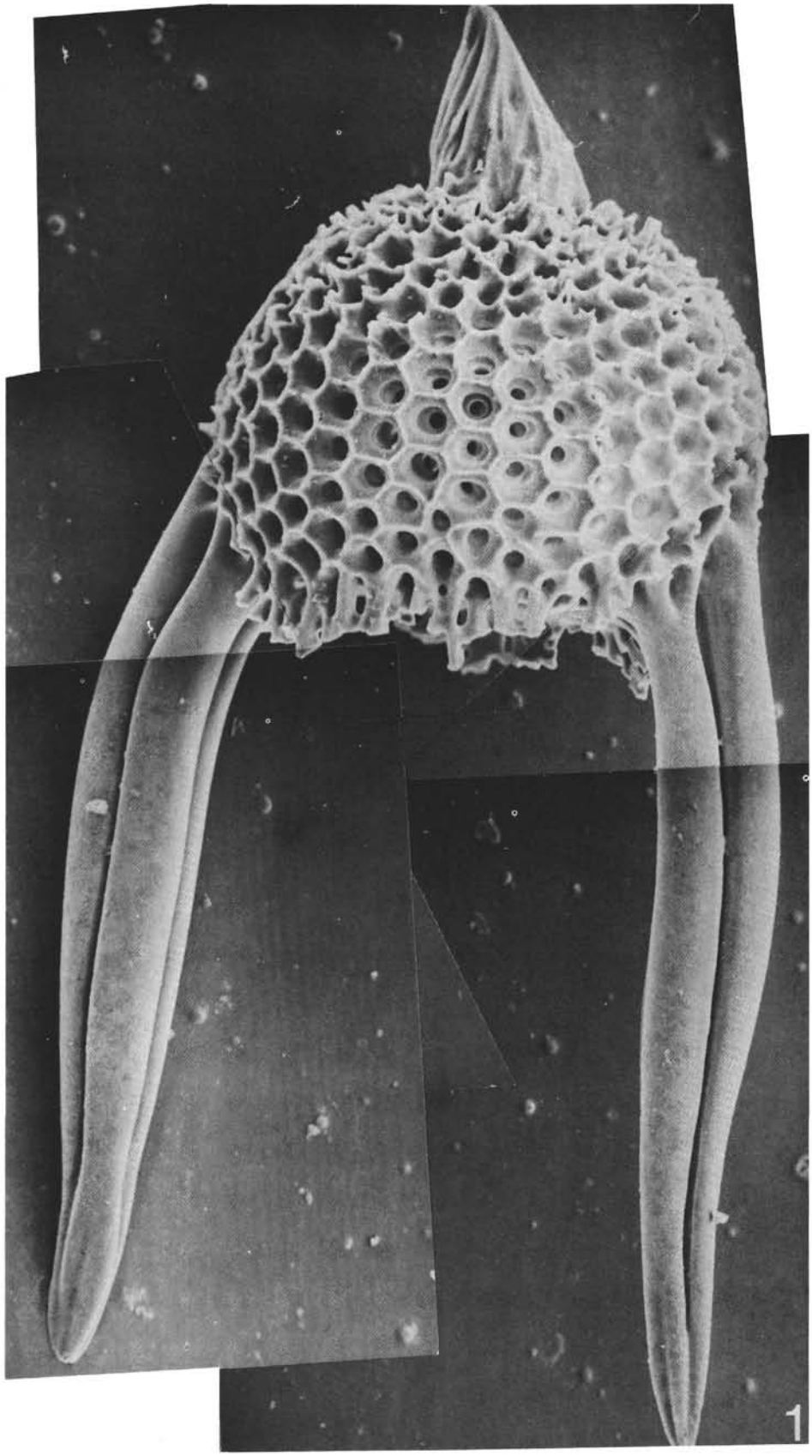


Figure 1 *Lychnocanium bipes.*
Hole 77B, Core 29, core catcher; ×500.

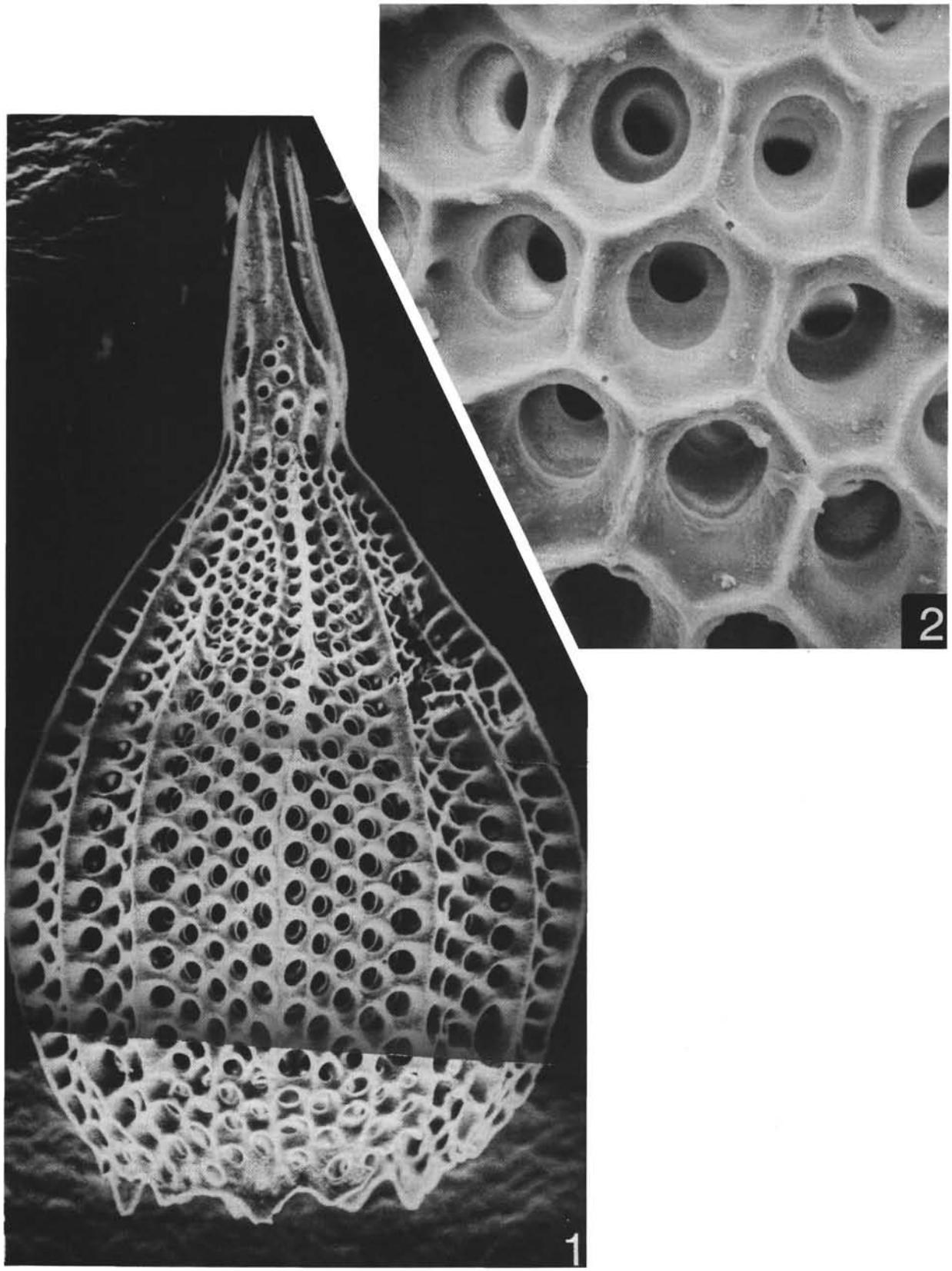
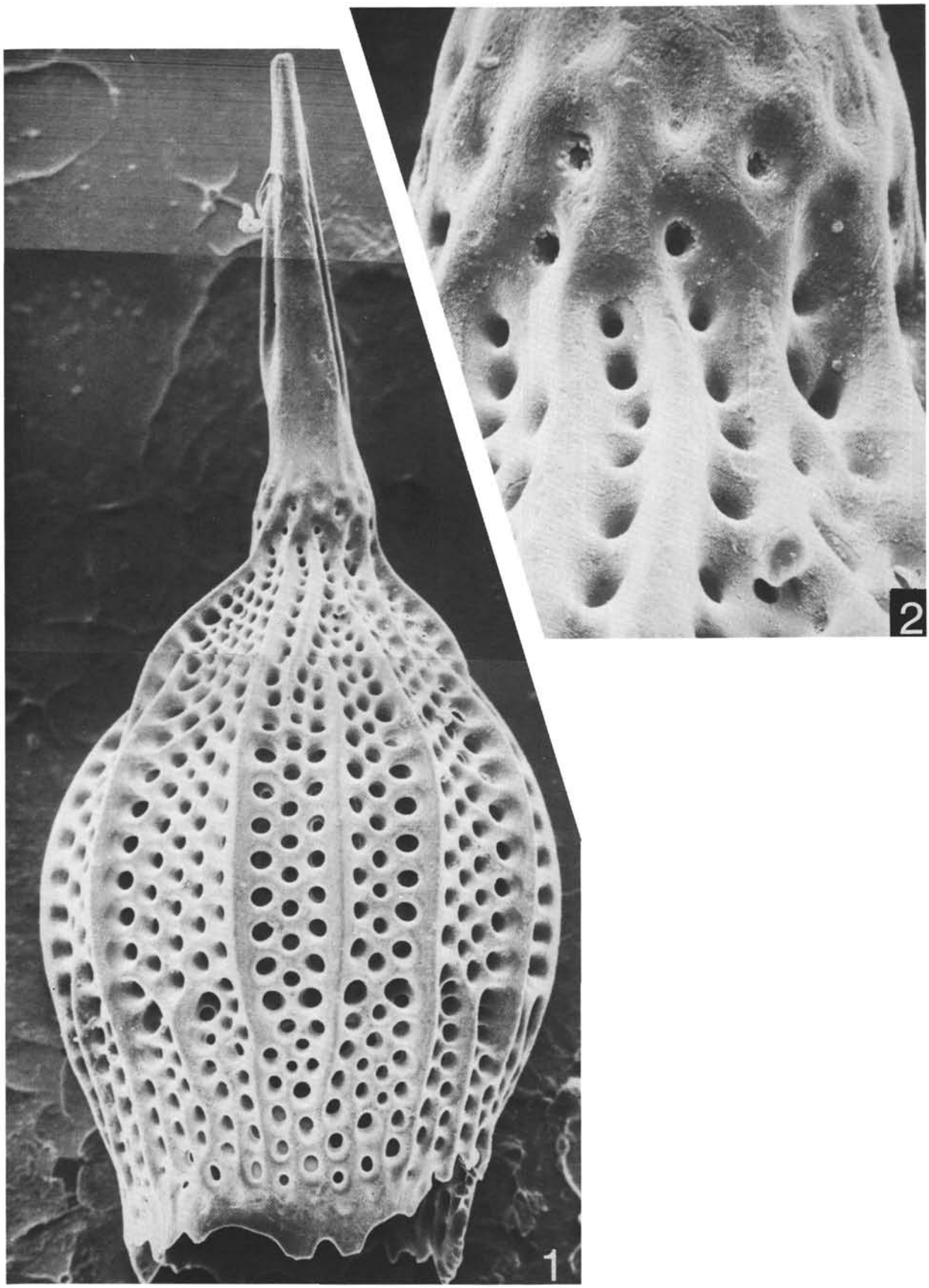


Figure 1 *Theocyrtis annosa.*
Hole 77B, Core 32, Section 4, 3-5 cm; ×520.

Figure 2 *Lychnocanium bipes.*
Same specimen as Plate 16; ×2000.



Figures 1, 2 *Theocyrtis annosa.*
Hole 78, Core 24, core catcher; ×500 and ×2000, respectively.

PLATE 19

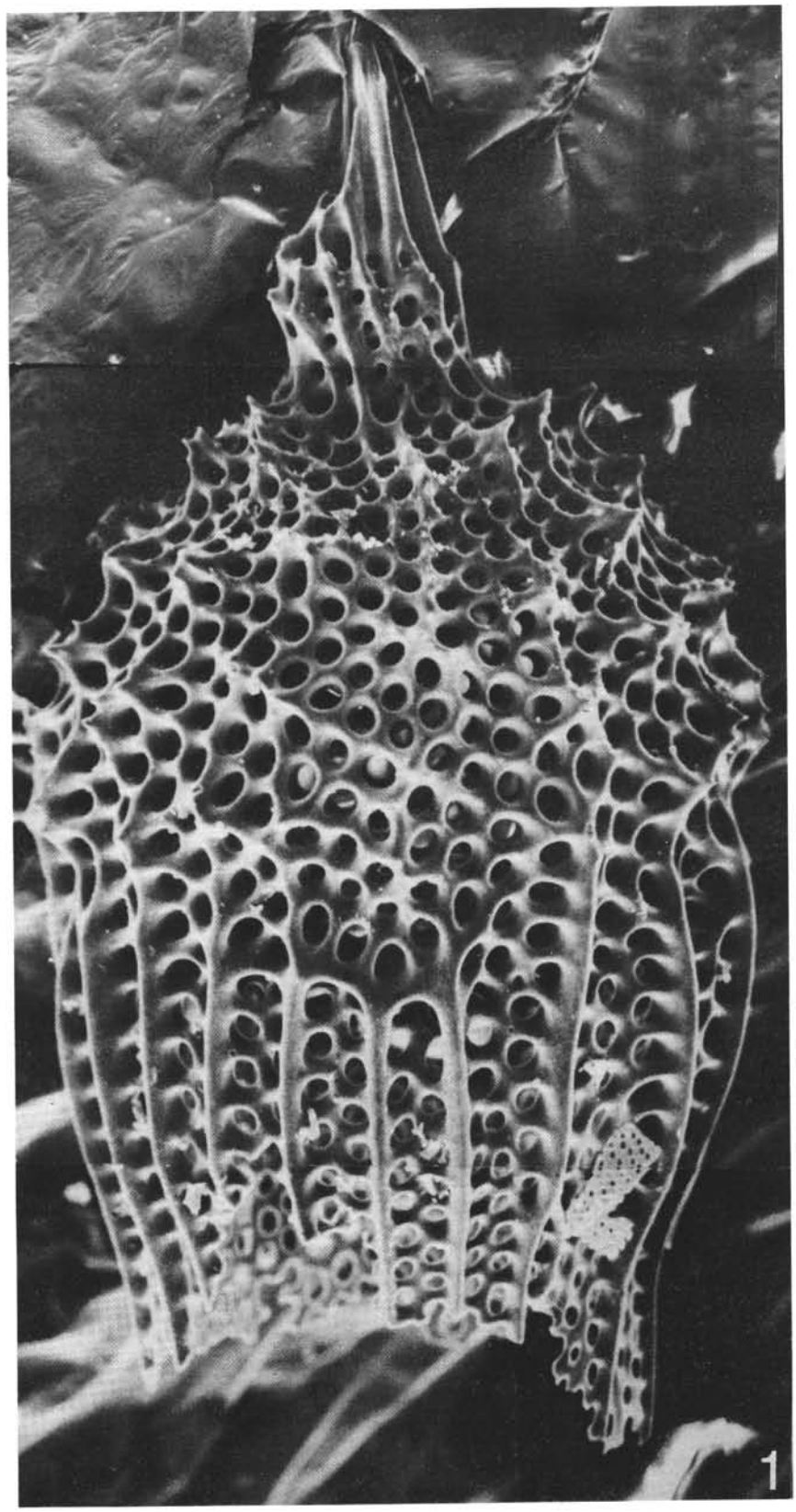
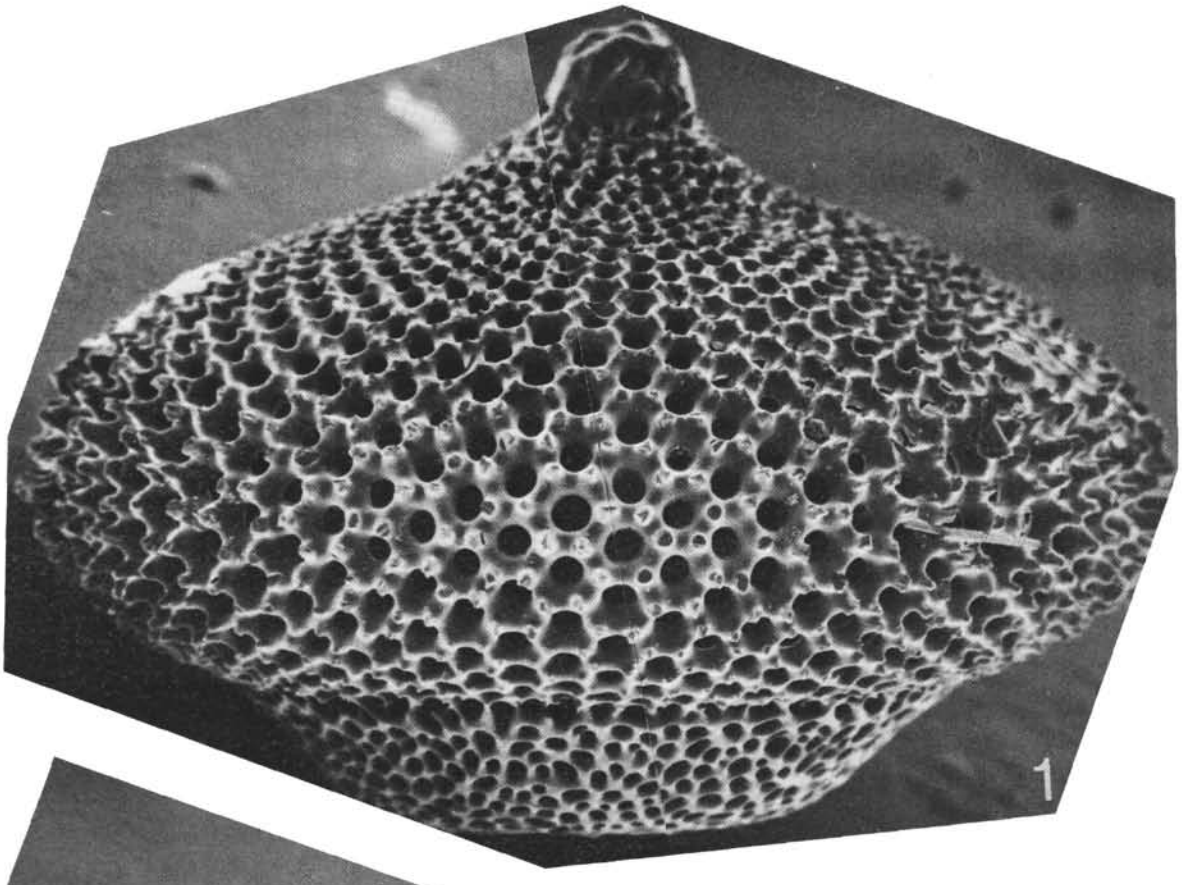
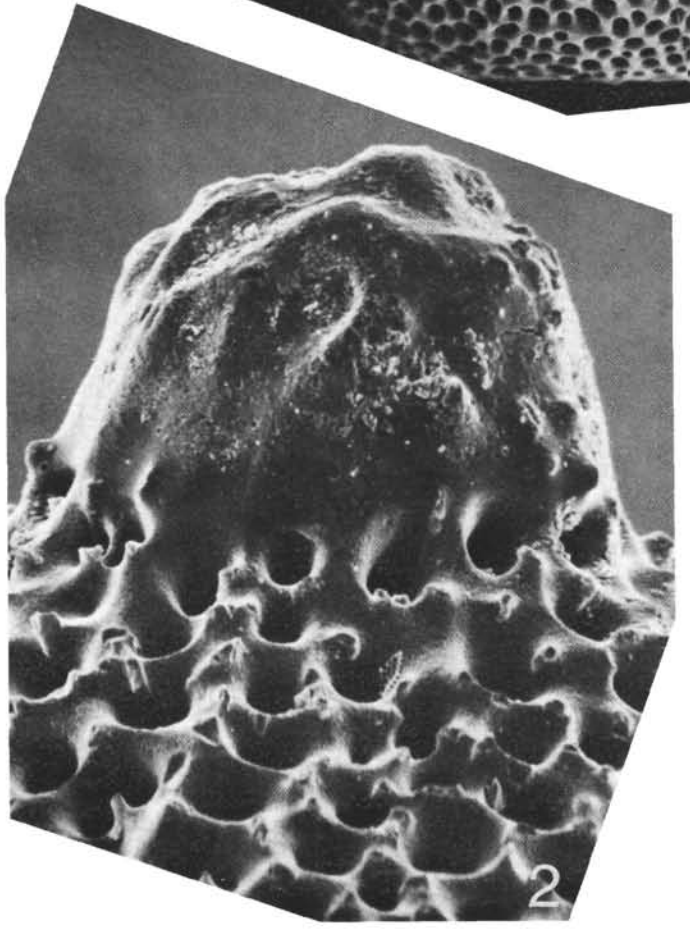
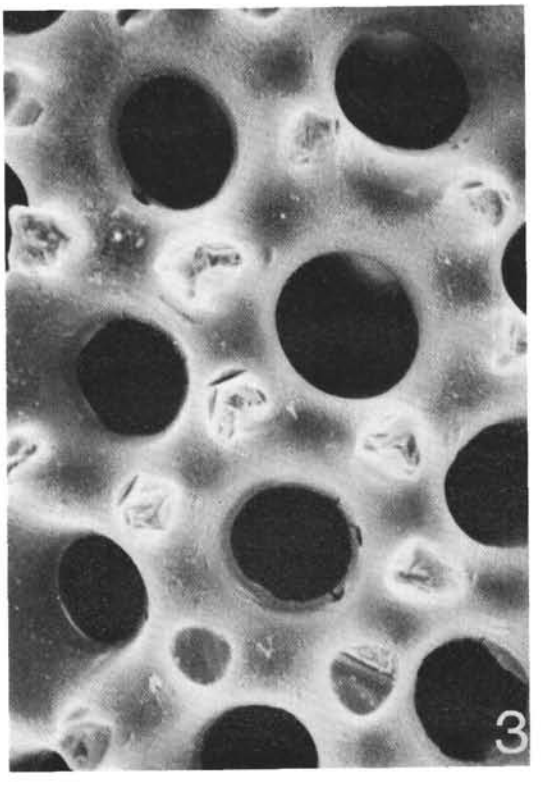


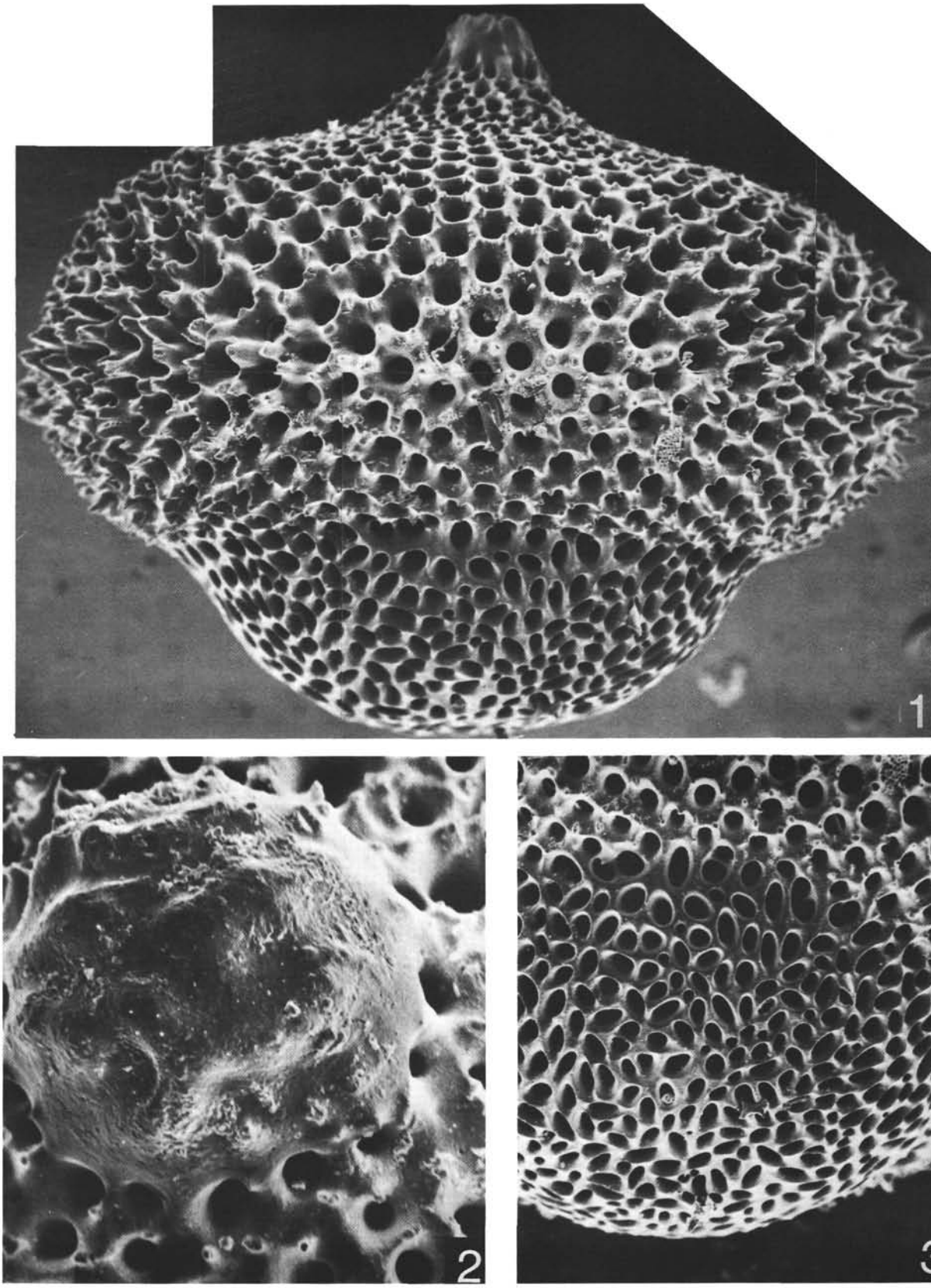
Figure 1 *Theocyrtis tuberosa.*
Hole 77B, Core 47, Section 4, 46-48 cm; X510.







Figures 1-3 *Cyclampterium* (?) *brachythorax.*
Hole 77B, Core 17, core catcher; X500, X2000 and X2000, respectively.



Figures 1-3 *Cyclampterium* (?) *brachythorax.*
Hole 77B, Core 17, core catcher.
1: Side view; ×500.
2: Oblique view of cephalis; ×2000.
3: Oblique view of the base; ×500.

PLATE 22

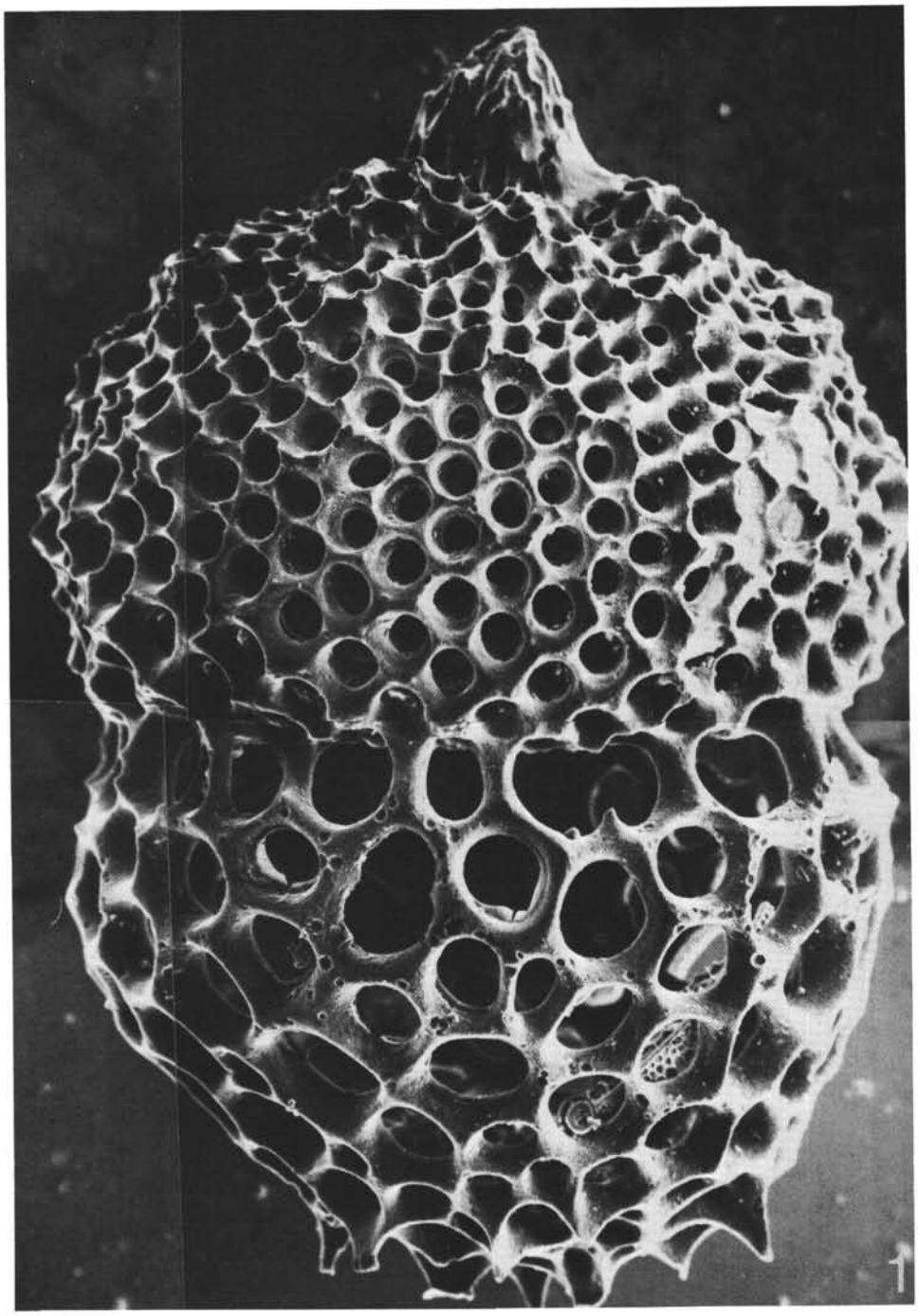
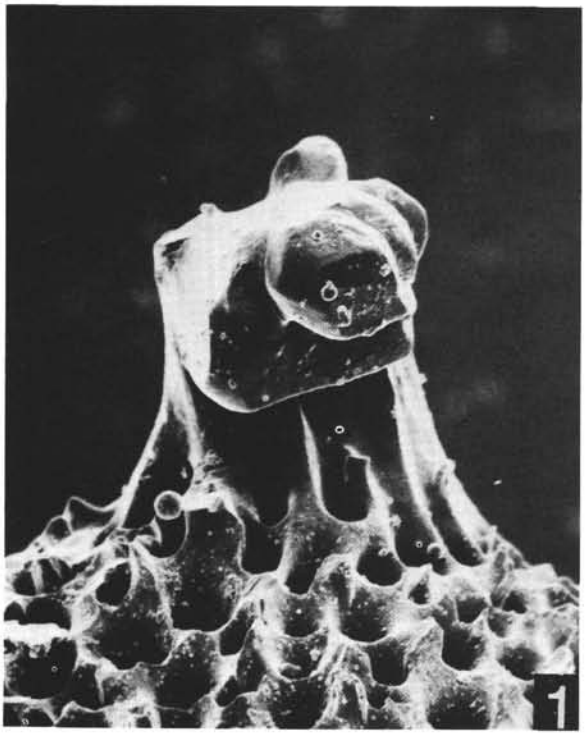
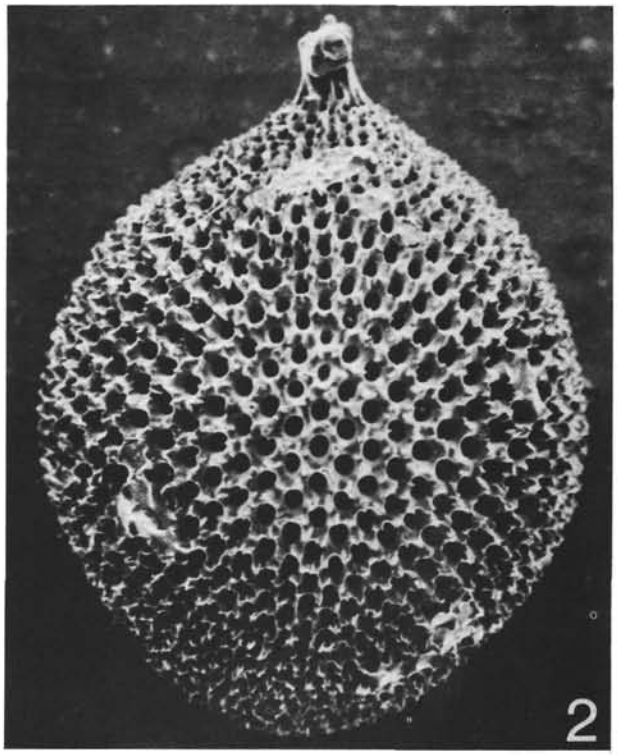
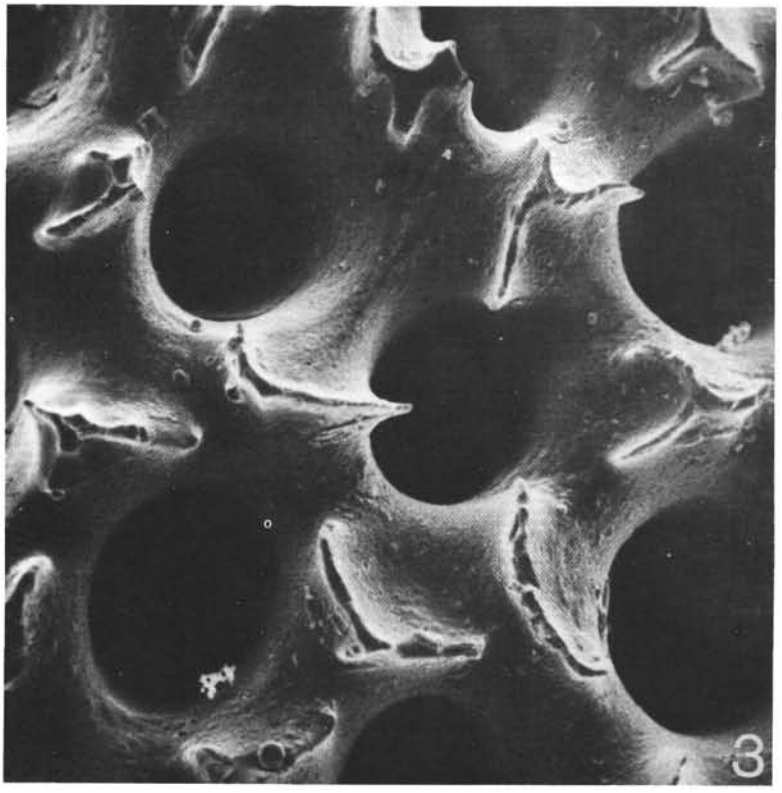


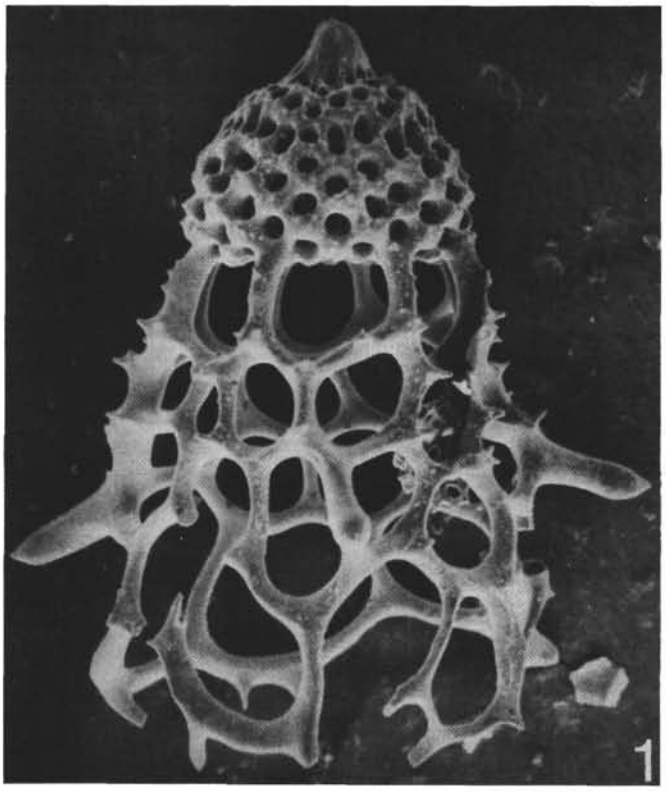
Figure 1 *Cyclampterium* (?) *leptetrum.*
Hole 77B, Core 27, Section 6, 74-76 cm; ×500.

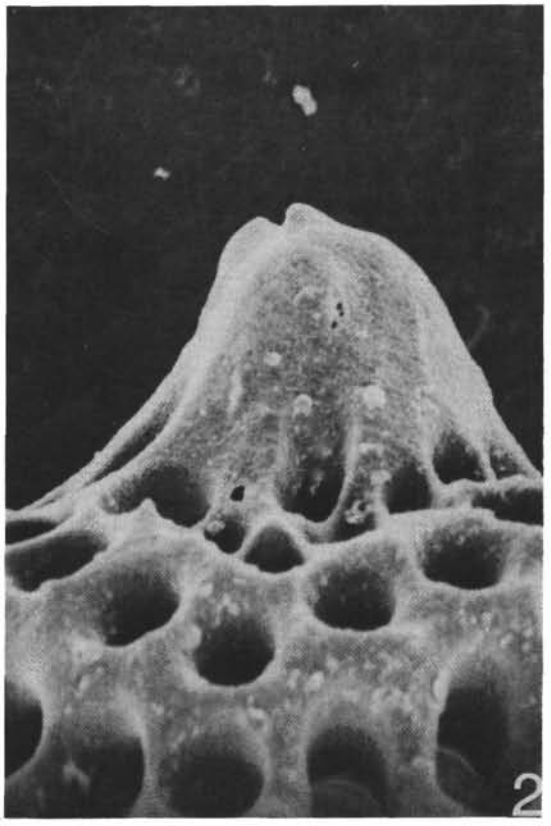


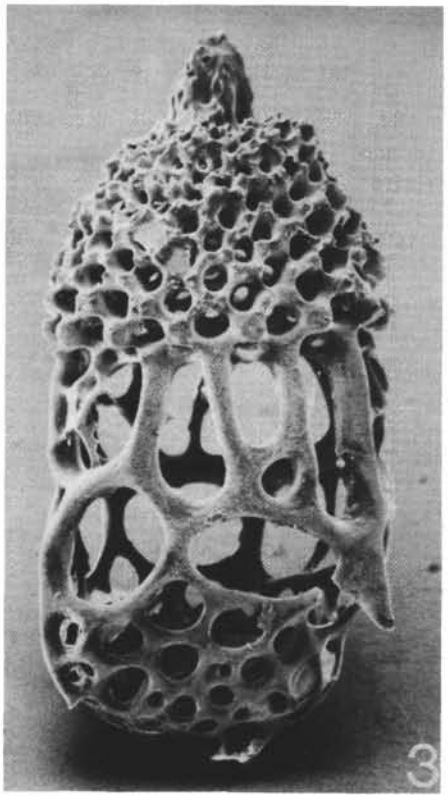


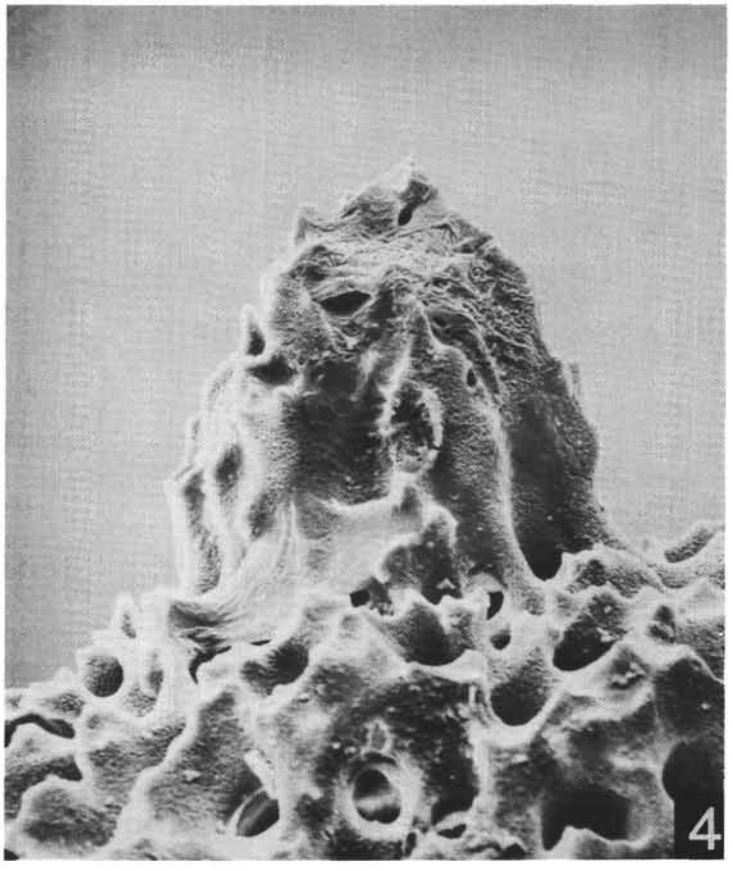


Figures 1-3 *Cyclampterium* (?) *neatum.*
Hole 77B, Core 12, Section 6, 17-19 cm; X1000, X200 and X2000, respectively.

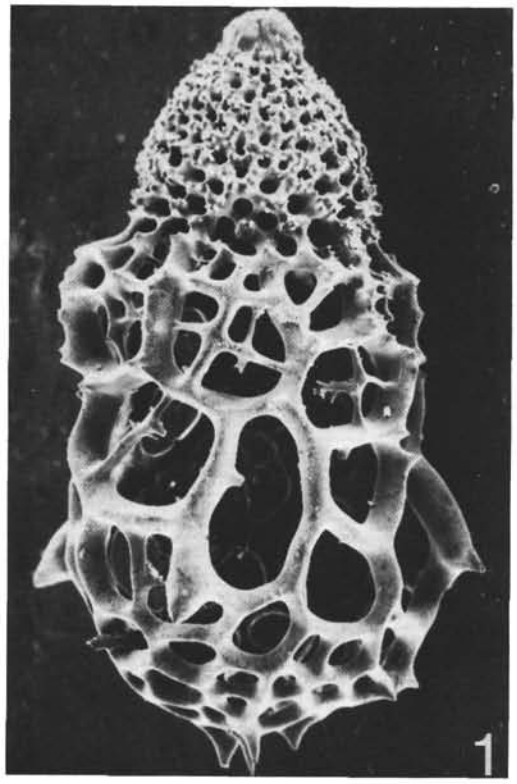


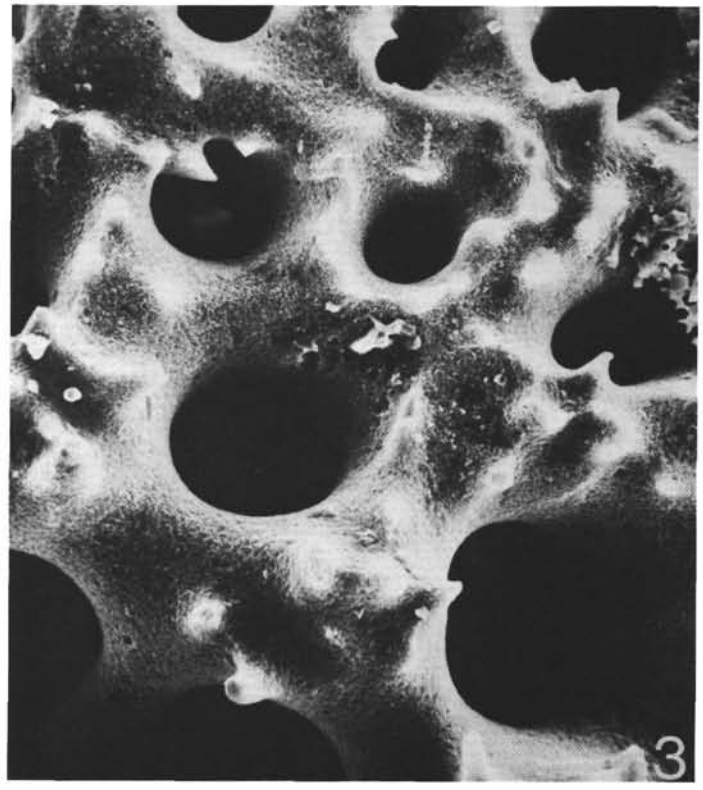




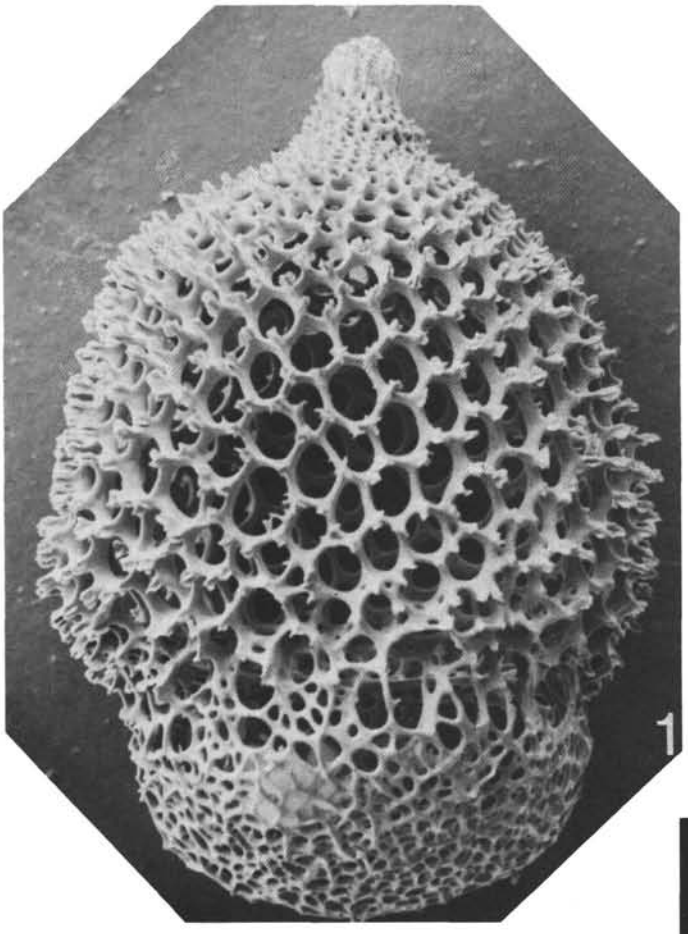


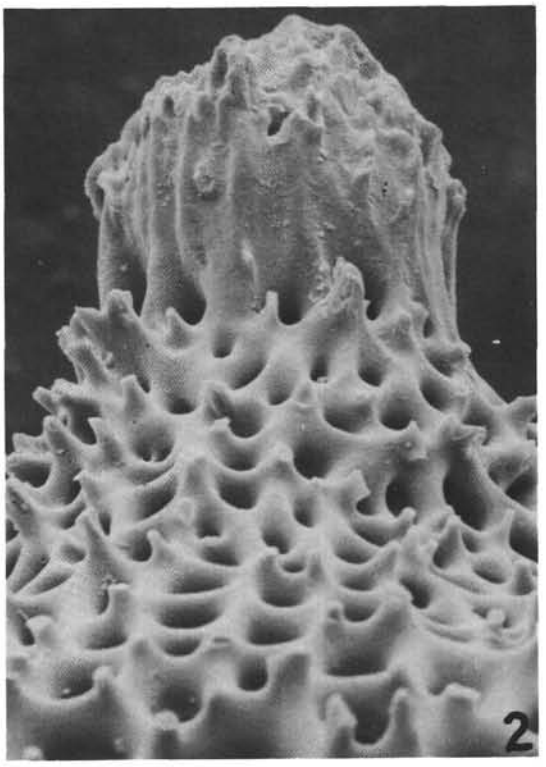
Figures 1-4 *Cyclampterium* (?) *pegetrum.*
1 and 2: Hole 77B, Core 43, Section 2, 18-20 cm; X210 and X1100, respectively.
3 and 4: Hole 78, Section 17, core catcher; X210 and X1100, respectively.

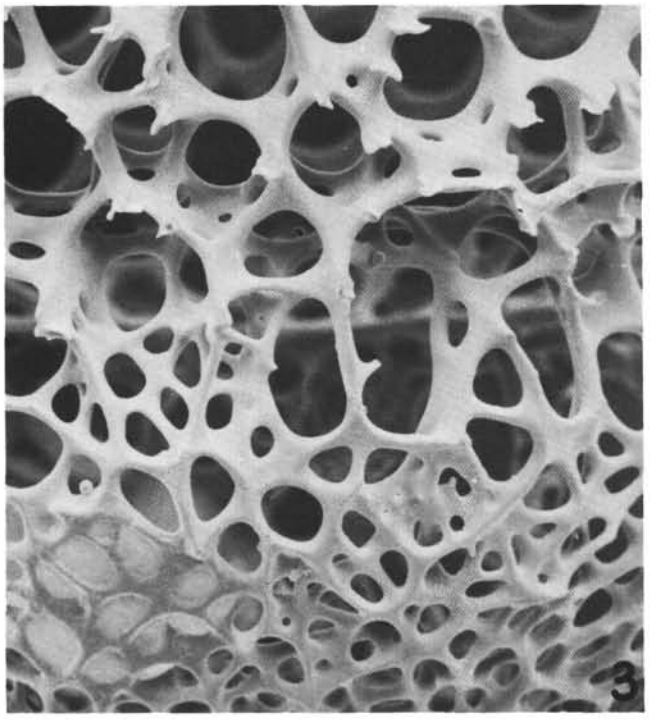


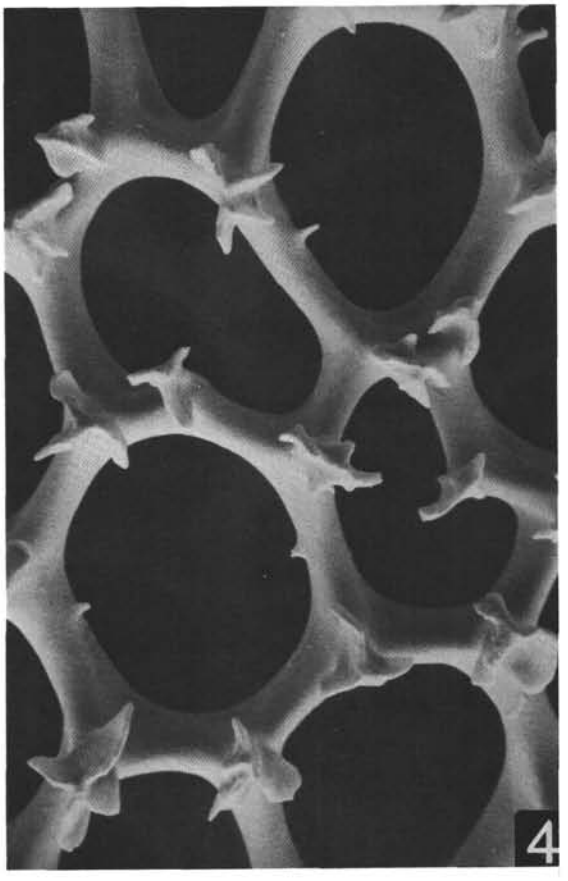


Figures 1-3 *Cyclampterium* (?) *pegetrum.*
Hole 78, Core 17, Section 4, 20-22 cm; X200, X1000 and X2000, respectively.

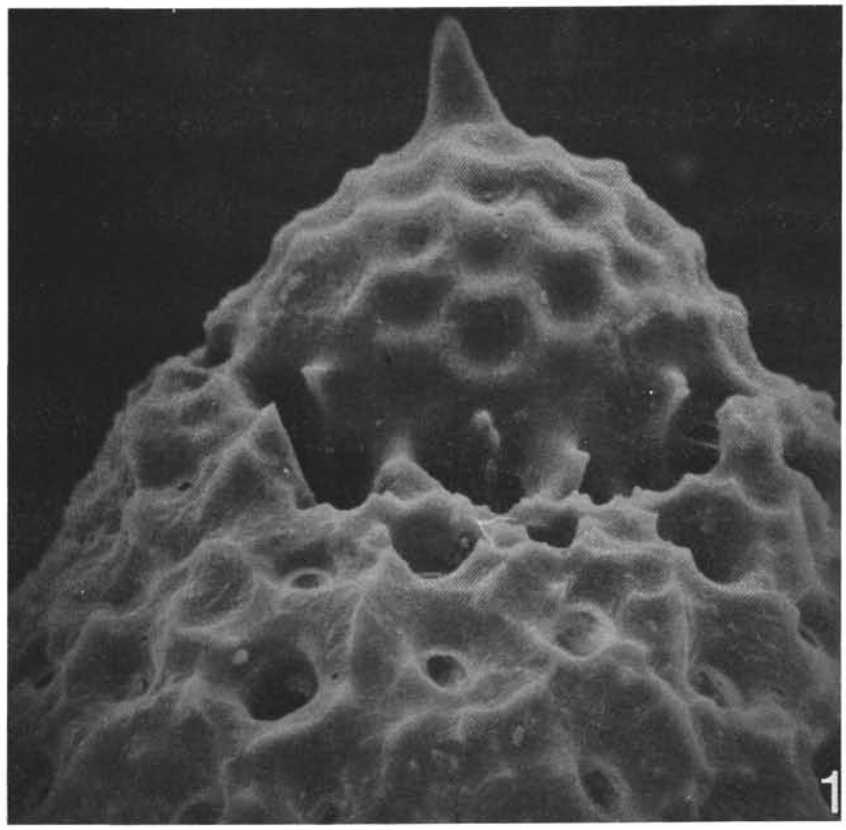


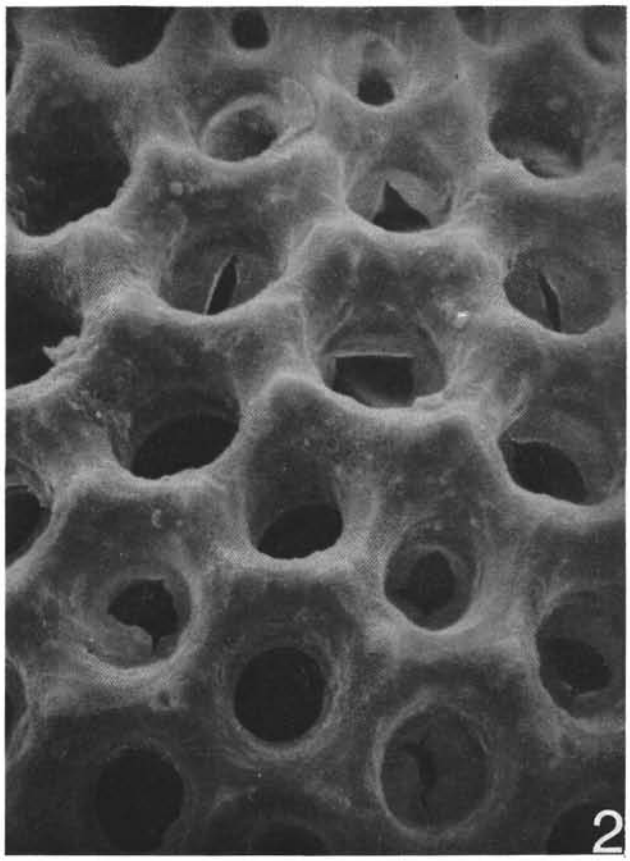


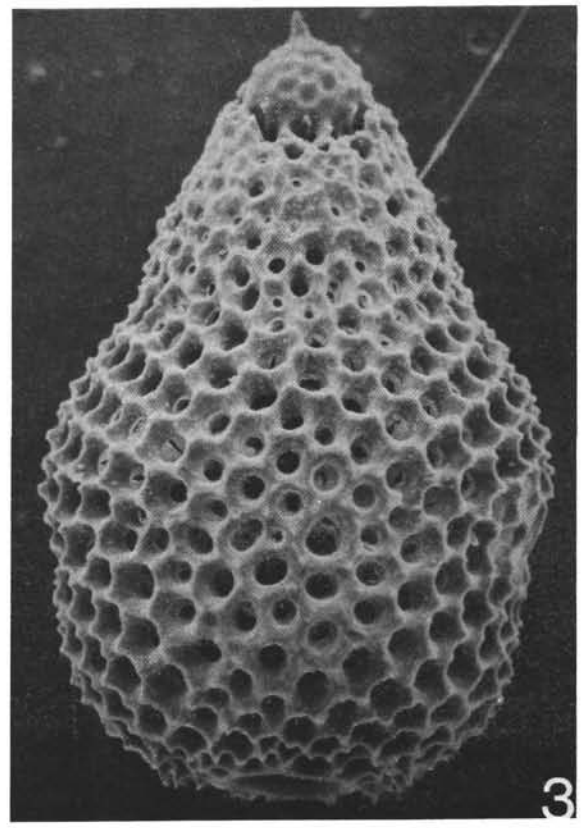




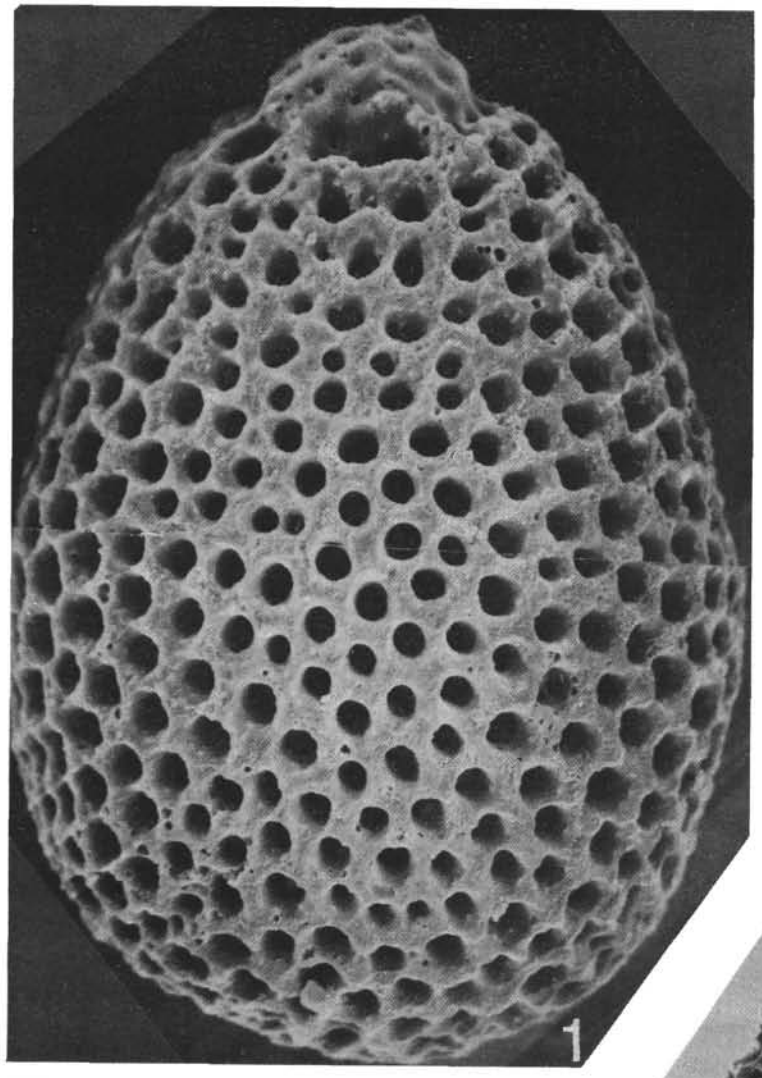
Figures 1-4 *Cyclampterium* (?) *tanythorax.*
Hole 80A, Core 3, Section 4, 17-19 cm; ×200, ×500, ×500 and ×1000, respectively.

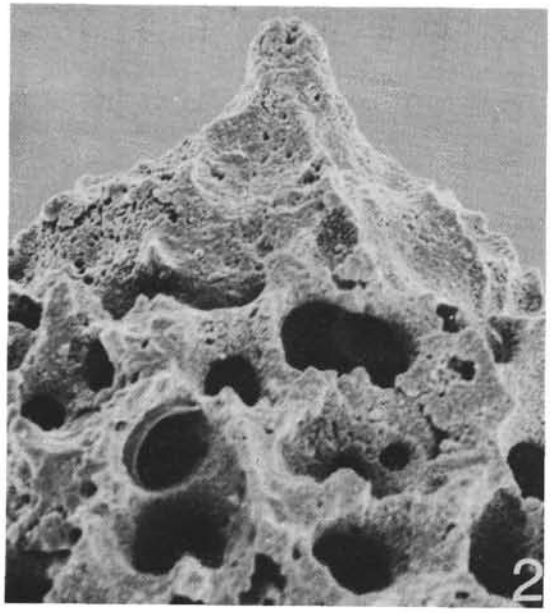






Figures 1-3 *Cyrtocapsella cornuta.*
Hole 77B, Core 27, Section 6, 17-19 cm; ×2000, ×2000 and ×500, respectively.





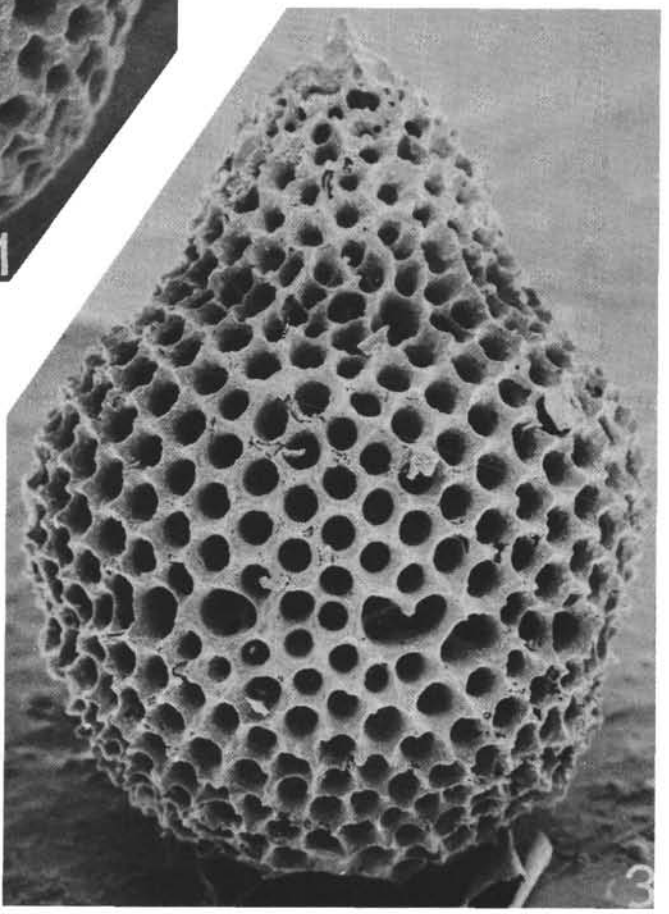
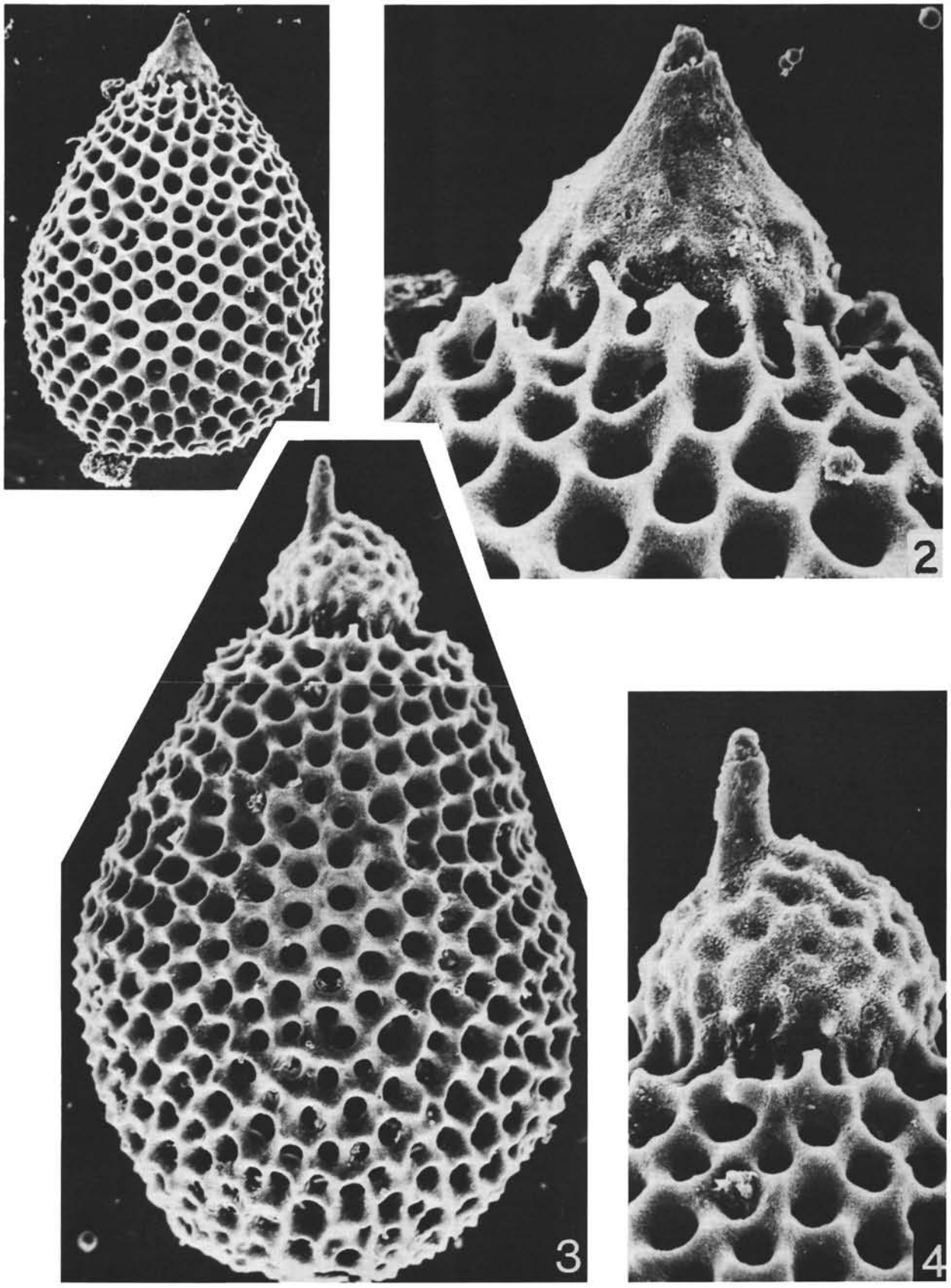


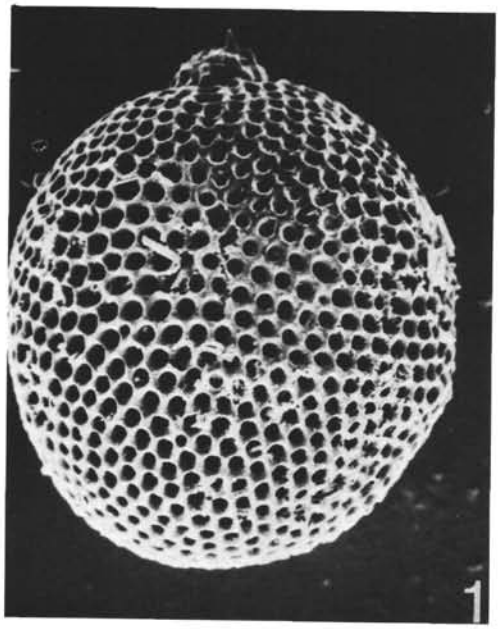
Figure 1 *Lithopera neotera.*
Hole 80A, Core 3, Section 4, 17-19 cm; ×1000.

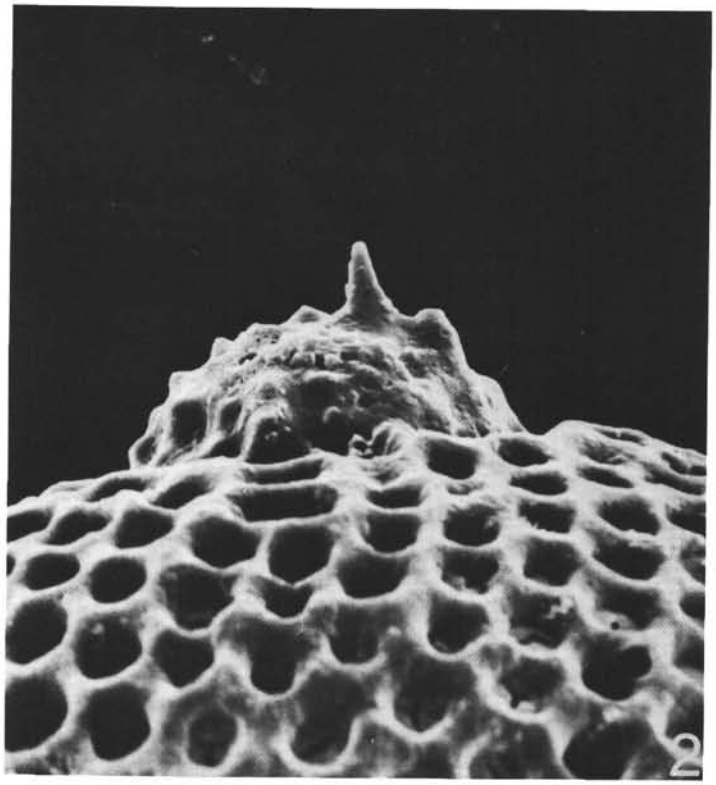
Figures 2, 3 *Cyrtocapsella cornuta.*
Hole 77B, Core 24, core catcher; ×1000 and ×500, respectively.

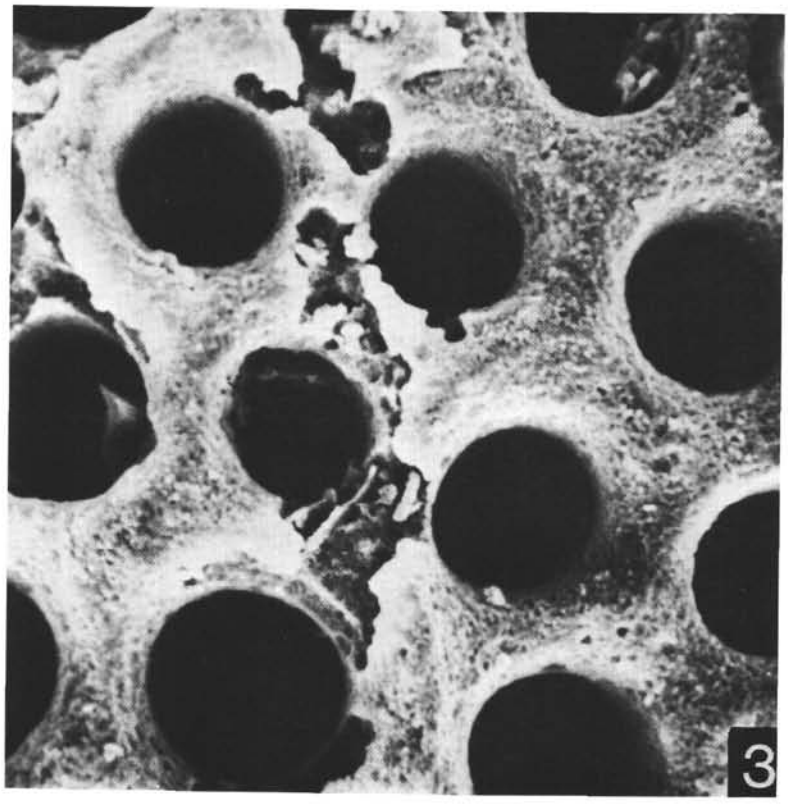


Figures 1-4 *Cyrtocapsella tetrapera.*
Hole 78, Core 9, Section 3, 0-2 cm.
1 and 2: X500 and X2000, respectively.
3 and 4: X1000 and X2000, respectively.

PLATE 30

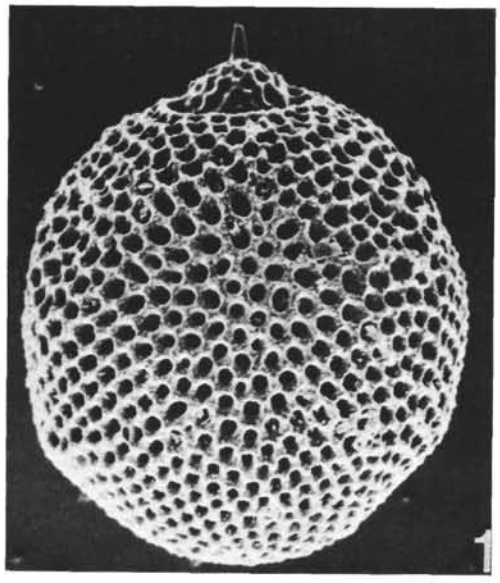


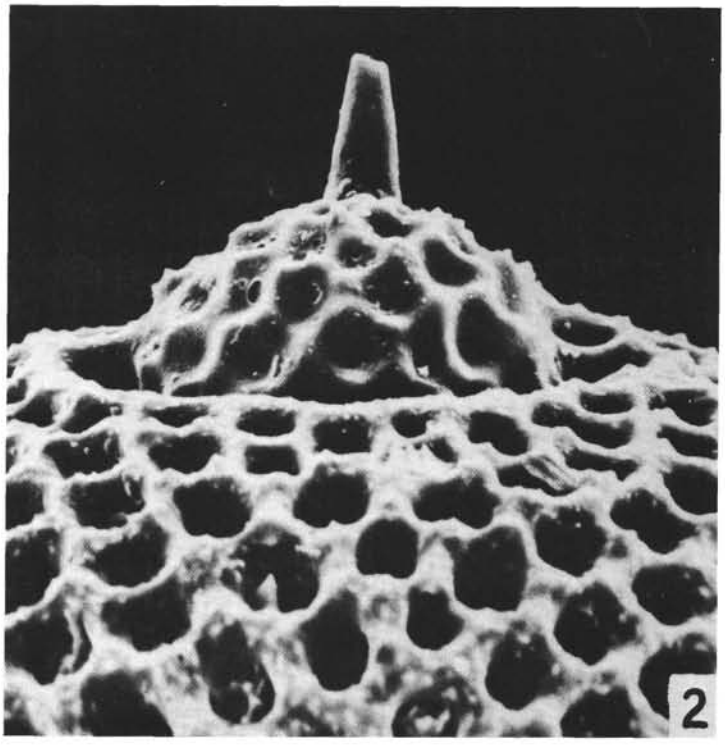


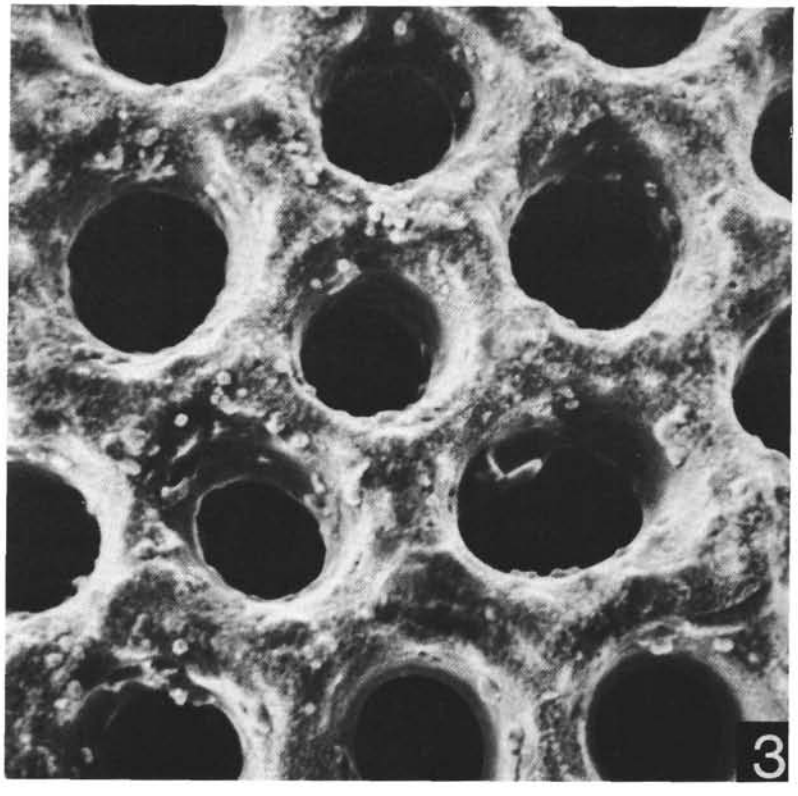


Figures 1-3 *Lithopera bacca.*
Hole 77B, Core 13, Section 5, 0-2 cm; X500, X2000 and X5000, respectively.

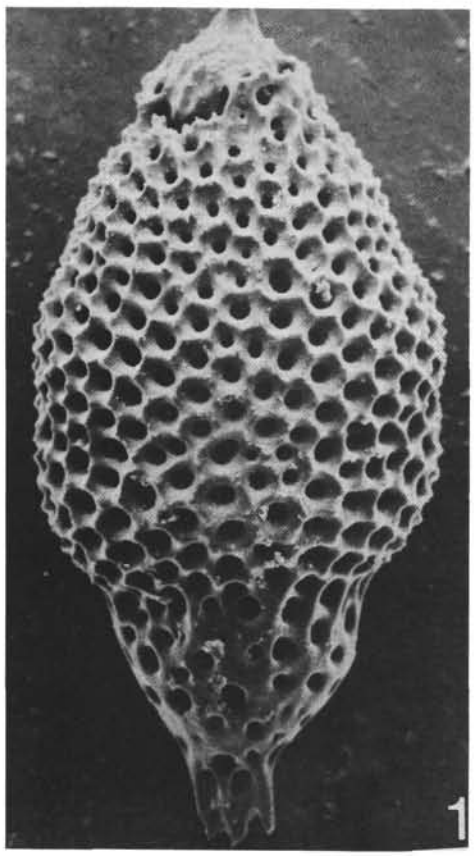
PLATE 31

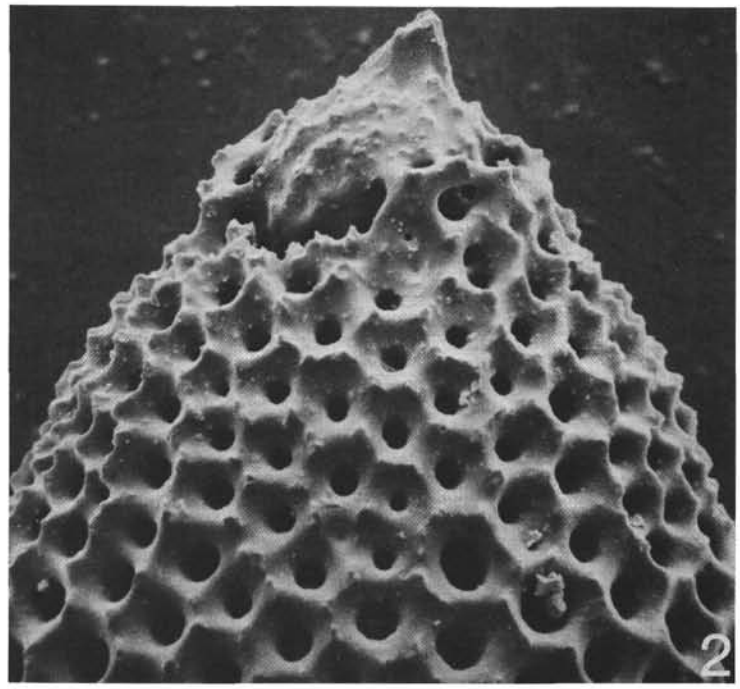


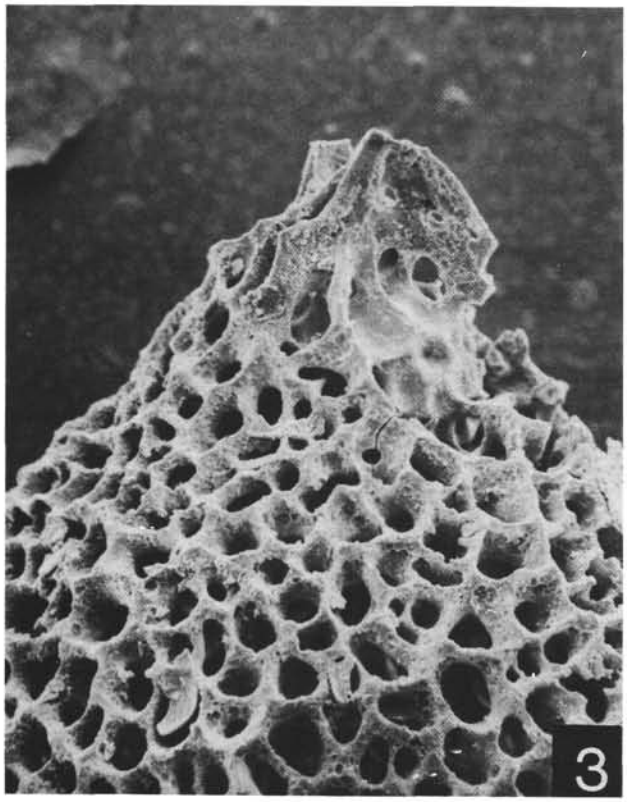


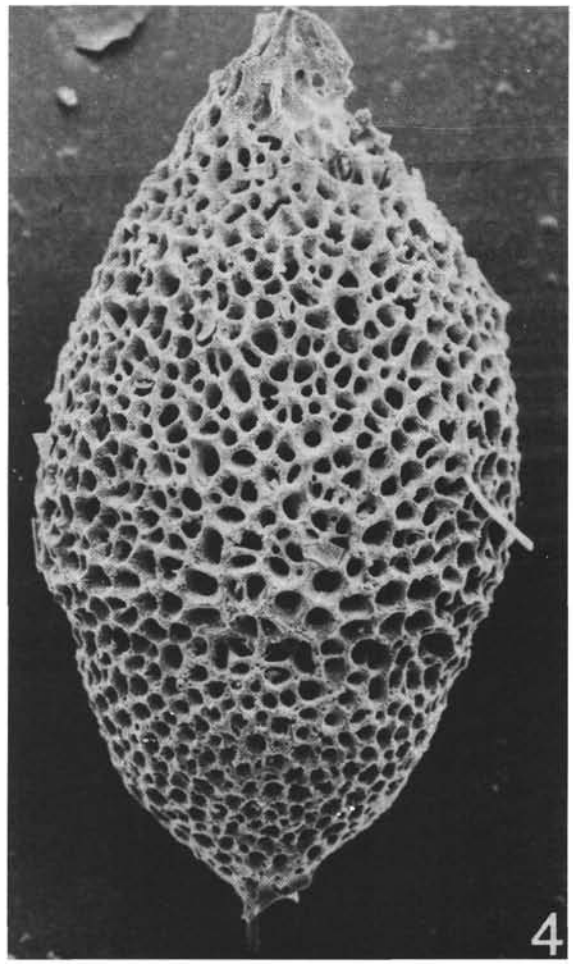


Figures 1-3 *Lithopera bacca.*
Hole 77B, Core 13, Section 5, 0-2 cm; X500, X2000 and X5000, respectively.









Figures 1, 2 *Lithopera thornburgi;*
Hole 77B, Core 24, core catcher; X1000 and X500, respectively.

Figures 3, 4 *Lithopera baueri.*
Hole 77B, Core 29, Section 4, 1-3 cm; X500 and X1000, respectively.

PLATE 33

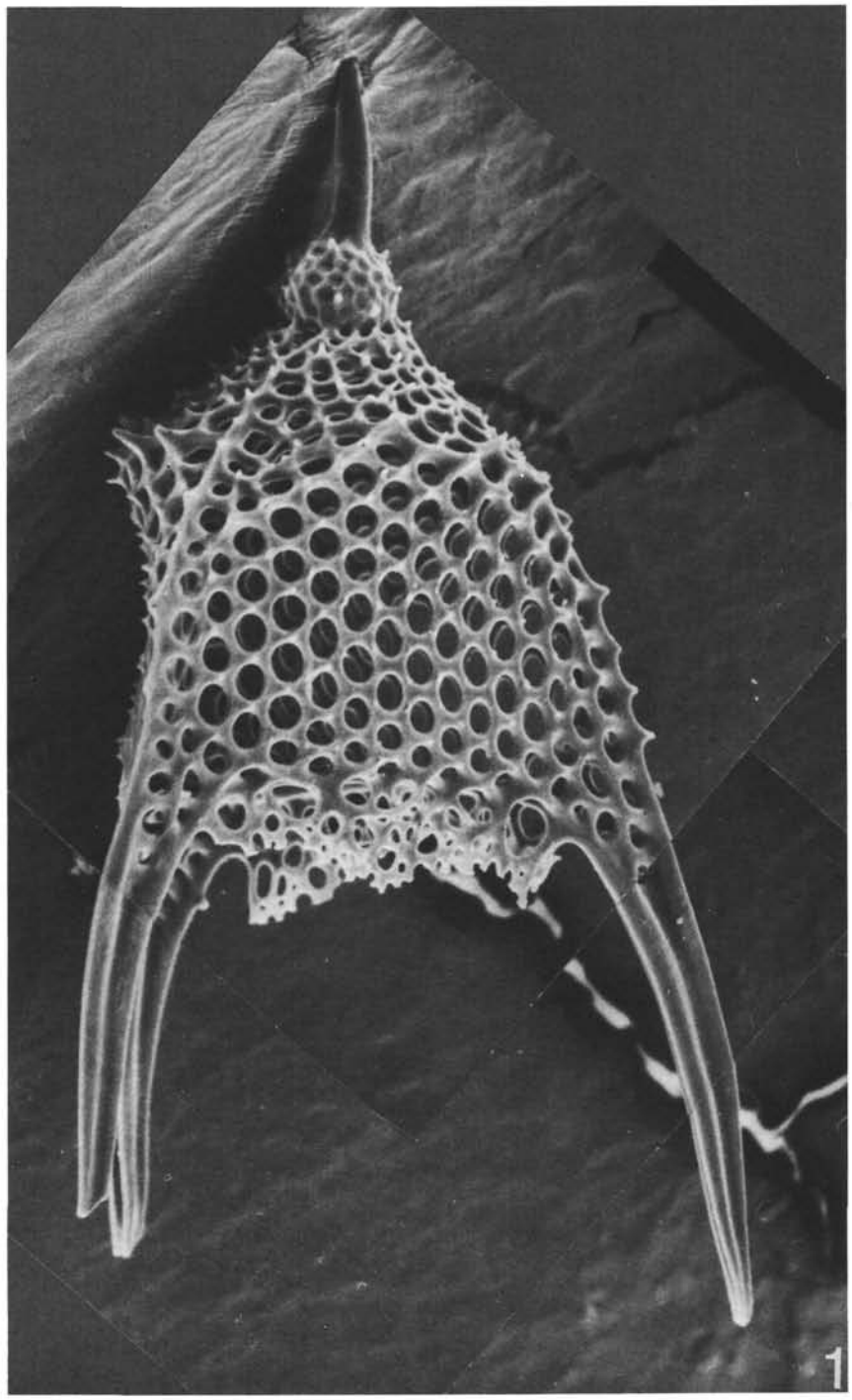
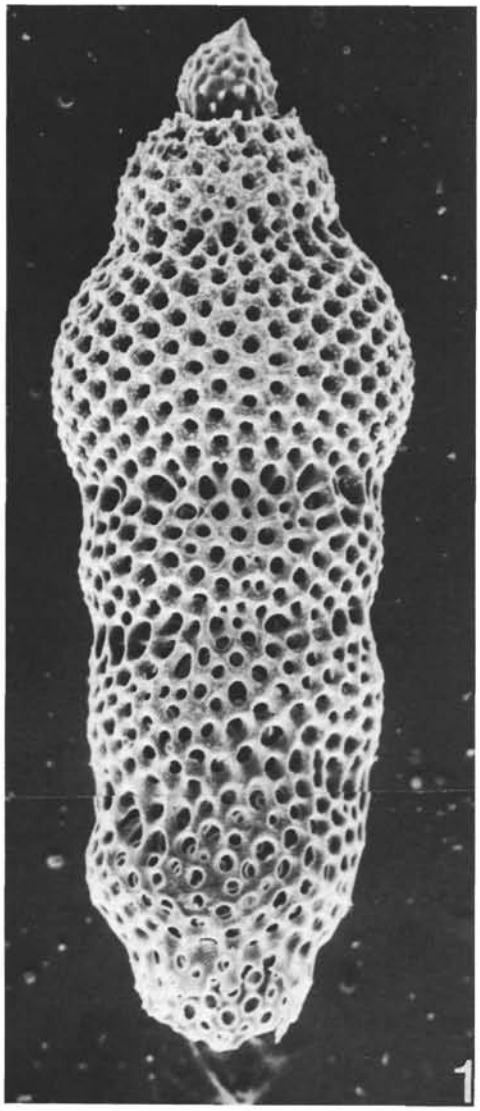
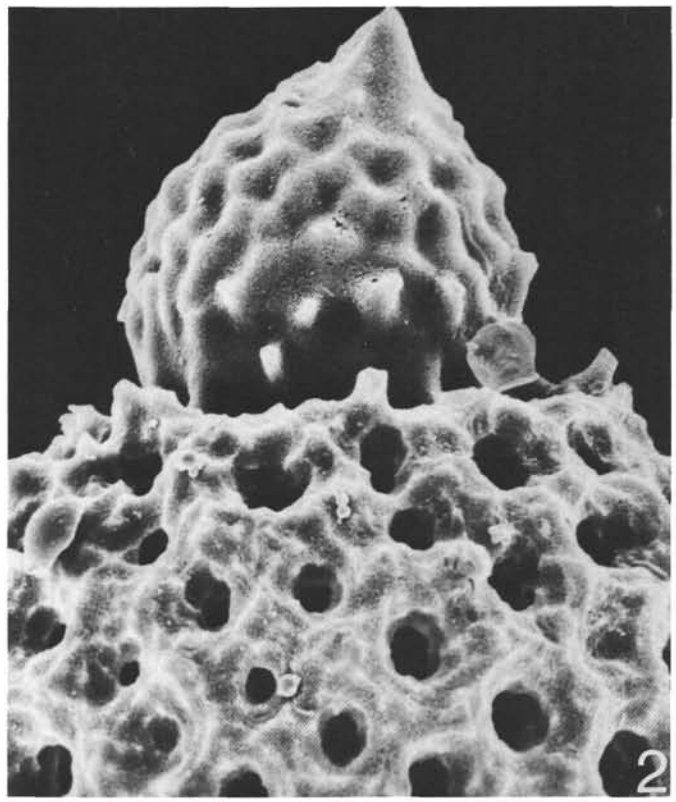
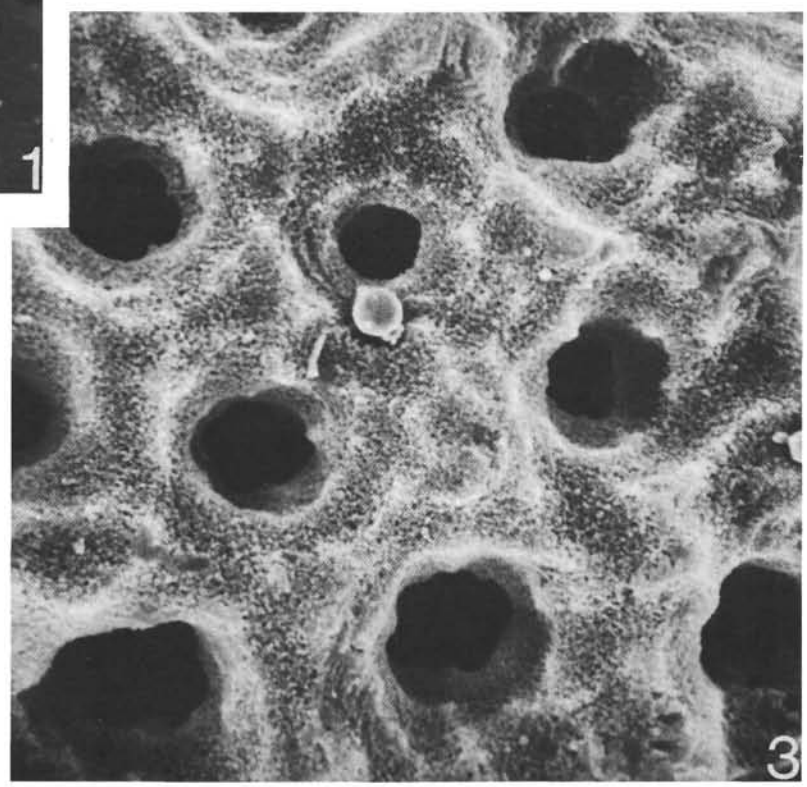


Figure 1 *Pterocanium prismatium.*
Hole 77B, Core 5, Section 5, 0-2 cm; X500.







Figures 1-3 *Stichocorys delmontense.*
Hole 77B, Core 13, Section 3, 0-2 cm; X500, X2000 and X5000, respectively.

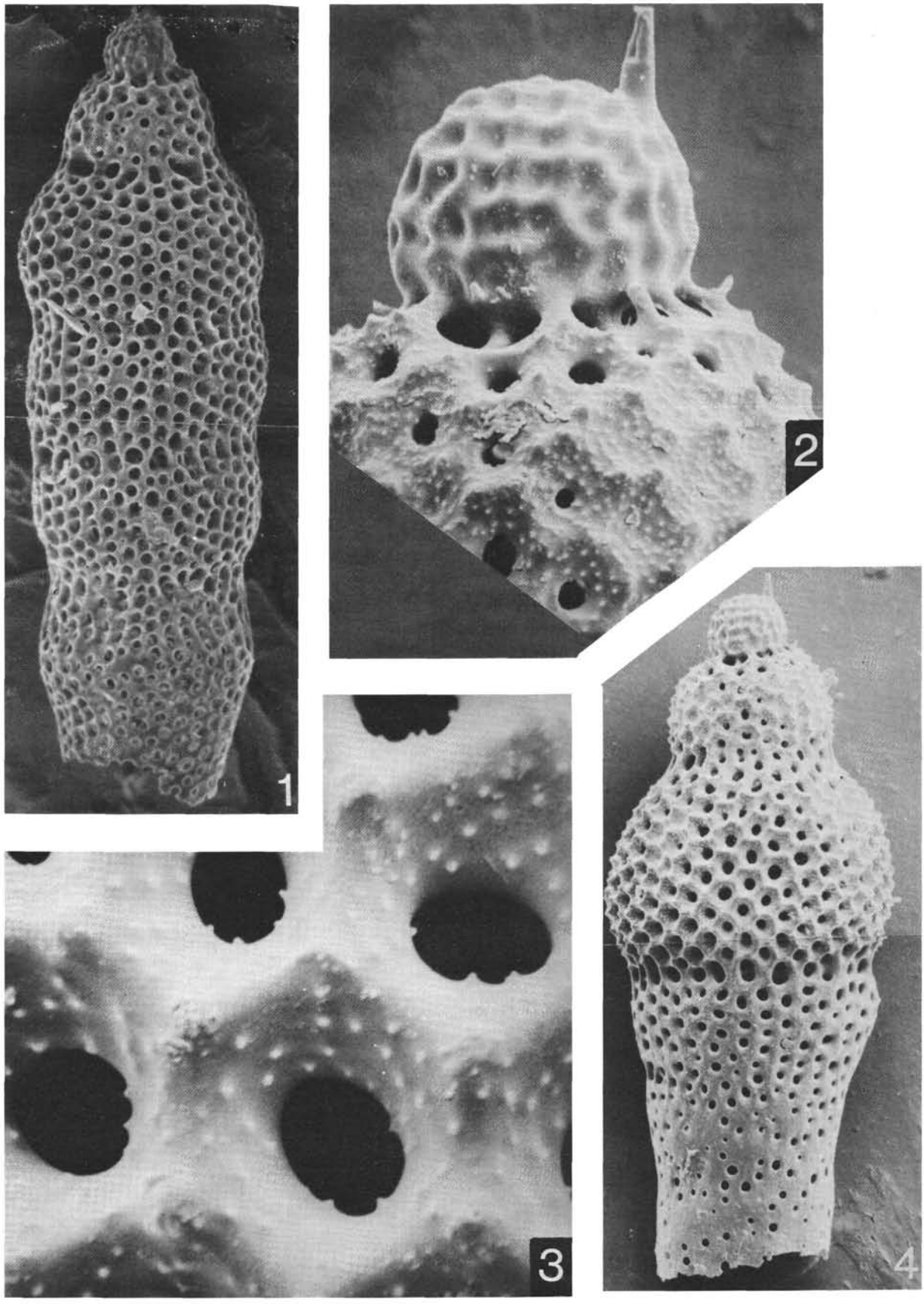
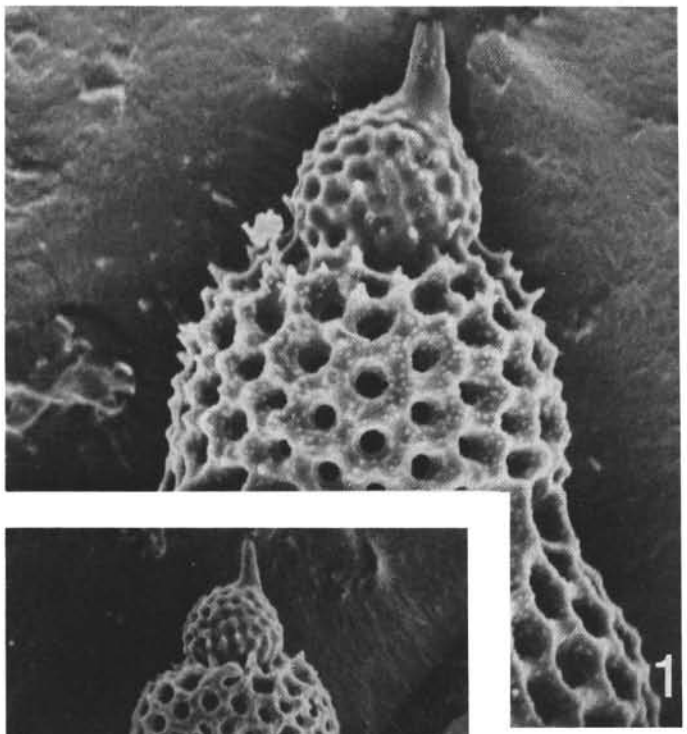
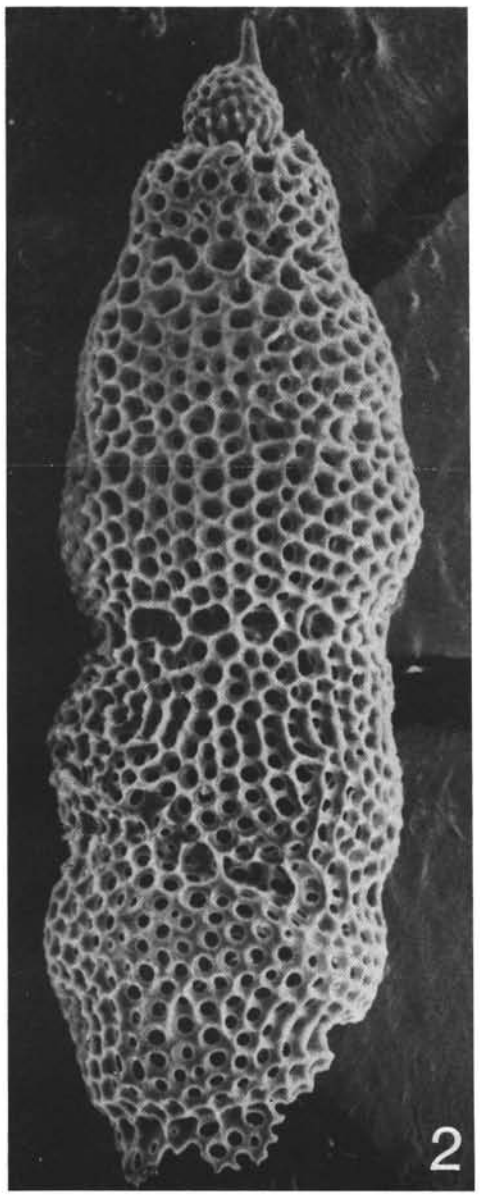
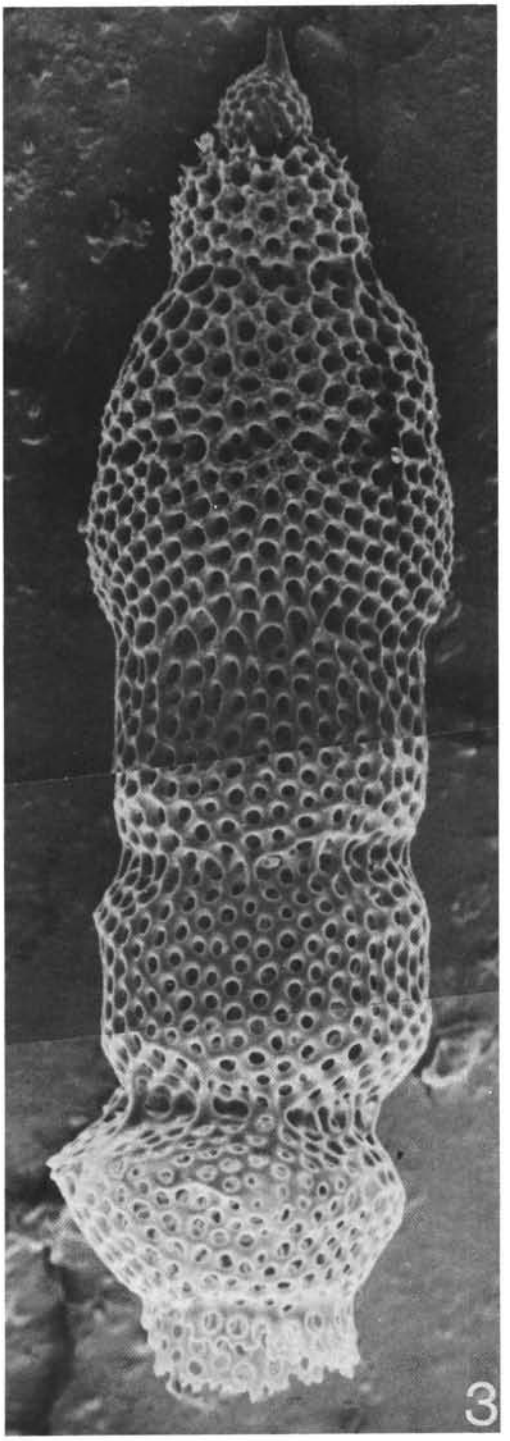


Figure 1 *Stichocorys delmontense.*
Hole 77B, Core 16, Section 3, 0-2 cm; X510.

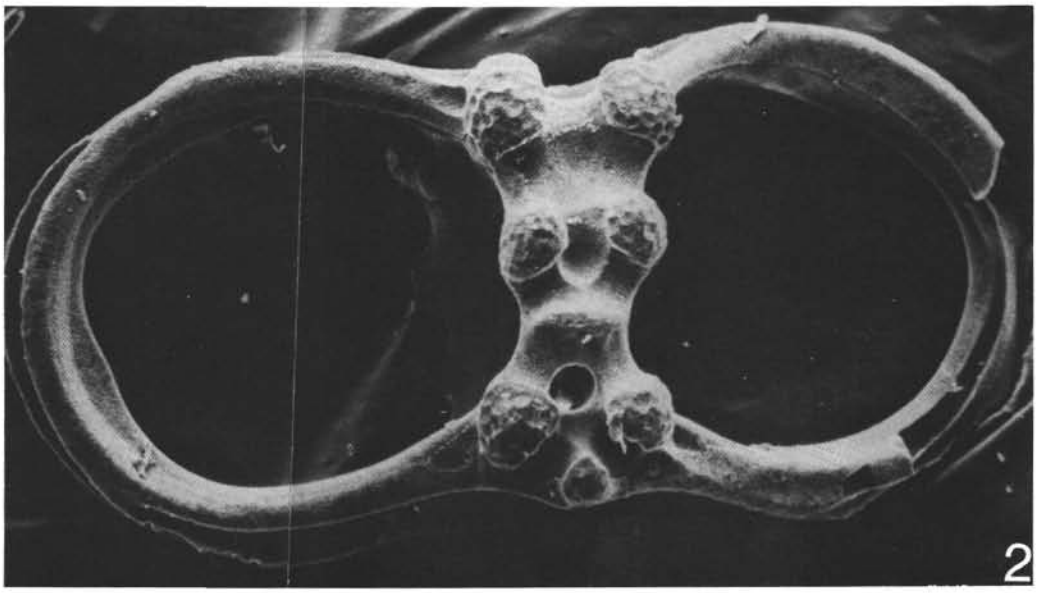
Figures 2-4 *Stichocorys diploconus.*
Hole 77B, Core 17, core catcher; X2050, X5100 and X510, respectively.







Figures 1-3 *Stichocorys peregrina.*
Hole 77B, Core 5, Section 5, 0-2 cm;
1 and 3: X1100 and X550, respectively.
2: X550.



Figures 1-3 *Acrocubus octopylus.*
Hole 77B, Core 36, core catcher.
1: Basal view, X440.
2: Rear view, X360.
3: Front view, X450.

PLATE 38

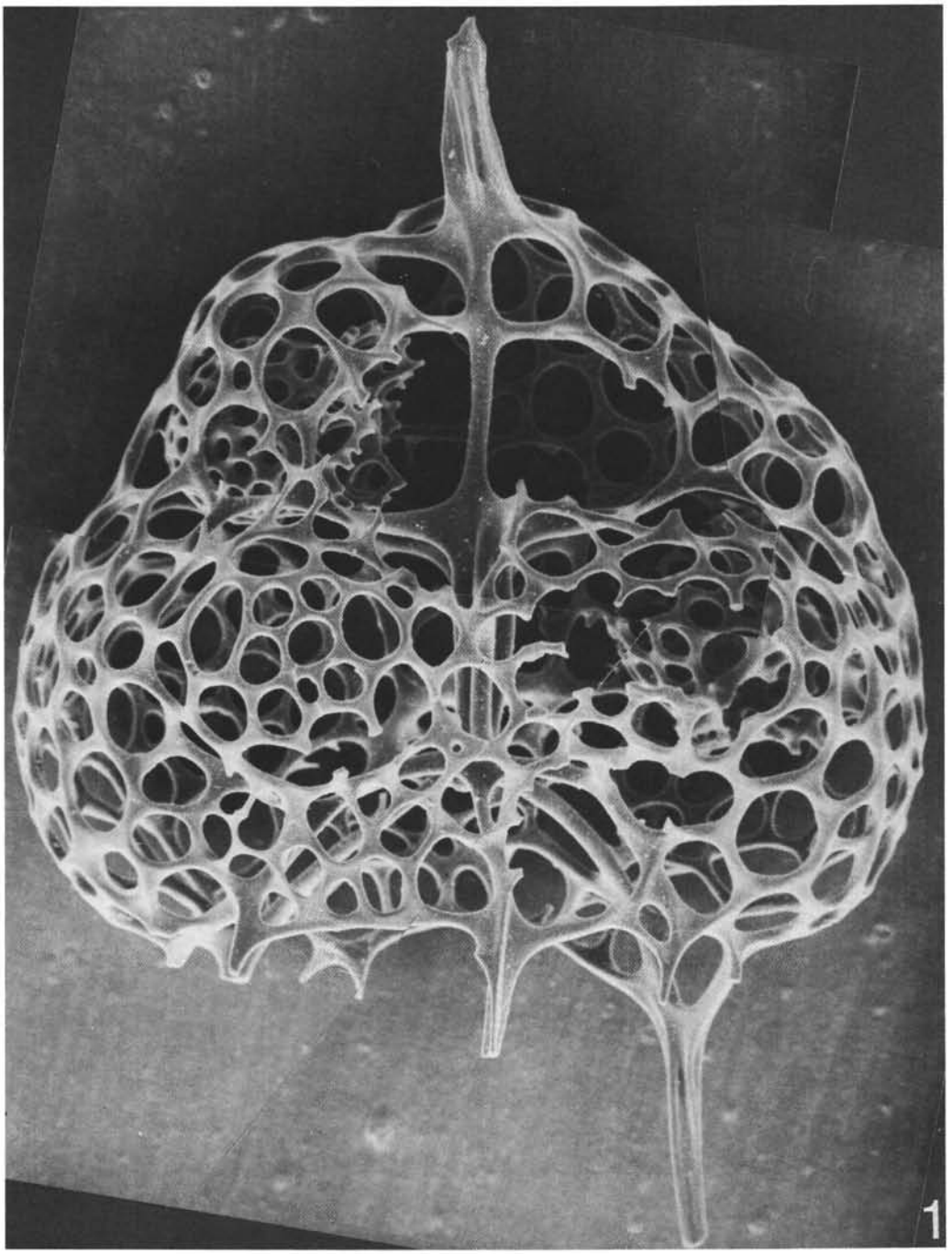


Figure 1 *Androspyris anthropiscus.*
Hole 80, Core 1, core catcher; ×500, front view.

PLATE 39

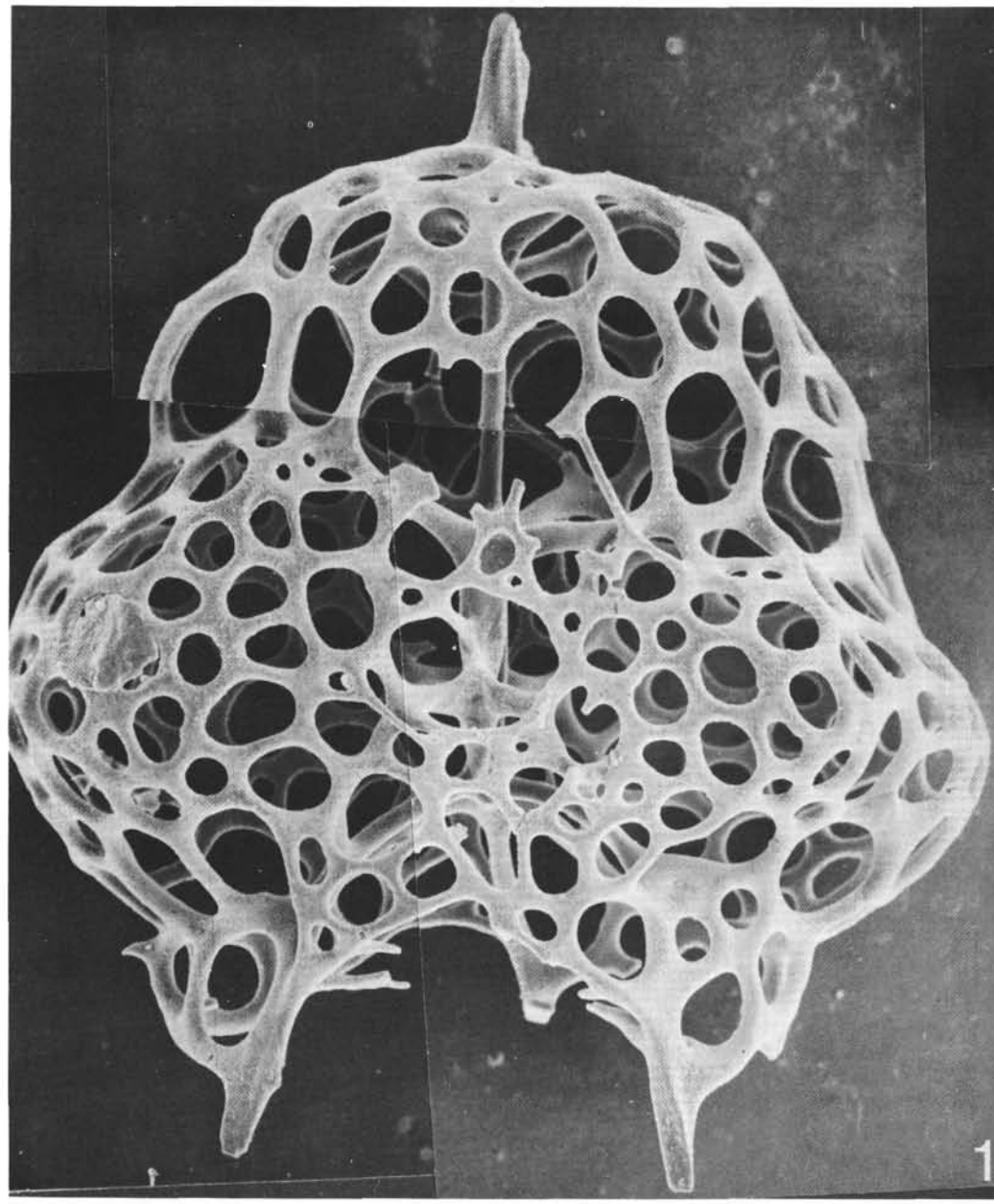
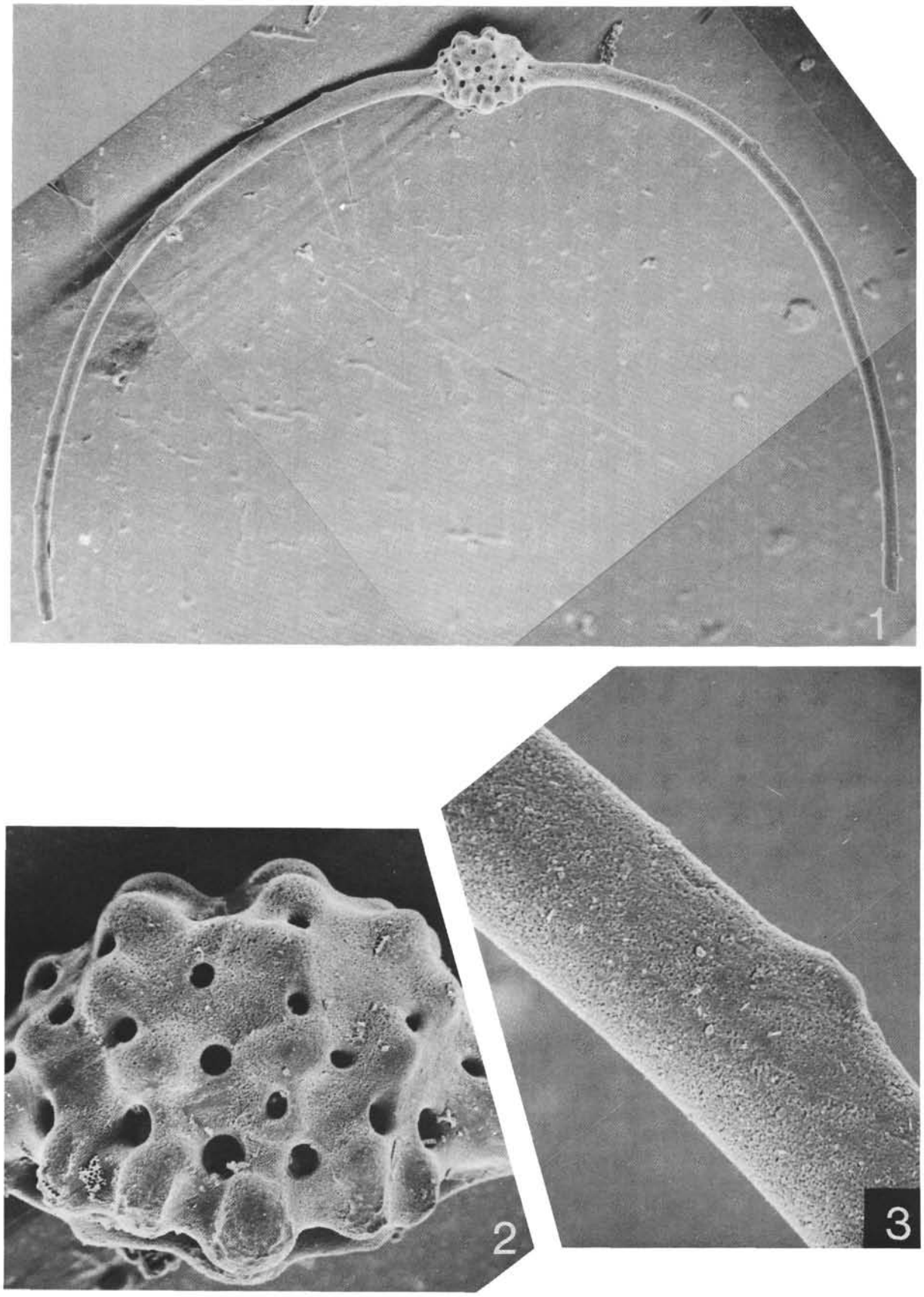
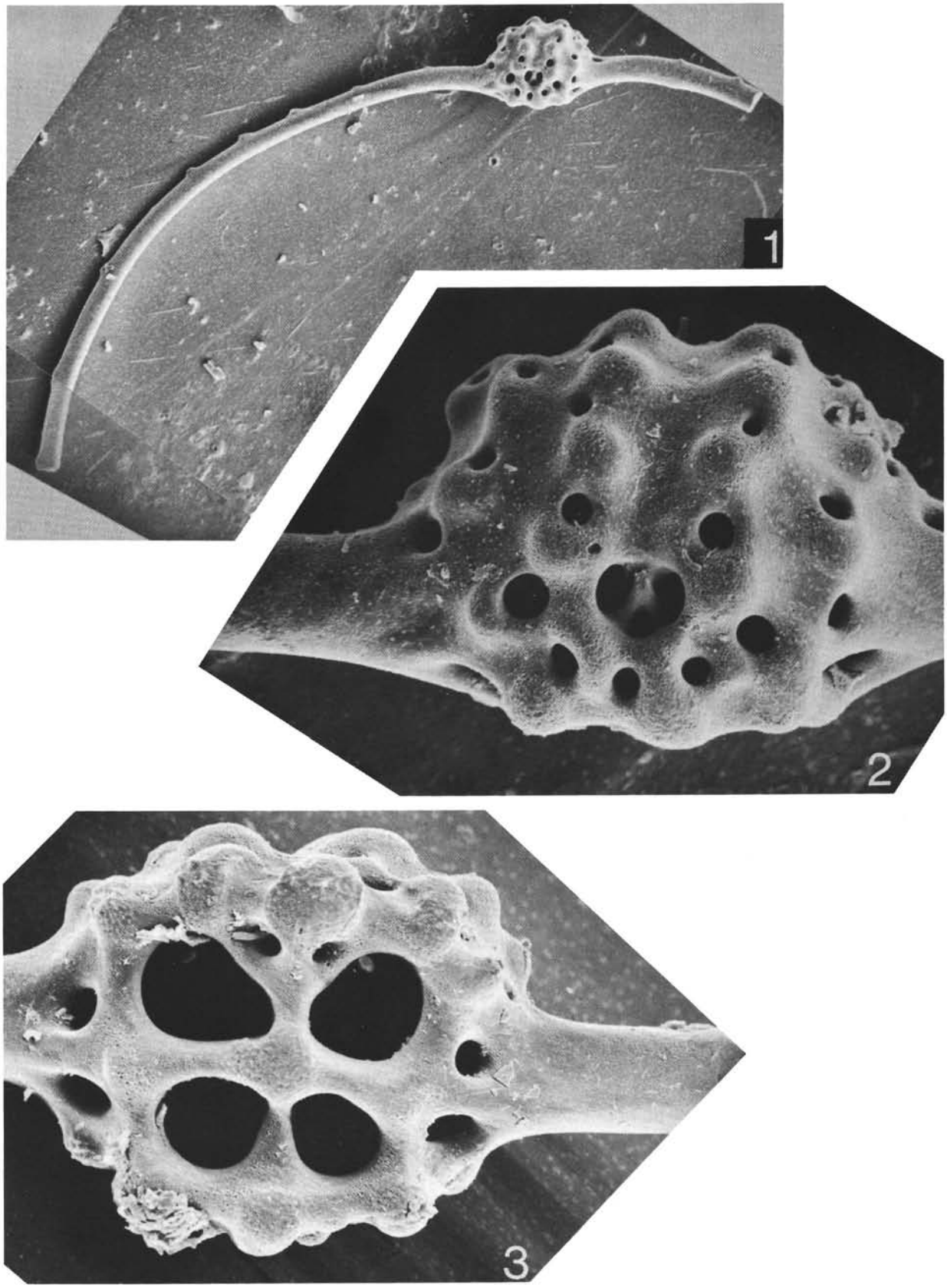


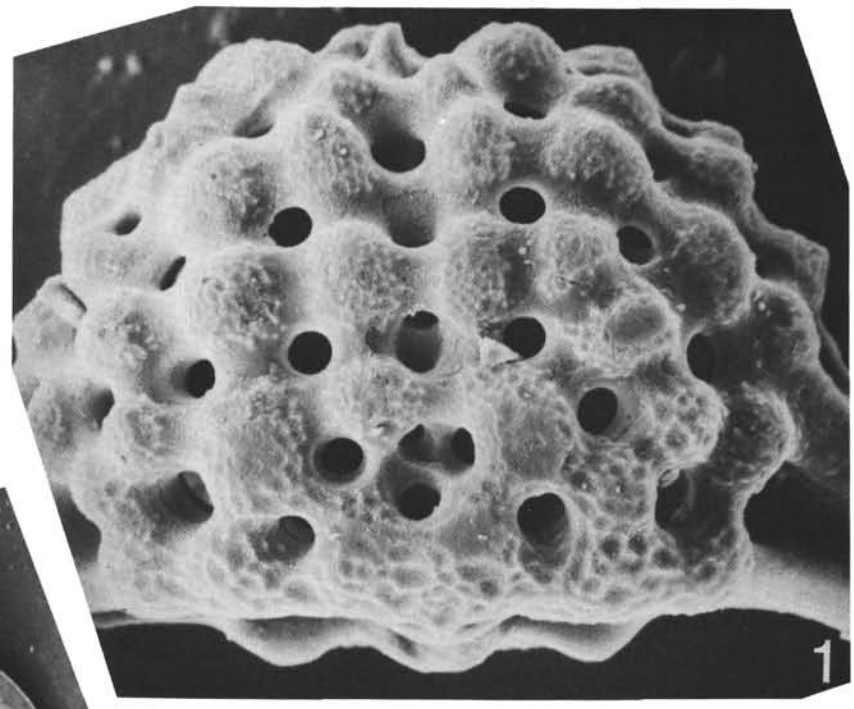
Figure 1 *Androspyris anthropiscus.*
Hole 80, Core 1, core catcher; ×500, rear view.

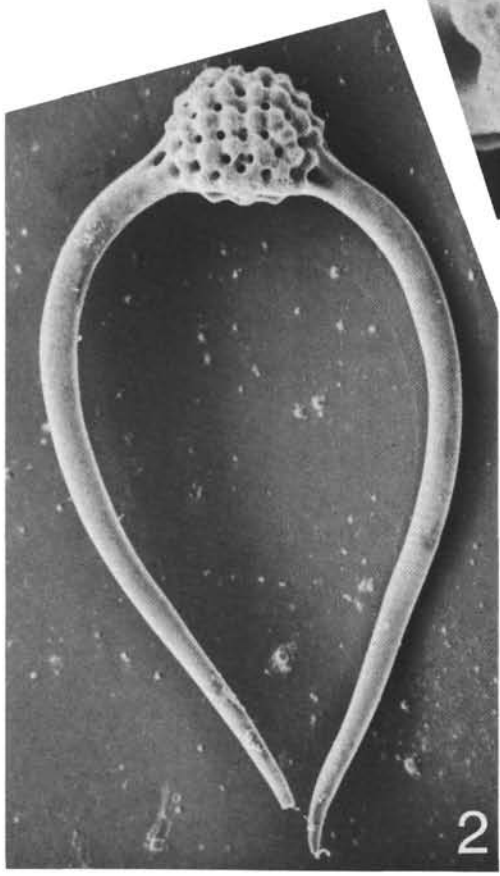


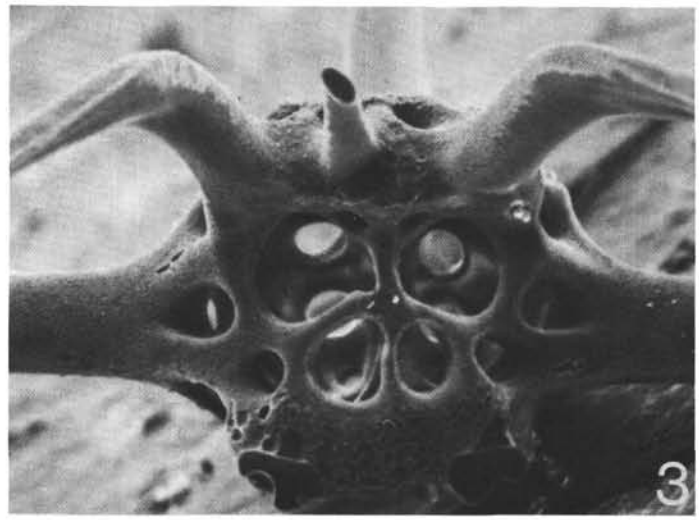
Figures 1-3 *Brachiospyris alata.*
Hole 77B, Core 24, core catcher; ×200, ×1000 and ×2000, respectively, front view.



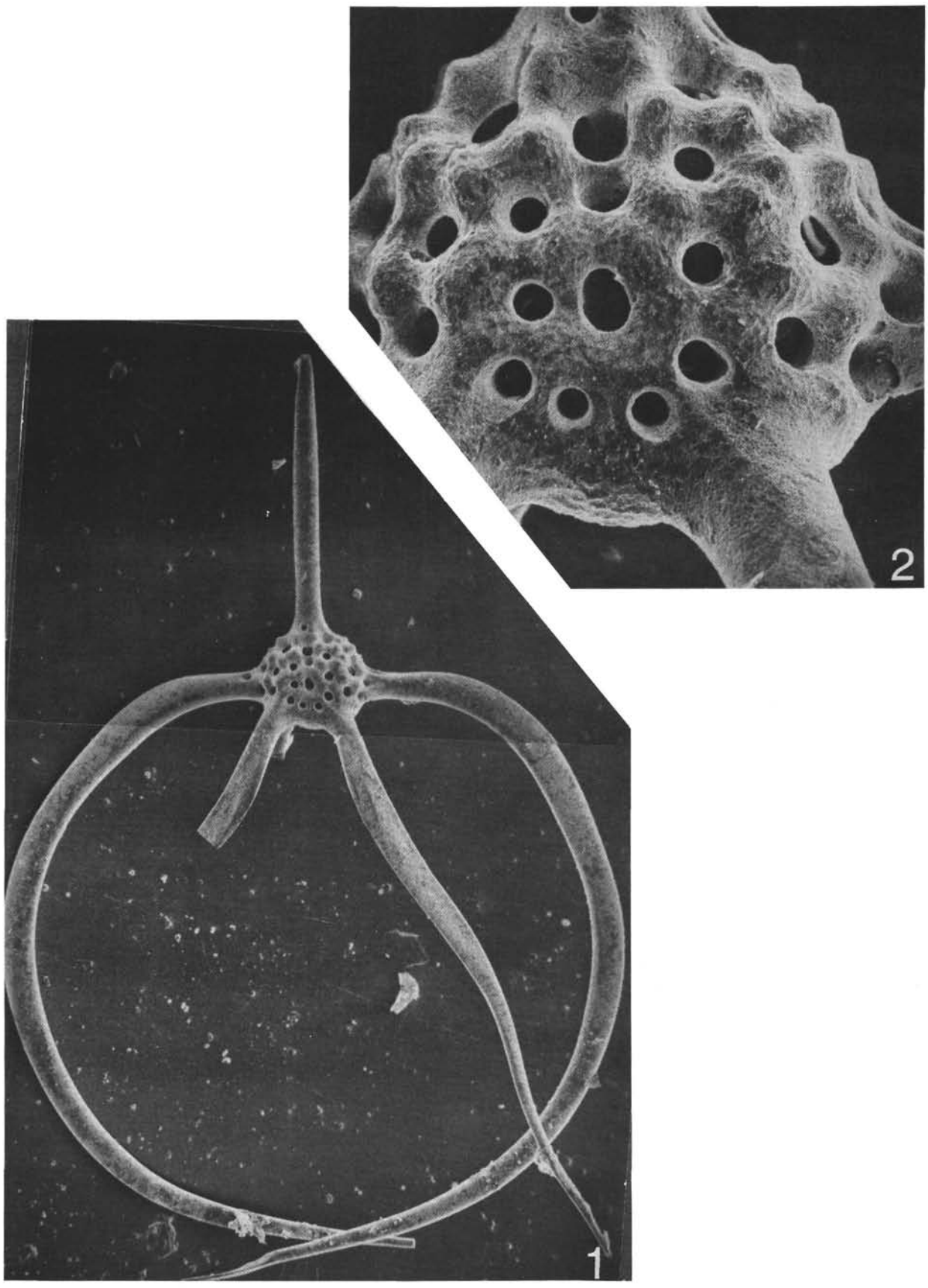
Figures 1-3 *Brachiospyris alata.*
Hole 77B, Core 24, core catcher.
1 and 2: Rear view, X205 and X1050.
3: Basal view, X1000.



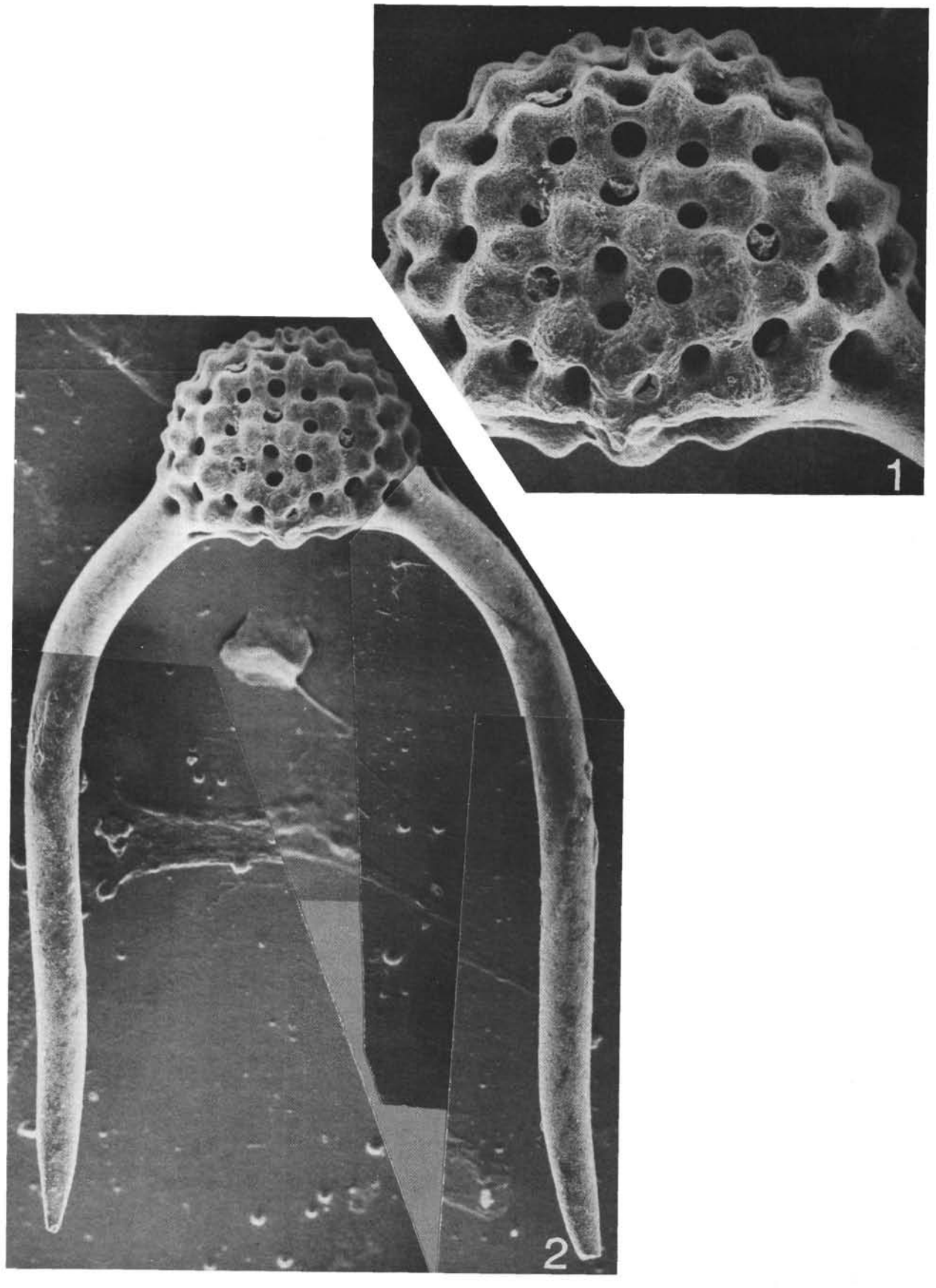




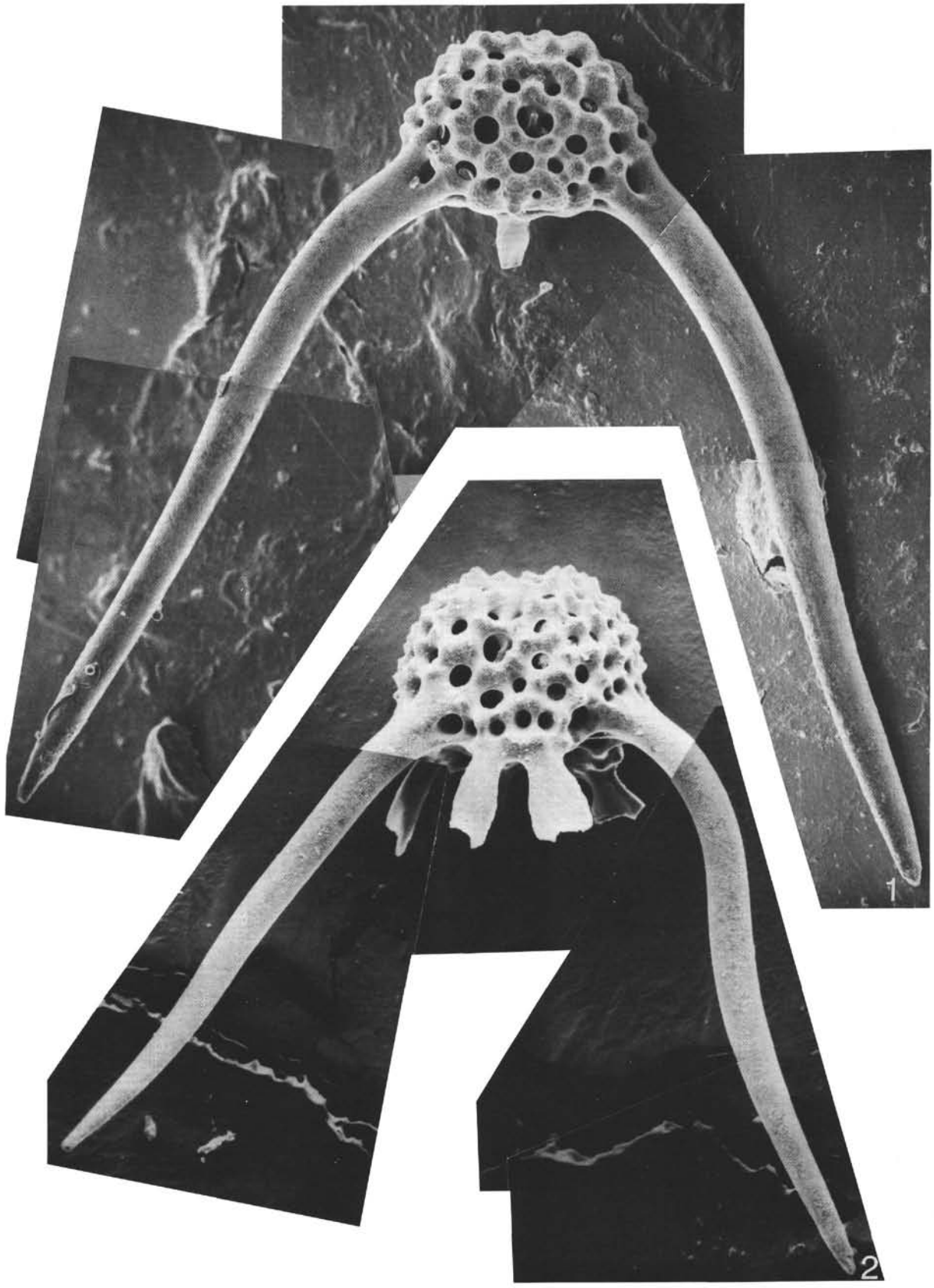
Figures 1, 2 *Brachiospyris simplex.*
Hole 77B, Core 29, core catcher; ×200 and ×1000, respectively.



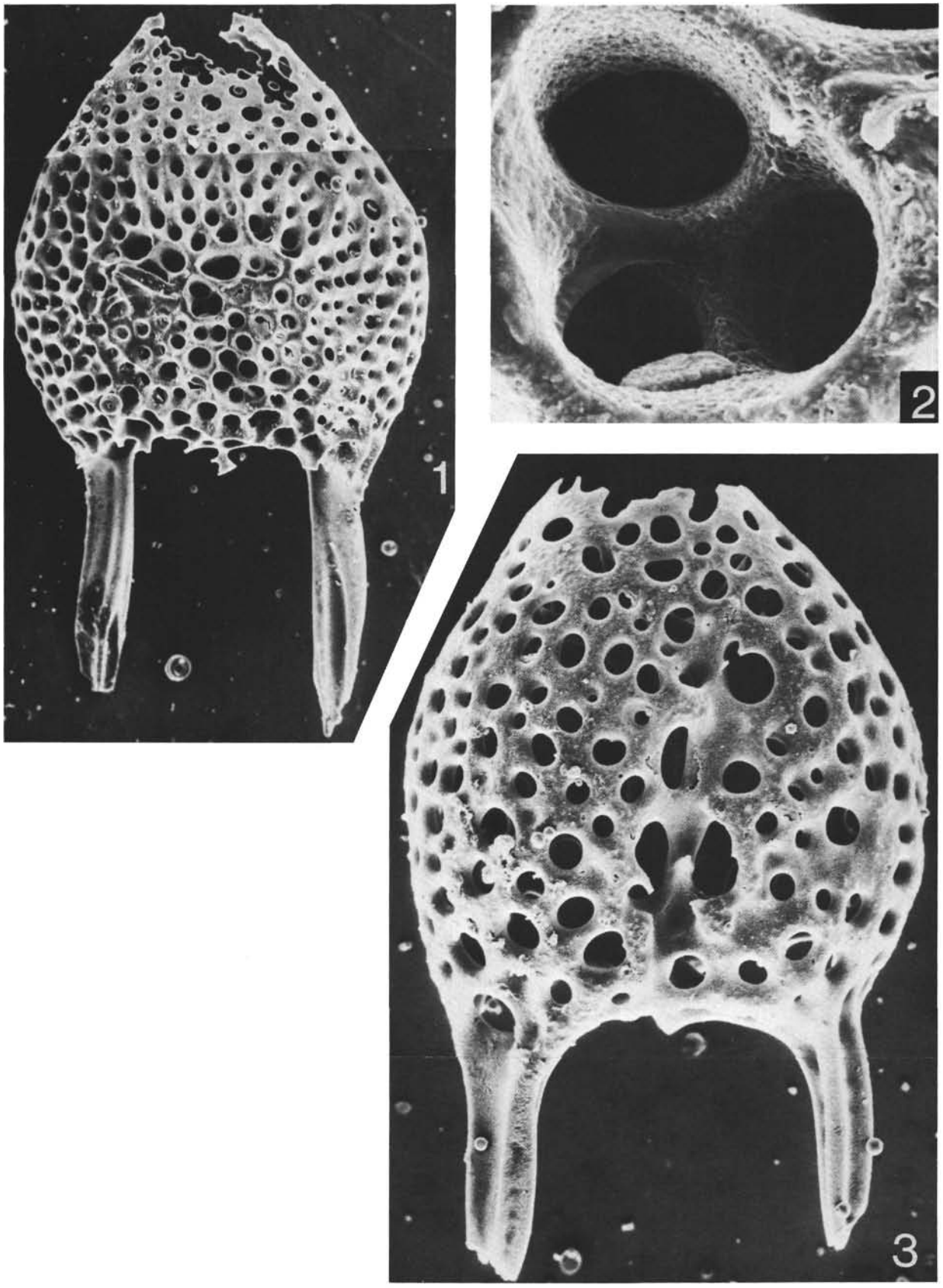
Figures 1, 2 *Hexaspyris papilio.*
Hole 78, Core 36, core catcher; X195 and X970, respectively.



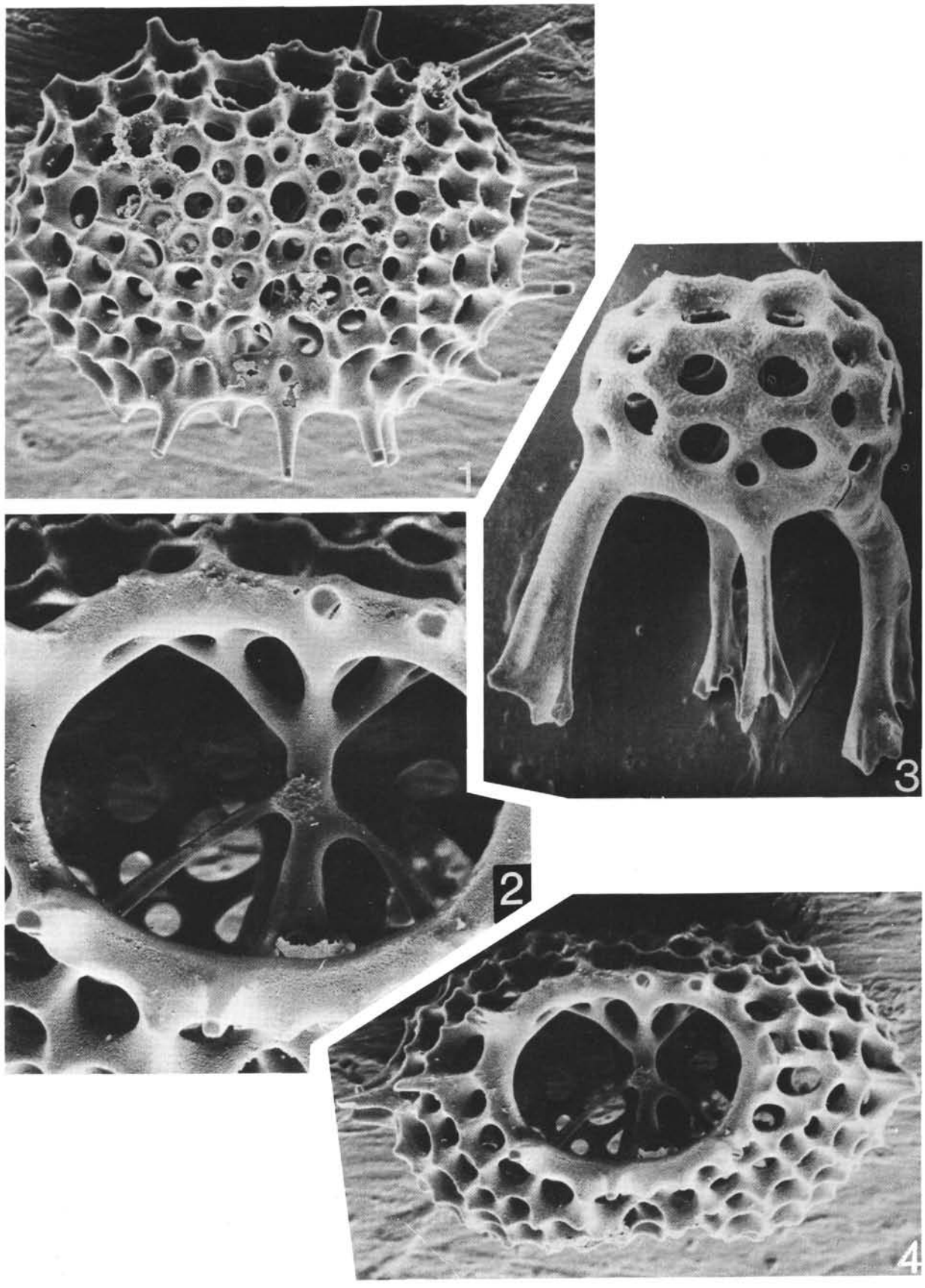
Figures 1, 2 *Cantharospyris ateuchus.*
Hole 78, Core 7, Section 4, 12-14 cm; X970 and X490, respectively.



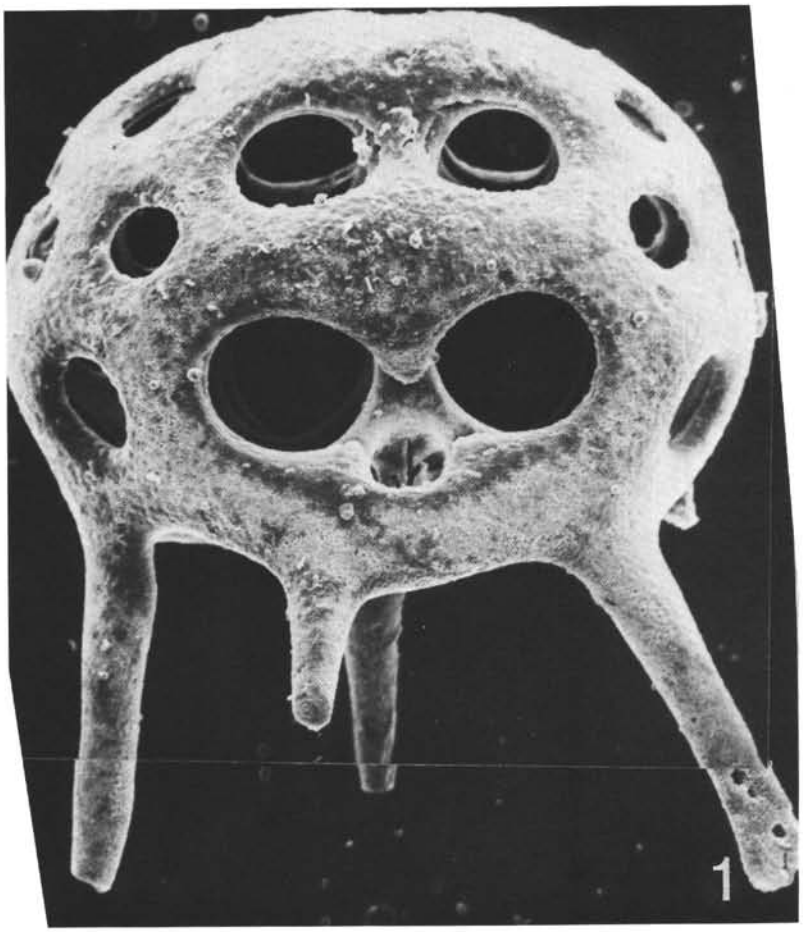
Figures 1, 2 *Cantharospyris ateuchus.*
1: Hole 77B, Core 43, Section 2, 18-29 cm; X375.
2: Hole 78, Core 7, Section 4, 12-14 cm; X380.

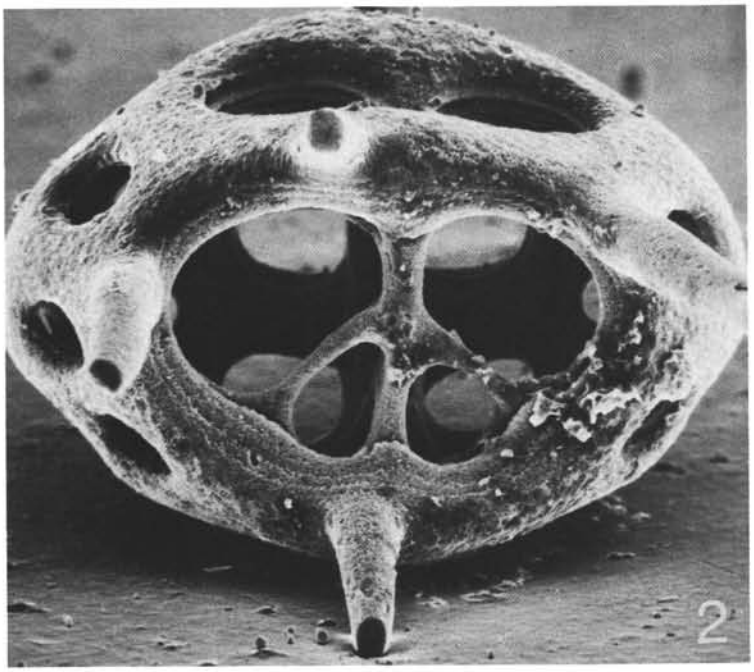


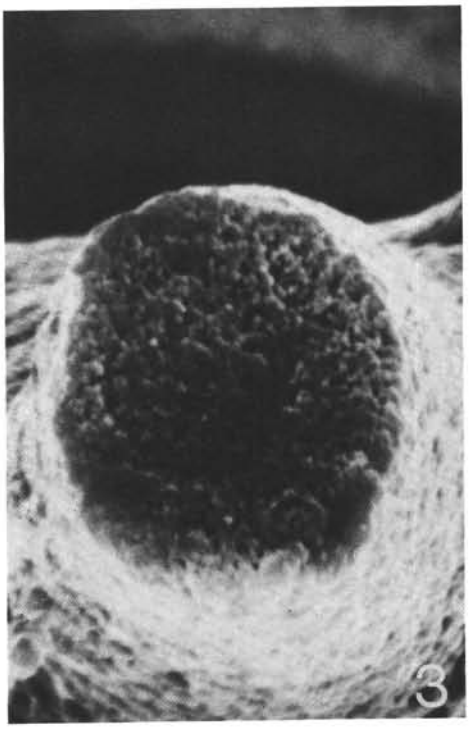
Figures 1-3 *Clathrobursa clathrobursa.*
Hole 78, Core 16, core catcher.
1 and 2: Front view; X500 and X5000, respectively.
3: Rear view; X500.



Figures 1, 2, 4 *Dendrospyris anthocyrtoides.*
Hole 78, Core 33, core catcher.
1: Front view; X500.
2 and 4: Basal view showing sculptured axial tubercule; X980 and X490, respectively.

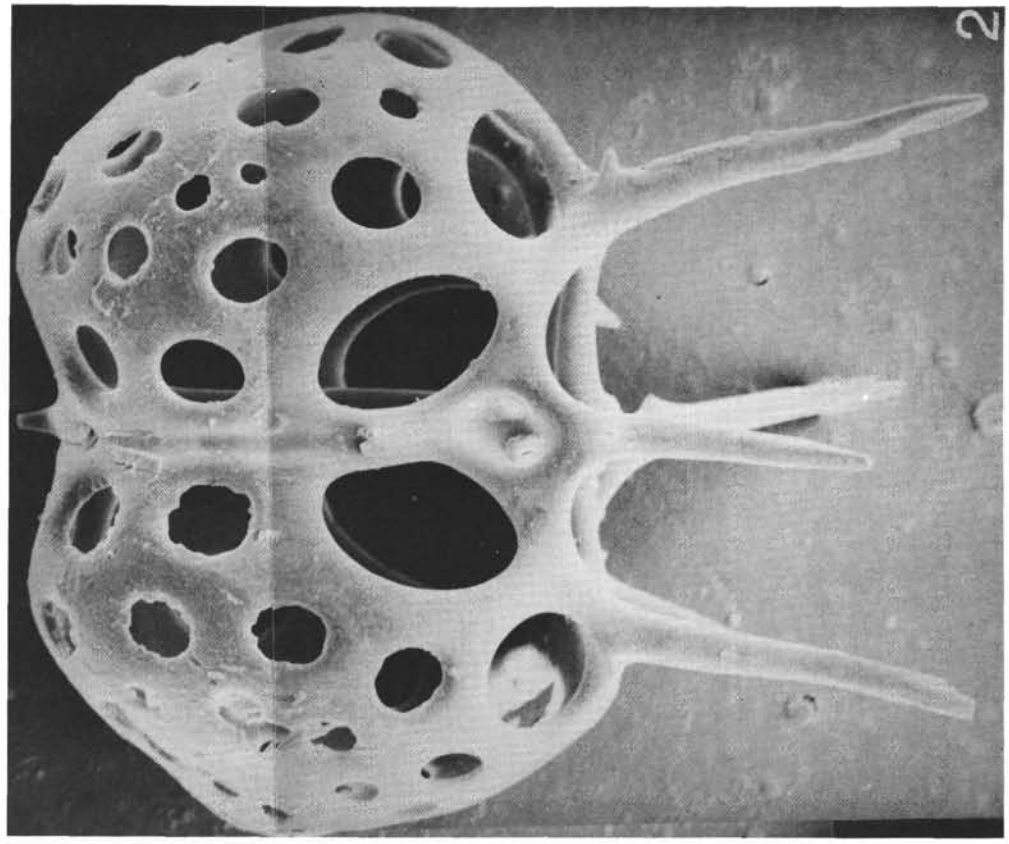


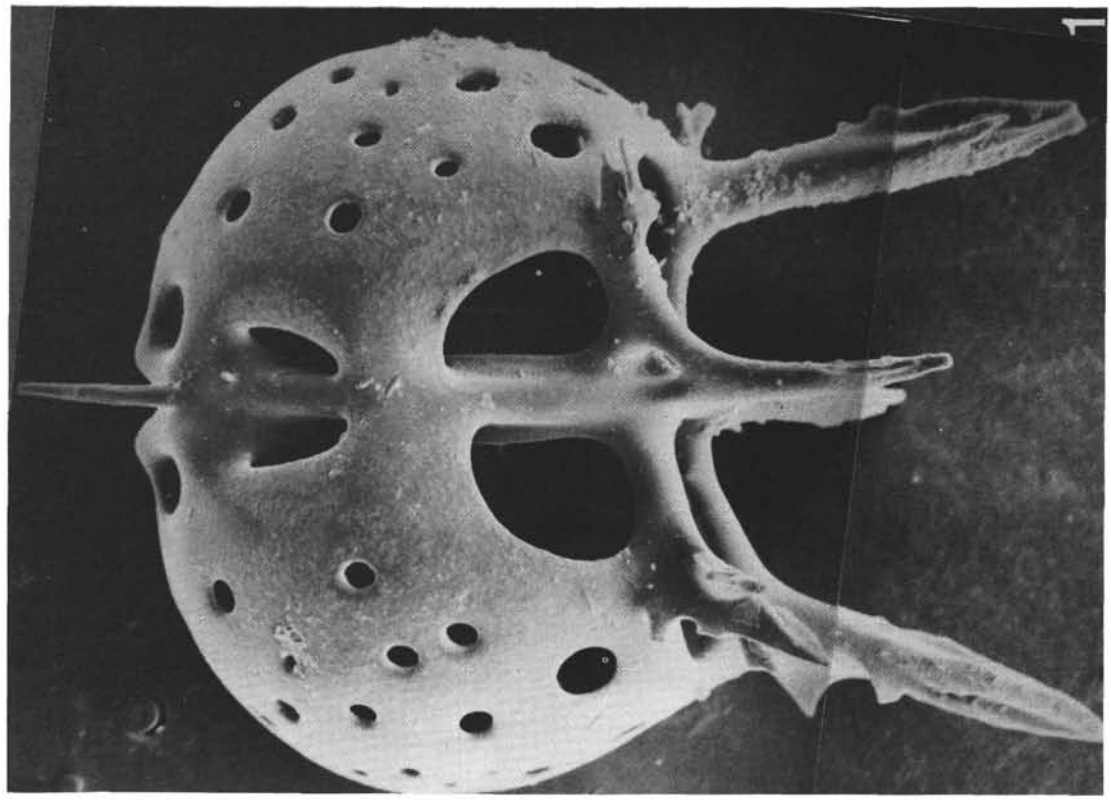




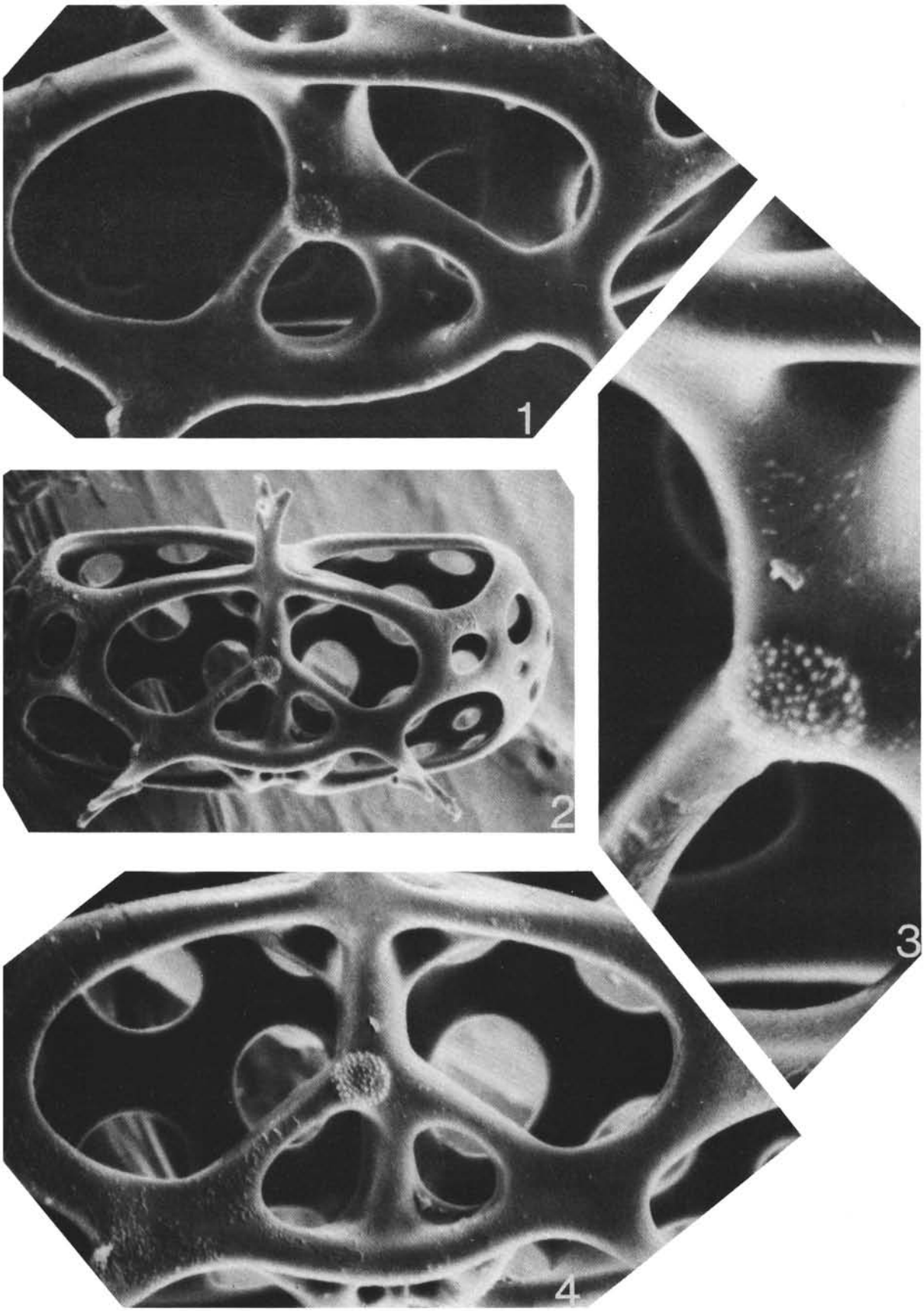
Figures 1-3 *Dendrospyris pododendros.*
Hole 78, Core 17, Section 4, 20-22 cm.
1: Front view; X1000.
1 and 3: Basal view; X1000 and X9000, respectively.

PLATE 49

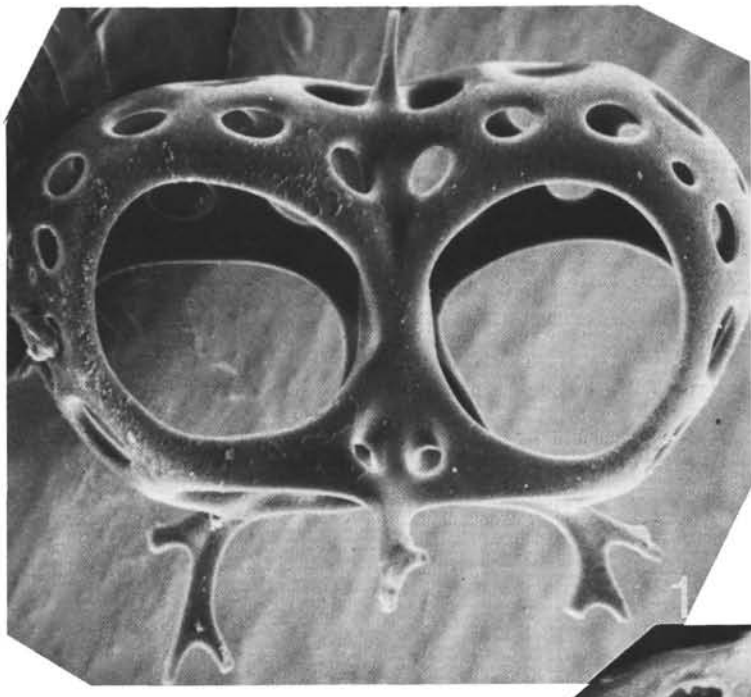


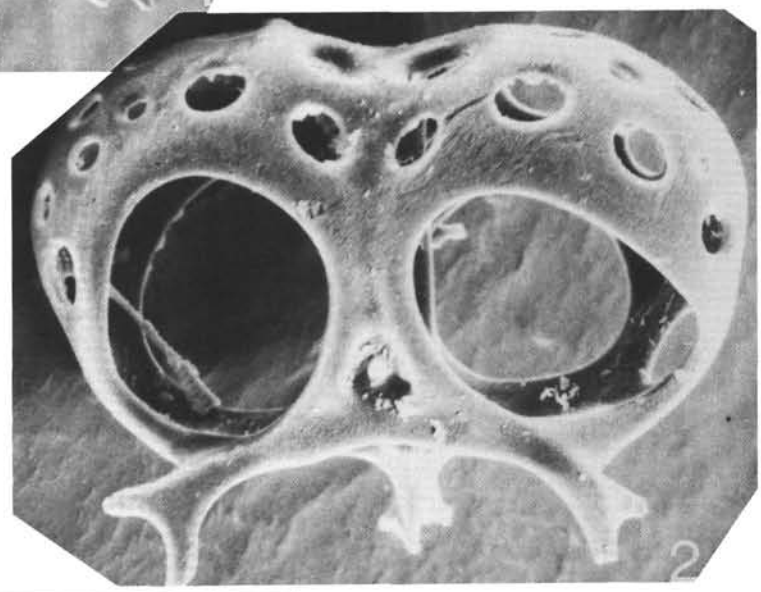


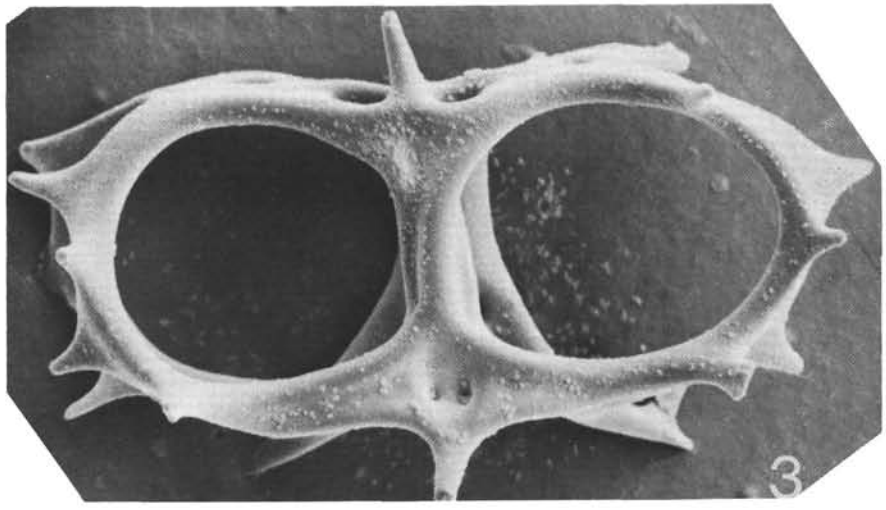
Figures 1, 2 *Dendrospyris binapertonis.*
Hole 77B, Core 17, core catcher; X1000.
1: Front view.
2: Rear view.



Figures 1-4 *Dendrospyris damaecornis.*
Hole 77B, Core 8, Section 3, 0-2 cm.
1 and 3: Oblique view of basal ring; ×1900 and ×4800, respectively.
2 and 4: Basal view showing sculptured axial tubercule; ×950 and ×1900.

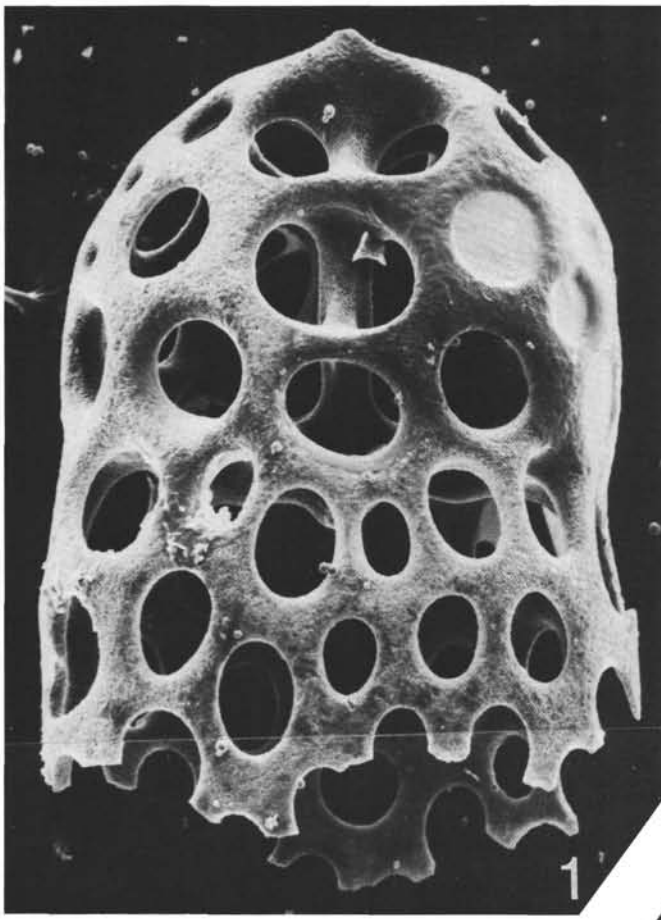


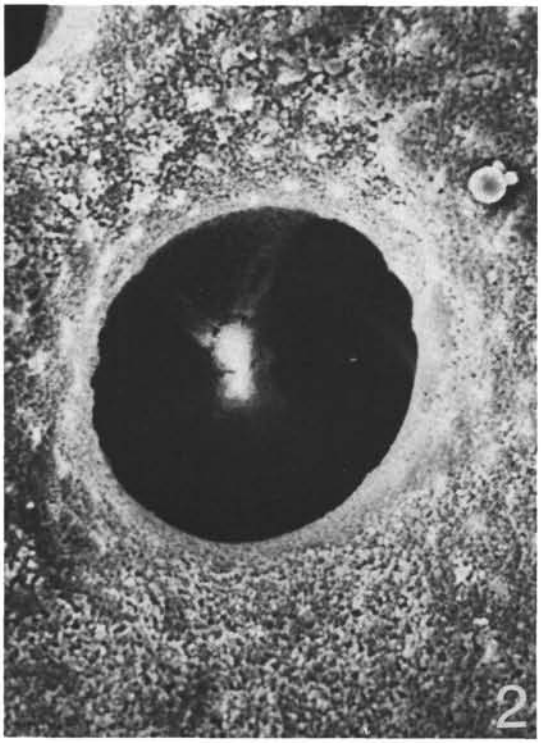


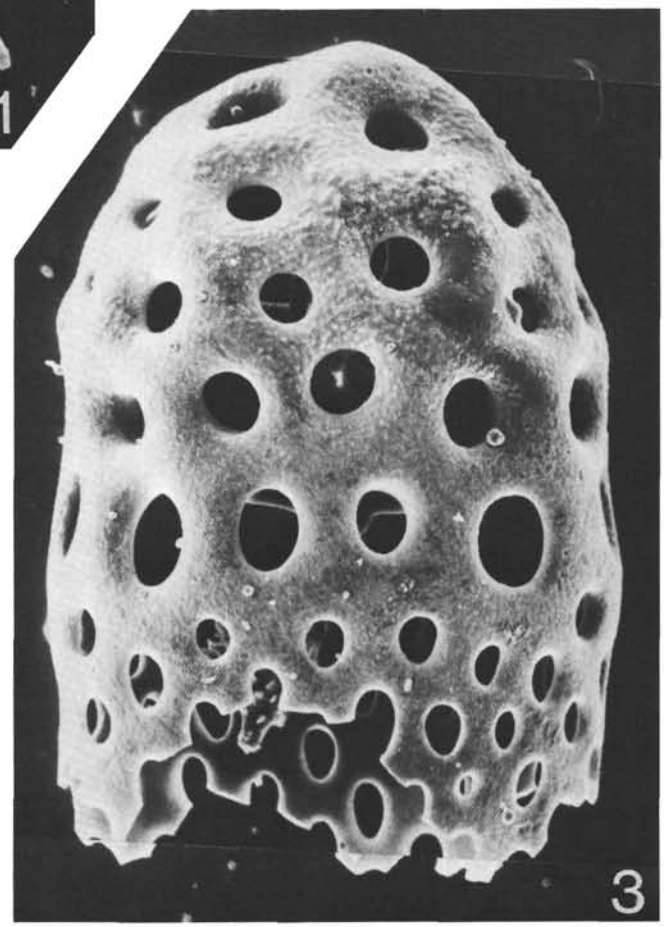


Figures 1, 2 *Dendrospyris damaecornis.*
Hole 77B, Core 8, Section 3, 0-2 cm; ×1000.
1: Front view. 2: Rear view.

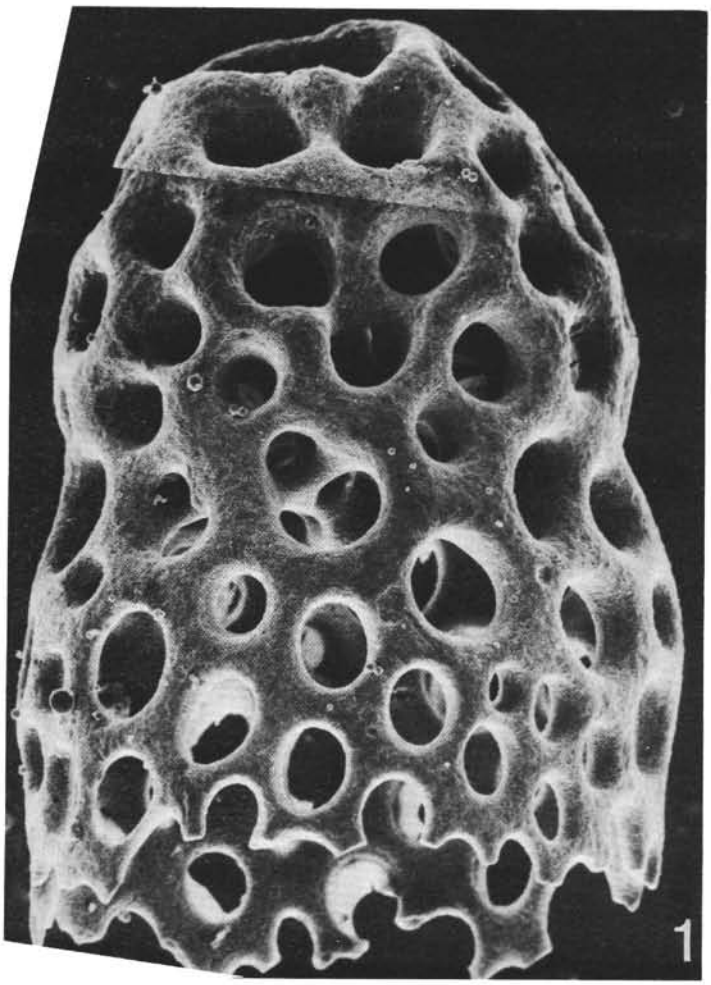
Figure 3 *Clathrocircus stapedius.*
Hole 80, Core 1, core catcher; ×1000, front view.

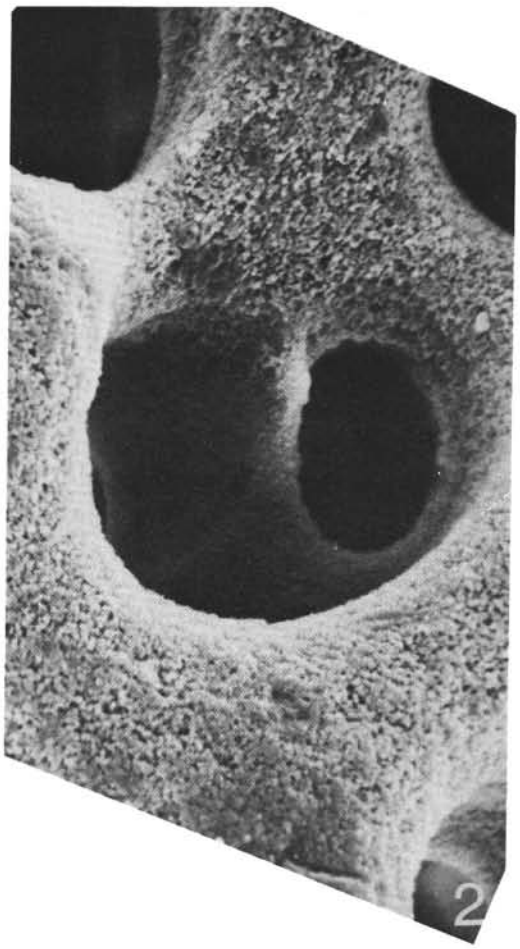


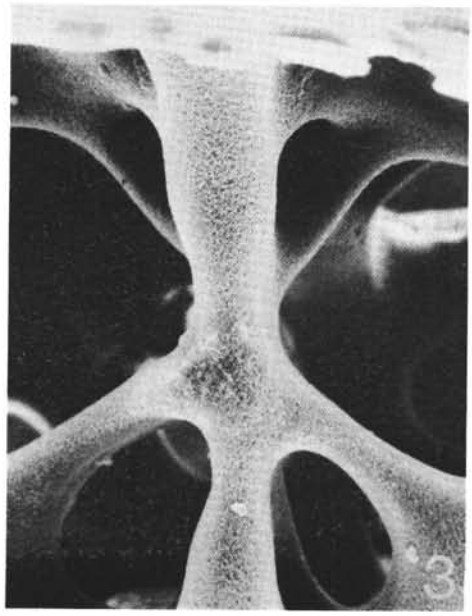


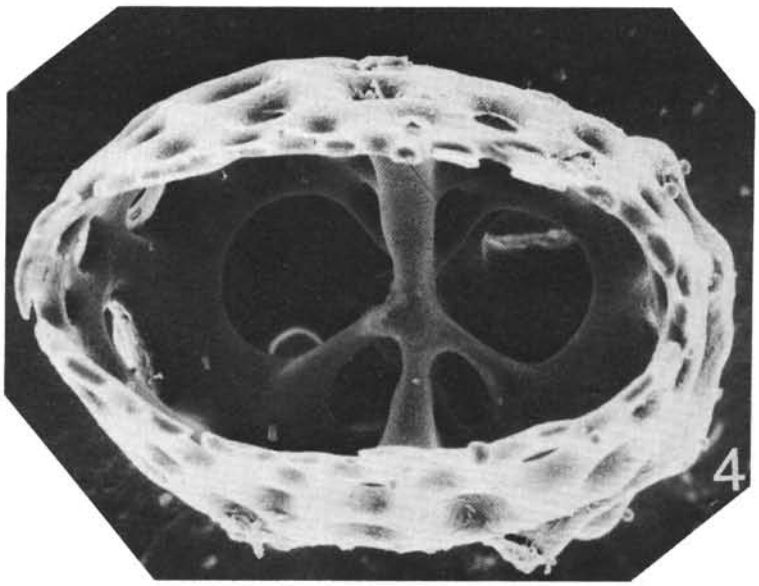


Figures 1-3 *Dendrospyris pannosa.*
Hole 78, Core 17, Section 4, 20-22 cm.
1: Front view, X1000.
2 and 3: Rear view; X5000 and X1000.

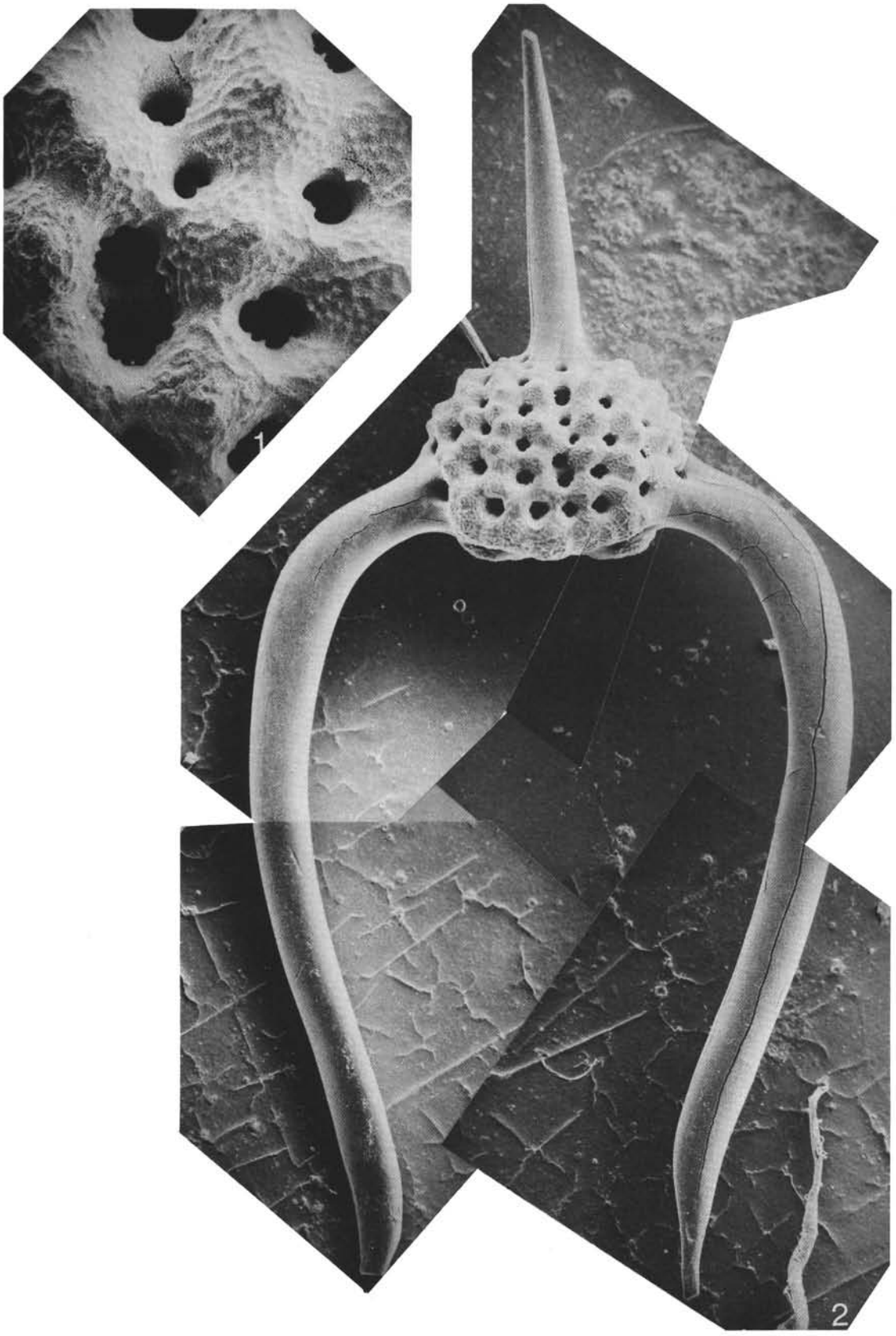




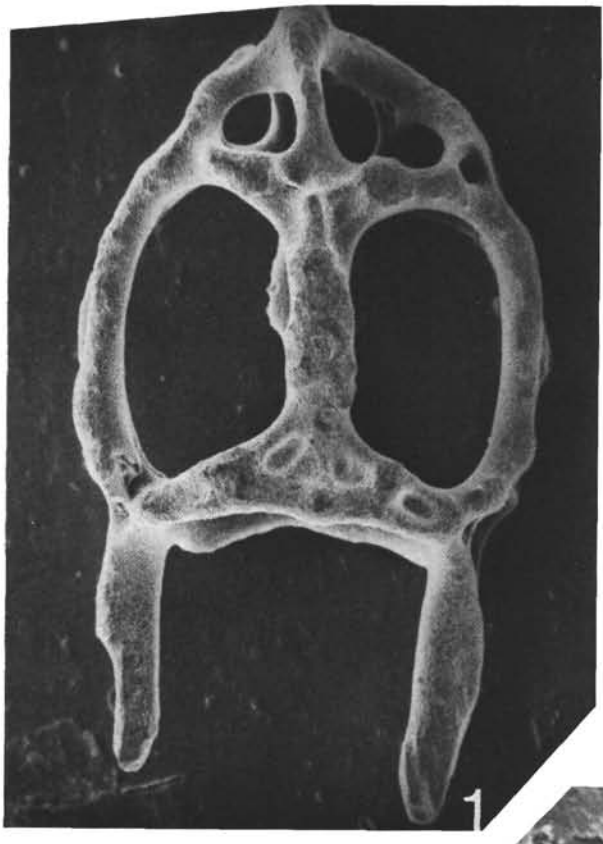


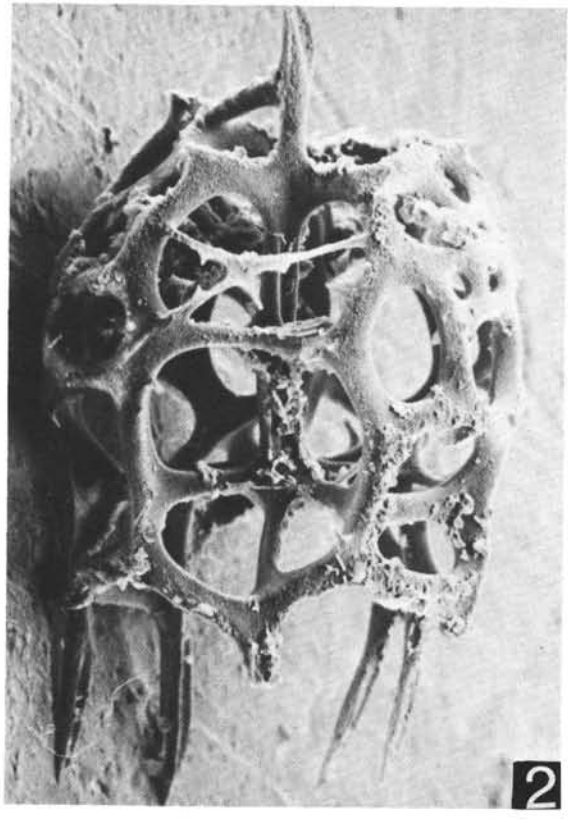


Figures 1-4 *Dendrospyris pannosa.*
Hole 78, Core 17, Section 4, 20-22 cm.
1 and 2: Rear view; X1000 and X5000, respectively.
3 and 4: Basal view; X2000 and X1000, respectively.



Figures 1, 2 *Dipodospyris forcipata.*
Hole 78, Core 17, Section 4, 20-22 cm; front view;
X1320 and X330, respectively.





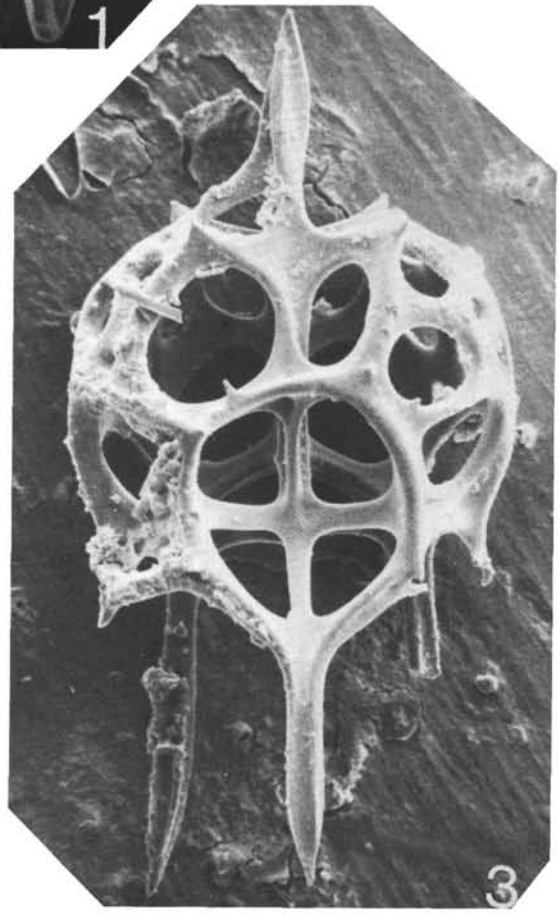
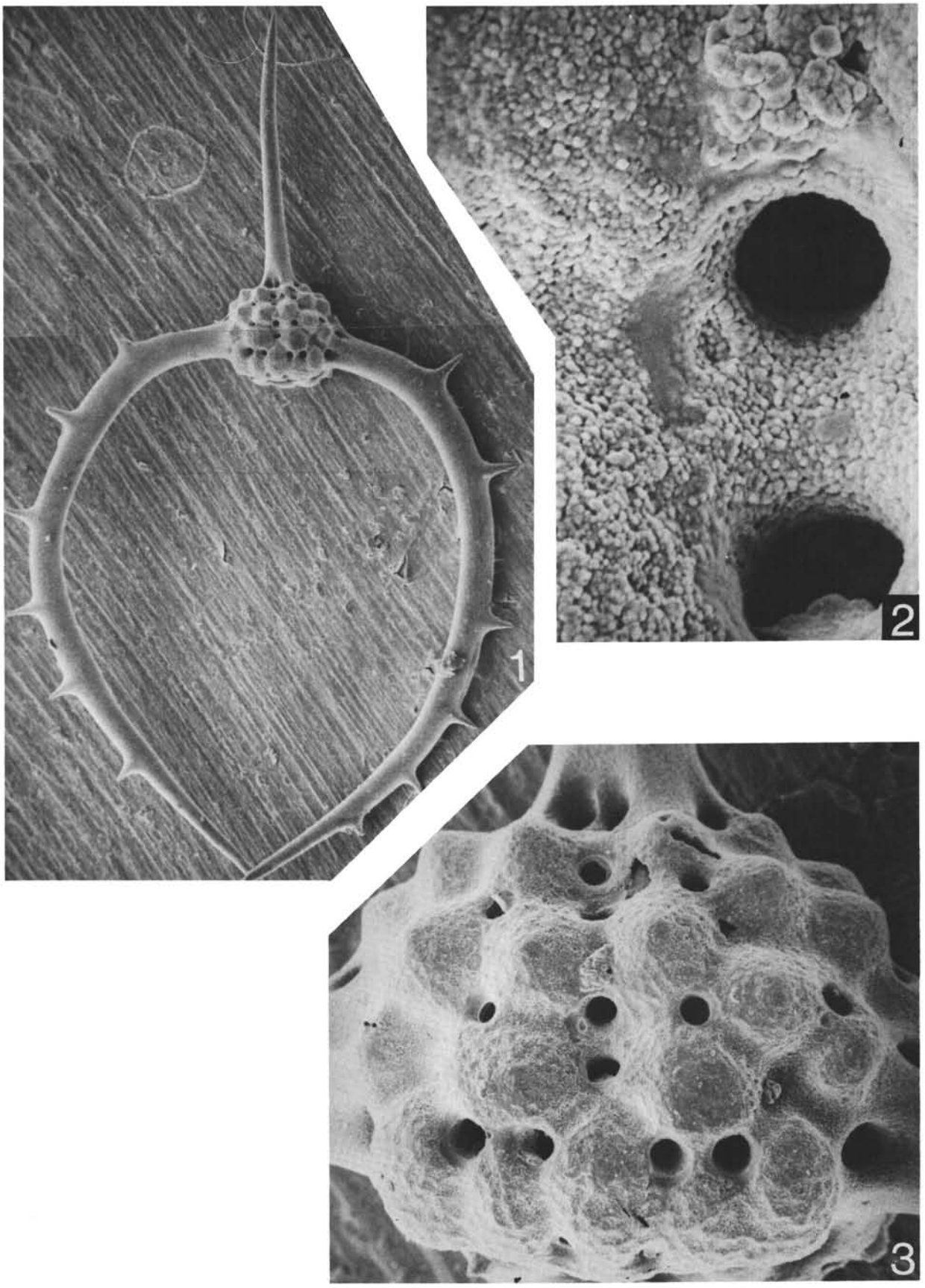
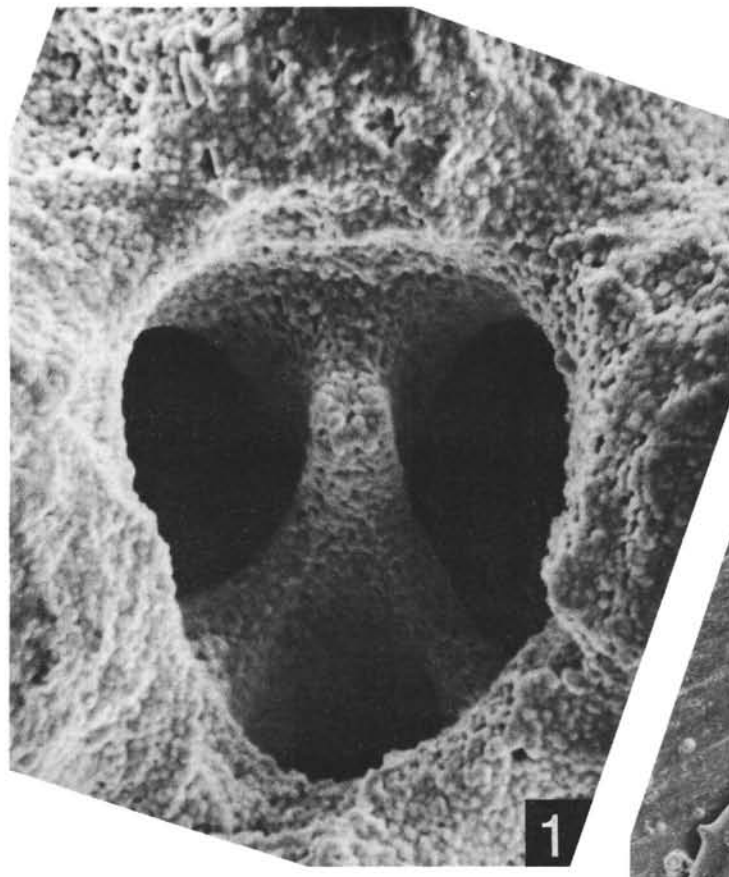


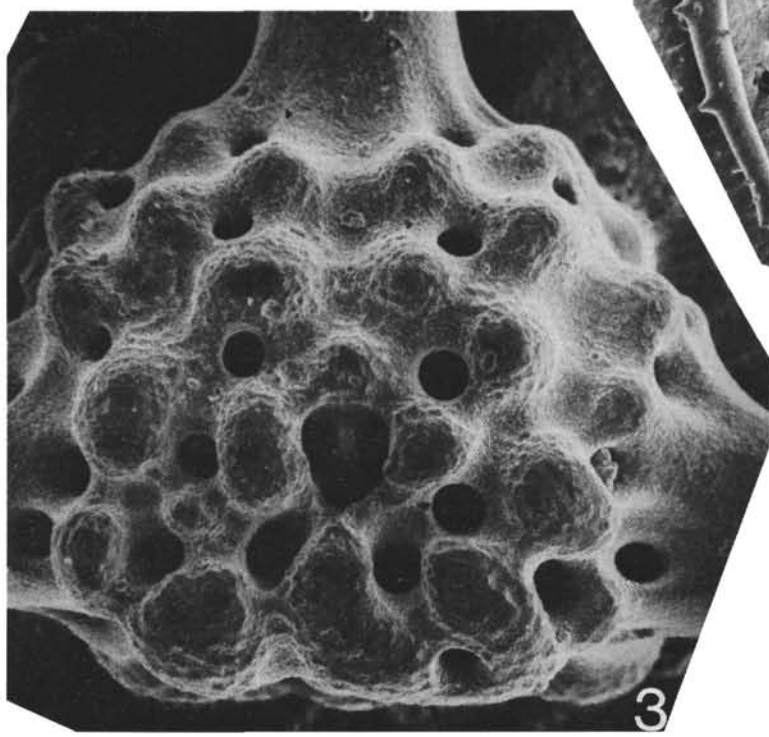
Figure 1 *Giraffospyris toxaria.*
Hole 78, Core 3, Section 4, 13-15 cm; front view, X515.

Figures 2, 3 *Dorcadospyris costatescens.*
Hole 78, Core 33, core catcher.
1: Front view: X500. 2: Front view: X540.

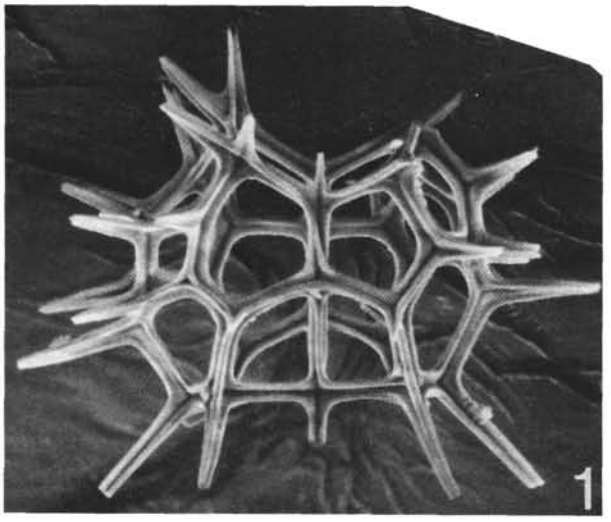


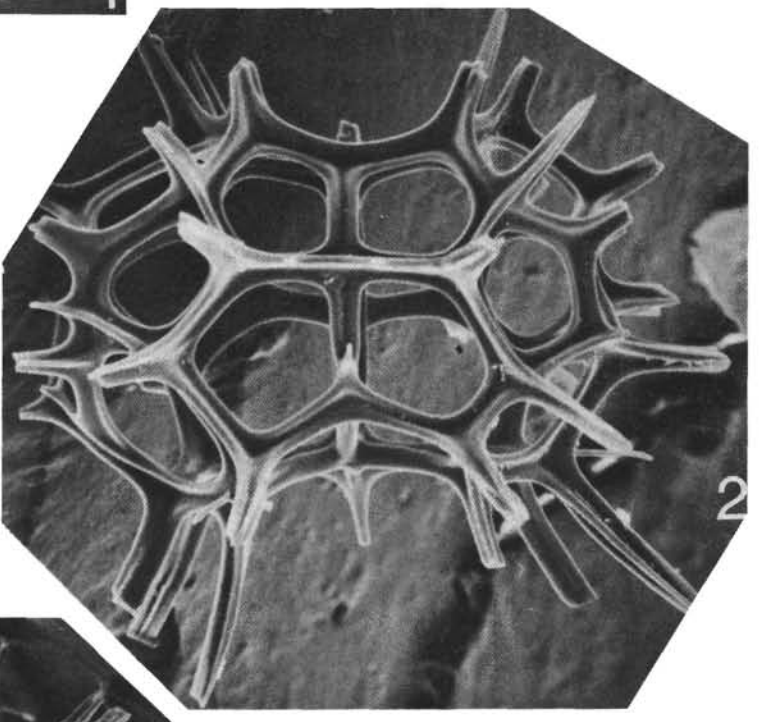
Figures 1-3 *Dorcadospyris dentata.*
Hole 79A, Core 2, Section 4, 21-23 cm; front view;
X215, X1080 and X5800.

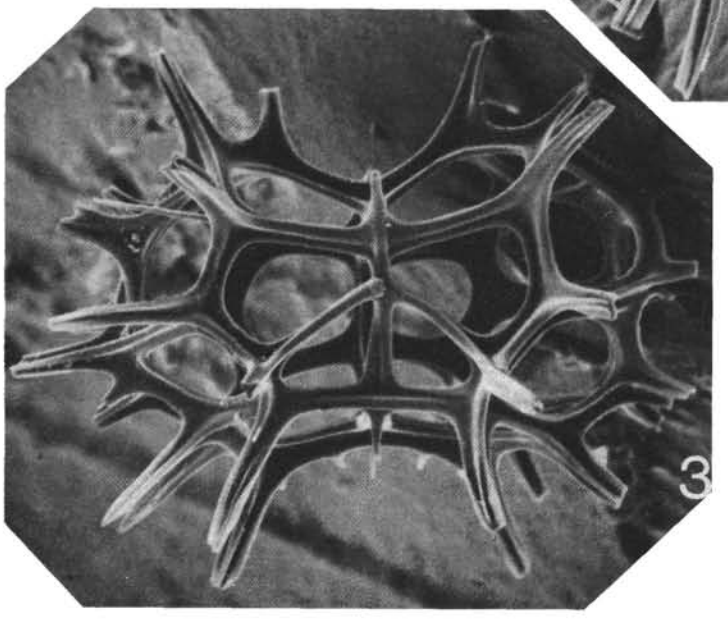




Figures 1-3 *Dorcadospyris dentata.*
Hole 79A, Core 2, Section 4, 21-23 cm; X4900, X195 and X980, respectively.







Figures 1-3 *Dorcadospyris pentagona.*
1: Hole 77B, Core 2, Section 5, 0-2 cm; front view, X500.
2: Hole 77B, Core 5, Section 5, 0-2 cm; rear view, X540.
3: Hole 77B, Core 5, Section 5, 0-2 cm; basal view, X510.

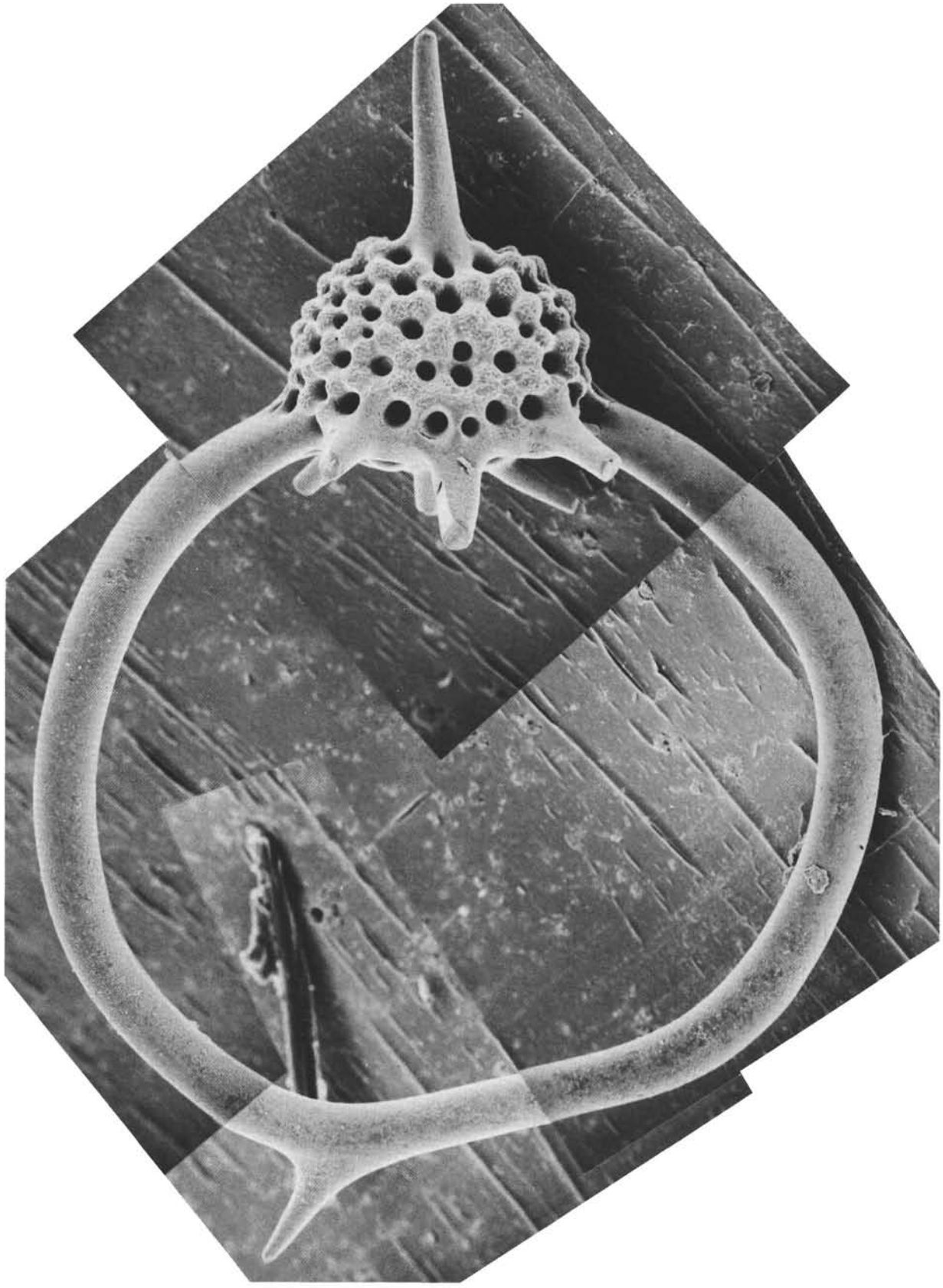
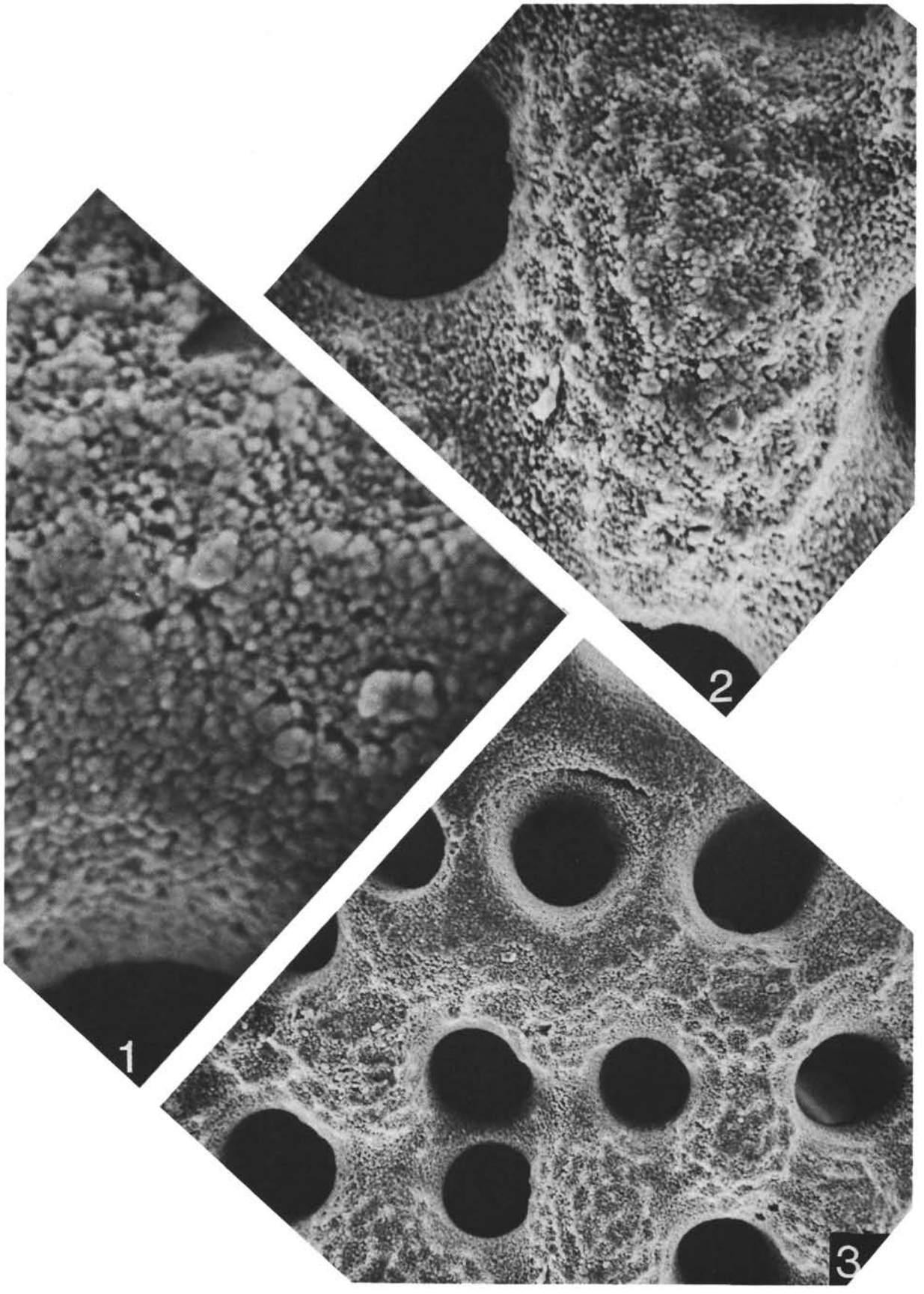


Figure 1 *Gamospyris circulus.*
Hole 78, Core 28, core catcher; front view, X430.



Figures 1-3 *Gamospyris circulus.*
Same specimen as Plate 59; X5000, X2000, and X1000, respectively.

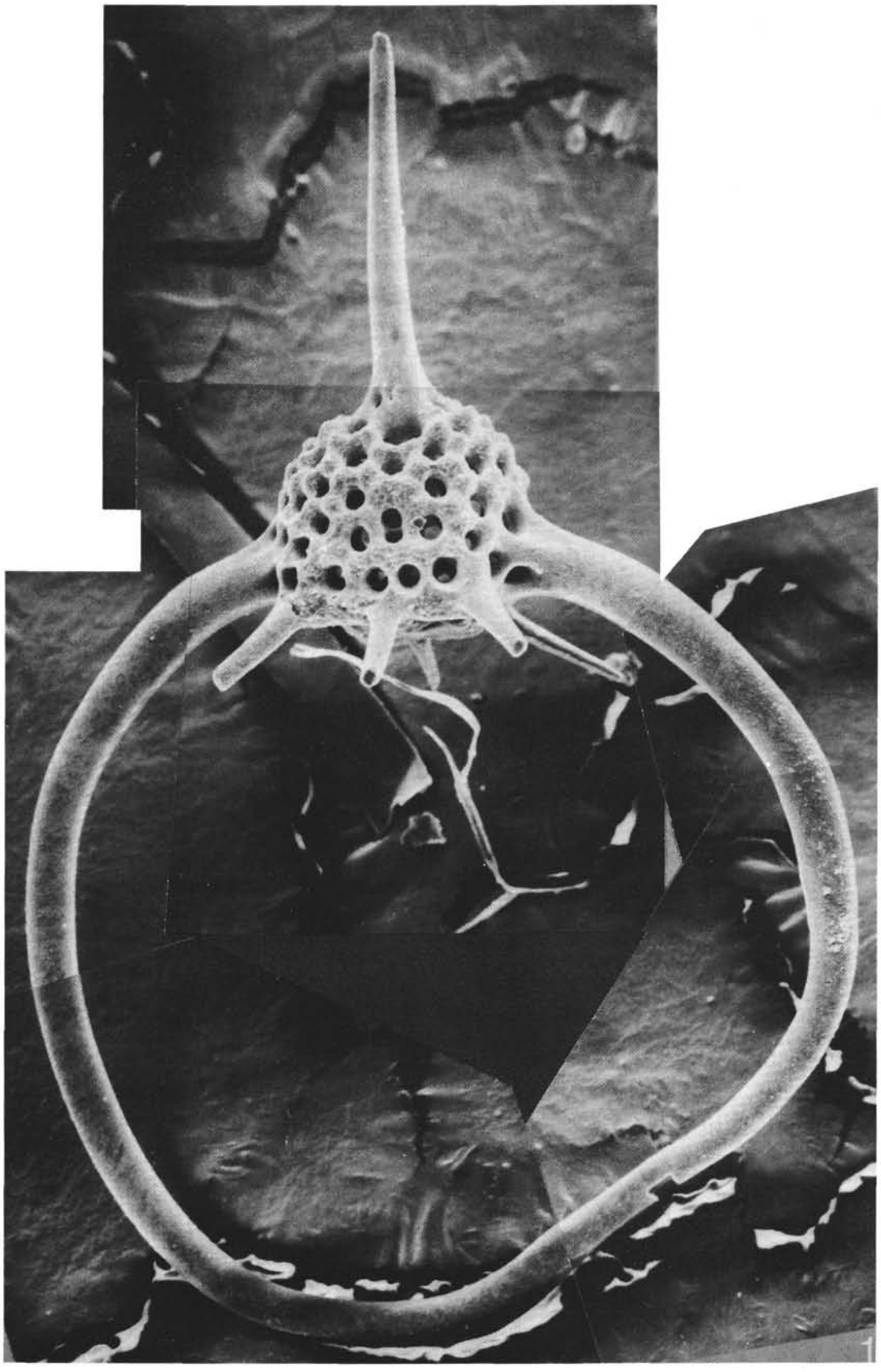
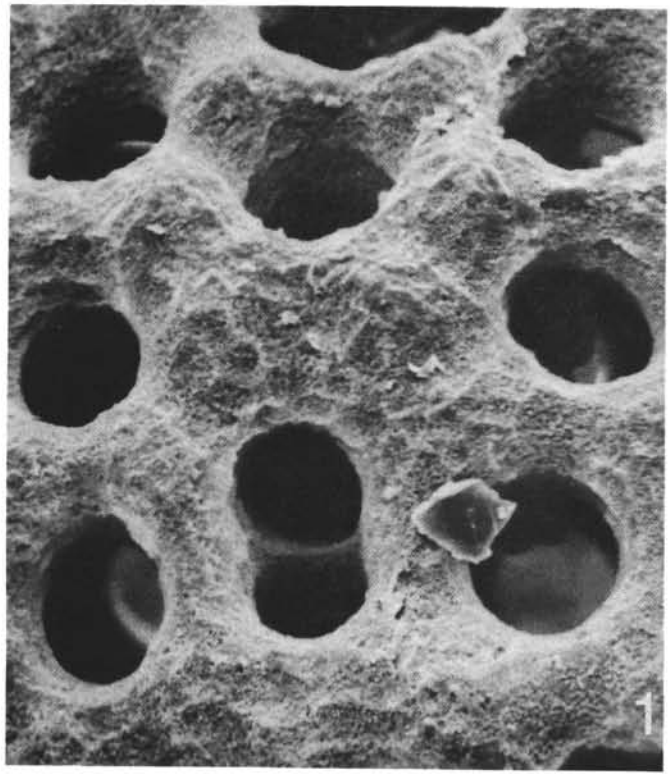
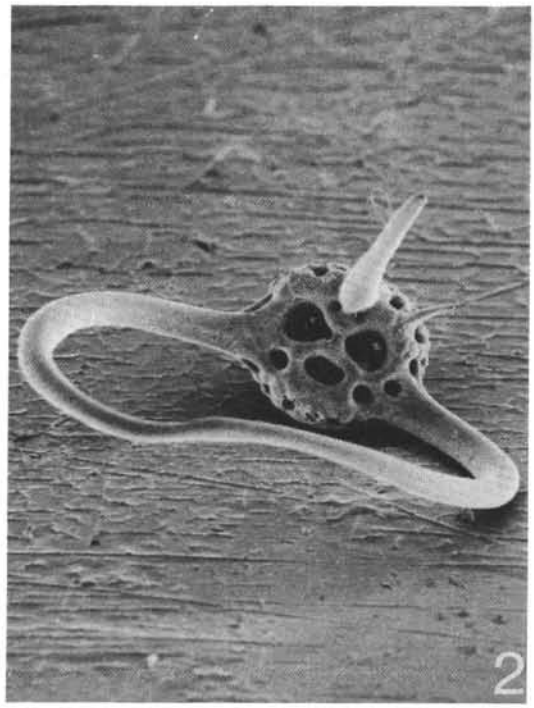
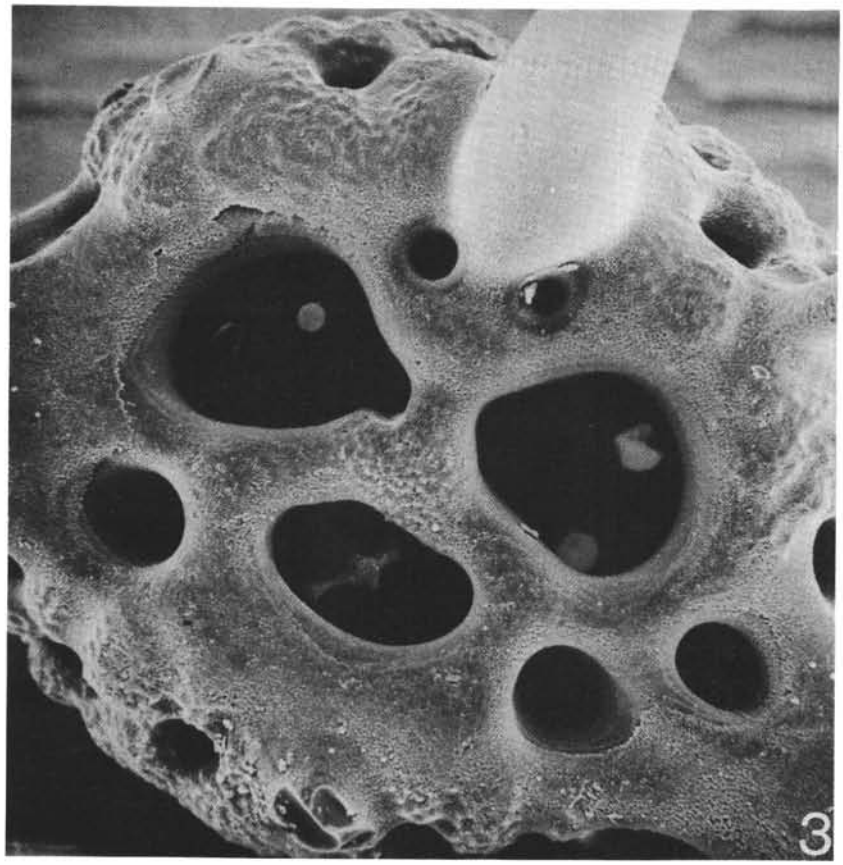


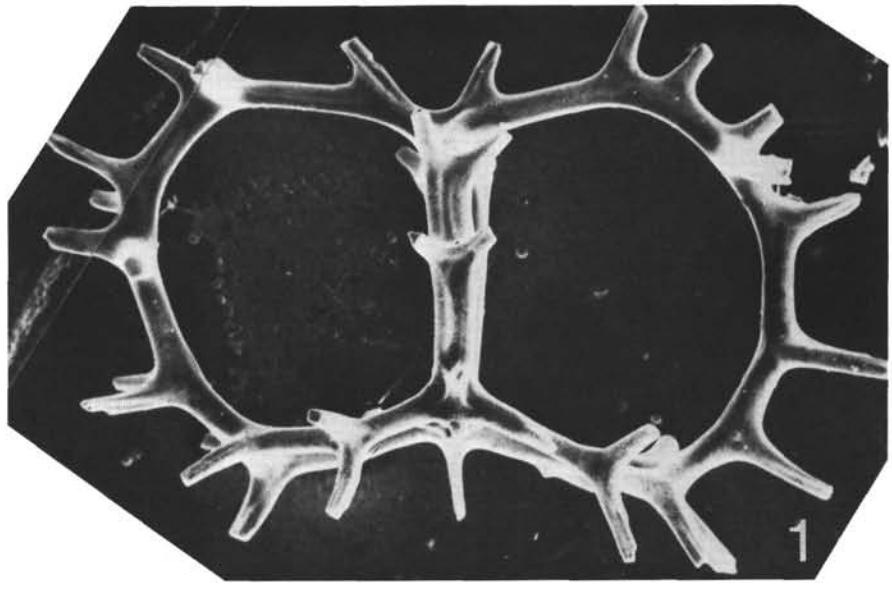
Figure 1 *Gamospyris circulus.*
Hole 77B, Core 43, Section 2, 113-115 cm; X410.

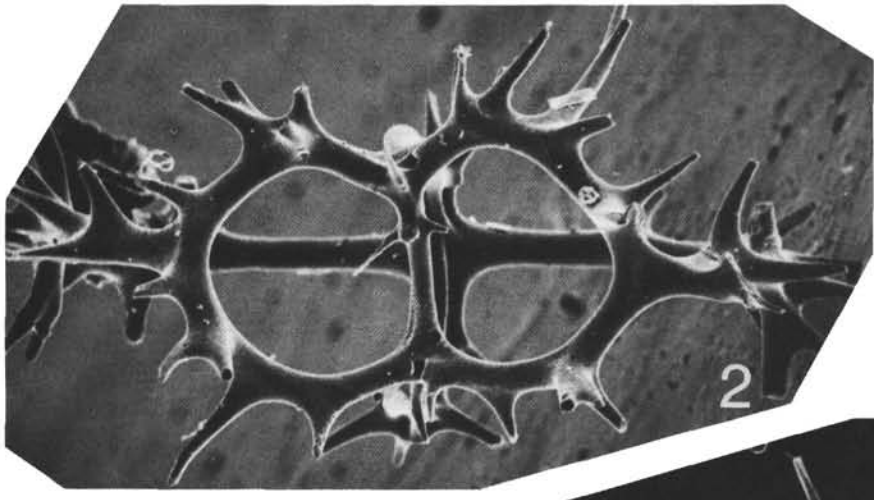


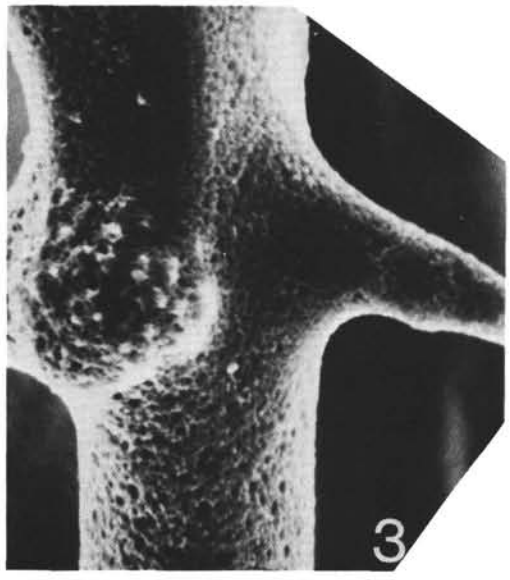


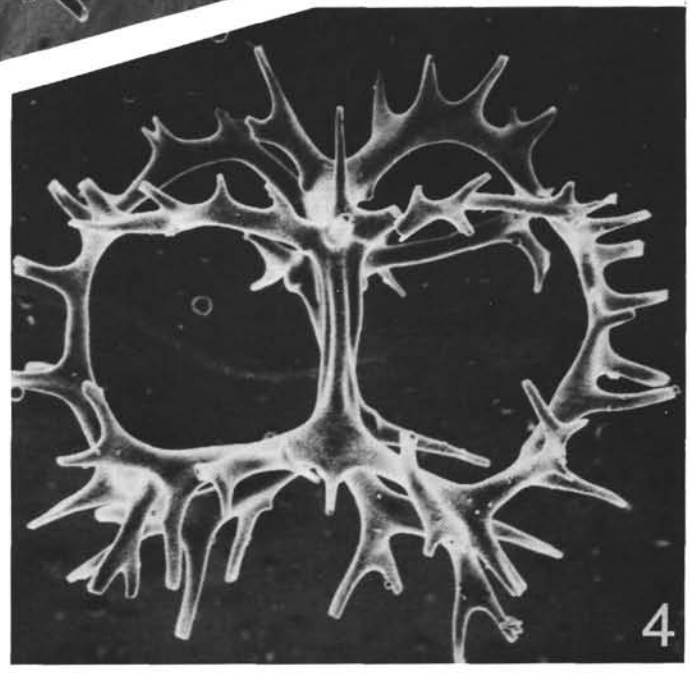


Figures 1-3 *Gamospyris circulus.*
1: Same specimen as Plate 61; X2100.
2 and 3: Hole 78, Core 28, core catcher; X200 and X1000, respectively.

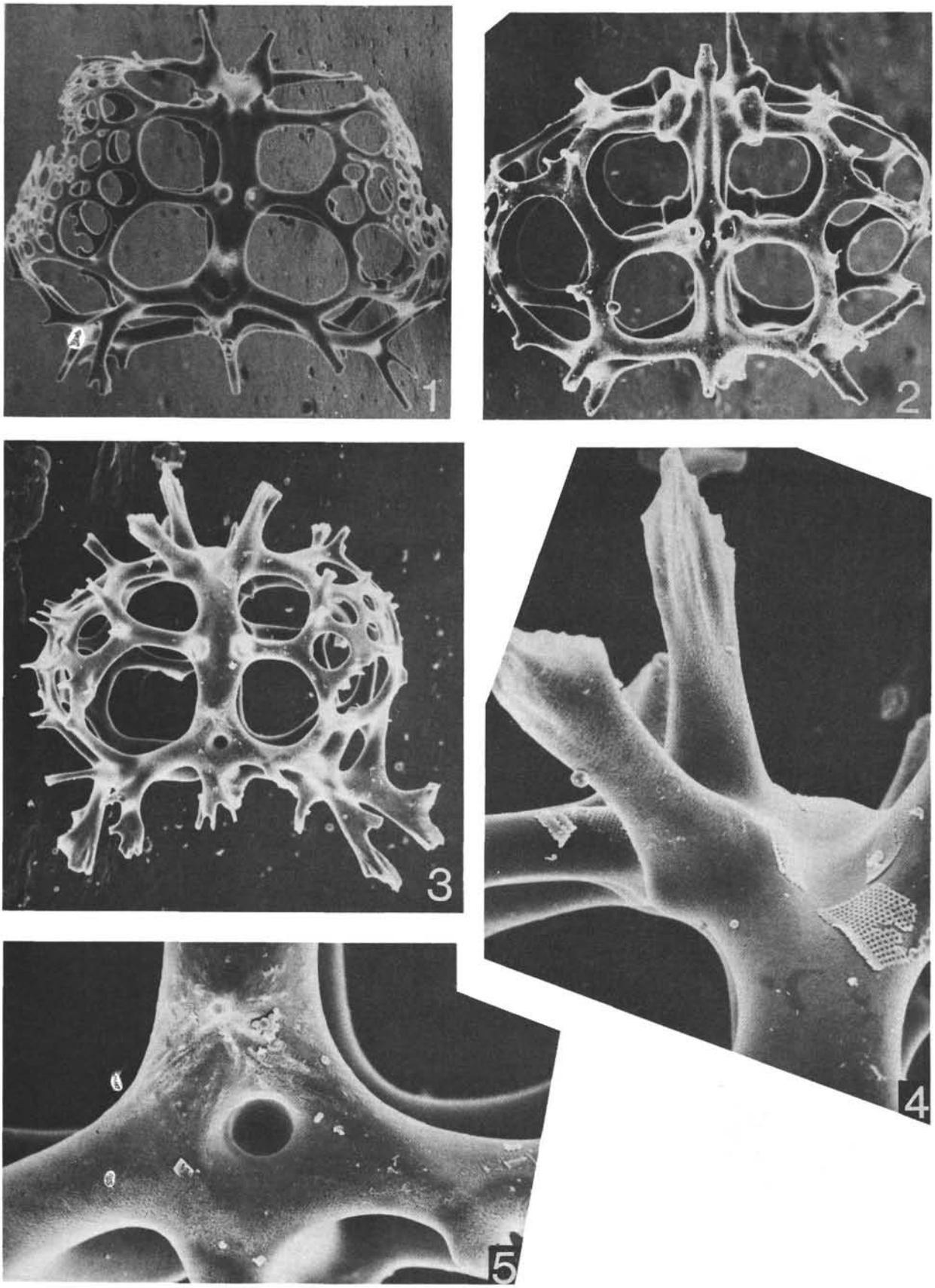




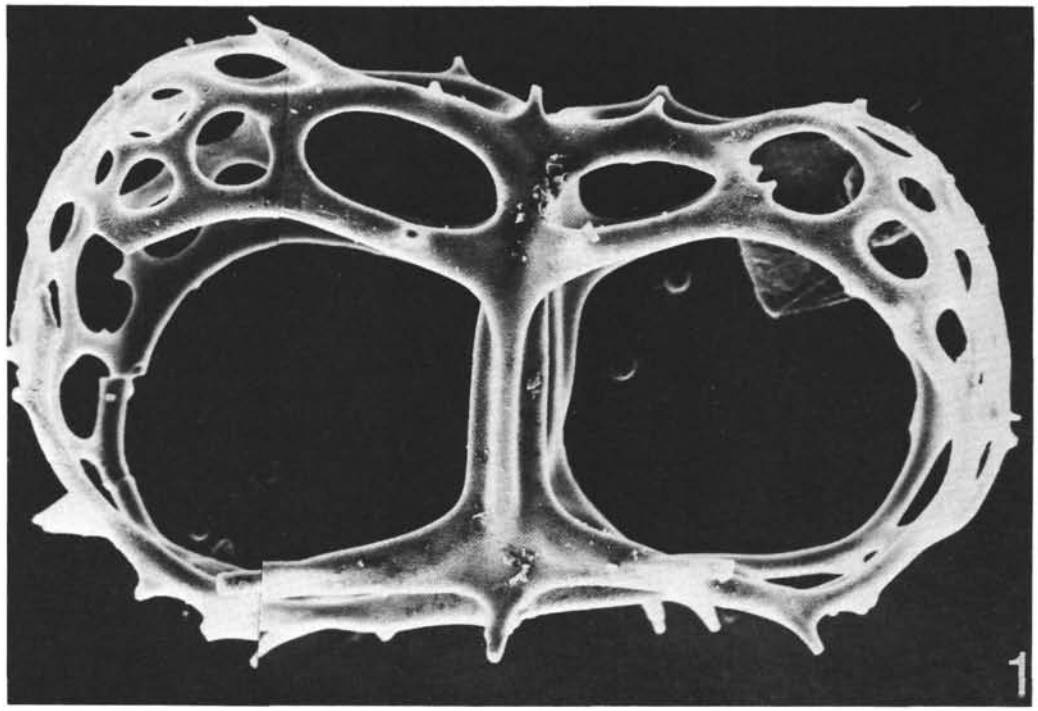


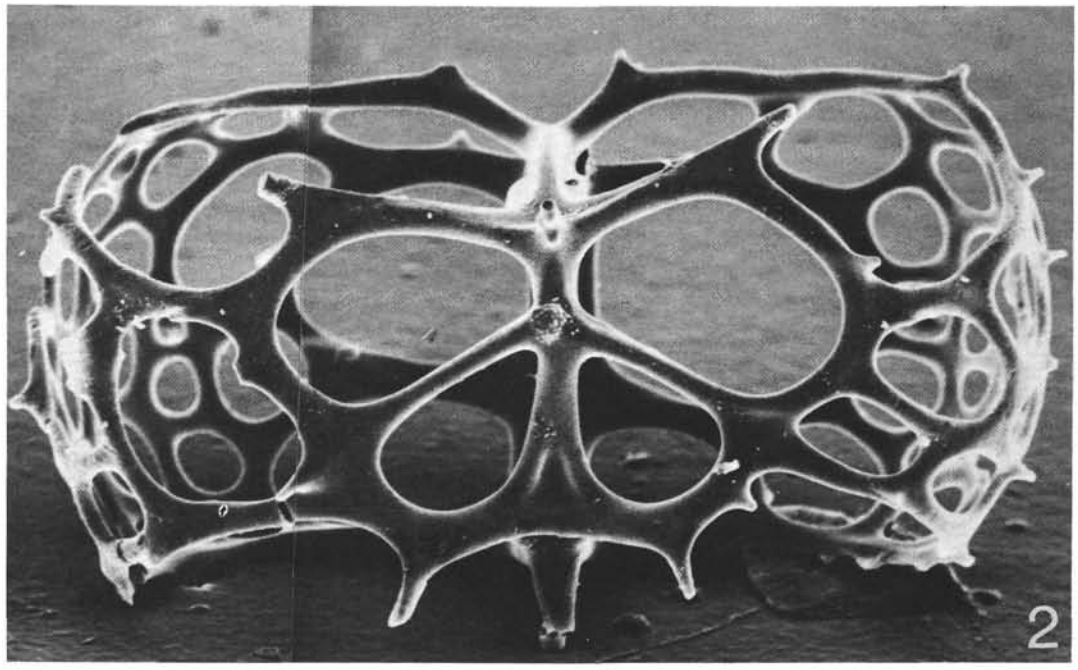


Figures 1-4 *Giraffospyris angulata.*
1: Hole 83A, Core 9, Section 2, 68-70 cm; rear view, X500.
2 and 3: Hole 77B, Core 14, Section 3, 0-2 cm; basal view; X500 and X5000, respectively.
4: Hole 77B, Core 14, Section 3, 0-2 cm; front view, X500.

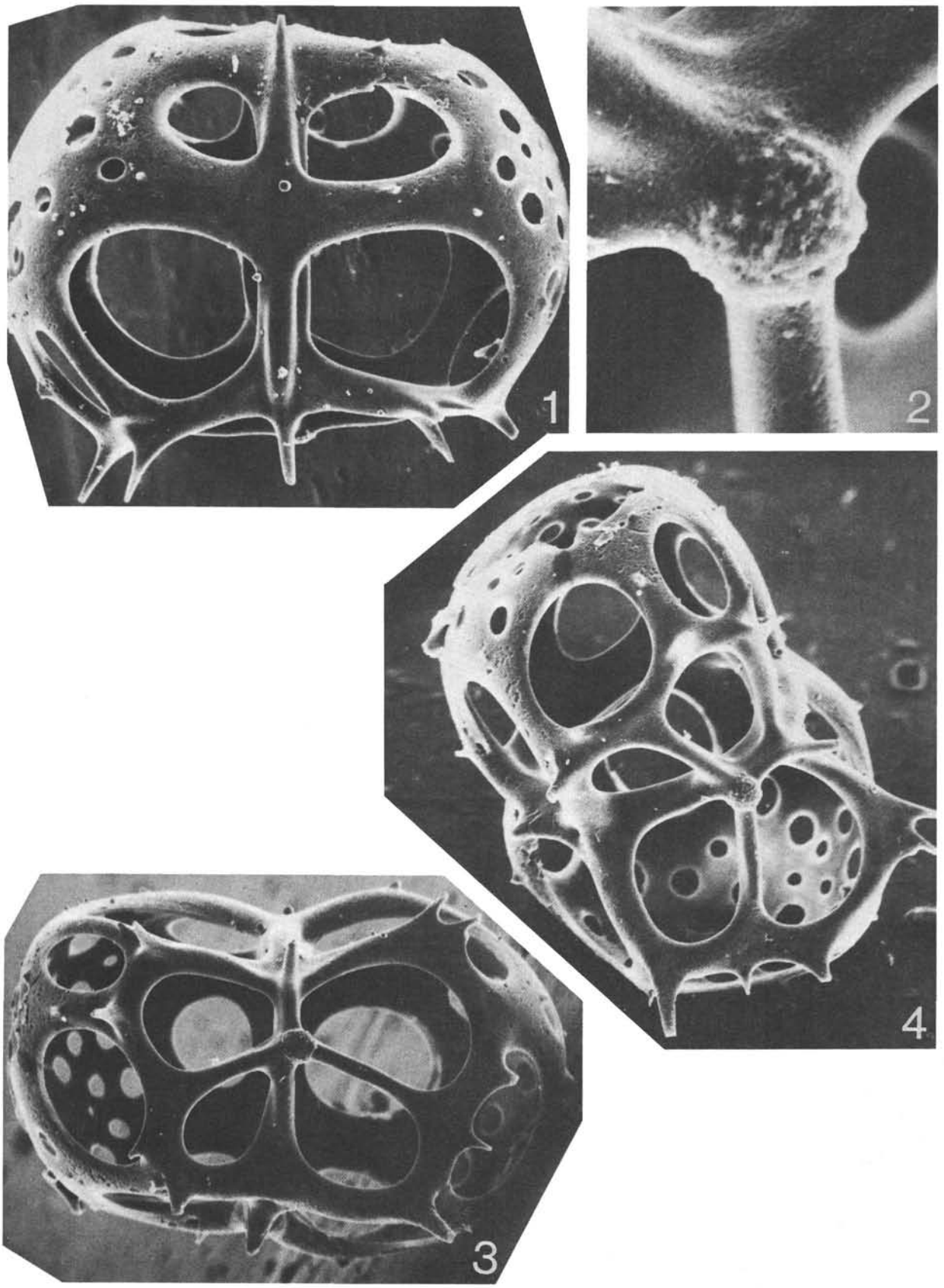


Figures 1-5 *Giraffospyris annulispina.*
1 and 2: Hole 78, Core 9, Section 3, 0-2 cm; rear view, ×500 and front view ×500, respectively.
3, 4 and 5: Hole 77B, Core 14, Section 3, 0-2 cm; rear view; ×500, ×2000 and ×2000, respectively.

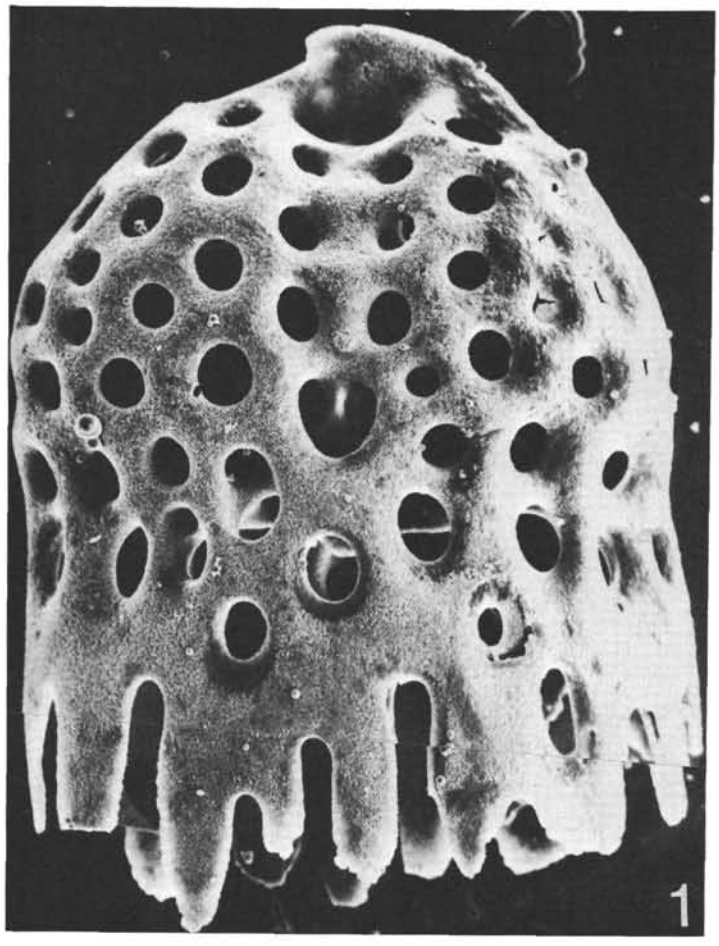


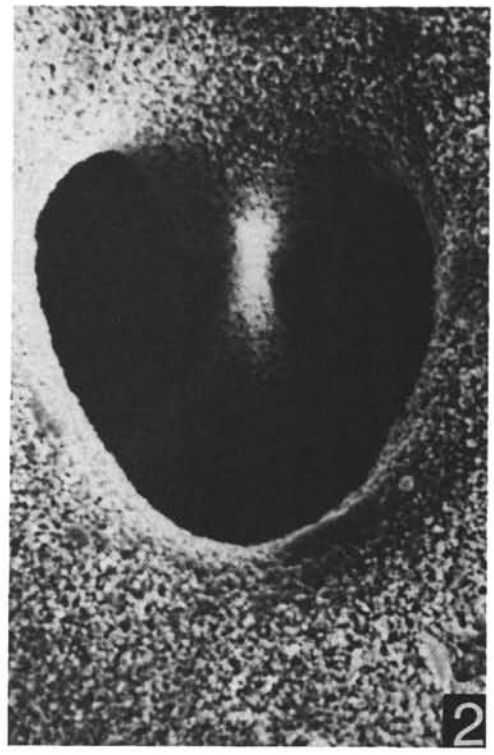


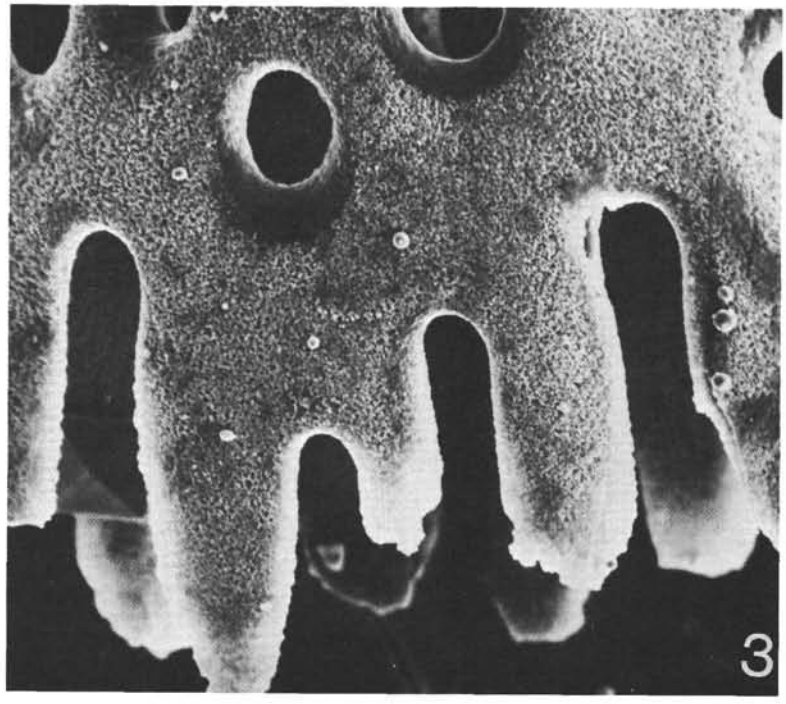
Figures 1, 2 *Giraffospyris laterispina.*
Hole 83A, Core 9, Section 2, 68-70 cm; X1000.
1: Front view.
2: Basal view.



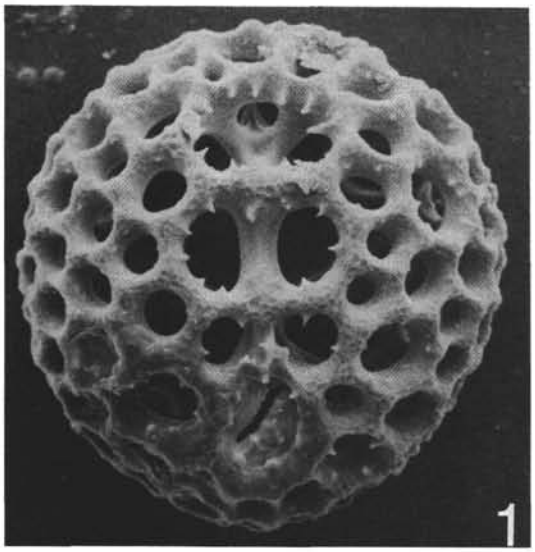
Figures 1-4 *Giraffospyris laterispina.*
Hole 77B, Core 12, Section 6, 17-19 cm. 1: Front view; X1000.
2 and 4: Oblique view of basal ring showing sculptured axial tubercule; X5000 and X1000, respectively.
3: Basal view, X1000.

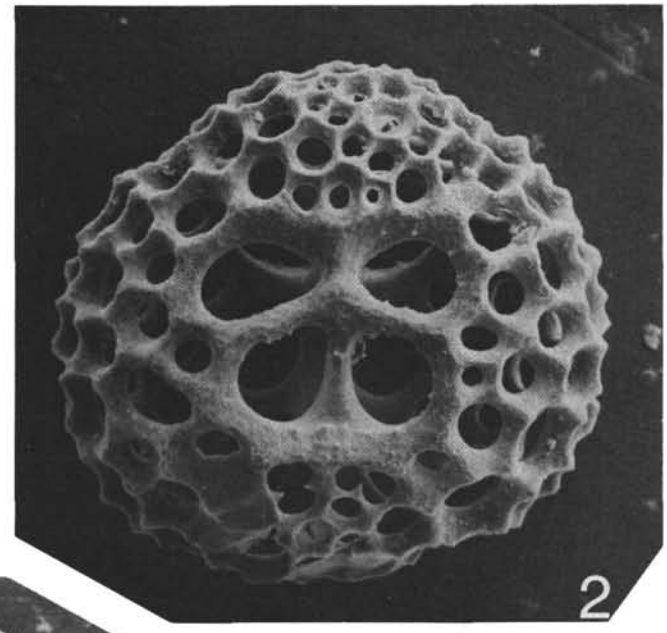


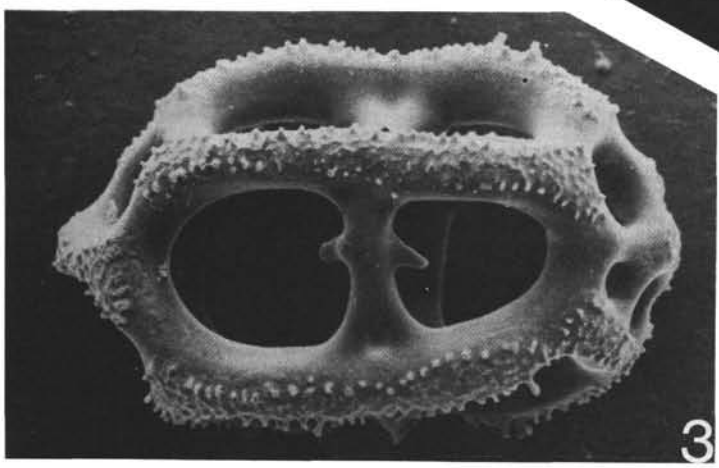


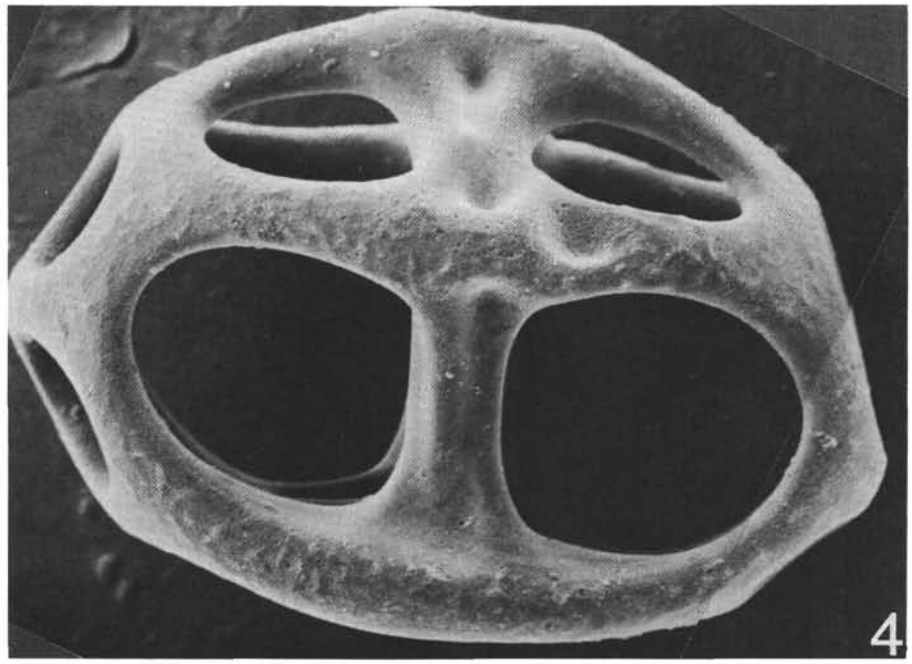


Figures 1-3 *Gorgospyris schizopodia.*
Hole 78, Core 9, Section 3, 0-2 cm; rear view; X1000, X5000 and X2000, respectively.



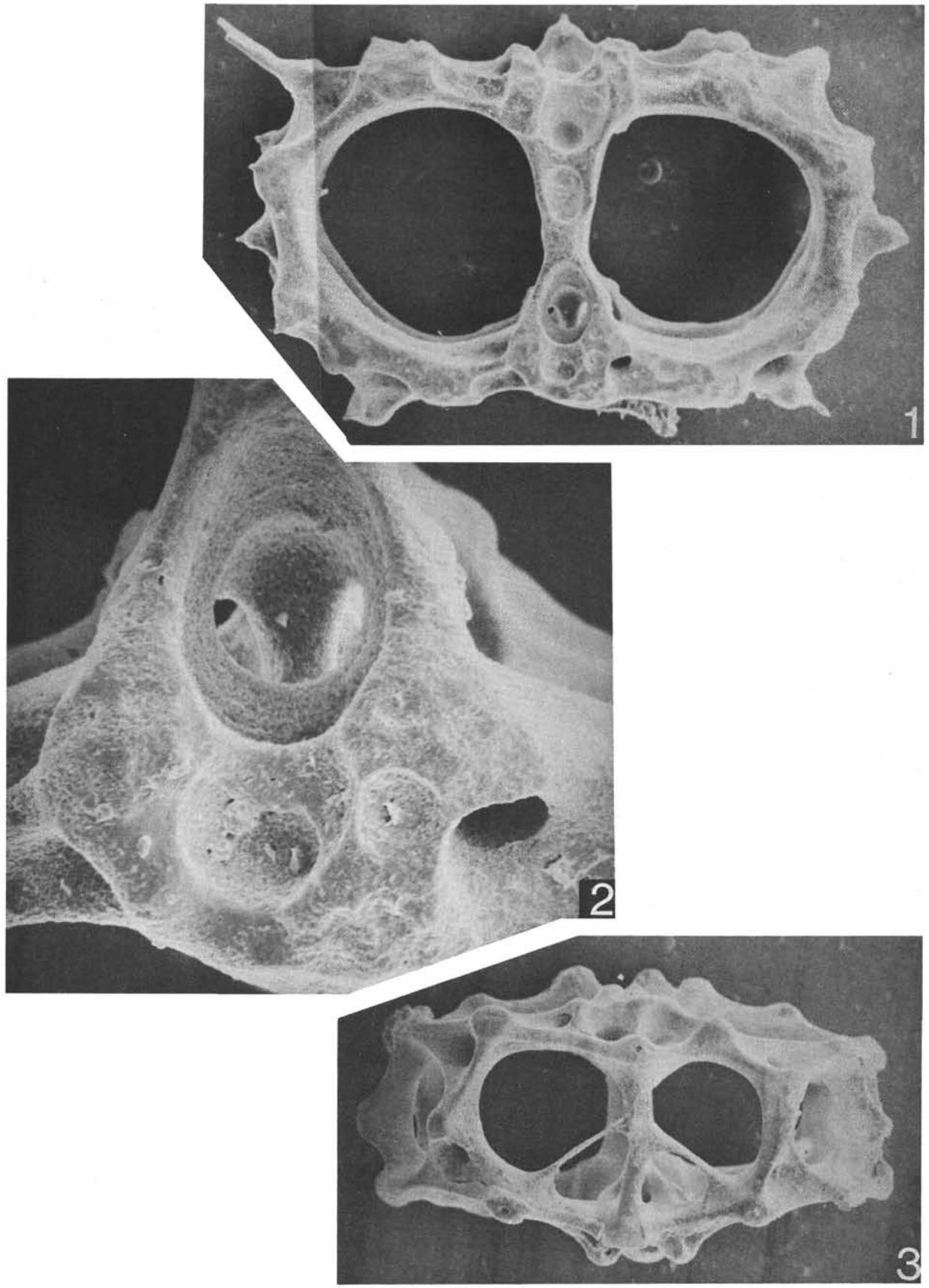






Figures 1, 2 *Liriospyris globosa.* Hole 77B, Core 27, Section 6, 17-19 cm.
1: Apical view; X500. 2: Basal view; X500.

Figures 3, 4 *Liriospyris elevata.* Hole 80A, Core 3, Section 4, 20-22 cm.
1: Basal view; X500. 2: Front view; X1000.



Figures 1-3 *Liriospyris longicornuta.*
Hole 78, Core 36, core catcher.
1 and 2: Rear view; X490 and X1960, respectively.
3: Basal view; X500.

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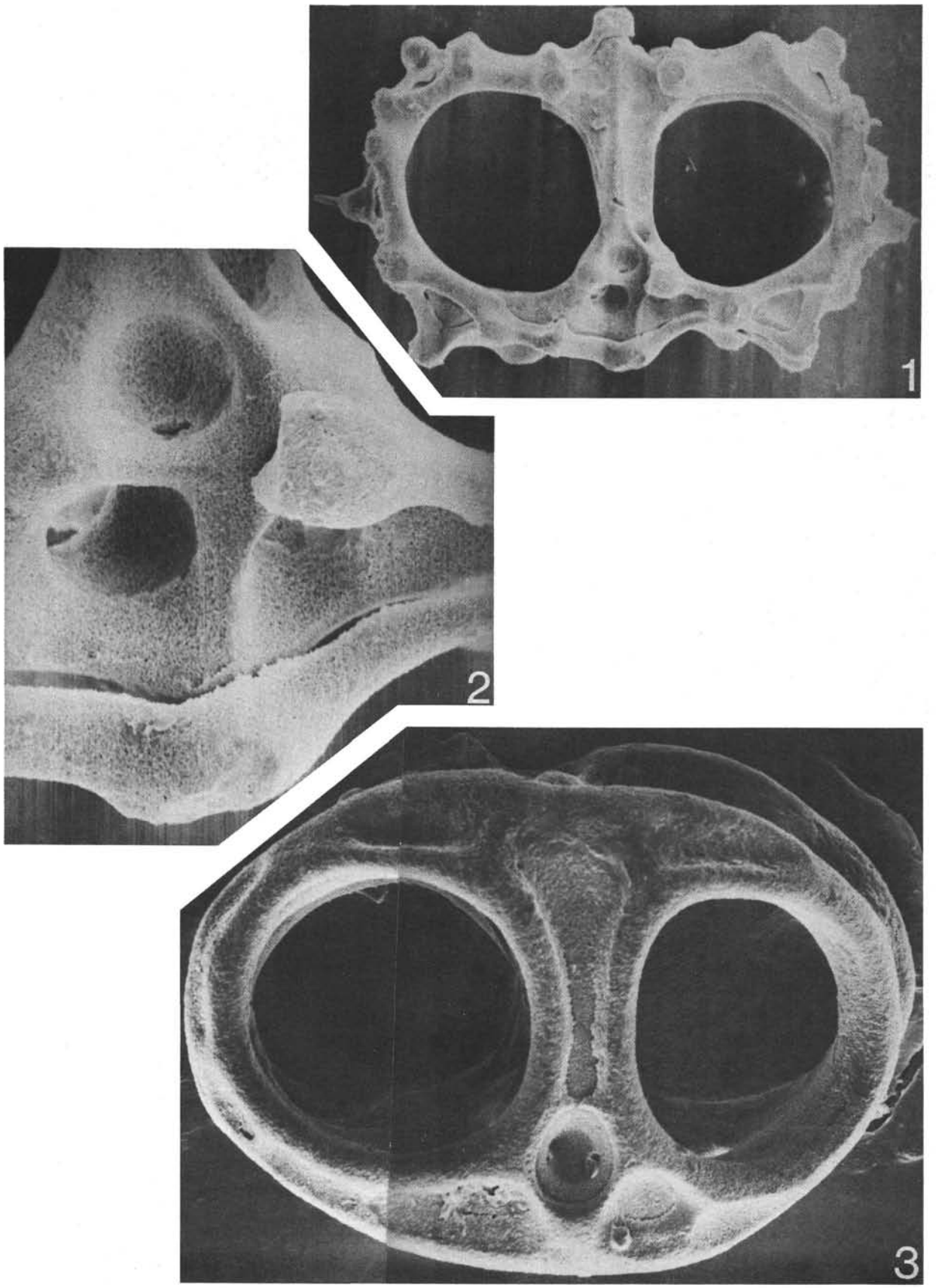


Figures 1, 2 *Liriospyris longicornuta.*
Hole 78, Core 36, core catcher; front view, X490 and X1950, respectively.

Figure 3 *Liriospyris stauropora.*
Hole 78, Core 3, Section 4, 13-15 cm; front view, X1025.

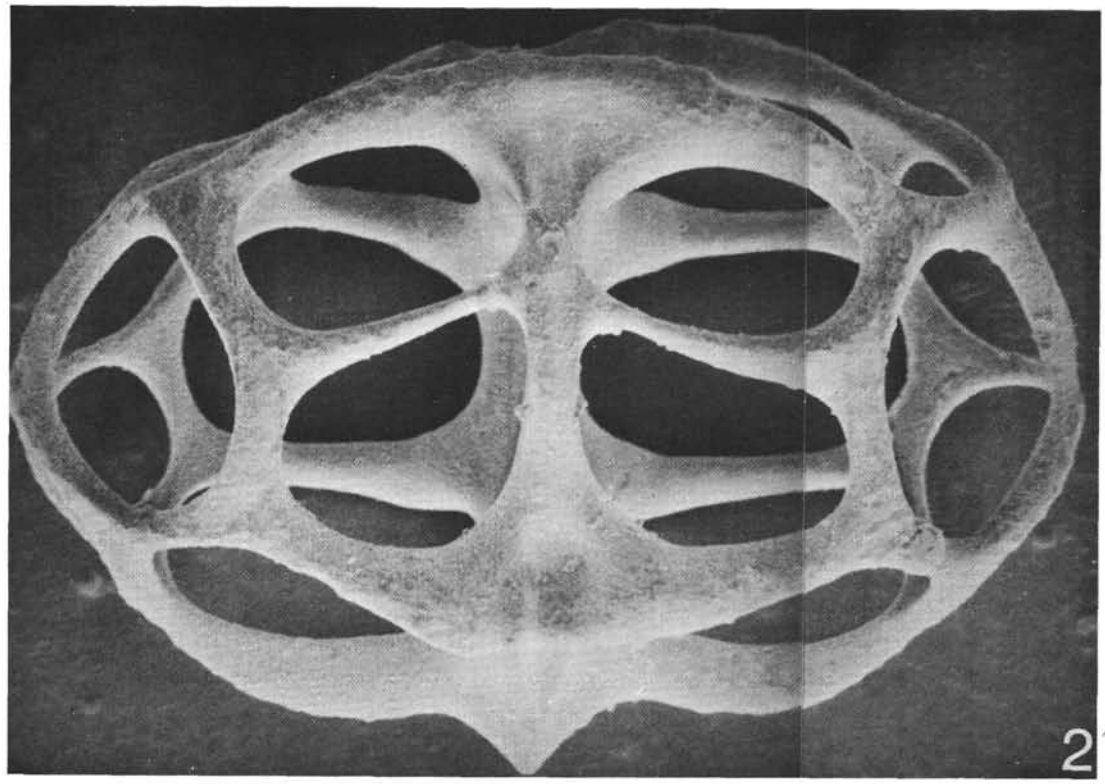
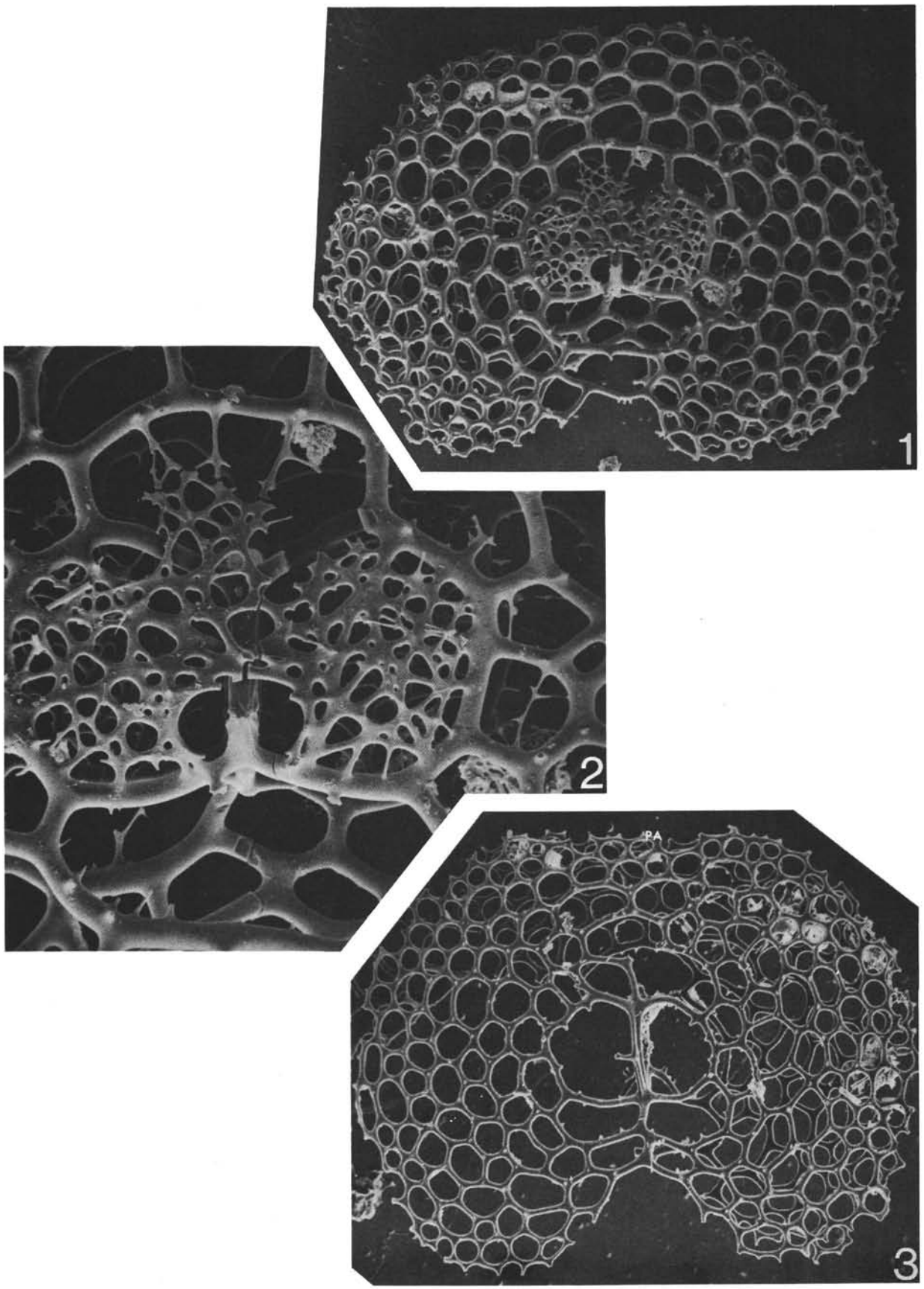
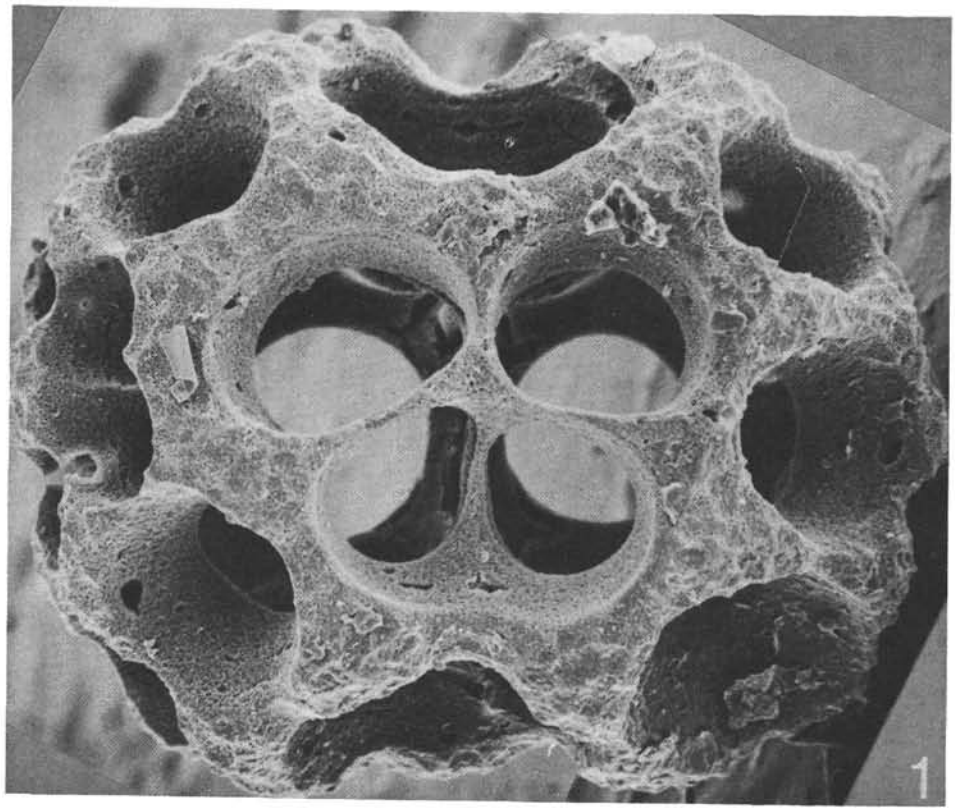


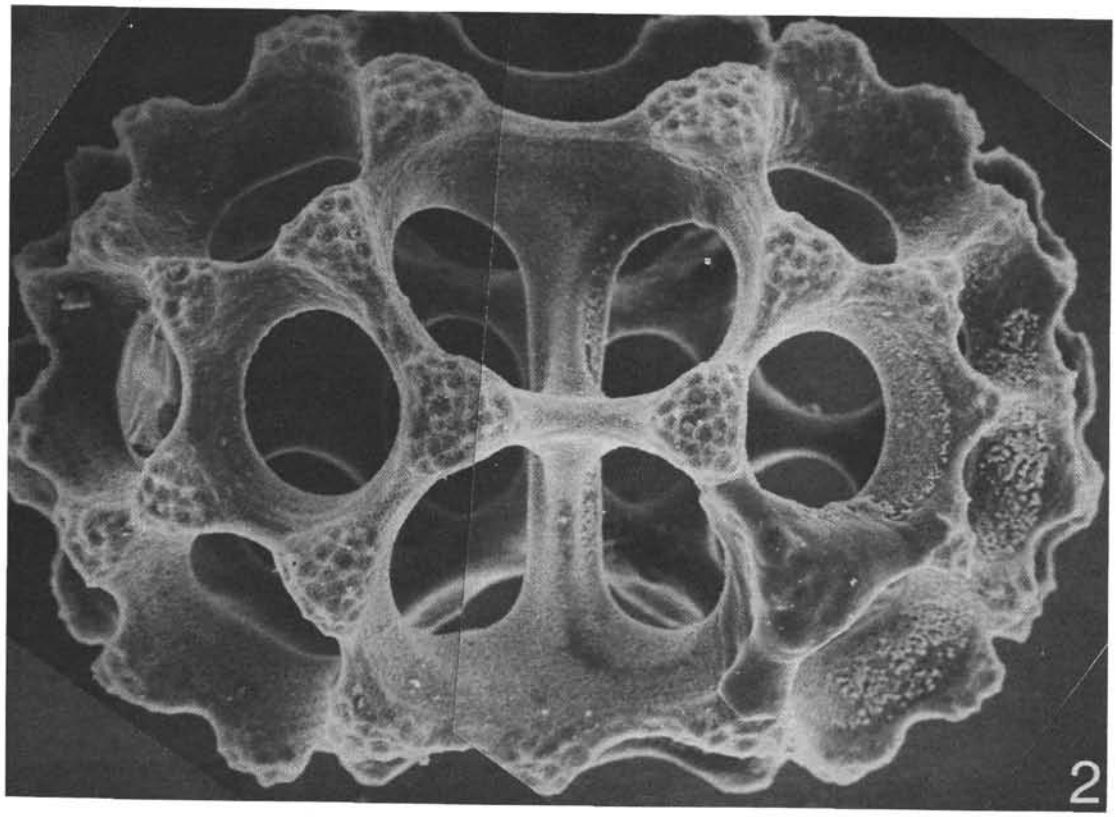
Figure 1 *Liriospyris reticulata.*
Hole 80, Core 1, core catcher; apical view, ×500.

Figure 2 *Liriospyris mutuaria.*
Hole 78, Core 24, core catcher; basal view, ×1000.

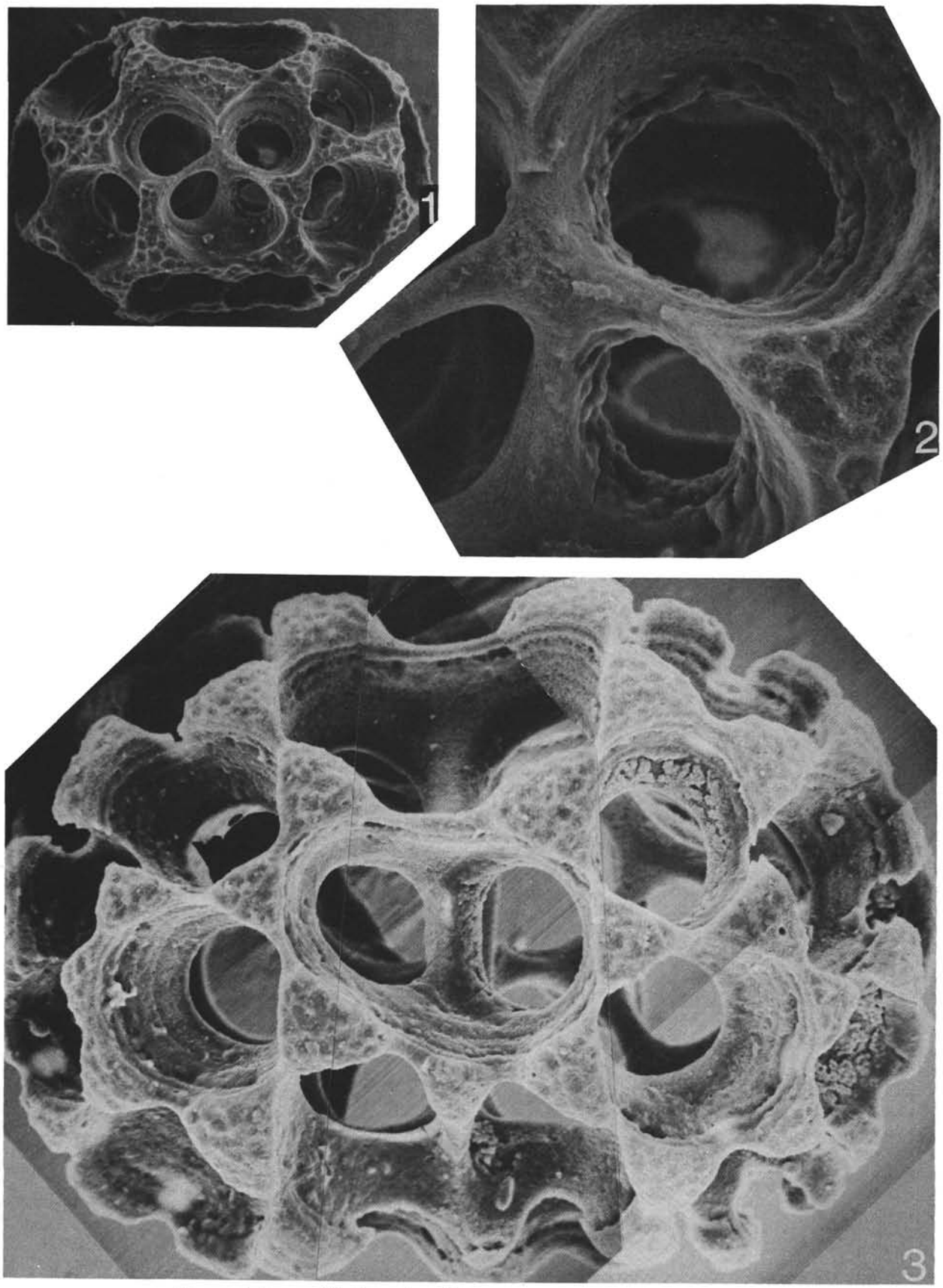


Figures 1-3 *Nephrospyris renilla.*
Hole 82, Core 2, Section 3, 0-2 cm.
1 and 2: Rear view; X190 and X475, respectively.
3: Front view; X200.

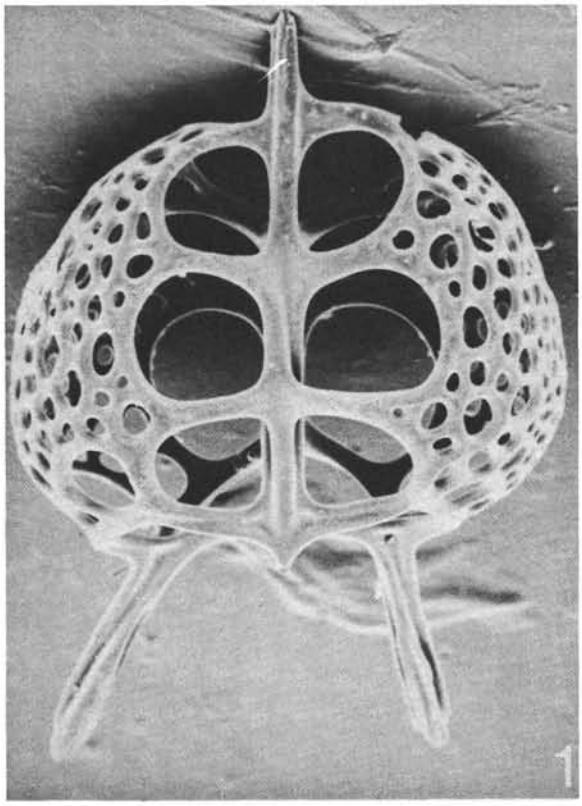


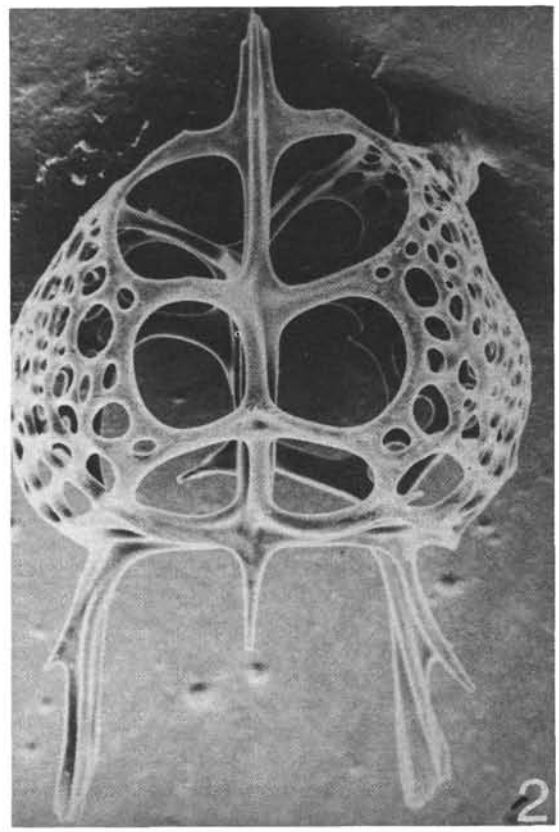


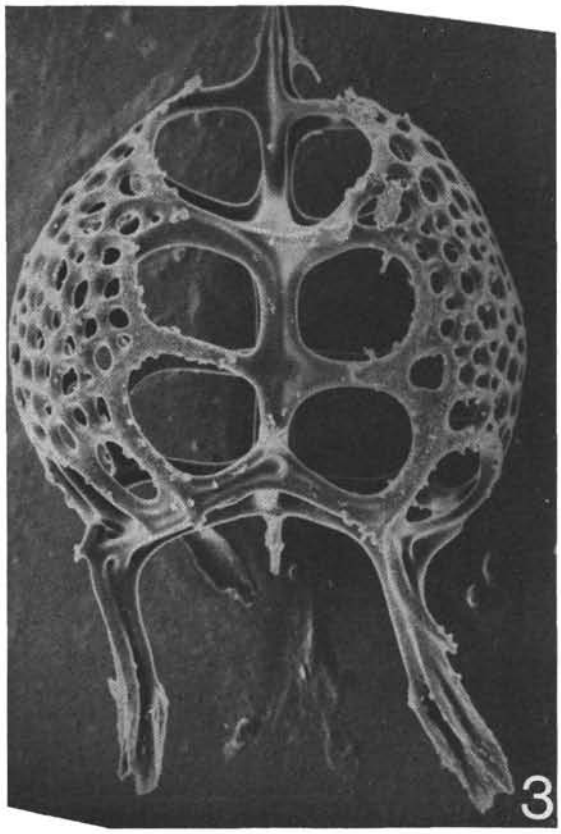
Figures 1, 2 *Tholospyris anthopora.*
1: Hole 77B, Core 36, core catcher; basal view, ×1000.
2: Hole 77B, Core 34, core catcher; front view, ×1000.

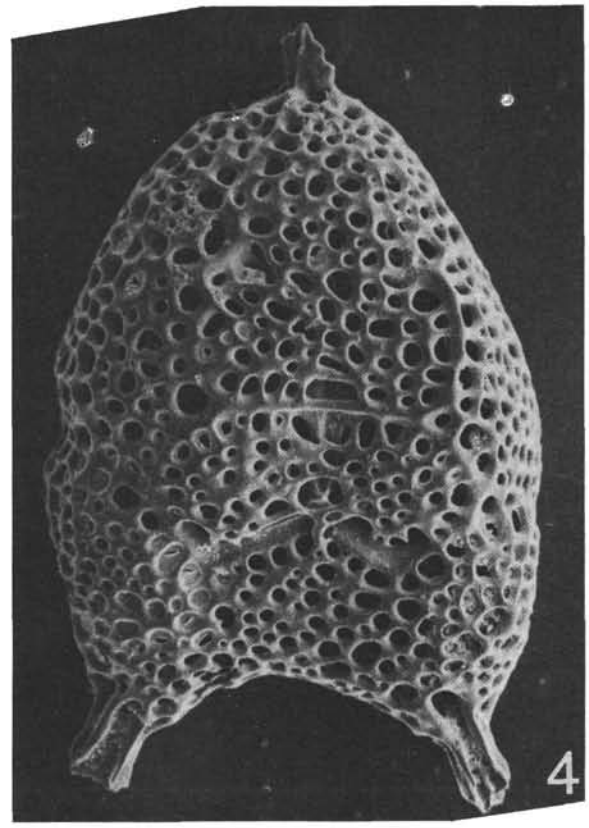


Figures 1-3 *Tholospyris anthopora.*
Hole 77B, Core 34, core catcher.
1 and 2: Basal view; X200 and X1000, respectively.
3: Rear view, X1000.



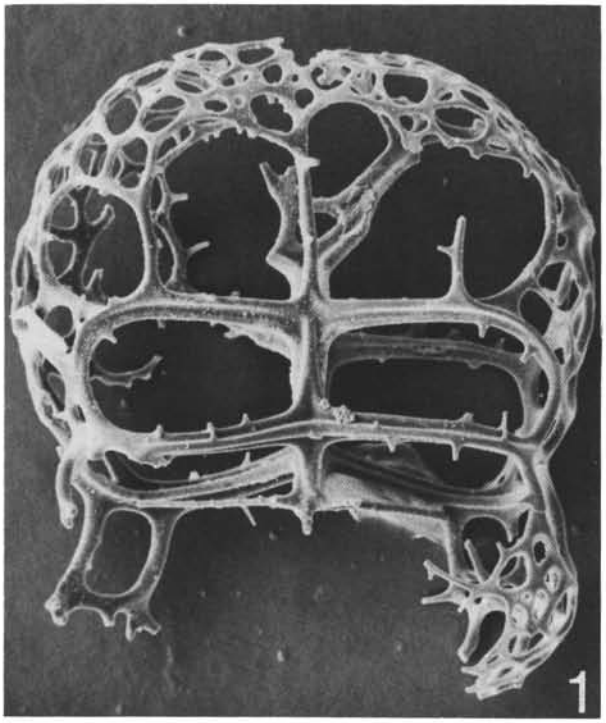


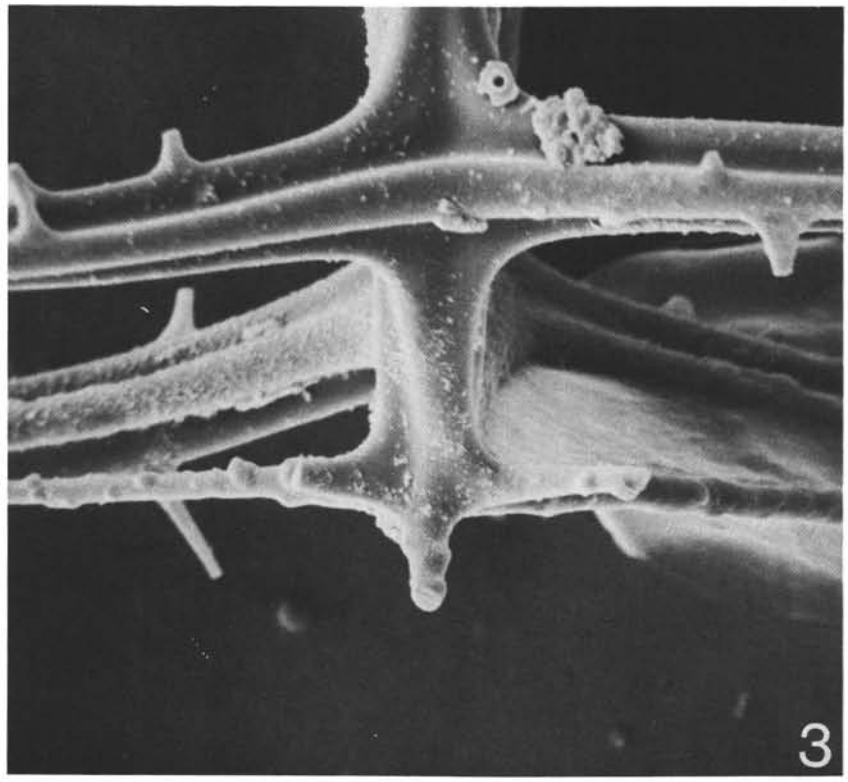




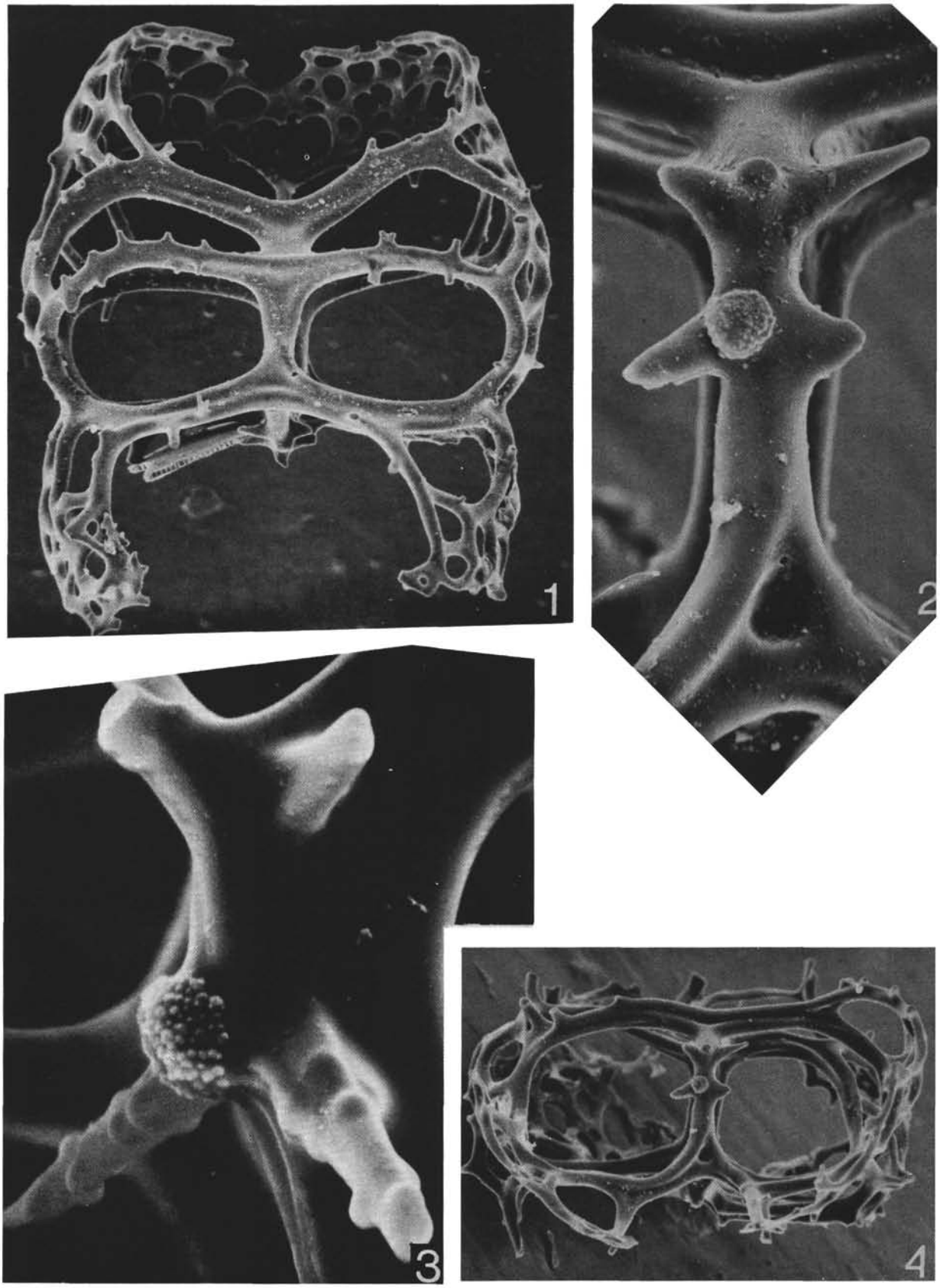
Figures 1-4 *Tholospyris cortinisca.*

1: Hole 77B, Core 12, core catcher; front view, X500.
2: Hole 78, Core 24, core catcher; front view, X505.
3: Hole 78, Core 24, core catcher; rear view, X495.
4: Hole 80A, Core 2, Section 4, 18-20 cm; rear view, X495.

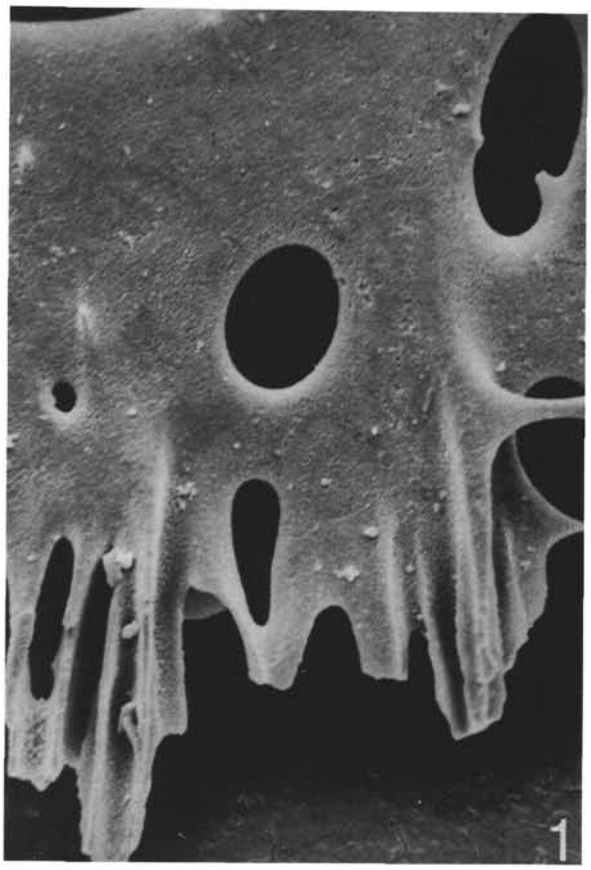


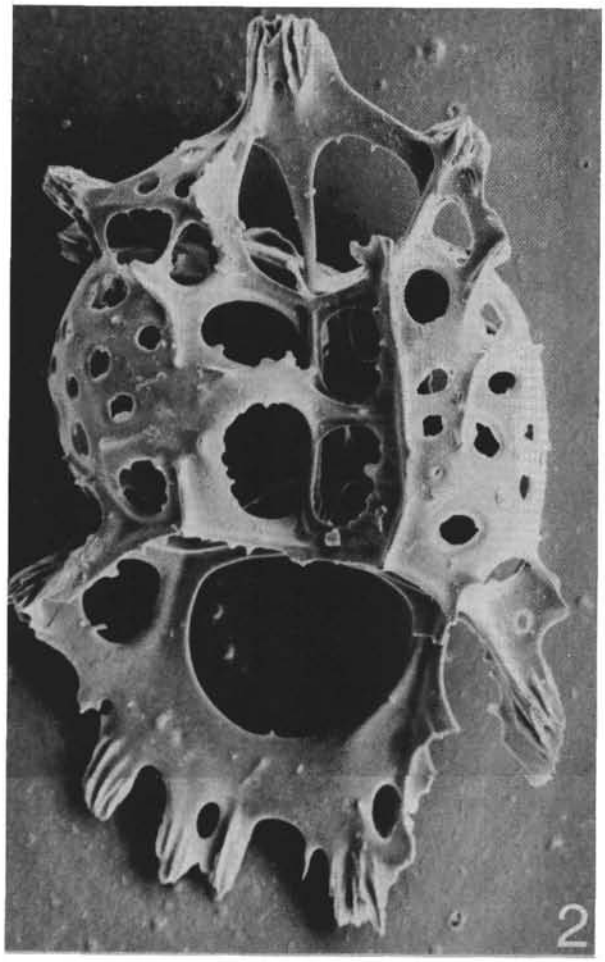


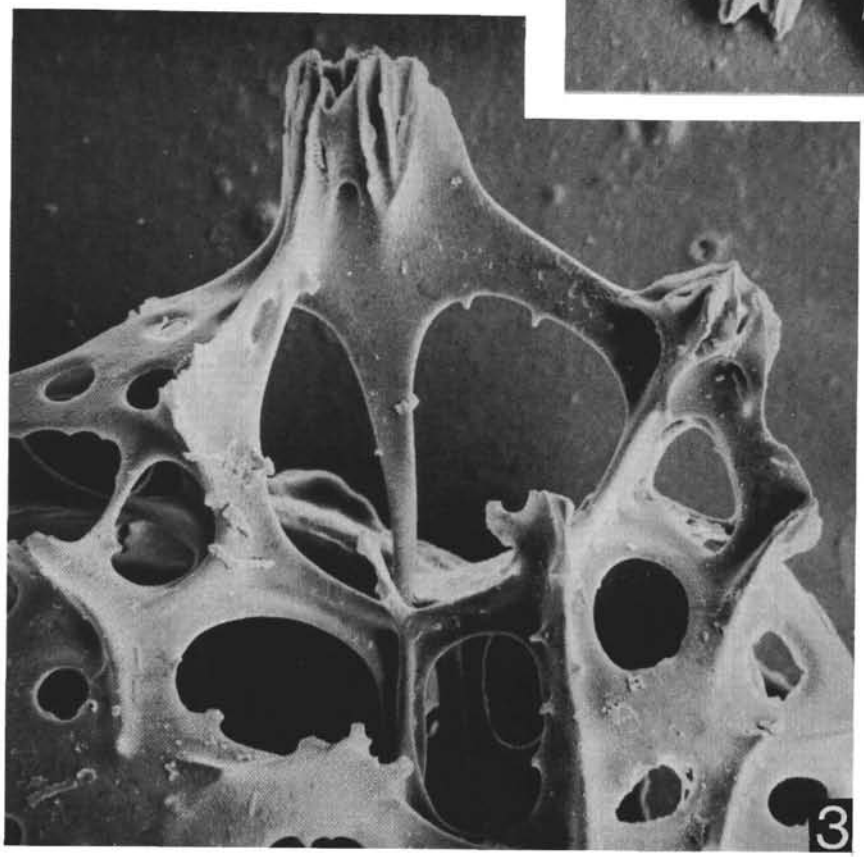
Figures 1-3 *Tholospyris devexa.*
Hole 80, Core 1, core catcher.
1 and 3: Front view; ×500 and ×2000, respectively.
2: Front view; ×500.



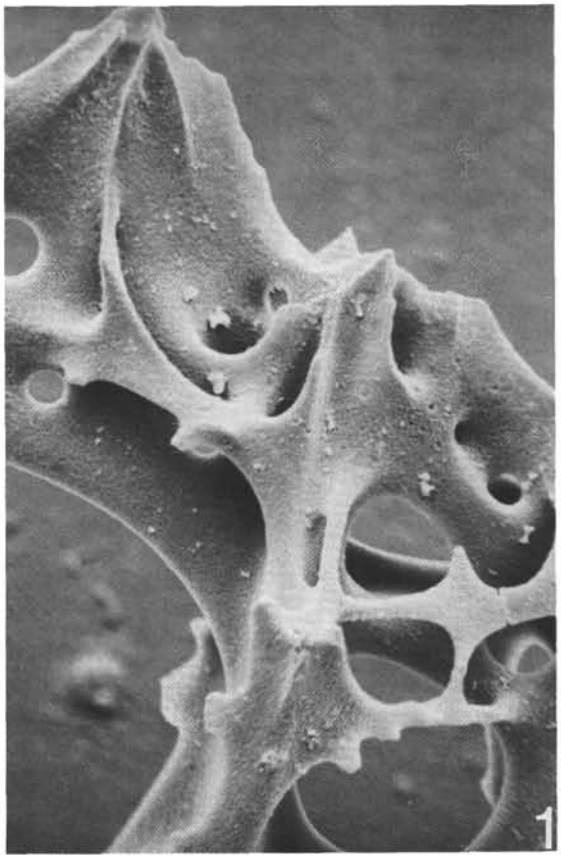
Figures 1-4 *Tholospyris devexa.* 1: Hole 80, Core 1, core catcher; rear view, X500.
2 and 4: Hole 80, Core 1, core catcher; basal view; X2000 and X500, respectively.
3: Hole 77B, Core 2, Section 5, 0-2 cm; oblique view of base of sagittal ring showing sculptured axial tubercule.

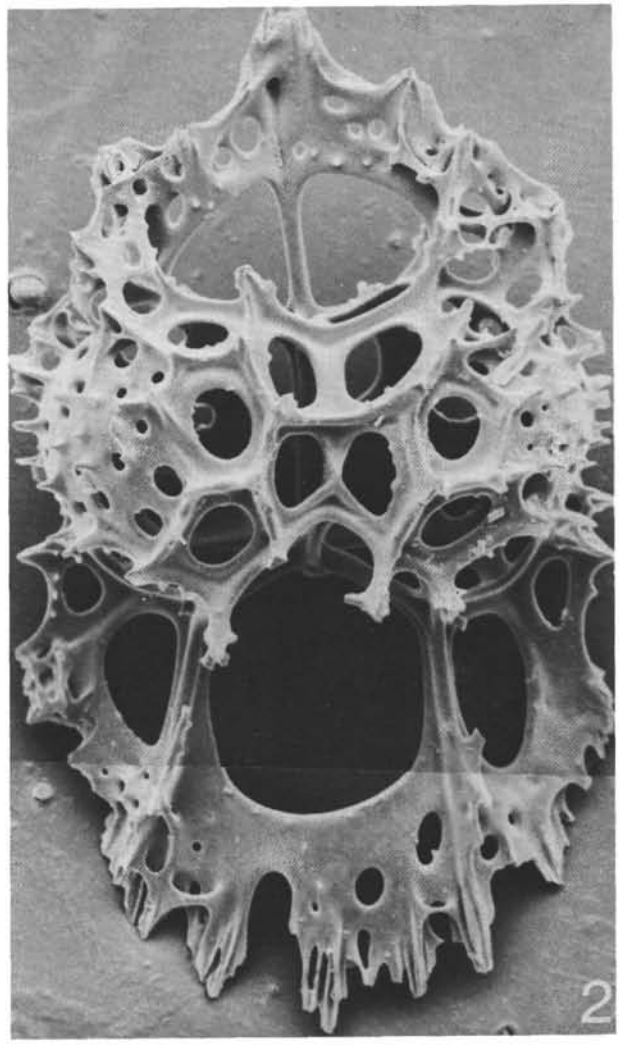


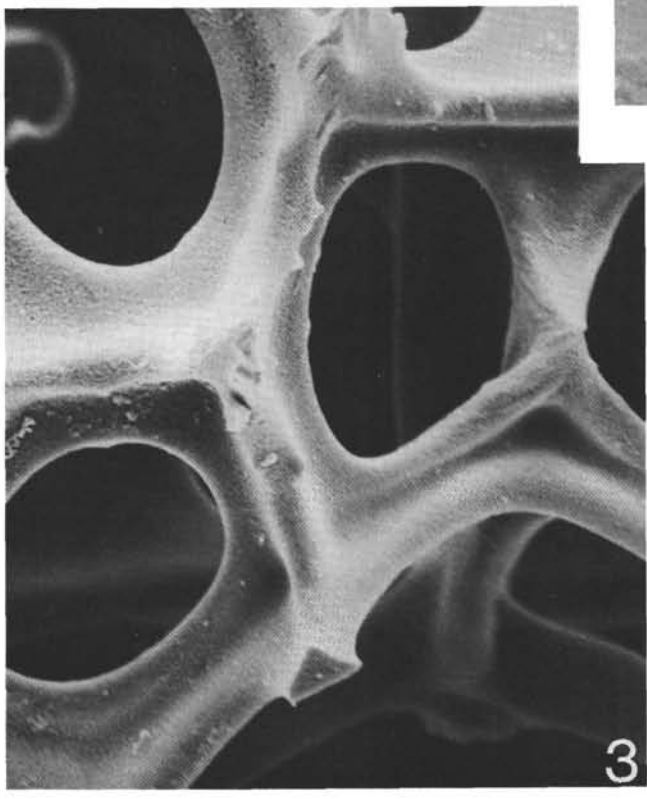


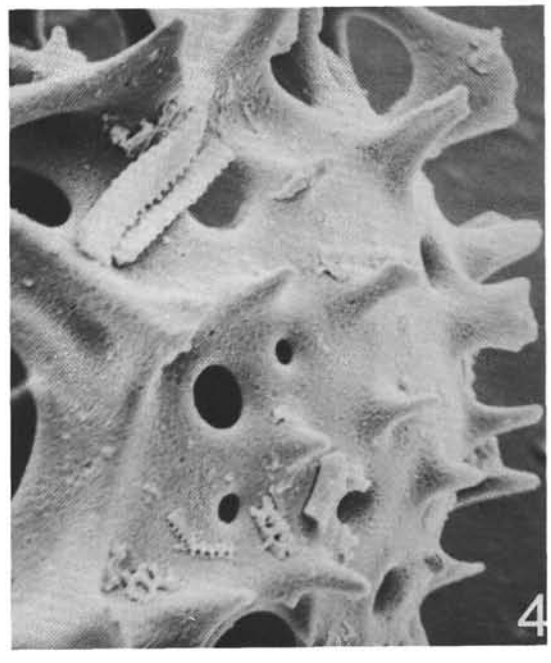


Figures 1-3 *Tholospyris infericosta.*
Hole 77B, Core 17, core catcher; front view; ×2050, ×510 and ×1030.

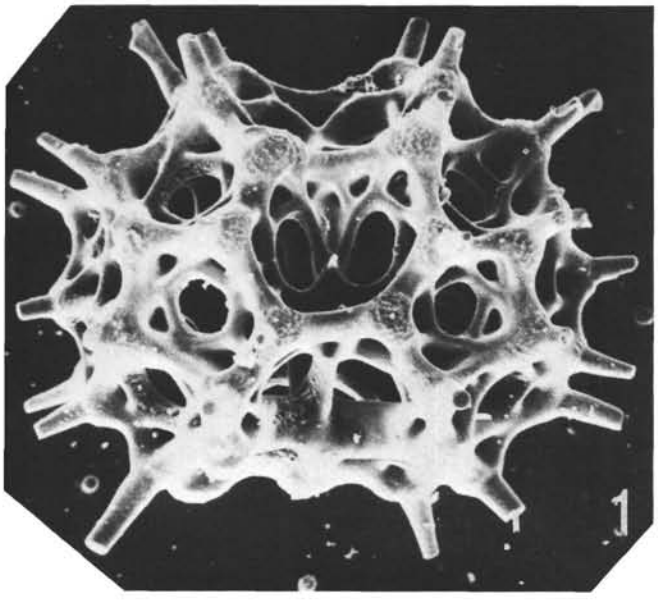


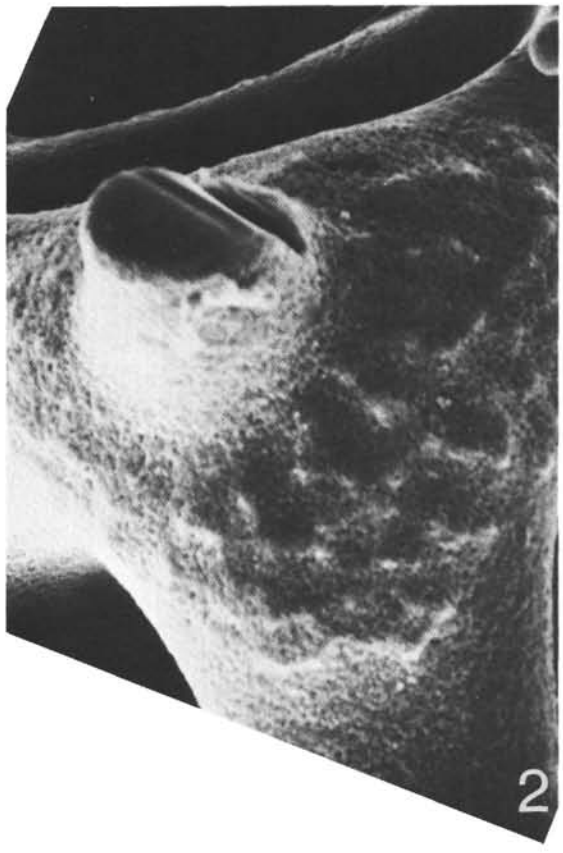


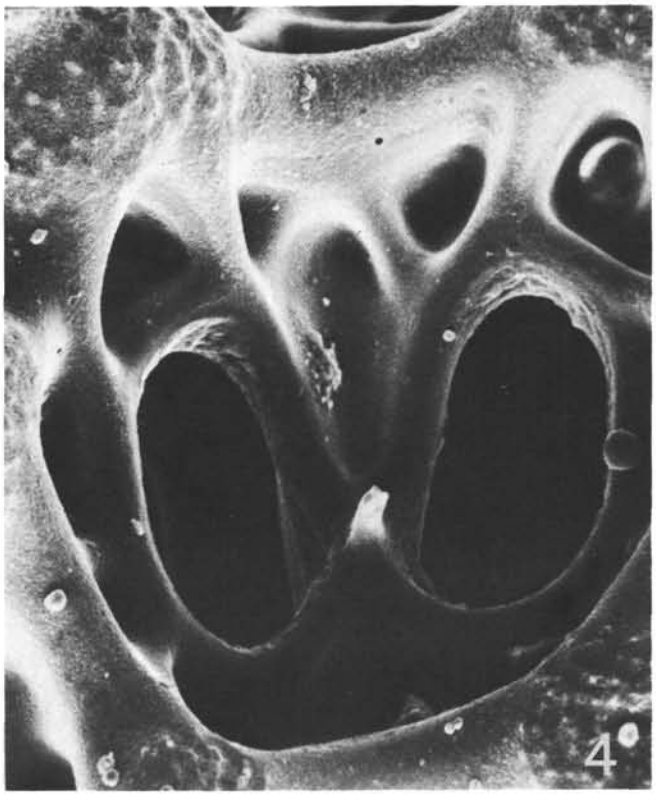




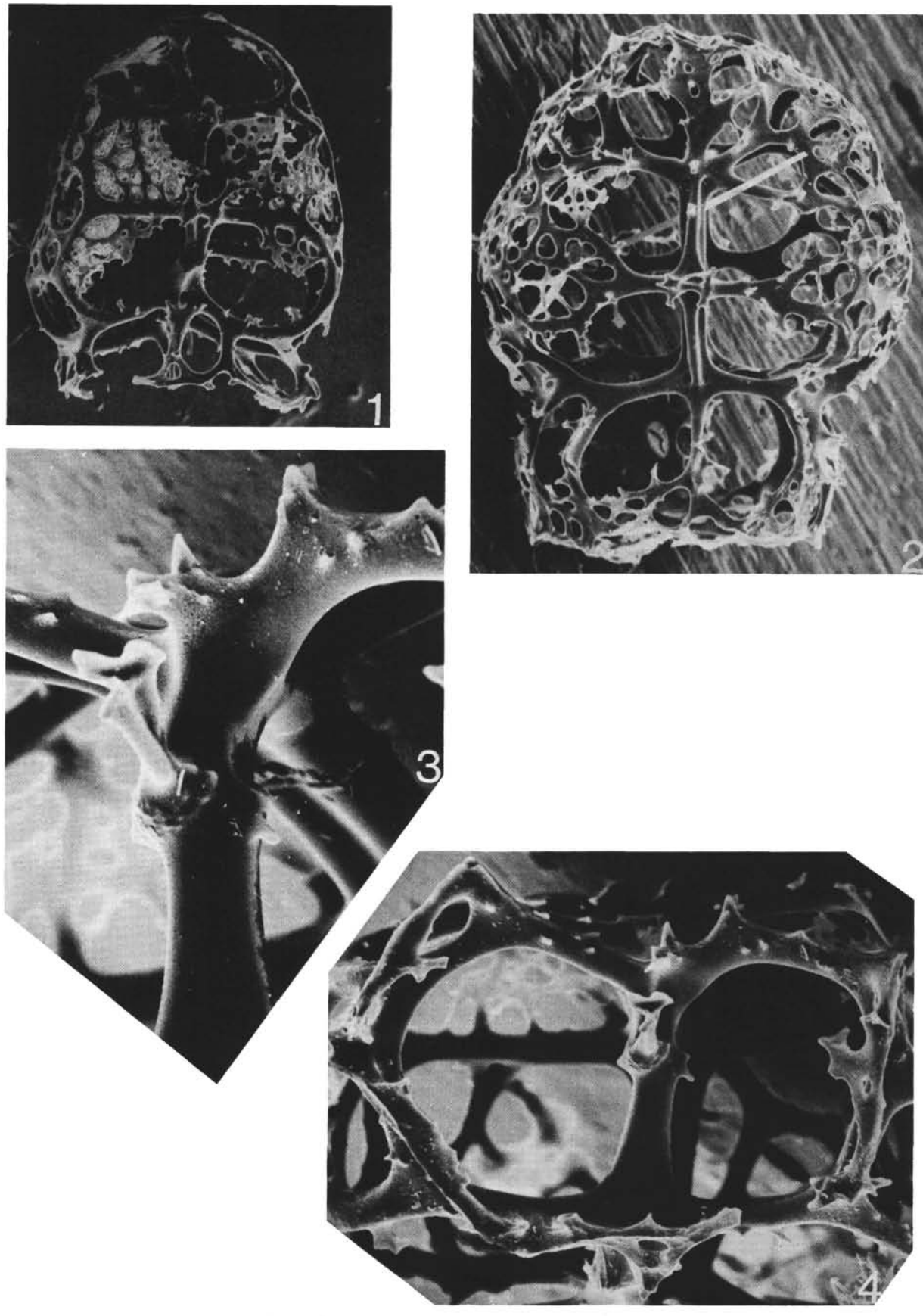
Figures 1-4 *Tholospyris infericosta.*
Hole 77B, Core 17, core catcher; rear view; X2050, X525, X2050 and X2050, respectively.



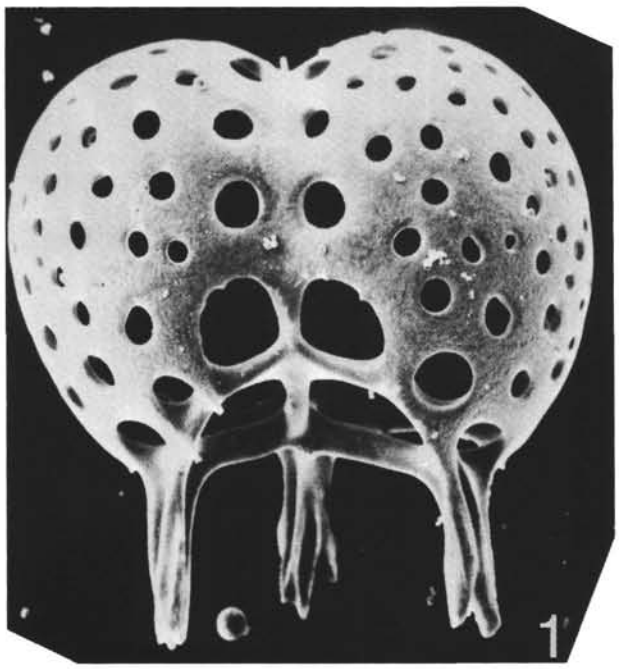


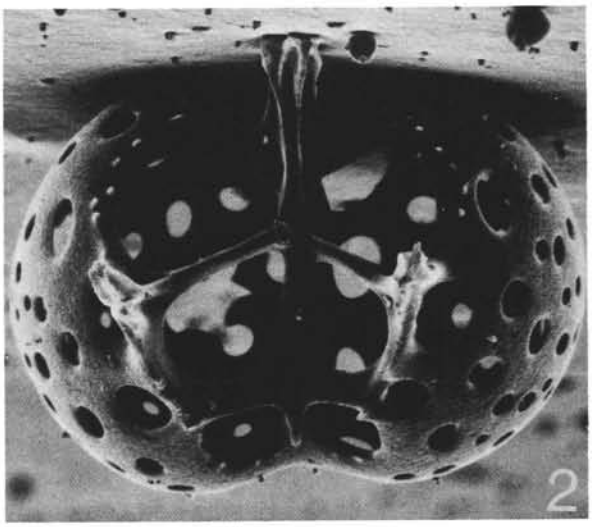


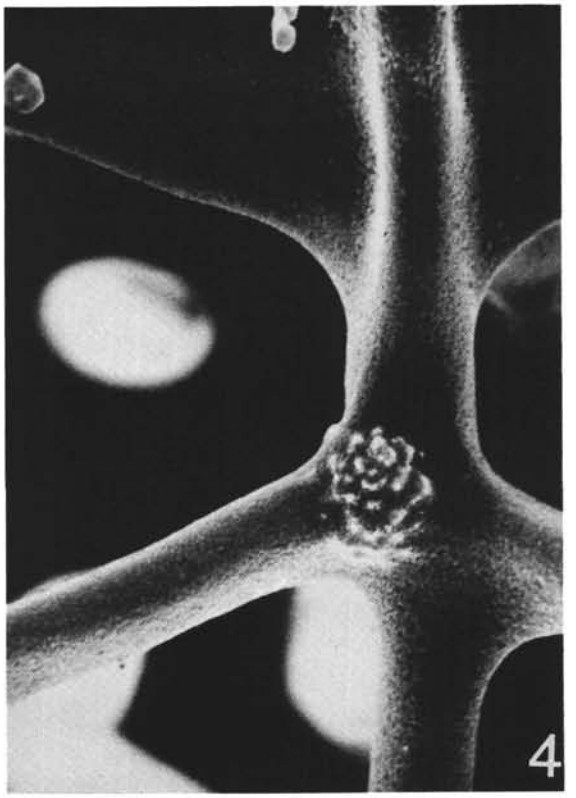
Figures 1-4 *Tholospyris mannalaris.*
Hole 78, Core 17, Section 4, 20-22 cm; rear view;
X200, X5000, X2000 and X2000, respectively.



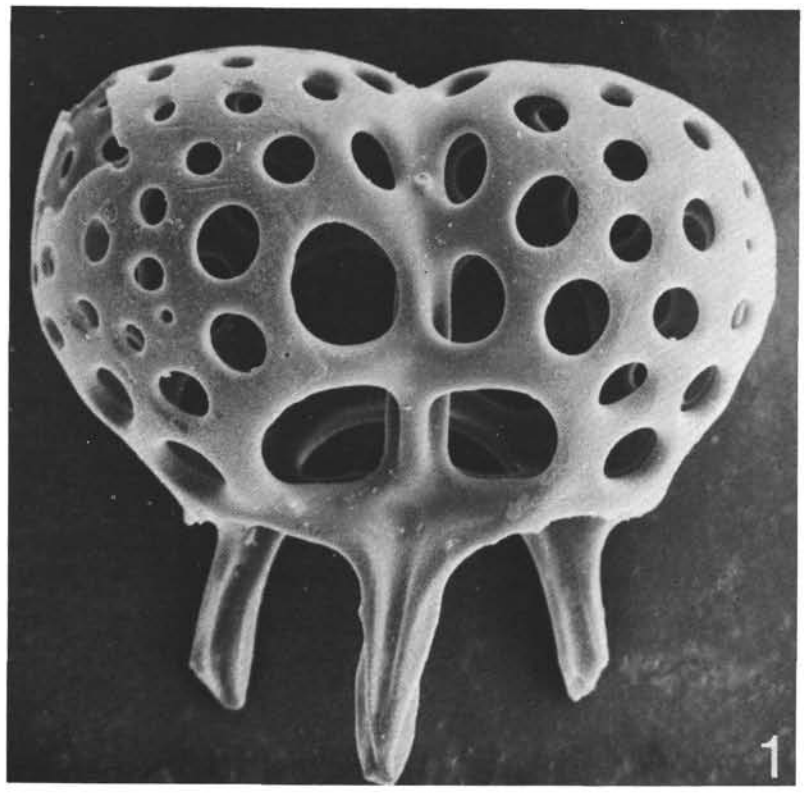
Figures 1-4 *Tholospyris procera.*
Hole 79, Core 2, Section 4, 1-3 cm.
1: Rear view; X470. 2: Front view; X505.
3 and 4: Basal views showing axial spine; X2000 and X1010, respectively.







Figures 1-4 *Tholospyris scaphipes.*
Hole 77B, Core 12, Section 6, 17-19 cm.
1: Rear view; X500.
2-4: Basal views; X500, X5000 and X5000, respectively.



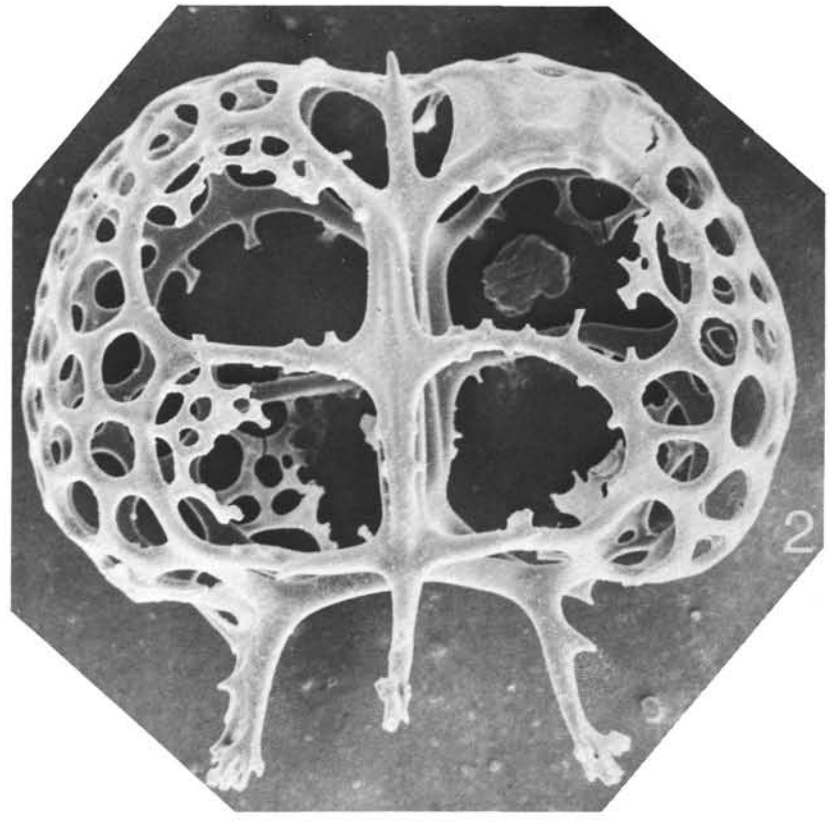
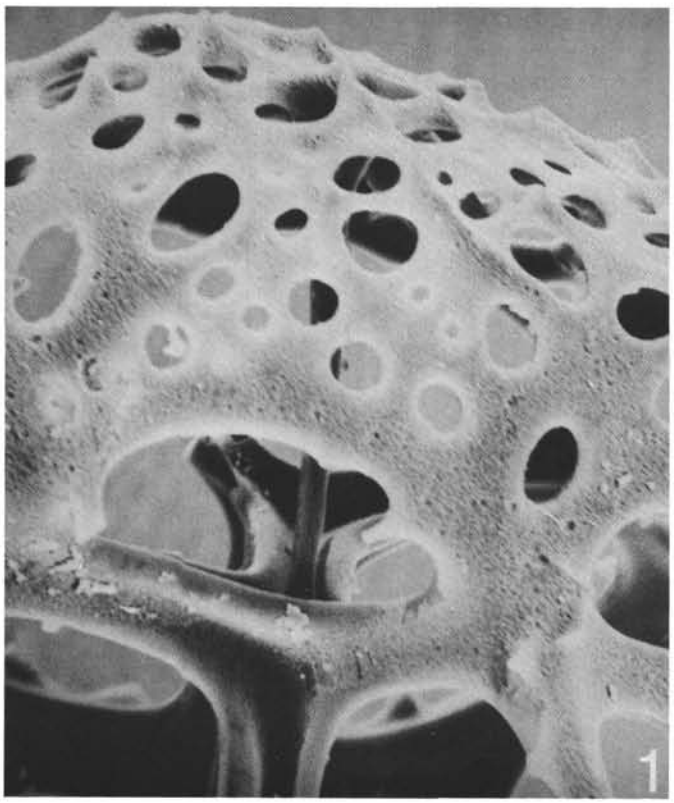
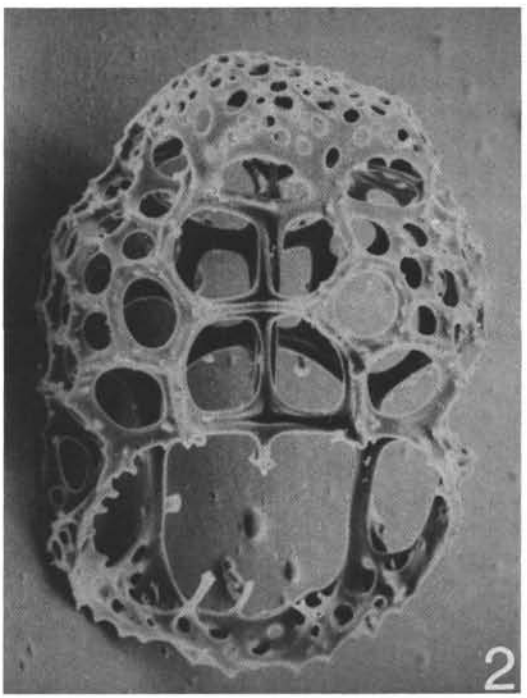


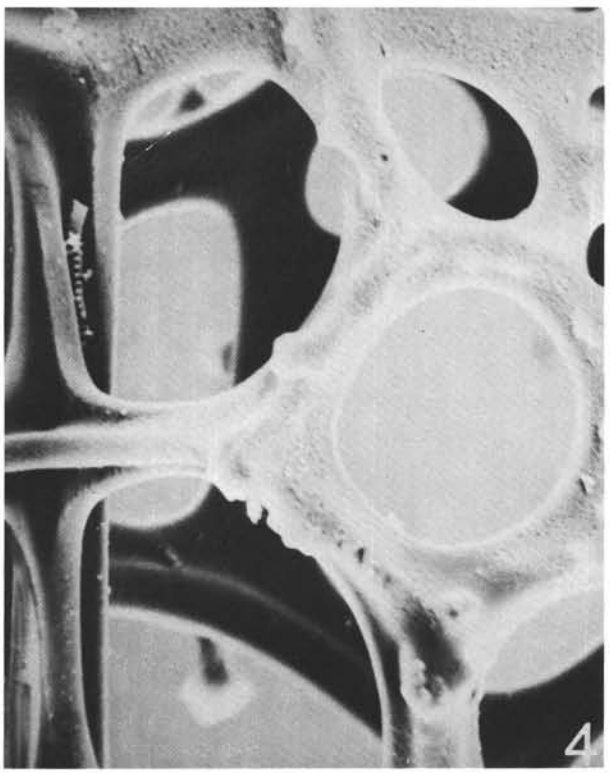
Figure 1 *Tholospyris scaphipes.*
Hole 80, Core 1, core catcher; front view, ×1000.

Figure 2 *Tristylospyris palmipes.*
Hole 80, Core 1, core catcher; front view, ×500.

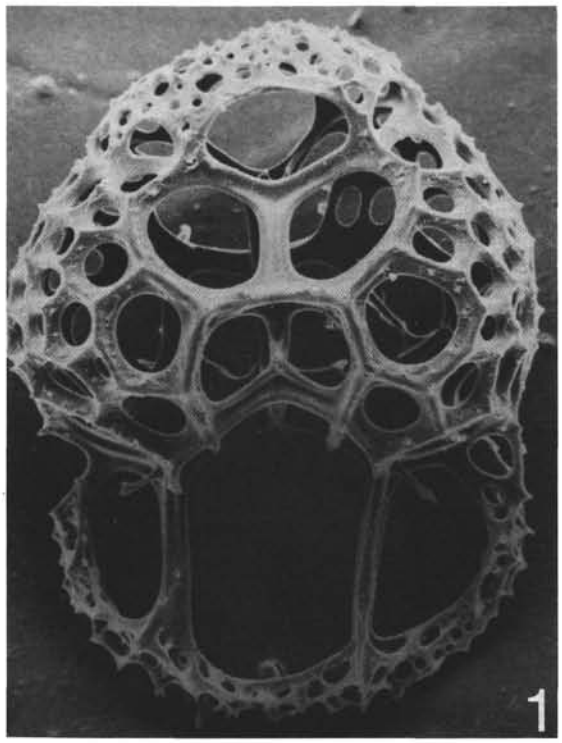
PLATE 84

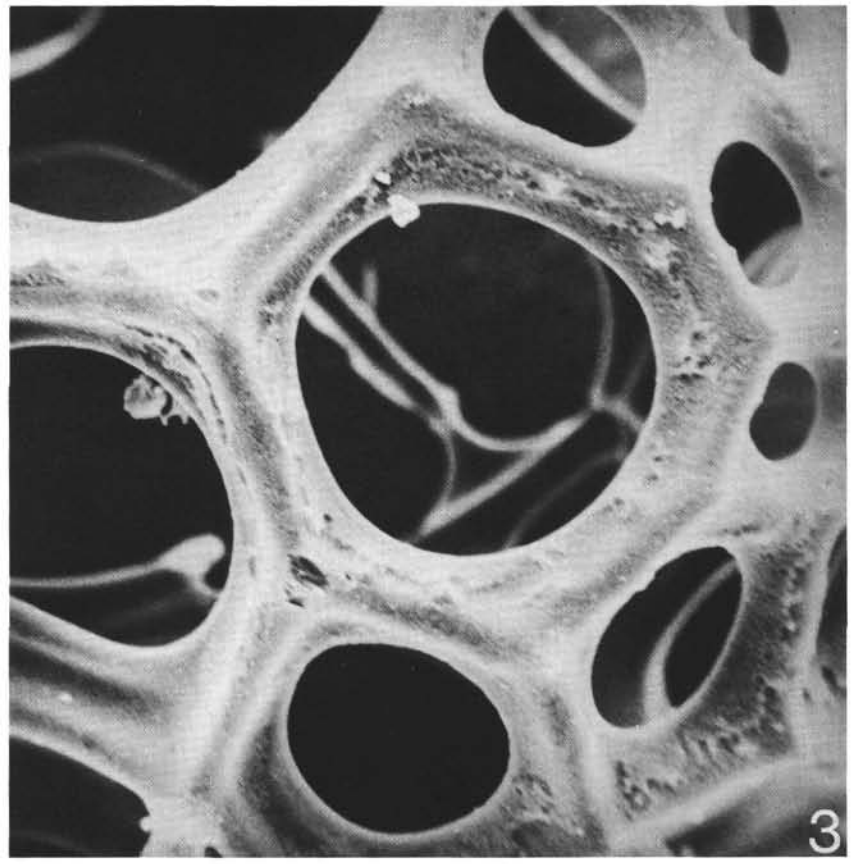






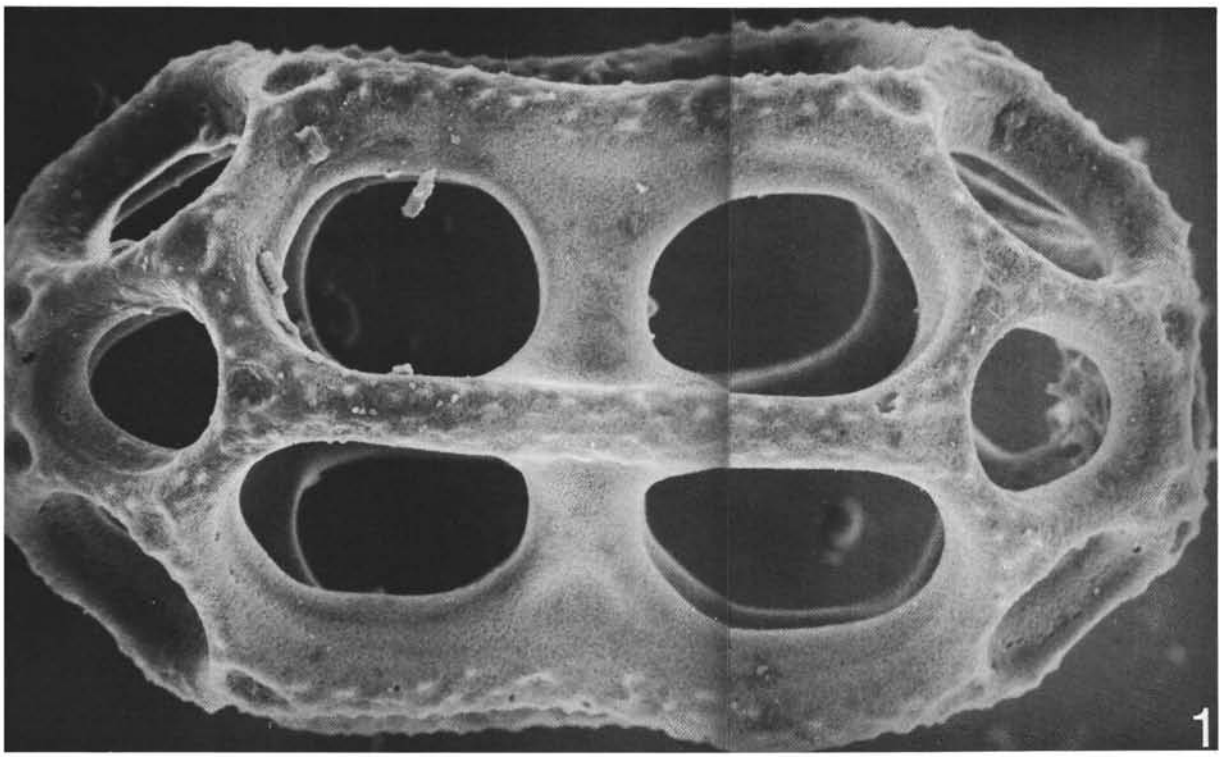
Figures 1-4 *Tricolospyris leibnitziana.*
Hole 77B, Core 12, core catcher; front view; X2000, X500, X2000 and X2000, respectively.

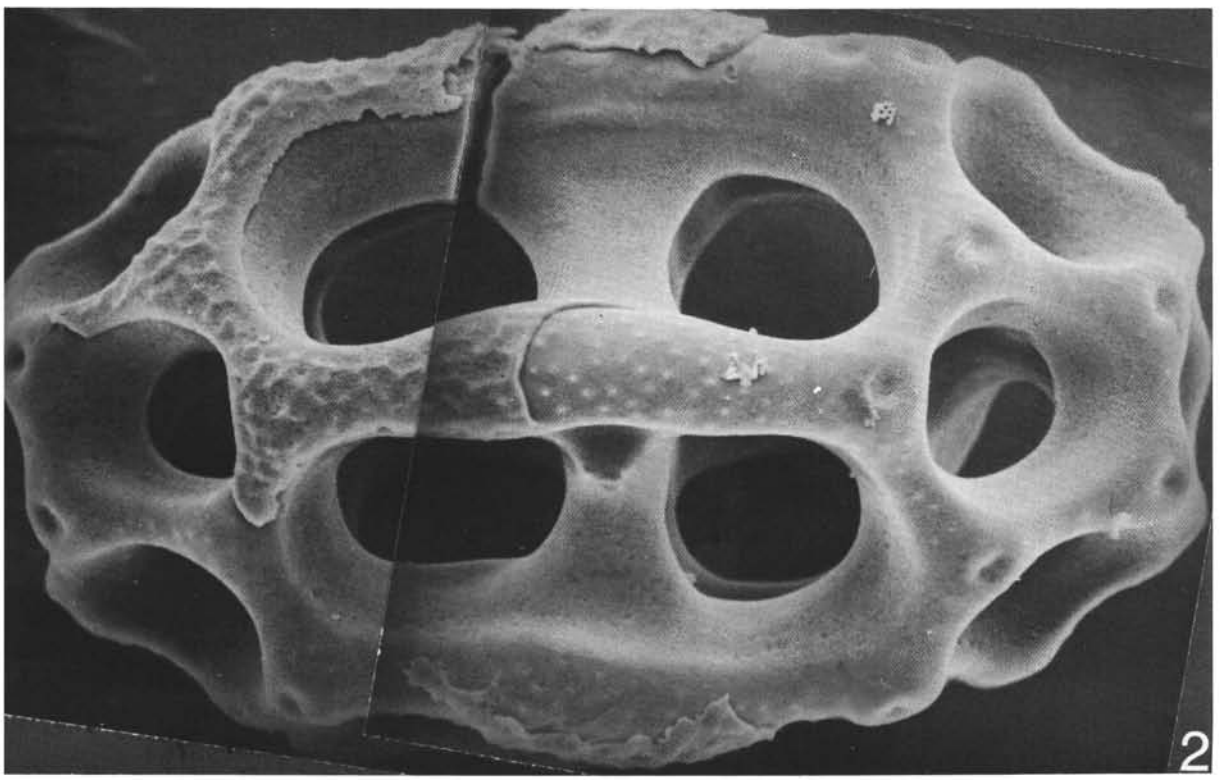




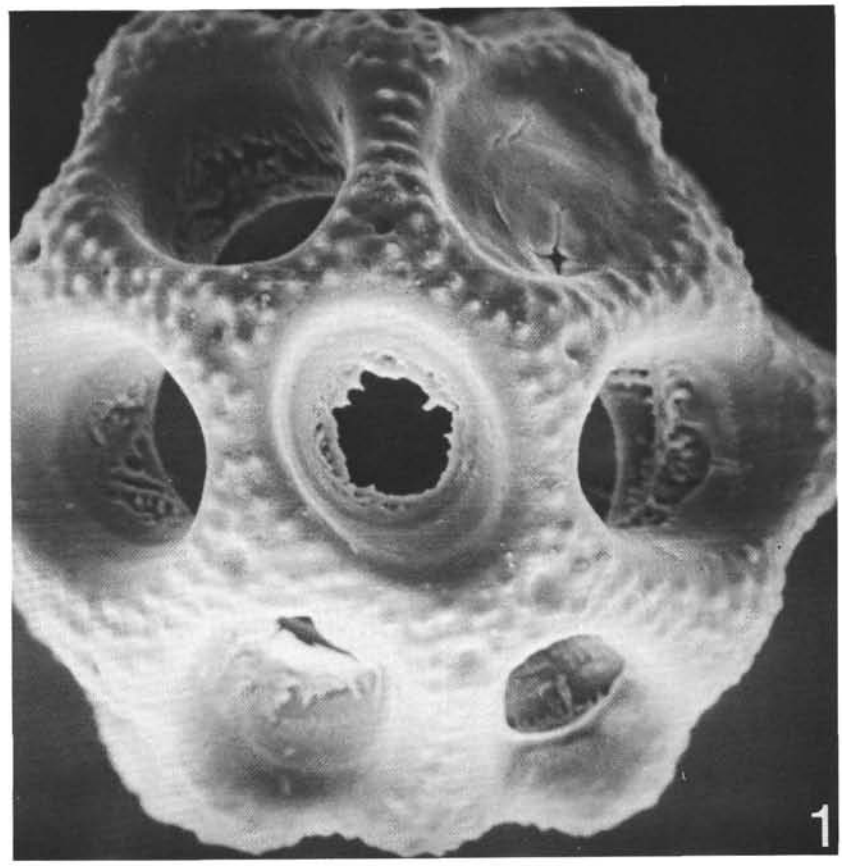
Figures 1-3 *Tholospyris leibnitiziana.*
1 and 3: Hole 77B, Core 12, core catcher; rear view; X520 and X2100, respectively.
2: Hole 77B, Core 5, Section 5, 0-2 cm; respectively.

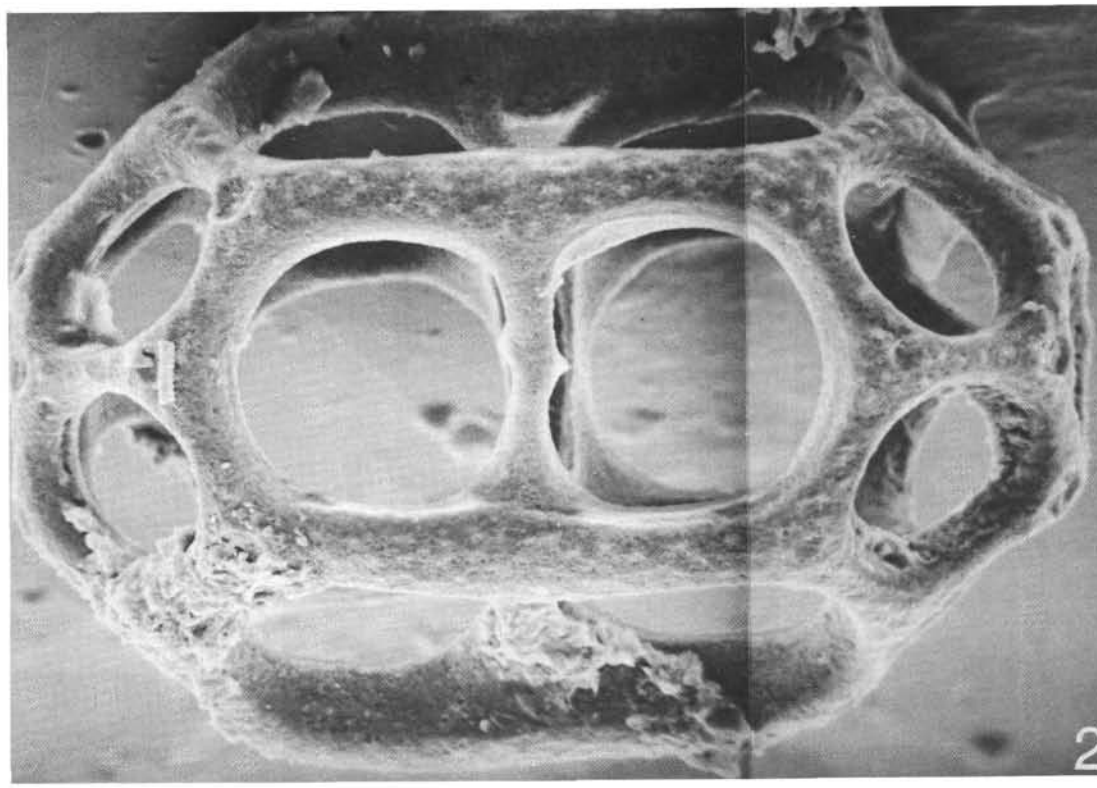
PLATE 86





Figures 1, 2 *Tympanidium binoctonum.*
1: Hole 77B, Core 29, core catcher; front view, ×920.
2: Hole 77B, Core 27, Section 6, 17-19 cm; rear view.





Figures 1, 2 *Tympanidium binoctonum.*
1: Hole 77B, Core 27, Section 6, 17-19 cm; side view, ×1000.
2: Hole 77B, Core 29, core catcher; basal view, ×1000.